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FEASIBILITY STUDY REPORT FOR OPERABLE UNIT 2, DRAFT AUGUST 1994 - VOLUME 6 OF 6

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COMPREHENSIVE RESPONSE ACTION RISK EVALUATION FOR OPERABLE UNIT 2

FERNALD ENVIRONMENTAL MANAGEMENT PROJECT
FERNALD, OHIO

REMEDIAL INVESTIGATION AND FEASIBILITY STUDY

VOLUME 6 OF 6
APPENDIX I

AUGUST 1994

U.S. DEPARTMENT OF ENERGY
FERNALD FIELD OFFICE

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Appendix I to Operable Unit 2 Feasibility Study Report

AUGUST 1994

U.S. DEPARTMENT OF ENERGY
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CRARE
EXECUTIVE SUMMARY

ES.1 BACKGROUND

The Fernald Environmental Management Project (FEMP) site is a federal facility where pure uranium metals were produced for DOE from 1951 to 1989. In 1991, the FEMP was officially closed as a production facility, but environmental studies, response actions, and site cleanup activities continue.

In accordance with the 1991 Amended Consent Agreement between the EPA and DOE, the FEMP was separated into five operable units, each requiring a remedial investigation and feasibility study. During each feasibility study, potential contaminants of concern are identified and cleanup levels are established to guide the remedial actions. As part of each feasibility study, a Comprehensive Response Action Risk Evaluation (CRARE) is prepared to analyze the residual human-health risks at the site after all remedial actions have been completed. The CRARE determines the risk to individual receptors from the combined sources of the five operable units. This allows all parties concerned to understand the impact of each operable unit on the site's total residual risk and provides a basis for revising cleanup levels as needed to meet EPA decision making criteria.

OPERABLE UNITS

The FEMP's five operable units and their associated structures are described below:

- Operable Unit 1:

  Waste Pit Area. Waste Pits 1-6, the clearwell, burnpit, berms, liners, and soil within the operable unit boundary.

- Operable Unit 2:

  Other Waste Units. Flyash piles, other South Field disposal areas, lime sludge ponds, solid waste landfill, berms, liners, and soil within the operable unit boundary.

- Operable Unit 3:

  Production Area. Production area and production-associated facilities and equipment (includes all above and below-grade improvements) including, but

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not limited to, all structures, equipment, utilities, drums, tanks, solid waste, waste product, thorium, effluent lines, K-65 transfer line, wastewater treatment facilities, fire training facilities, scrap metal piles, feedstocks, and the coal pile.

- Operable Unit 4:

  Silos 1-4. Silos 1, 2, 3, and 4, berms, decant tank system, and soil within the operable unit boundary.

- Operable Unit 5:

  Environmental Media. Groundwater, surface water, soil not included in the definitions of Operable Unit 1-4, sediments, flora, and fauna.

FEMP REMEDIATION

The remedial investigations and feasibility studies at the FEMP have led to the development and implementation of numerous removal actions. As defined in the Amended Consent Agreement, removal actions abate, minimize, stabilize, mitigate, or eliminate the release or threatened release of hazardous substances, pollutants, contaminants, or hazardous constituents at or from the FEMP. In 1993, the DOE published a comprehensive survey of the FEMP site called the Site-Wide Characterization Report. This report, which includes a baseline risk assessment, provides data and risk analyses on the effects of the removal actions completed as of March 1993. Because the CRARE is a postremediation document, by definition all removal actions will have been completed well before the time periods examined in the CRARE.

REMEDIAL ALTERNATIVES

Within the CRARE, the preferred remedial alternative from each operable unit's feasibility study is evaluated. If an operable unit's feasibility study has not been completed, then the leading remedial alternative from the Site-Wide Characterization Report is used as the preferred remedial alternative. This CRARE incorporates the preferred remedial alternatives for Operable Units 1, 2, and 4 (which have been updated using the feasibility study reports for those units) and the leading remedial alternatives for Operable Units 3 and 5 (whose feasibility studies have not yet been completed). With the development of new field data and new approaches to remediation, major changes may be expected for some of the operable unit remedial alternatives. While the remedial alternatives do not dictate what proposed remedial goals should be, they do indicate what level of cleanup the remedial technologies can possibly achieve. Changes to the Operable

Unit 3 and 5 leading remedial alternatives, therefore, may result in significant changes to future CRARE transport modeling and risk assessment. The enclosed foldout illustrates the postremediation permanent disposal facilities to be constructed as projected based on the remedial alternatives presented below.

Operable Unit 1 Preferred Remedial Alternative

The preferred remedial alternative for Operable Unit 1 includes removal, pretreatment drying, and off-property disposal of waste pit materials, covers, liners, and contaminated soils. The excavated areas will be backfilled with clean soil. Additional components of the preferred remedial alternative include construction of waste processing and loading facilities and equipment, and removal of water from open waste pits for treatment at the Advanced Waste Water Treatment (AWWT) facility.

Operable Unit 2 Preferred Remedial Alternative

The preferred remedial alternative for Operable Unit 2 includes excavation of all soils with COCs above the proposed remediation levels (PRLs), material processing for size reduction and moisture control (if required), on-site disposal in an engineered disposal cell and off-site disposal of a small fraction of the excavated material that exceeds the waste acceptance criteria (WAC) of the on-site disposal facility. Excavation activities and construction of the disposal cell would be coordinated with Operable Units 1, 3, 4, and 5.

At the Lime Sludge Ponds, free-standing water would be removed. In the South Field area, excavation of contaminated material with COC concentrations above the PRLs would prevent significant amounts of contaminants from the source material from entering the Great Miami Aquifer via the sand lenses in the glacial till. Nonsoil material (e.g., concrete, drums, steel, pallets, etc.) from all subunits would be visually segregated, hauled to the staging/material preparation area, processed for size reduction, and placed in the on-site disposal cell.

The contaminated material from the subunits would be excavated, transported, and placed in the on-site disposal cell in a manner to provide a stable mass. To improve its handling/compaction characteristics, lime sludge would be mixed with other waste material as necessary.

The amount of excavated material that exceeds the WAC is expected to be approximately 2350 cubic meters (3100 cubic yards). This waste will be sent to a designated off-site disposal facility.

Operable Unit 3 Leading Remedial Alternative

For the Operable Unit 3 leading remedial alternative (LRA), buildings will be decontaminated and demolished; contaminated material would be removed, treated and/or decontaminated, temporarily placed in storage, and finally disposed to reduce the potential for contaminant migration. Decontamination and treatment residue would require further treatment and disposal. Contaminated material would be disposed in the vaults while clean material would be free-released for reuse or recycling.

Operable Unit 4 Preferred Remedial Alternative

The PRA for Operable Unit 4 includes removing the waste stored in Silos 1, 2, and 3, stabilizing it via vitrification, and removing it to an off-site disposal facility. Silos 1, 2, 3 and 4 will be decontaminated to the extent practical and demolished. Contaminated soil and construction material from the silo berms, subsoil, and decant tank would be removed to the extent necessary based on cleanup levels and temporarily stored on-site for eventual treatment and disposal with Operable Unit 3 debris and/or Operable Unit 5 soil. These actions are presented in the Proposed Plan For Remedial Actions at Operable Unit 4.

Operable Unit 5 Leading Remedial Alternative

Under the LRA for Operable Unit 5, contaminated groundwater would be extracted, treated at an on-property facility, and discharged to the Great Miami River through the newly constructed effluent line. Treatment residuals would be disposed in on-property disposal facilities. The LRA also involves excavating contaminated sediment and soil necessary to meet cleanup levels, transporting the contaminated material to an on-property location for treatment using soil-washing, and returning the treated material as backfill. For U-238, a 60-pCi/g target cleanup level was selected. This cleanup level and those for other COCs were defined in the SWCR. The soil-washing fluids would be recycled and the removed contaminants stabilized and disposed in on-property disposal facilities.

ES.2 CRARE TECHNICAL APPROACH

This Operable Unit 2 CRARE presents a postremediation risk evaluation for all FEMP contaminants of concern transported via the direct pathways of air, soil, groundwater, surface water, and radiation, as well as the indirect pathway of farm product consumption. The technical approach and results have been summarized by the following categories and graphically presented on the foldout:

- Site-wide sources of contamination
- Identification of contaminants of concern
- Receptor characterization
- Pathways of exposure
- Postremediation residual risk characterization
- Operable unit contribution to risk
- Impact of uncertainty on the risk estimates

SITE-WIDE SOURCES OF CONTAMINATION

The primary sources of contamination remaining after site remediation include:

- Residual foot print areas for all operable units
- Eastern Vaults
- Operable Unit 1 and 2 capped/covered areas

IDENTIFICATION OF CONTAMINANTS OF CONCERN

Potential contaminants of concern detected on-property were identified using Appendix R of the Site-Wide Characterization Report and the remedial investigation/feasibility study reports for Operable Units 1, 2, and 4. A multi-step screening process identified those contaminants of concern that would be present on FEMP property during the 70- and 1000-year postremediation time frames. These 51 contaminants are presented on the foldout.

Volatile organic compounds were eliminated from consideration as contaminants of concern because evaporation would rapidly remove these compounds from the FEMP before the time periods under evaluation. Also, remediation activities implemented before the time frame considered in the CRARE would be expected to disturb, expose and mix many of the soils containing volatiles and thereby hasten the evaporation of these contaminants. Similarly, other

organic compounds were removed from consideration after evaluating their organic decay rates in water and soil.

The remaining contaminants were then used in fate and transport modeling of air, surface water, groundwater, and farm products. During the groundwater fate and transport analysis, the contaminants were further screened using preliminary modeling techniques to determine if significant quantities would reach groundwater within the 1000-year time frame. It is unlikely that any major contaminants of concern were overlooked.

LAND USE

The CRARE evaluates sources, release mechanisms, transport-media and risk pathways for various human receptors under the Current and two Future Land Use scenarios of the five operable units. The Current Land Use scenario describes the FEMP for a 70-year period starting after all remedial actions are complete. The 70-year period is based on the risk assessment work plan addendum, and is the life span of an individual. The scenario assumes DOE ownership, site access control, and maintenance of the FEMP and associated remedial structures for 70 years. The only remaining treatment facility active on the site at the start of the 70 years should be the wastewater treatment plant in Operable Unit 5.

The two Future Land Use scenarios describe the FEMP for up to 1000 years after all remedial actions are complete: Future Land Use With Federal Ownership assumes continued government ownership and land use restrictions, while Future Land Use Without Federal Ownership assumes occupation by a resident farm. Contaminant fate and transport have been modeled for 1000 years.

RECEPTORS

The following on-property and off-property reasonable maximum exposure (RME) receptors have been evaluated in this CRARE.

On-Property

- Resident farm adult (who ingests water from the Great Miami Aquifer)
- Resident farm adult (who ingests perched groundwater)
- Resident farm child
- Expanded trespasser
- Trespassing child
- Groundskeeper

Off-Property

- Resident farm adult
- Resident farm child
- Great Miami River User
  - Agricultural
  - Residential
  - Recreational

These receptors represent a wide array of potential land uses. Even though the FEMP was not evaluated for residential-only land use, the use of resident farm receptors (who consume on-property farm produce) is more conservative than the use of a residential-only receptor. For the evaluation of carcinogenic risk, all adult farmers were assumed to be exposed for their entire 70-year life spans.

For reference, the ILCR is defined as the incremental lifetime cancer risk to an individual as a result of exposure to a contaminant for a 70-year lifetime. The health hazard resulting from exposure to noncarcinogenic contaminants was evaluated and expressed as the hazard index (HI). The HIs were estimated by comparing an exposure level or intake to the EPA reference dose. If the resulting HI is greater than 1, there is a concern for potential health effects.

PATHWAYS

The pathways considered in this CRARE are:

- Inhalation of radon gas and particulates
- Incidental ingestion of soil and sediment
- Dermal contact with soil and sediment
- External radiation exposure
- Ingestion of groundwater (Great Miami Aquifer or perched)
- Ingestion of farm products (milk, meat, and vegetables)
- Ingestion of surface water
- GMR Water User

CONTAMINANT-RELATED POSTREMEDIATION RESIDUAL RISK

The estimated risks from the FEMP are summarized in the drawing. The detailed risk analysis indicates that the major radionuclides of concern are uranium-238, uranium-234, technicium-99, thorium-228 and radon-222. The principal contributors to the chemical carcinogenic risk are arsenic, beryllium, chromium, and the PCBs. The principal contributors to the noncarcinogenic hazards are antimony, arsenic, boron, cadmium cobalt, manganese, mercury, molybdenum, silver, and zinc.

OPERABLE UNIT CONTRIBUTIONS TO RISK

Based on a review of risk estimations for the RME receptors and the three land use scenarios, it is evident that the combined contribution to total risk from Operable Units 1, 2, 3, is less than four percent. Operable Unit 5 contributes from 96 to 99 percent of total risk.

UNCERTAINTIES

The preparation of this Operable Unit 2 CRARE employed conservative assumptions and the best scientific and engineering judgement consistent with the EPA guidance. The risk principles and equations found in the FEMP Risk Assessment Work Plan Addendum were used throughout this analysis, as were the exposure parameters from the Operable Unit 2 Remedial Investigation Report. Results of the CRARE have identified points of departure from target risk ranges for ILCRs as discussed in the National Contingency Plan (which translates to carcinogenic risk beyond the range of 10^{-4} to 10^{-6}) and from the benchmark HI of 1 discussed in the EPA Risk Assessment Guidance for Superfund.

ES.3 SUMMARY AND CONCLUSIONS

Potential health hazards and risks to on-property and off-property receptors were quantified and evaluated in this Operable Unit 2 CRARE. *The conclusion reached by applying the CRARE process is that the FEMP would appear to be unsuitable as a family farm even after remediation is complete.* The foldout is a comprehensive summary of the CRARE process and includes risk results for each receptor by land use. For this CRARE, the major pathways of concern were found to be the inhalation of fugitive particulates, the consumption of drinking water, the ingestion of meat, dairy products, fruits and vegetables, and dermal contact with soils. Direct radiation was a significant pathway of concern for the on-property farmer (child) resident receptor.

The carcinogenic risk estimate for the on-property resident farmer is the most-elevated and exceeded the target risk range. The ingestion of and dermal contact with perched groundwater while bathing would increase the ILCR by about 10 fold for this receptor. Risks for the trespassing child and expanded trespasser are within the target risk range for both carcinogenic and noncarcinogenic health effects.

The risks for the groundskeeper are within the target range for both carcinogenic and noncarcinogenic health effects. The carcinogenic risks for the off-property farmer are above 10^{-4} for all adult exposure scenarios. The noncarcinogenic HI causes the most concern for the on-property farm child. The risks for the agricultural, residential and recreational GMR user are within the target range for both carcinogenic and noncarcinogenic effects.

A review of the estimated carcinogenic risks and noncarcinogenic hazards follows.

Current Land Use

- Carcinogenic Risk:

  The groundskeeper, trespassing child and off-property resident farm adult and child have ILCRs within the target range of 10^{-4} to 10^{-6}.

- Noncarcinogenic Hazard:

  The groundskeeper, trespassing child, and the off-property resident farm adult and child have HIs less than 1.

Future Land Use With Federal Ownership

- Carcinogenic Risk:

  The trespassing child and the expanded trespasser have estimated ILCRs of less than 10^{-4}. The off-property resident farm adult has an estimated ILCR greater than 10^{-4}.

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- Noncarcinogenic Hazard:

  The trespassing child, expanded trespasser, and off-property resident farm adult have HIs less than 1. The off-property resident farm child has an estimated HI greater than 1.

Future Land Use Without Federal Ownership

- Carcinogenic Risk:

  The on-property receptors have ILCRs above the target range of 10^{-4} to 10^{-6}. The off-property adult receptor has an ILCR greater than 10^{-4}. The agricultural, residential, and recreational GMR (Great Miami River) users all have ILCRs less than 10^{-4}.

- Noncarcinogenic Hazard:

  All on-property receptors have HIs above 1. The off-property resident farm child also has an HI above 1. The agricultural, residential, and recreational GMR users all have HIs less the 1.

ES.4 RECOMMENDATIONS

Because the majority of the FEMP residual risk is associated with Operable Unit 5 soils, future CRAREs should focus on refining and completing information on this unit. Further research should be conducted on refining groundwater modeling parameters that apply to specific operable units or the FEMP as a whole. Bench-scale testing of how remediated soil conditions will change may be warranted. Additionally, investigations should be conducted into the physical characteristics of the remediated soils and into developing an appropriate fugitive particulate emission model for long-term risk analysis.

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COMPREHENSIVE RESPONSE ACTION RISK EVALUATION - DOE FERNALD REMEDIATION

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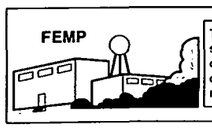
COLLECT AND EVALUATE DATA



The Fernald Environmental Management Project (FEMP) site is a federal facility where uranium metals were produced for DOE from 1951 to 1989. In 1991, the FEMP was closed as a production facility, but environmental studies, response actions and site cleanup activities continue.

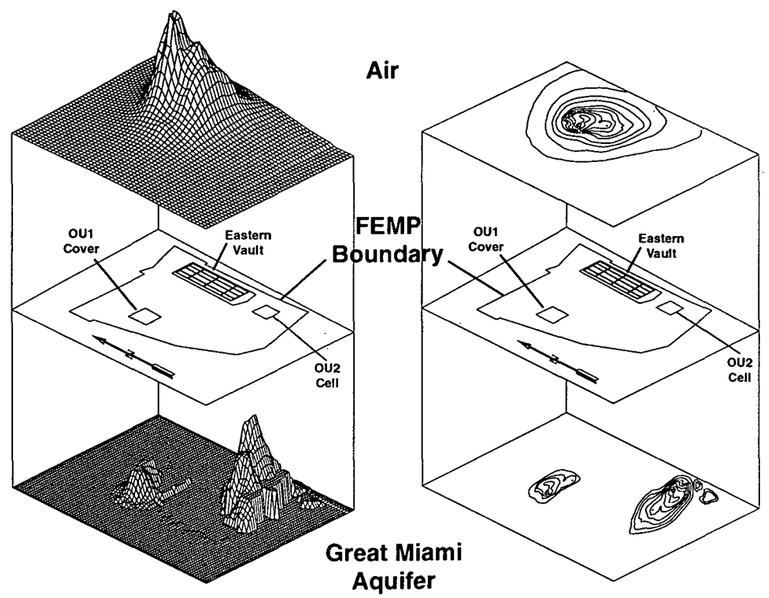
SWCR (Site-Wide Characterization Report) + RAWPA (Risk Assessment Work Plan Addendum) + OU4 RI/FS (Remedial Investigation/ Feasibility Study) + OU1 RI/FS (Remedial Investigation/ Feasibility Study) + OU2 RI/FS (Remedial Investigation/ Feasibility Study) + EPA Comments on OU4 CRARE & OU2 CRARE

IDENTIFY CONTAMINANTS OF CONCERN

SWCR Appendix R – RI/FS Screening OU1, 2, 4 – Remove Volatile Organics Over Time – Organic Degradation – Pump and Treat Removes Semivolatiles

ASSESS EXPOSURE

U-238 Modeled Concentrations in 3-D and 2-D Isopleths



Computer Modeling:
Air Particulates
Air-Radon
Groundwater
Surface Water
Radiation

BACKGROUND

In accordance with the 1991 Amended Consent Agreement between the US EPA and DOE, a Comprehensive Response Action Risk Evaluation (CRARE) will be prepared for each operable unit at the FEMP site. The CRAREs are to analyze the residual human-health risks projected to remain on-site following the implementation of the remedial actions for the five operable units.

This Operable Unit 1&2 CRARE presents a postremediation risk evaluation for all FEMP contaminants of concern transported via the direct pathways of air, soil, groundwater, surface water and radiation, as well as the indirect pathway of farm product consumption.

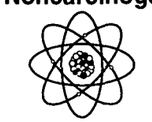
HEALTH RISKS AND HAZARDS

RME Receptor *	ILCR *	HI *
Current Land Use		
Groundskeeper	3.2×10^{-5}	0.33
Trespassing Child	2.0×10^{-6}	0.23
Off-Property Farm Residents		
Adult	1.0×10^{-4}	0.08
Child	6.0×10^{-6}	0.21
Future Land Use with Federal Ownership		
Expanded Trespasser	1.7×10^{-6}	0.23
Trespassing Child	2.0×10^{-6}	0.23
Off-Property Farm Residents		
Adult	2.0×10^{-4}	0.78
Child	1.1×10^{-5}	1.8
Future Land Use without Federal Ownership		
On-Property Farm Residents		
Adult (ingests perched ground water)	4.9×10^{-2}	100.0
Adult (ingests Great Miami Aquifer water)	2.8×10^{-3}	33.0
Child	8.9×10^{-4}	100.0
Off-Property Farm Residents		
Adult	2.0×10^{-4}	0.78
Child	1.1×10^{-5}	1.8
Great Miami River User		
Agricultural	4.5×10^{-6}	0.01
Residential	1.5×10^{-5}	0.04
Recreational	8.9×10^{-6}	0.02

* ILCR = Incremental Lifetime Cancer Risk over a 70-year lifetime (NCP target range is 10^{-4} to 10^{-6})
* HI = Hazard Index not to exceed 1.0
* RME = Reasonable Maximum Exposure

ASSESS TOXICITY

- Carcinogenic
- Noncarcinogenic



Radionuclide

Cs-137	Ru-106
Np-237	Sr-90
Pa-231	Tc-99
Pb-210	Th-228
Pu-238	Th-230
Pu-239	Th-232
Pu-240	U-234
Ra-226	U-235
Ra-228	U-236
Rn-222	U-238

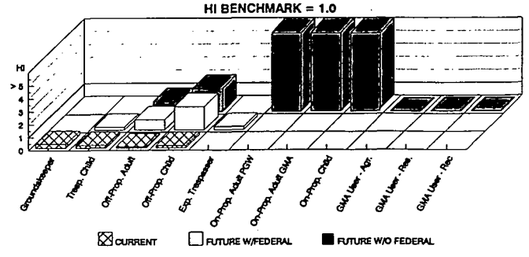
Chemical

2-Methylnaphthalene	Cyanide
4,4-DDE	Endrin
Antimony	Lead
Aroclor-1221	Manganese
Aroclor-1248	Mercury
Aroclor-1254	Molybdenum
Aroclor-1260	Nickel
Arsenic	Selenium
Barium	Silver
Beryllium	TCDD
Boron	Thallium
Cadmium	Thorium
Carbazole	Uranium
Chromium	Vanadium
Cobalt	Zinc
Copper	

CHARACTERIZE RISK

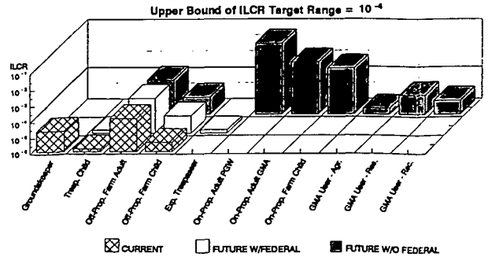
NONCARCINOGENIC HEALTH HAZARD

HI BENCHMARK = 1.0



CARCINOGENIC RISK

Upper Bound of ILCR Target Range = 10^{-4}



The results of the human-health risk characterization were compiled and analyzed. Noncarcinogenic health hazards and carcinogenic health risks were summarized.

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ACRONYMS

AAQS	Ambient Air Quality Standards
ARAR	applicable, relevant, and appropriate requirements
ASI	American Standards Institute
BEIR	biological effects of ionizing radiation
BGS	below ground surface
CAA	Clean Air Act
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
cfs	cubic feet per second
cm/s	centimeter per second
cm/yr	centimeter per year
COC	contaminant of concern
CRARE	Comprehensive Response Action Risk Evaluation
DOD	U.S. Department of Defense
DOE	U.S. Department of Energy
DOT	U.S. Department of Transportation
ECAO	U.S. Environmental Criteria and Assessment Office
EE/CA	engineering evaluation/cost analysis
EIS	environmental impact statement
EPA	Environmental Protection Agency
ERA	ecological risk assessment
FEMP	Fernald Environmental Management Project
FERMCO	Fernald Environmental Restoration Management Co.
FFCA	Federal Facility Compliance Agreement
FMPC	Feed Materials Production Center
FRG	final remedial goal
FS	feasibility study
FS/RA	feasibility study/risk assessment
GI	gastrointestinal
GMA	Great Miami Aquifer
GMR	Great Miami River
HDPE	high density polyethylene
HEAST	Health Effects Assessment Summary Tables
HEC-1	U.S. Army Corps of Engineers Hydrologic Engineering Center
HELP	Hydraulic Evaluation of Landfill Performance
HI	hazard index
HQ	hazard quotient
IAWWT	interim advanced waste water treatment
ICRP	International Commission of Radiological Production
ILCR	incremental lifetime cancer risk
IRIS	Integrated Risk Information System
ISCLT2	Industrial Source Complex Dispersion Model, Long-Term, Version 2
K_d	solid-liquid partitioning coefficient
kg	kilogram
KPH	kilometers per hour
LC/DS	leachate collection/detection system
LET	linear energy transfer
LOAEL	lowest observed adverse effect level

ACRONYMS
(Continued)

LRA	leading remedial alternative
MAGLC	maximum allowable ground level concentration
MAV	mass-weighted average
MCL	maximum concentration level
MCLG	maximum concentration level goal
mg	milligram
mph	miles per hour
mrem	millirem
MSL	mean sea level
MUSLE	Modified Universal Soil Loss Equation
NCP	National Contingency Plan
NCRP	National Council on Radiation Protection
NEPA	National Environmental Policy Act
NESHAPS	National Emission Standards for Hazardous Air Pollutants
NOAEL	no observed adverse effect level
NPDES	National Pollutant Discharge Elimination System
NRC	Nuclear Regulatory Commission
NTS	Nevada Test Site
NWS	News Weather Service
ODAST	One-Dimensional Analytical Solute Transport
OEPA	Ohio Environmental Protection Agency
ORP	Office of Radiation Program
OU	Operable Unit
PAH	polycyclic aromatic hydrocarbons
PCB	polychlorinated biphenyl
pCi/g	picocurie per gram
pCi/l	picocurie per liter
ppm	parts per million
PRA	preferred remedial alternative
PRG	preliminary remedial goal
PRL	proposed remediation level
QA	quality assurance
RA	risk assessment
RAGS	Risk Assessment Guidelines for Superfund
RAWPA	Risk Assessment Work Plan Addendum
RCRA	Resource Conservation and Recovery Act
RDA	recommended daily allowance
RfC	reference concentration
RfD	reference dose
RI	remedial investigation
RI/FS	remedial investigation/feasibility study
RIQO	risk information quality objective
RME	reasonable maximum exposure
ROD	record of decision
SARA	Superfund Amendment and Reauthorization Act
SOWC	Southern Ohio Water Company
SSOD	storm sewer outfall ditch
SWCR	Site-Wide Characterization Report

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ACRONYMS
(Continued)

SWF&IM	Surface Water Flow and Infiltration Model
TBC	to be considered
TCLP	toxicity characteristic leaching procedure
TEF	toxicity equivalency factor
TFV	threshold fraction value
TSP	total suspended particulate
TWA	time-weighted average
UCL	upper confidence limit
UMTRA	Uranium Mill Tailings Remedial Action
UNSCEAR	United Nations Scientific Committee on the Effects of Atomic Radiation
USDA	United States Department of Agriculture
USGS	U.S. Geological Survey
USLE	Universal Soil Loss Equation
VOC	volatile organic compound
VS2DT	Variability Saturated 2-Dimentional Transport

ENGLISH/METRIC AND METRIC/ENGLISH EQUIVALENTS

In this document, units of measure are presented With the metric unit first, followed by the English equivalent in parentheses. In Tables, the data are generally in English or metric units only. The following table lists the appropriate equivalents for English and metric units.

English/Metric Equivalents

Multiply	By	To Obtain
acres	0.4047	hectares (ha)
cubic feet (ft^3)	0.02832	cubic meters (m^3)
cubic yards (yd^3)	0.7646	cubic meters (m^3)
degrees Fahrenheit (°F) -32	0.5555	degrees Celsius (°C)
feet (ft)	0.3048	meters (m)
gallons (gal)	3.785	liters (l)
gallons (gal)	0.003785	cubic meters (m^3)
inches (in.)	2.540	centimeters (cm)
miles (mi)	1.609	kilometers (km)
pounds (lb)	0.4536	kilograms (kg)
short tons (tons)	907.2	kilograms (kg)
short tons (tons)	0.9072	metric tons (t)
square feet (ft^2)	0.09290	square meters (m^2)
square yards (yd^2)	0.8361	square meters (m^2)
square miles (mi^2)	2.590	square kilometers (km^2)
yards (yd)	0.9144	meters (m)

Metric/English Equivalents

Multiply	By	To Obtain
centimeters (cm)	0.3937	inches (in.)
cubic meters (m^3)	35.31	cubic feet (ft^3)
cubic meters (m^3)	1.308	cubic yards (yd^3)
cubic meters (m^3)	264.2	gallons (gal)
degrees Celsius (°C) + 17.78	1.8	degrees Fahrenheit (°F)
hectares (ha)	2.471	acres
kilograms (kg)	2.205	pounds (lb)
kilograms (kg)	0.001102	short tons (tons)
kilometers (km)	0.6214	miles (mi)
liters (l)	0.2642	gallons (gal)
meters (m)	3.281	feet (ft)
meters (m)	1.094	yards (yd)
metric tons (t)	1.102	short tons (tons)
square kilometers (km^2)	0.3861	square miles (mi^2)
square meters (m^2)	10.76	square feet (ft^2)
square meters (m^2)	1.196	square yards (yd^2)

EXPOSURE ASSESSMENT SYMBOLS

Inhalation of Dusts, Volatiles, and Radon

I_a = Intake from inhalation (pCi) or (mg/kg/day)
C_a = Concentration in air (pCi/m^3) or (mg/m^3)
IR = Inhalation rate (m^3/hr)
ET = Exposure time (hr/day)
EF = Exposure frequency (days/yr)
ED = Exposure duration (yr)
BW = Body weight (kg)
AT = Averaging time (days); for noncarcinogens, AT equals (ED)(365 days/yr); for carcinogens, AT equals (70-year lifetime)(365 days/yr)

Ingestion of Drinking Water, Food Stuffs

I_w = Intake from drinking water (pCi) or (mg/kg/day)
C_w = Concentration in water (pCi/l) or (mg/l)
IR = Ingestion rate (l/day)
EF = Exposure frequency (days/yr)
ED = Exposure duration (yr)
FI = Fraction ingested from the contaminated source (unitless)
BW = Body weight (kg)
AT = Averaging time (days); for noncarcinogens, AT equals (ED)(365 days/yr); for carcinogens, AT equals (70-year lifetime)(365 days/yr)

Inhalation of Volatiles from Water While Showering

I_a = Intake from inhalation (pCi) or (mg/kg/day)
C_a = Concentration in air (pCi/m^3) or (mg/m^3)
IR = Inhalation rate (m^3/hr)
ET = Exposure time (hr/day)
EF = Exposure frequency (days/yr)
ED = Exposure duration (yr)
BW = Body weight (kg)
AT = Averaging time (days); for noncarcinogens, AT equals (ED)(365 days/yr); for carcinogens, AT equals (70-year lifetime)(365 days/yr)

Dermal Contact with Soil/Sediment and While Bathing or Swimming

AB_w = Absorbed dose from contact with water (mg/kg/day)
C_w = Concentration in water (mg/l)
SA = Skin surface area available for contact (cm^2)
PC = Dermal permeability constant (cm/hr)
ABS = Absorption factor (unitless)
AF = Skin adherence factor (mg/cm^2)
ET = Exposure time (hr/day)
ED = Exposure duration (yr)
EF = Exposure frequency (days/yr)
CF = Conversion factor (1l/1000 cm^3)
BW = Body weight (kg)
AT = Averaging time (days); for noncarcinogens, AT equals (ED)(365 days/yr); for carcinogens, AT equals (70-year lifetime)(365 days/yr)

Incidental Ingestion of Soil/Sediment and While Swimming

I_s = Intake from soil or sediment (pCi) or (mg/kg/day)
C_s = Concentration in soil or sediment (pCi/g) or (mg/kg)
IR = Ingestion rate (g/day) or (mg/day)
CF = Conversion factor 10-6 kg/mg
FI = Fraction ingested from contaminated source (unitless)
EF = Exposure frequency (days/yr)
ED = Exposure duration (yr)
BW = Body weight (kg)
AT = Averaging time (days); for noncarcinogens, AT equals (ED)(365 days/yr); for carcinogens, AT equals (70-year lifetime)(365 days/yr)

External Radiation Exposure

DE = Dose equivalent (mrem)
DR = Dose equivalent rate (mrem/hr)
EF = Exposure frequency (days/yr)
ETi = Exposure time, fraction spent indoors (unitless)
ETo = Exposure time, fraction spent indoors (unitless)
ED = Exposure duration (yr)
FD = Fraction of a day
FY = Fraction of a year
SHi = Building shielding factor for dose equivalent rate reduction indoors (unitless)
SHo = Building shielding factor for dose equivalent rate reduction outdoors (unitless)

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I.1.0

I.1.0 INTRODUCTION

In accordance with the 1991 Amended Consent Agreement, a Comprehensive Response Action Risk Evaluation (CRARE) will be prepared for each operable unit at the Fernald Environmental Management Project (FEMP) site. The CRAREs estimate the cumulative human-health risks that will remain on-site following implementation of the remedial actions for the five operable units. Each operable unit feasibility study (FS) report will include a CRARE as an appendix. This CRARE is submitted as Appendix I to the Operable Unit 2 FS report.

As a starting point, the CRAREs use the preferred remedial alternatives (PRAs) for Operable Units 1, 2, and 4 selected as a result of the comparative analysis of alternatives in the respective FS reports. *However, since the FS analyses for Operable Units 3 and 5 have not yet been completed, this CRARE uses the leading remedial alternatives (LRAs) from the Site-Wide Characterization Report (SWCR) for those operable units (DOE 1993a).* When the Operable Unit 3 and 5 FSs are complete, the original LRAs will be updated with any changes necessary for consistency with the proposed plans based on the comparative analysis of alternatives in the FS reports. As noted in the SWCR, "the LRA does not represent the pre-selection of the remedy and will be used solely for the purpose of estimating and evaluating the risks presented by the entire site." Because the CRAREs are based in part on assumptions regarding site activities that are subject to change, all but the final CRARE (for Operable Unit 3) must be considered preliminary evaluations of final residual risk. One of the most important uses of the early CRAREs is to identify areas potentially contributing greater risk and thus provide focus and direction to future site management.

The CRAREs for Operable Units 1, 2, and 4 address human health risk, but not environmental risk. A detailed, quantitative Ecological Risk Assessment (ERA) is included in the Operable Unit 5 Remedial Investigation (RI) report (site-wide baseline ecological risks were not estimated in the SWCR). Therefore, the final CRAREs will be used to evaluate both the human and ecological residual risks of the remediated FEMP with respect to the National Contingency Plan (NCP) and U.S. Environmental Protection Agency (EPA) guidance.

I.1.1 CRARE OBJECTIVES

The objective of the CRARE is to estimate, from a site-wide perspective, the risk remaining after all operable unit remedial activities have been completed. This objective and other supporting objectives are depicted in Figure I.1-1. The figure also presents the iterative nature of the CRARE documents and demonstrates the scope of the CRARE analysis, according to the Risk Assessment Work Plan Addendum (RAWPA), dated June 1992 (DOE 1992a). The CRARE focuses on long-term residual risks after the remedial activities at the site have been completed. This information is integrated into a qualitative discussion addressing the risk contributions of remaining operable units.

Specifically, this CRARE:

- Quantifies operable-unit-specific contributions to potential site-wide, risk-based carcinogenic (radiological and chemical) and noncarcinogenic effects.
- Provides information to address revisions of site-wide cleanup levels, based on associated carcinogenic and noncarcinogenic effects on human receptors.
- Incorporates operable-unit-specific information from the Operable Unit 1, 2, and 4 FS risk assessments (DOE 1994b, 1994a, and 1993b) and identifies areas of potential risk management per operable unit. (As the RI/FS reports for Operable Units 3 and 5 are not yet complete, SWCR data have been used for those units.)

Human-health-based cleanup levels are derived in each operable unit's RI as preliminary remediation goals (PRGs). During the FS process, the risk-based PRGs established in the RI may be modified for various reasons, including administrative controls and considerations such as appropriate, relevant and applicable regulations (ARARs), cross-media impacts, and engineering controls and design constraints. Proposed remedial levels (PRLs) are values based on modified PRGs which are then approved by the EPA and entered into the Record of Decision (ROD). See Figure I.1-1 for further details.

> Note that for this CRARE, the PRGs for the expanded trespasser – 10^{-6} for carcinogenic risk – were used for all fate and transport modeling. The PRGs for other receptors were not used. Therefore, the calculated risk to the other receptors is based on the expanded trespasser information.
>
> Also, during remediation to the uramium PRGs, other contaminants may be removed or cleaned to levels below their own PRGs.

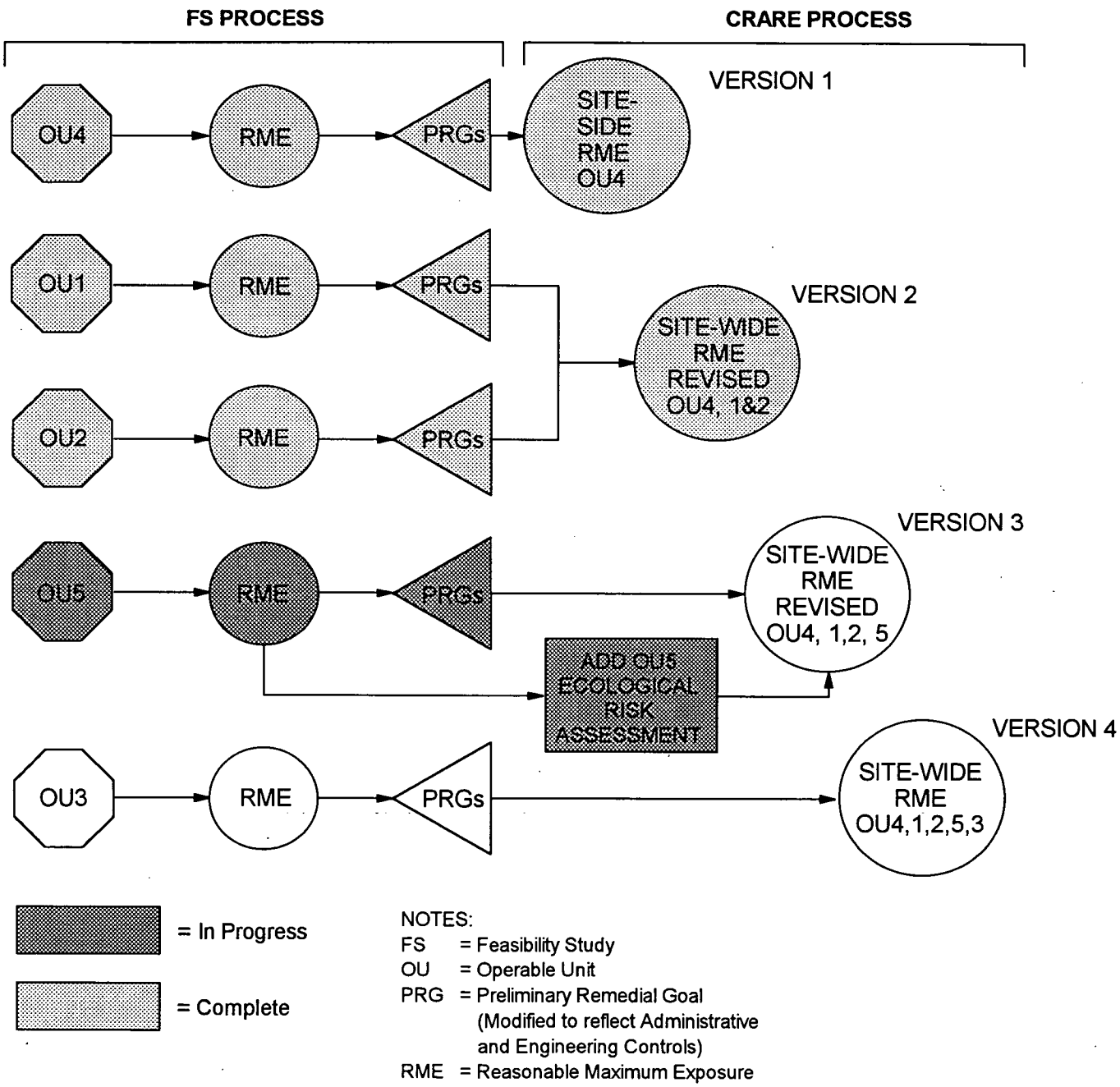

FIGURE I.1-1. ITERATIVE NATURE OF THE CRARE

EPA's comments on previous versions of the CRARE have been addressed in this submission, with a few exceptions. For example, the expanded trespasser, and possibly other receptors or more conservative exposure parameters, will be reexamined in future CRAREs. Central tendency analysis as applied to the receptors has been reviewed and is described in Section I.5.1.3 of this CRARE. Other specific information on Operable Units 3 and 5, such as the PRA and the duration of groundwater and surface water treatment operations, will need to be examined. EPA comments were received on the following dates for the indicated operable unit CRAREs:

- Operable Unit 4, December 1993
- Operable Unit 4, February 1994
- Operable Unit 1&2, June 27, 1994

I.1.2 FEMP SITE HISTORY

Formerly known as the Feed Materials Production Center, the FEMP (Figure I.1-2) is a contractor-operated federal facility where pure uranium metals were produced for the DOE from 1951 to 1989. No isotopic separation of uranium in the starting materials was performed. After production ceased, plant resources were focused on an environmental restoration program. In 1991, the FEMP was officially closed as a federal production facility, but the environmental studies and cleanup activities continued. The FEMP site is located on 425 hectares (1050 acres) in a rural area of Hamilton and Butler counties, which is approximately 29 kilometers (18 miles) northwest of Cincinnati, Ohio.

I.1.3 OPERABLE UNITS

The FEMP was divided into five operable units under the original 1990 Consent Agreement, and the units were later redefined under the 1991 Amended Consent Agreement. Figure I.1-3 shows the existing FEMP site. The five operable units are detailed in Figures I.1-4 through I.1-8; their definitions, as stated in the Amended Consent Agreement, are presented below:

- Operable Unit 1:

  Waste Pit Area. Waste Pits 1-6, the clearwell, burnpit, berms, liners, and soil within the operable unit boundary. (Figure I.1-4).

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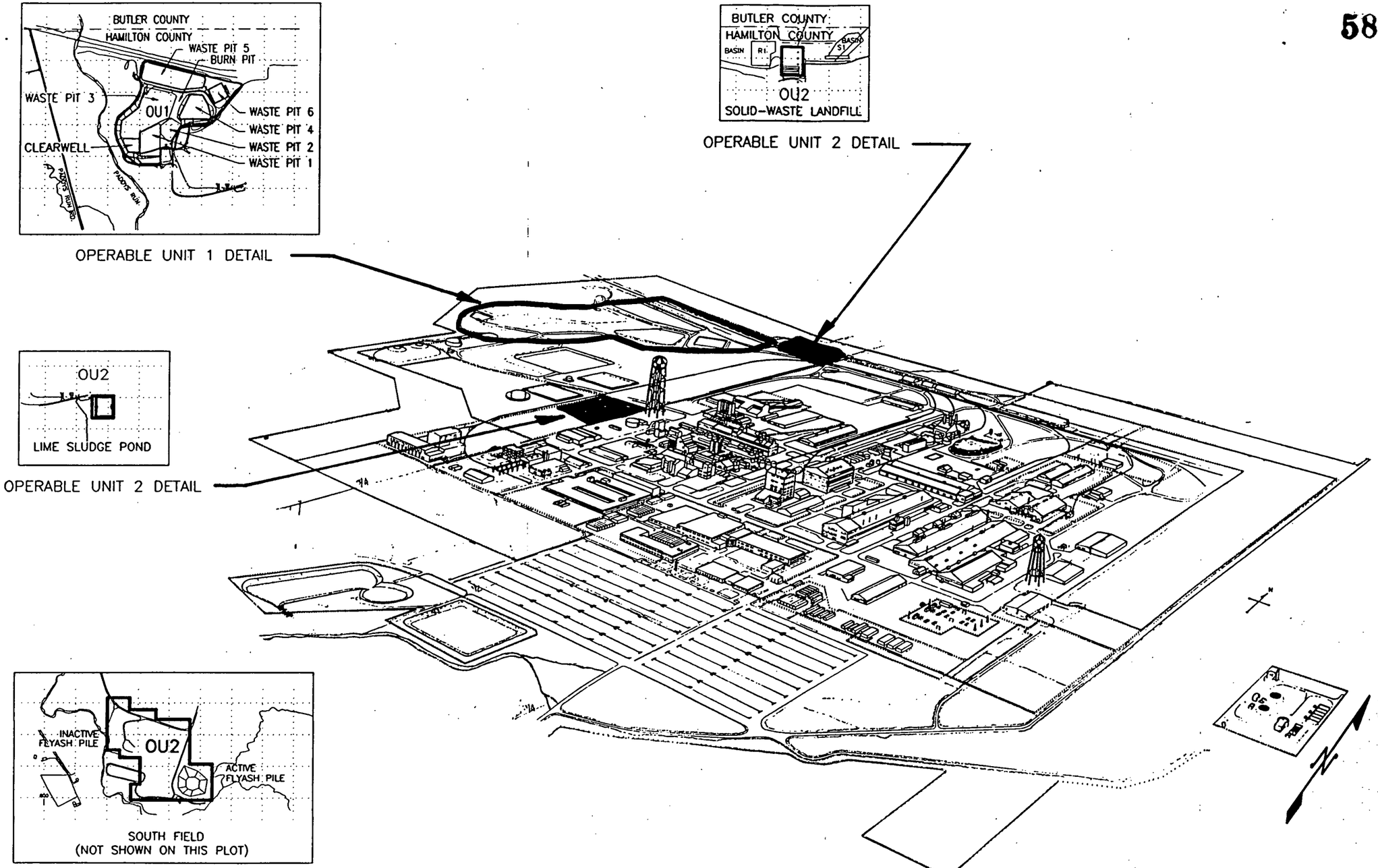
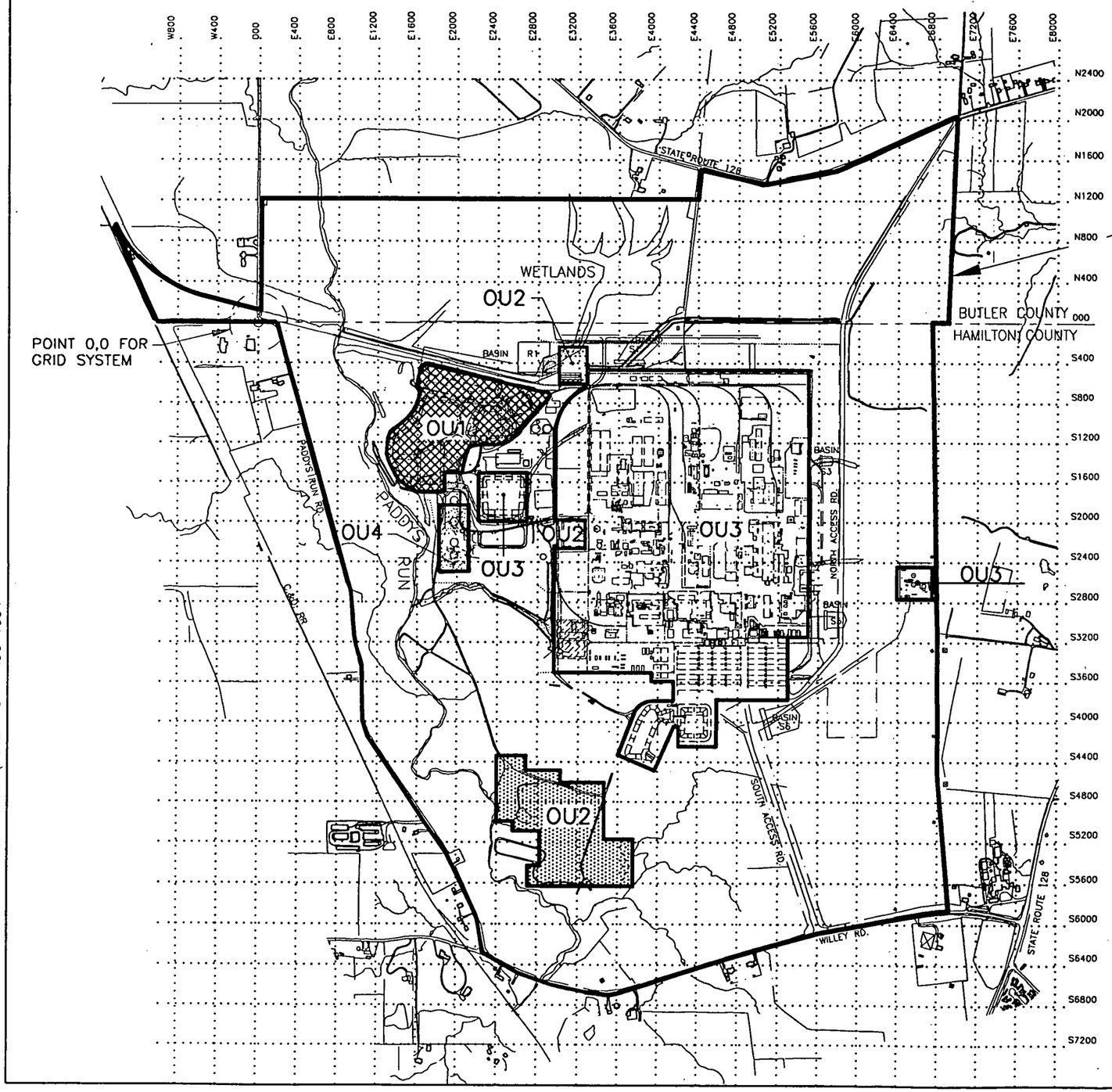


OU2 CRARE ACAD FILE: 424331\AU1211-2 AUG 1994

FIGURE 1.1-2 FEMP SITE
OPERABLE UNIT 1&2 DETAIL



SITE BOUNDARY

LEGEND:
POSTREMEDIATION RESIDUAL FOOTPRINTS OF EACH OU.

- RESIDUAL FOOTPRINT OF OU1 COCs
- RESIDUAL FOOTPRINT OF OU2 COCs
- RESIDUAL FOOTPRINT OF OU3 COCs
- RESIDUAL FOOTPRINT OF OU4 COCs

NOTES:
OU5 IS A SITE-WIDE OU INVOLVING GROUNDWATER AND SOILS

400 0 400 800
SCALE IN FEET

GRID SPACING = 400 FEET

OU2 CRARE ACAD FILE: 424331\AU1211-3 AUG 1994

FIGURE 1.1-3 EXISTING FEMP DETAIL

OU2 CRARE ACAD FILE: 424331\AU12I1-4 AUG 1994

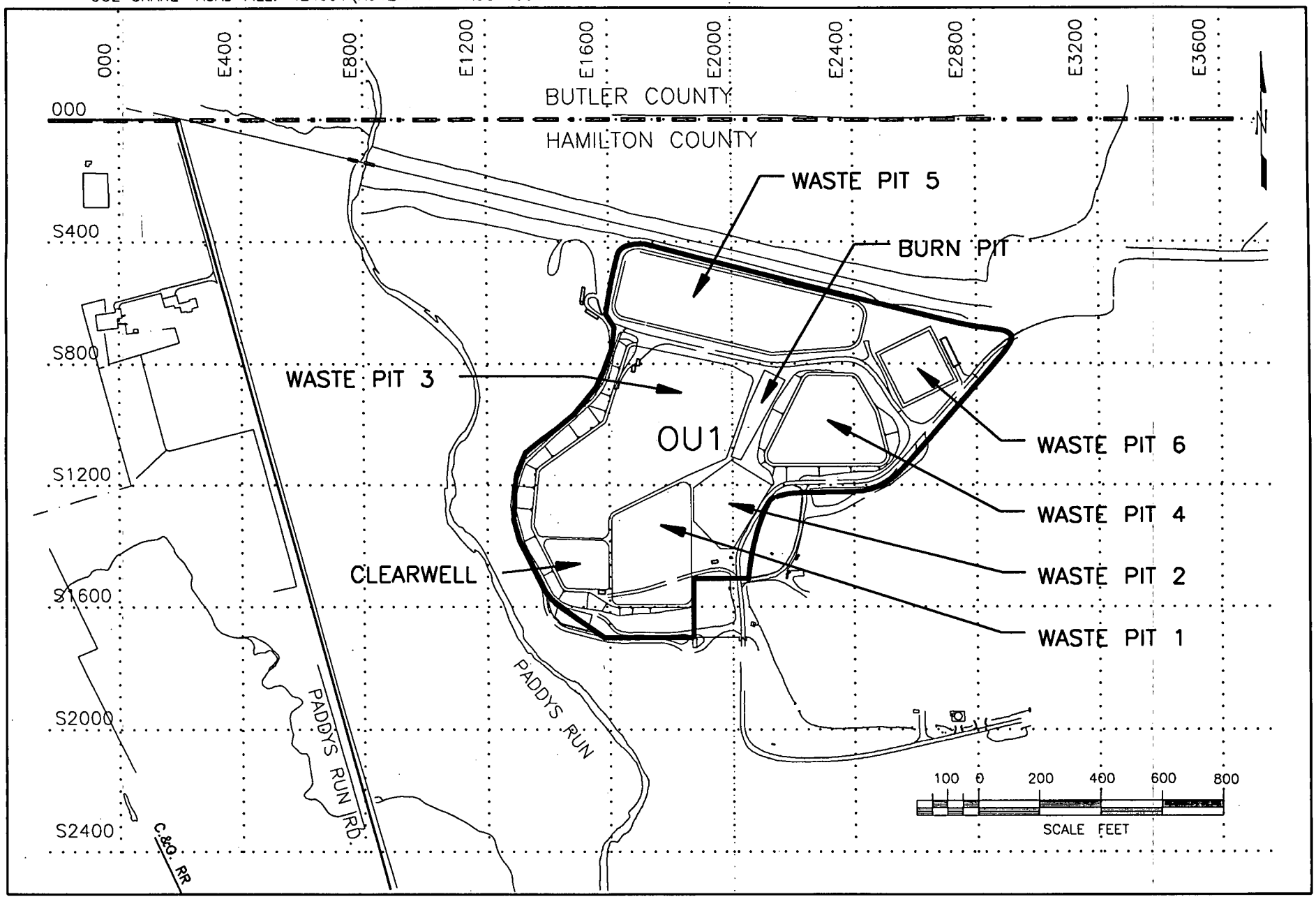


FIGURE 1.1-4
EXISTING DETAIL, OPERABLE UNIT 1

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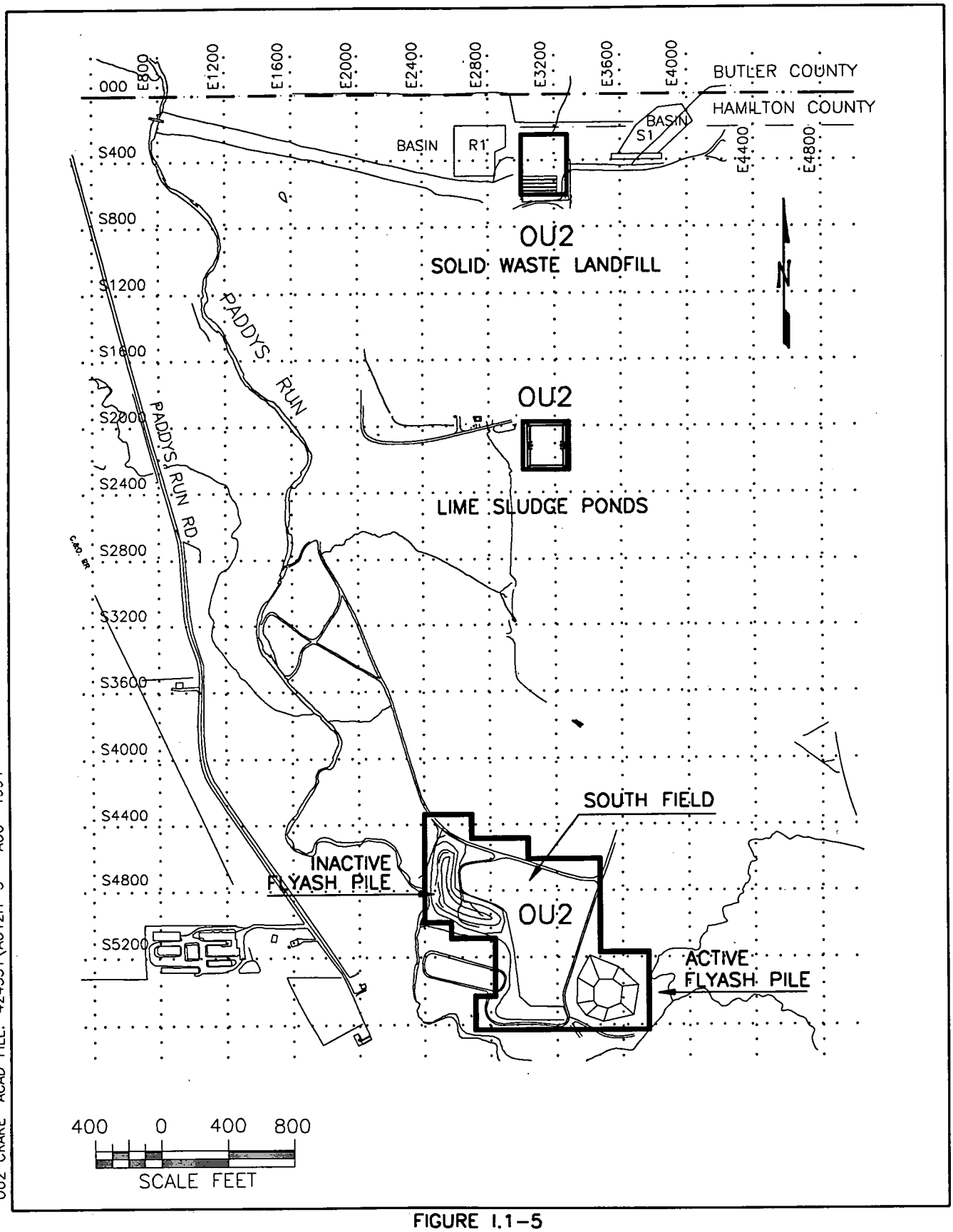

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FIGURE 1.1-5
EXISTING DETAIL, OPERABLE UNIT 2

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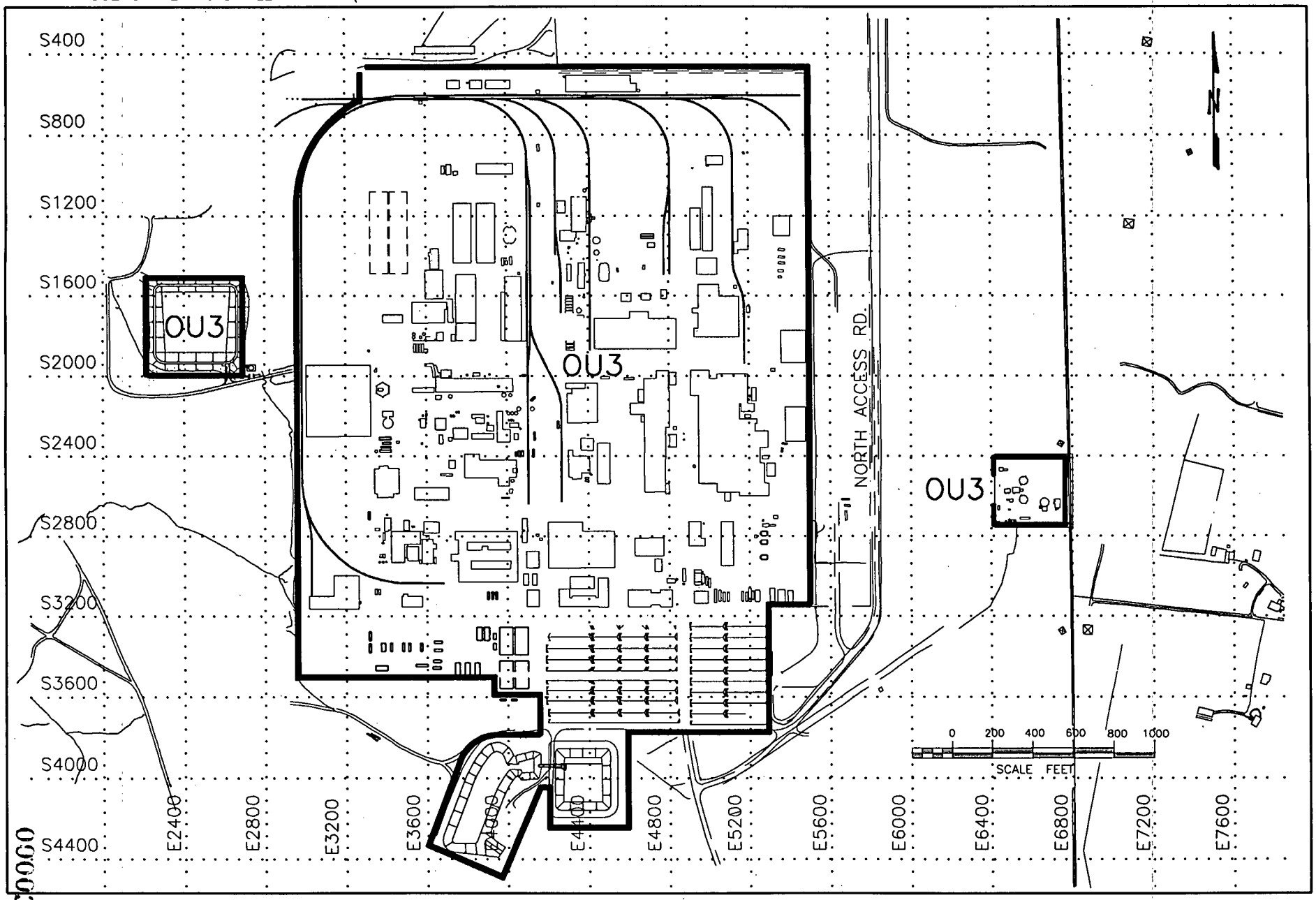

FIGURE 1.1-6
EXISTING DETAIL, OPERABLE UNIT 3

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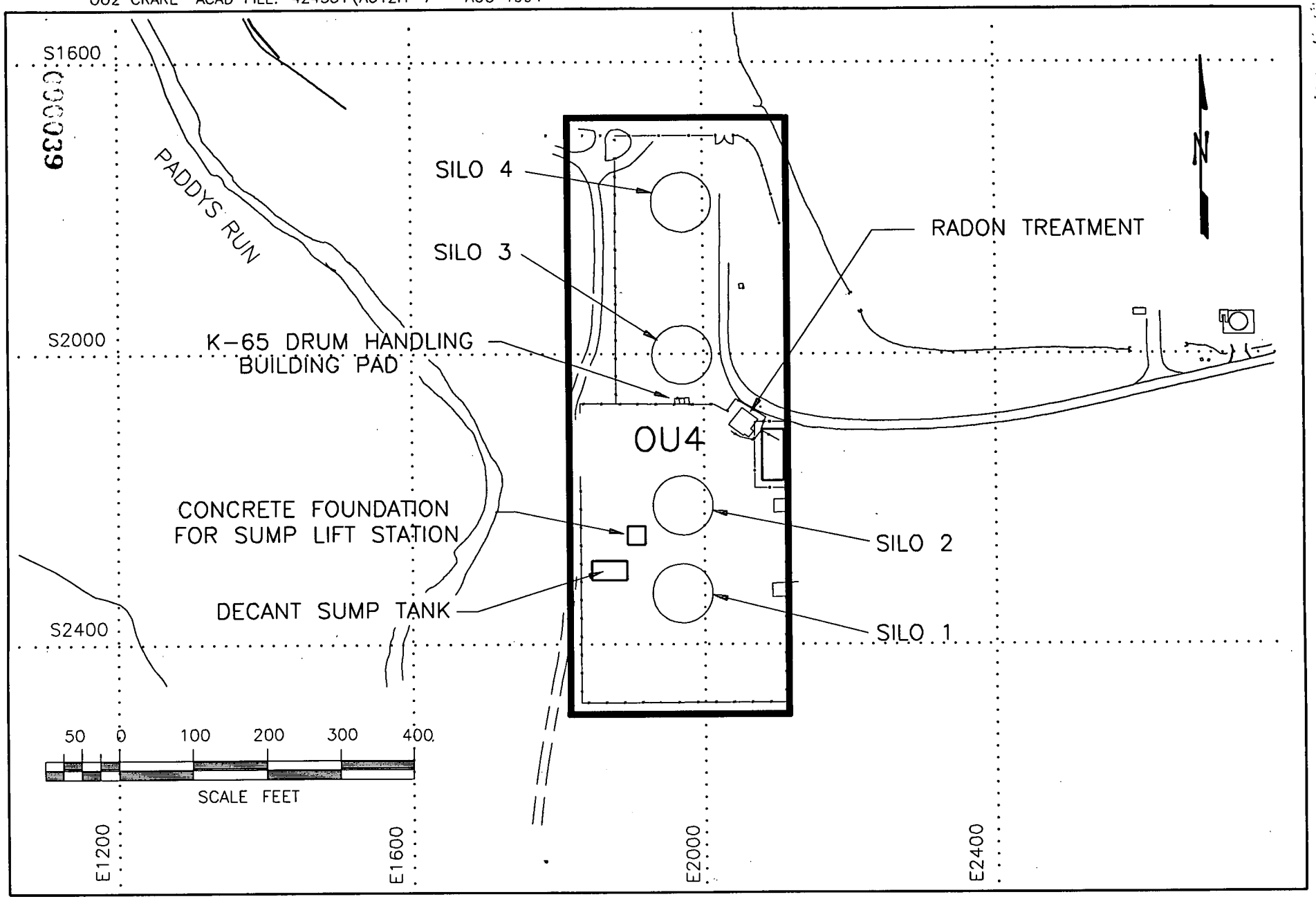

FIGURE 1.1-7
EXISTING DETAIL, OPERABLE UNIT 4

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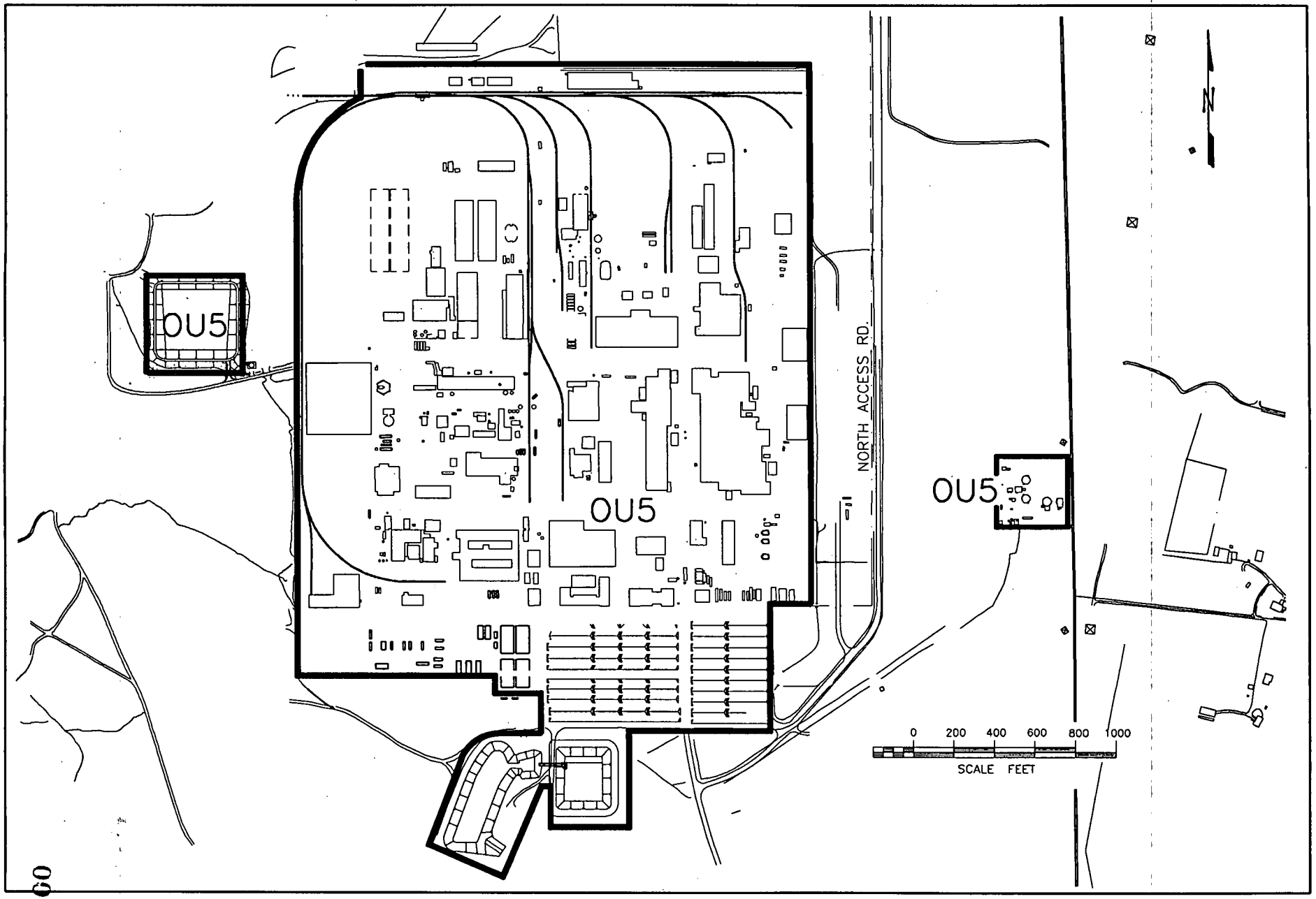

FIGURE 1.1-8
EXISTING DETAIL, OPERABLE UNIT 5 (SOILS)

- Operable Unit 2:

  Other Waste Units. Flyash piles, other South Field disposal areas, lime sludge ponds, solid waste landfill, berms, liners, and soil within the operable unit boundary. (Figure I.1-5).

- Operable Unit 3:

  Production Area. Production area and production-associated facilities and equipment (includes all above and below-grade improvements) including, but not limited to, all structures, equipment, utilities, drums, tanks, solid waste, waste product, thorium, effluent lines, K-65 transfer line, wastewater treatment facilities, fire training facilities, scrap metal piles, feedstocks, and the coal pile. (Figure I.1-6).

- Operable Unit 4:

  Silos 1-4. Silos 1, 2, 3, and 4, berms, decant tank system, and soil within the operable unit boundary (Figure I.1-7).

- Operable Unit 5:

  Environmental Media. Groundwater, surface water, soil not included in the definitions of Operable Unit 1-4, sediments, flora, and fauna. (Figure I.1-8).

I.1.4 FEMP REMEDIATION

The RI/FS activities at the FEMP have led to the development and implementation of removal actions. As defined in the 1991 Amended Consent Agreement, removal actions abate, minimize, stabilize, mitigate, or eliminate the release or threatened release of hazardous substances, pollutants, contaminants, or hazardous constituents at the FEMP. A significant purpose of the SWCR and its associated baseline risk assessment has been to provide data and risk analyses of the impacts of any removal actions completed as of March 1993, the publishing date for SWCR data. Because the CRARE estimates postremediation risk, by definition, all removal actions will have been completed well before the time periods examined in the CRARE.

The remedial action time frame is currently assumed to last from 30 to 70 years (for more information, see Section I.2.2).

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I.1.5 CRARE SITE-WIDE CONCEPTUAL MODEL

The CRAREs examine specific time periods after the remediation of all operable units is complete. The CRAREs are not intended to provide information on baseline risks presented in the Operable Unit 2 RI. A key component of the CRAREs is the CRARE Site-Wide Conceptual Model, which examines current and future land uses for the periods immediately after and up to 1000 years after all remedial actions are complete. The model depicts the final combination of FS remedial alternatives to ensure the FEMP achieves a residual risk that protects human health and the environment on a site-wide basis.

The health effects quantified in the CRAREs include: 1) the excess incremental lifetime cancer risk (ILCR) for exposure to chemical carcinogens, 2) the hazard quotient (HQ) for exposure to noncarcinogens, and 3) the carcinogenic effects to human receptors caused by exposure to radionuclides.

Figure I.1-9 provides a future overview of the contaminated sources for the five operable units from remedial action to remediated site conditions. For each operable unit, the conceptual model depicts the remedial alternatives anticipated for implementation. Potential releases from the source areas form the basis for pathway evaluation. After site-wide remediation is complete, it is assumed that all existing structures would be removed. As shown in the figure, the remaining features and contaminant sources at the FEMP would be:

- Permanent disposal facilities known as vaults or cells
- Capped or covered areas
- Areas where treated soil has been placed
- Residual contamination (surface soils, groundwater, surface water, and sediment)

The CRARE Site-Wide Conceptual Model graphically represents the sources, release mechanisms, transport media, and risk pathways for various human receptors under the Current and two Future Land Use scenarios of the five operable units. The Current Land Use scenario describes the FEMP for 70 years starting immediately after all remedial actions are complete. The 70-year period is based on guidance provided by the RAWPA, and is the life span of an individual. The scenario assumes DOE ownership, site access control, and maintenance of the

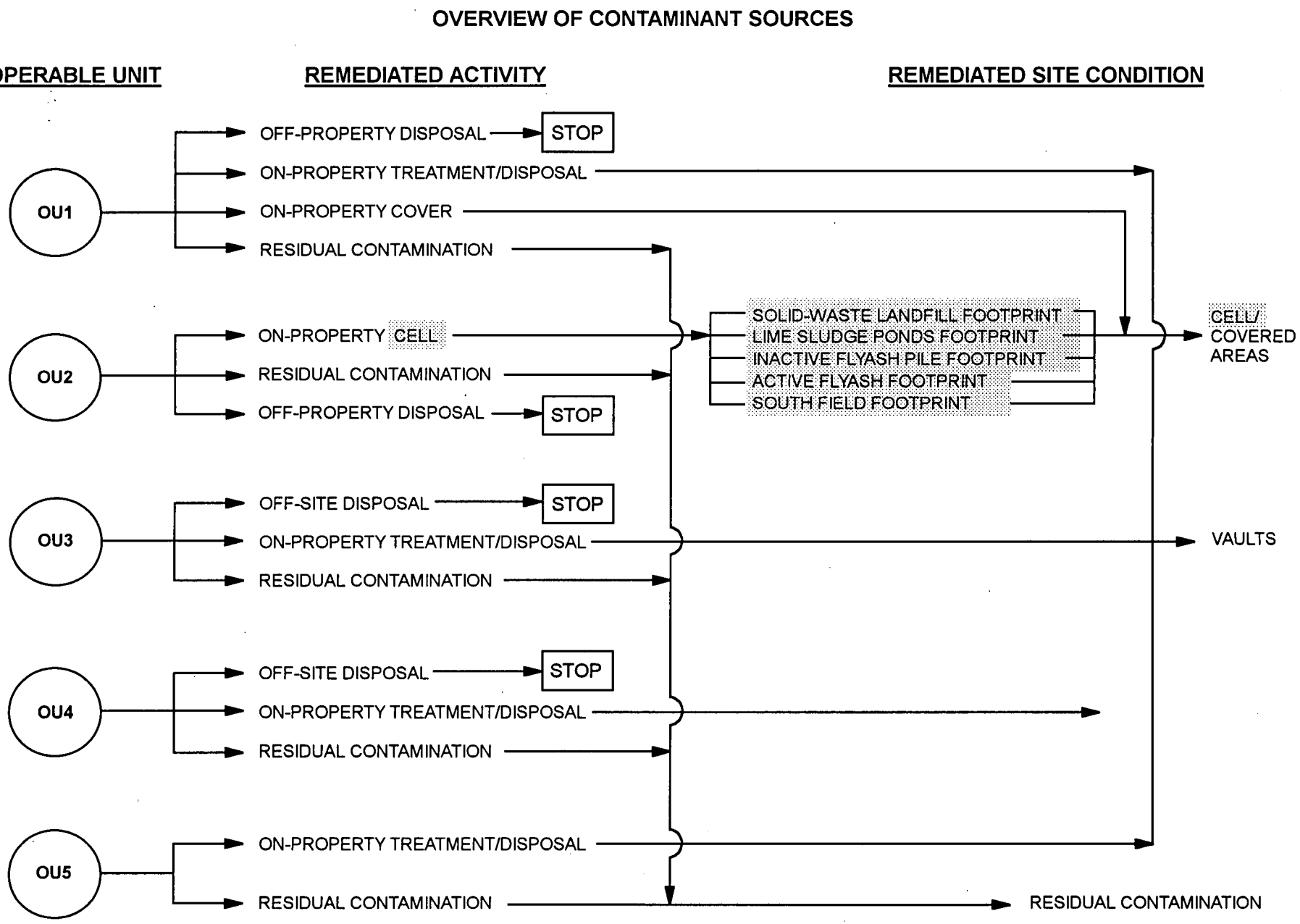

FIGURE I.1-9
OVERVIEW OF CONTAMINANTSOURCES, OPERABLE UNITS 1 THROUGH 5

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FEMP and associated remedial structures for 70 years. The only remaining treatment facility active on the site at the start of the 70 years should be the wastewater treatment plant in Operable Unit 5, which may remain operational for 70 years.

The two Future Land Use scenarios describe alternate versions of the FEMP for up to 1000 years after all remedial actions are complete: Future Land Use With Federal Ownership and access controls assumes continued government ownership with administrative controls, while Future Land Use Without Federal Ownership assumes occupation by a resident farm family. Contaminant fate and transport have been modeled in both air and groundwater for 1000 years. Figures I-1-10 through I-1-12 present the conceptual models for the current and future land use scenarios.

Figure I.1-10 presents the Current Land Use scenario and displays the risks and exposure pathways for four human receptors. The center portions of the figure represent each exposure pathway by which radioactive or chemical contaminants of concern (COCs) migrate from their sources to human receptors on and off the FEMP. For each exposure pathway, the following elements are addressed:

- Primary contaminant sources
- Secondary sources
- Release mechanisms
- Transport media
- Exposure points
- Exposure routes
- Primary exposed populations (receptors)

Figures I.1-11 and 12 present the scenarios covering the 1000-year postremediation period. Both of these Future Land Use scenarios assume no ongoing treatment activities. The scenario without federal ownership assumes a total loss of institutional controls.

Throughout the conceptual model, terminology for release mechanisms, transport media, exposure routes, etc. have used a limited set of technical terms for ease of use and understanding. As each subsequent operable unit is examined, the pathway model will become more complex, which will improve its ability to predict future situations. Receptors have been standardized in the model to reflect the three CRARE scenarios (Table I.1-1).

These same receptors are used as the primary exposed population in the risk assessments for each of the five operable units. It is anticipated that, by using standard receptors, the cumulative risks for all operable unit CRAREs can be readily added and compared. A more detailed discussion of this concept, as well as a description of the receptors, is presented in Section I.5.

The exposure pathways considered for the receptors include:

- ingesting soil and sediment
- dermal contact with sediment, soil and water
- direct radiation with soil and sediment
- inhalation of radioactive and contaminated particles and radon gas
- ingestion of groundwater and surface water
- ingestion of food including crops, fish, milk, and meat
- inhalation of radon

The conceptual model is presented as a basis to develop risk pathways for each CRARE. As the RI/FS process proceeds, the model evolves to reflect the actual remedial action for each operable unit. This is a dynamic process, subject to input from many parties at the FEMP including EPA and OSHA.

Table I.1-2 compares the land uses and receptors for the RI, FS, and CRARE reports. Because the CRAREs encompass a site-wide evaluation, they differ slightly from the RI and FS reports, which are prepared for single operable units.

I.1.6 ORGANIZATION OF THE CRARE

This CRARE is organized as follows for the step-wise progression of detailed information:

- I.1.0 Introduction:

  This section outlines the methodology to be used in preparing the FEMP CRAREs. It serves as a protocol with an emphasis on the procedures and techniques for characterizing the possible risks related to the remediated FEMP site.

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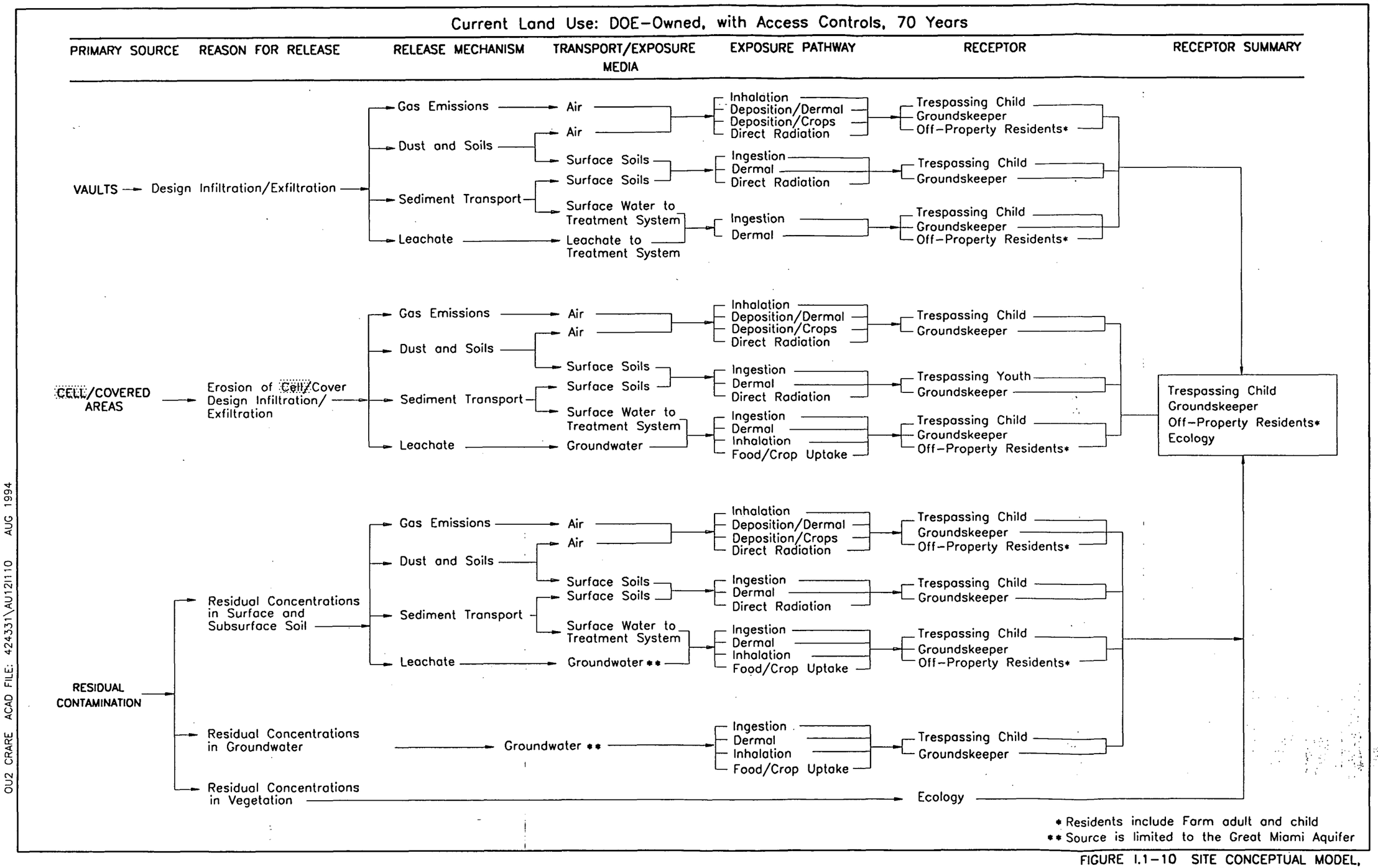

FIGURE 1.1-10 SITE CONCEPTUAL MODEL, CURRENT LAND USE

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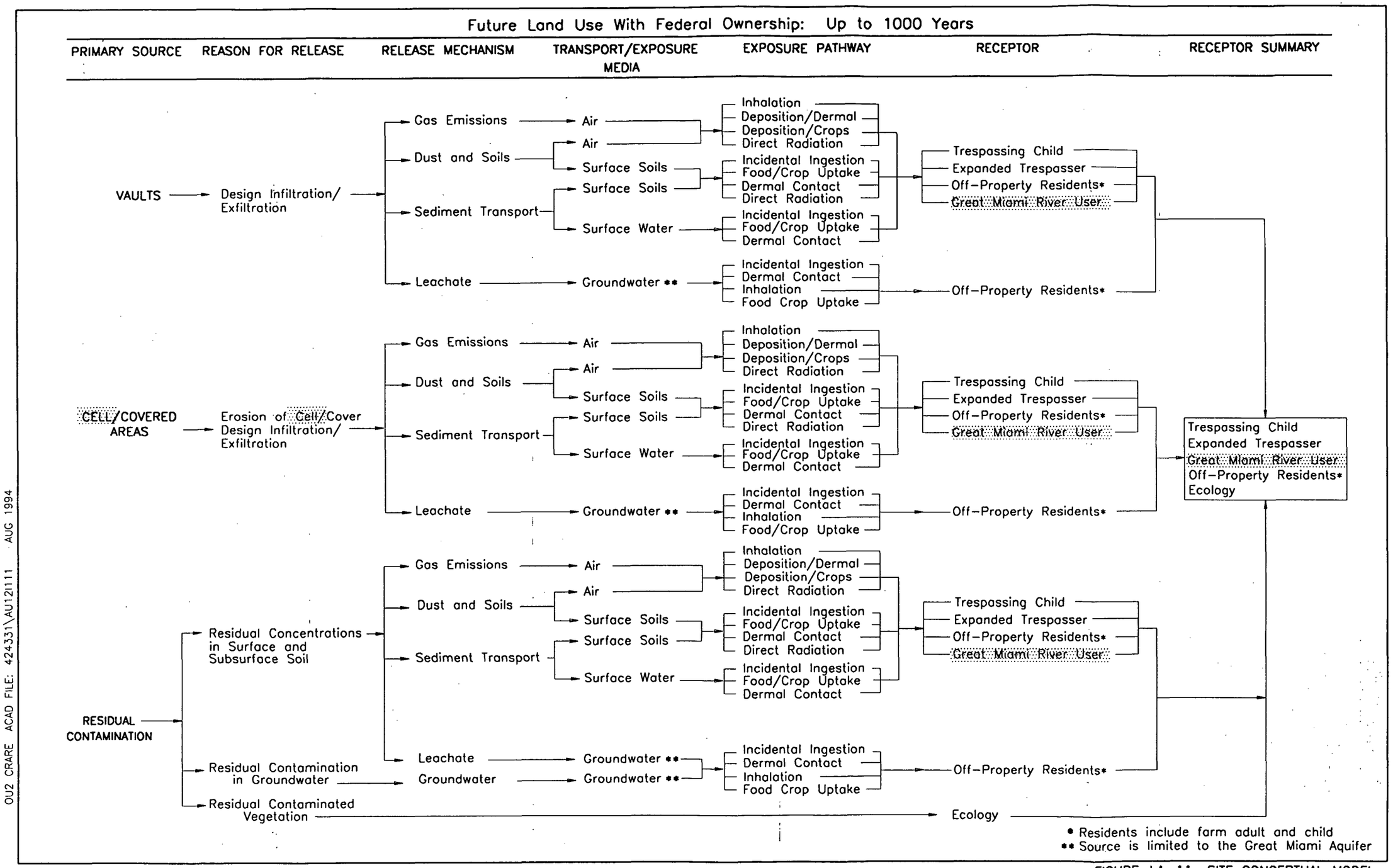

FIGURE I.1-11 SITE CONCEPTUAL MODEL, FUTURE LAND USE WITH FEDERAL OWNERSHIP

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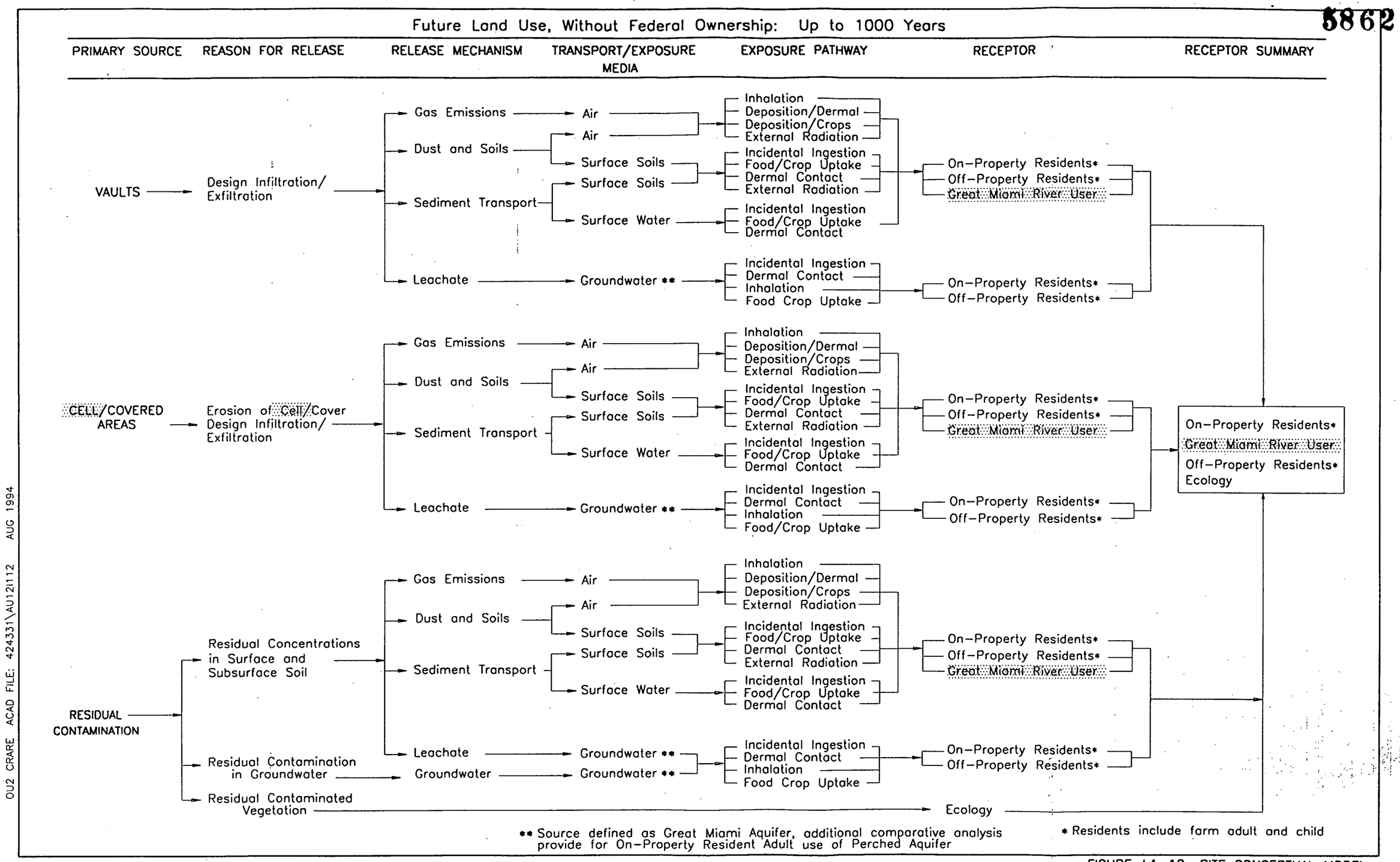

FIGURE 1.1-12 SITE CONCEPTUAL MODEL, FUTURE LAND USE WITHOUT FEDERAL OWNERSHIP

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TABLE I.1-1
CRARE SCENARIOS AND RECEPTORS

Scenario	Time Frame	RME Receptor
Current Land Use	70 years after remedial actions are complete	Groundskeeper Trespassing Child Off-Property Farm Residents: Adult (ingests Great Miami Aquifer Water) Child (ingests Great Miami Aquifer Water)
Future Land Use With Federal Ownership	1000 years after remedial actions are complete	Expanded Trespasser Off-Property Farm Residents: Adult (ingests Great Miami Aquifer Water) Child (ingests Great Miami Aquifer Water) Great Miami River User
Future Land Use Without Federal Ownership	1000 years after remedial actions are complete	On-Property Farm Residents: Adult (ingests Great Miami Aquifer Water) Adult (ingests perched groundwater) Child (ingests Great Miami Aquifer Water) Off-Property Farm Residents: Adult (ingests Great Miami Aquifer Water) Child (ingests Great Miami Aquifer Water) Great Miami River User

See Section I.5.0 for a discussion of all receptors initially evaluated.

TABLE I.1-2
CONSISTENCY OF LAND USE AND RECEPTOR SCENARIOS: OPERABLE UNIT 1, 2, AND 4 REPORTS

Report	Land Use[1]	Ownership	Access	Use	RECEPTORS									
					Grounds-keeper	Trespassing Child	User of Meat/Milk	Expanded Trespasser	Off-Property Farmer/Child	On-Property Farmer/Child	CT On-Property Farmer	Perched GW User	Home Builder	River User
OU1 RI[a]	Current Land Use With Access Controls	Federal	Limited	FEMP					•					
	Current Land Use Without Access Controls	Federal	Limited	FEMP		•	•							•
	Future Land Use With Access Controls	Federal	Limited	Gov't										
	Future Land Use Without Access Controls	Private	Unlimited	Farm						•	•		•	•
OU2 RI[b]	Current Land Use With Access Controls	Federal	Limited	FEMP	•	•			•					•
	Current Land Use Without Access Controls	Federal	Limited	FEMP			•		•					
	Future Land Use With Access Controls	Federal	Limited	Gov't				•	•					
	Future Land Use Without Access Controls	Private	Unlimited	Farm					•	•	•	•	•	•
OU4 RI[c]	Current Land Use With Access Controls	Federal	Limited	FEMP		•			•					
	Current Land Use Without Access Controls	Federal	Limited	FEMP	•	•			•					
	Future Land Use	Private	Unlimited	Farm					•	•	•			
OU1&2 CRARE[d]	Current Land Use	Federal	Limited	FEMP	•	•			•					
	Future Land Use With Federal Ownership	Federal	Limited	Gov't		•		•	•					•
	Future Land Use Without Federal Ownership	Private	Unlimited	Farm					•	•		•		•

TABLE I.1-2
(Continued)

Report	Land Use[i]	Ownership	Access	Use	RECEPTORS									
					Grounds-keeper	Trespassing Child	User of Meat/Milk	Expanded Trespasser	Off-Property Farmer/Child	On-Property Farmer/Child	CT On-Property Farmer	Perched GW User	Home Builder	River User
OU4 CRARE[e]	Current Land Use	Federal	Limited	FEMP	•	•			•[j]					
	Future Land Use With Federal Ownership	Federal	Limited	Gov't				•[k]	•					
	Future Land Use Without Federal Ownership	Private	Unlimited	Farm					•[j]	•[l]				
OU1 FS[f]	Future Land Use With Continued Federal Ownership	Federal	Limited	Gov't				•	•					
	Future Land Use With Private Ownership	Private	Unlimited	Farm					•	•				
OU2 FS[g]	Future Land Use With Continued Federal Ownership	Federal	Limited	Gov't				•	•					
	Future Land Use With Private Ownership	Private	Unlimited	Farm					•	•		•		
OU4 FS[h]	Future Land Use With Continued Federal Ownership	Federal	Limited	Gov't		•		•	•					
	Future Land Use Without Continued Federal Ownership	Private	Unlimited	Farm					•	•	•			

[a] Operable Unit 1 Remedial Investigation report (1994f)
[b] Operable Unit 2 Remedial Investigation report (1994a)
[c] Operable Unit 4 Remedial Investigation report (1993d)
[d] Operable Unit 1 & 2 CRARE report, April 29, 1994 (1994b)
[e] Operable Unit 4 CRARE report (1993l)
[f] Operable Unit 1 Feasibility Study report (1994e)
[g] Operable Unit 2 Feasibility Study report, Appendix C
[h] Operable Unit 4 Feasibility Study report (1993h)
[i] Land Use descriptions from operable unit-specific reports
[j] OU4 CRARE evaluated an Off-Property Youth in addition to adult and child
[k] OU4 CRARE evaluated a recreational user, which was established before the expanded trespasser
[l] OU4 CRARE evaluated an On-Property Youth in addition to adult and child

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- I.2.0 Overview of Information Base and Assumptions:

  This section describes the development of several factors and assumptions that have been employed for the CRARE. Generic site conditions, as well as data completeness, future facility management, demographics, and material containment assumptions, have been addressed. Additionally, the remedial alternatives for the other operable units are presented.

- I.3.0 Overview of CRARE Technical Approach:

  This section addresses the types and sources of data, site conditions after remediation, and other site-specific information used in the CRARE.

- I.4.0 Contaminants of Concern:

  The COCs are developed in this section. Individual operable unit FS risk assessments were used to develop Operable Unit 1, 2, and 4 COCs. For Operable Units 3 and 5, the COCs were extracted from the SWCR, Appendix R, accounting for postremediation conditions.

- I.5.0 Exposure Scenarios:

  This section defines the components of the exposure scenarios, discusses the steps involved in identifying and developing the scenarios, and covers the screening and selection of the exposure scenarios currently identified. Selected exposure scenarios are those that are determined to require a quantitative evaluation of the risk assessment.

- I.6.0 Fate and Transport Modeling:

  This section describes the methodology used to quantitatively predict contaminant concentrations due to migration of contaminants in the media at the FEMP. It includes discussions of: 1) the fate and transport models used, 2) their required data and default parameter values, 3) the technical approach that determines the appropriate model for each potential exposure assessment, and 4) model results.

- I.7.0 Toxicity Assessment:

  In this section, a toxicity assessment is presented for a qualitative evaluation of the scientific data to determine the nature and severity of the toxic properties associated with operable unit-specific COCs. The section includes a critical review and interpretation of toxicity data from epidemiological, clinical, and animal in vitro studies, and a quantitative estimation of the amount of exposure to a contaminant that may result in an adverse effect on a biological receptor. This defines the relationship between the dose received by a receptor and the incidence of the adverse effect.

- I.8.0 Quantification of Contaminant Exposure and Intake:

This section contains a description of the methodology and parameters employed to quantify long-term exposures for significant exposure pathways at the FEMP. This methodology employs the concept of the reasonable maximum exposure (RME), the maximum exposure reasonably expected to occur to a receptor at the site.

- I.9.0 Risk Characterization:

Risk characterization is the final step in the CRARE process and involves combining the information developed in the toxicity and exposure assessments. This information is integrated and presented as qualitative and quantitative estimates of health risk.

- I.10.0 Uncertainties:

This section presents the potential for the methods used in the CRARE to under- or over-predict risk via a series of assumptions and numerical models.

- I.11.0 Summary of Methodology and Results:

A summary of methodologies used and the site-wide residual risk by receptor is presented for the current and future postremediation scenarios.

- I.12.0 Conclusions and Recommendations:

Conclusions about the allocation of residual risk to receptors and scenarios for carcinogenic and noncarcinogenic health hazard are presented. Recommendations to be addressed in future CRARE are given.

- I.13.0 References:

Literature cited is presented in this section.

I.2.0

I.2.0 OVERVIEW OF INFORMATION BASE AND ASSUMPTIONS

Site-wide data are used in this CRARE to: 1) characterize the concentration or activity of contaminants, 2) model the fate and transport of constituents, and 3) estimate exposures.

Data from the Operable Unit 1, 2, and 4 RI/FS and the Operable Unit 5 RI reports were used in this CRARE. Data generated as a result of RI/FS activities are considered primary sources of data in this CRARE. Data derived from the Site-Wide Characterization Report (SWCR) for Operable Unit 3 for use in this CRARE are considered secondary sources of data. Data from the SWCR were used for Operable Unit 3 in this report. Primary sources of data are based on validated data whereas the secondary data have not been validated by the RI/FS process.

The following FEMP documents supplied much of the primary and secondary source data for this CRARE:

- *Risk Assessment Work Plan Addendum* (Final), (DOE 1992a)
- *Site-Wide Characterization Report* (Final), (DOE 1993a)
- *Remedial Investigation Report for Operable Unit 1* (Draft), (DOE 1994c)
- *Feasibility Study Report for Operable Unit 1* (Draft), (DOE 1994b)
- *Remedial Investigation Report for Operable Unit 2* (Draft), (DOE 1994d)
- *Feasibility Study Report for Operable Unit 2* (Draft), (DOE 1994a)
- *Remedial Investigation Report for Operable Unit 4* (Final), (DOE 1993c)
- *Feasibility Study Report for Operable Unit 4* (Final), (DOE 1993b)

I.2.1 SITE DESCRIPTION

This section summarizes the regional and site-specific environment of the FEMP, focusing on the climate, geology, topography, surface water, hydrology, ecology, land use, and demographics. Additional information can be found in the Operable Unit 1, 2, and 4 FS reports and the SWCR.

I.2.1.1 Climate

Information on the local climate has been gathered from an on-property meteorological system installed in 1986, and the National Weather Service Office at the Greater Cincinnati Airport. The *Final Interim Report-Air, Soil, Water, and Health Risk Assessment in the Vicinity of FEMP* (DOE 1986) indicated that data obtained from monitoring stations at the airport sufficiently represented local climate conditions.

Winds

The prevailing winds are generally from the southwest and west-southwest. The average monthly wind speeds, based on National Weather Service meteorological data, range from 11 kilometers per hour (kph) or 7 miles per hour (mph) in August to 17.6 kph (11 mph) in March. For more information, refer to the SWCR or the Operable Unit 2 RI report.

Six years of meteorological data collected on-site indicate that the mean annual wind speed at the FEMP is approximately 7.3 kph (4.5 mph). The on-site data also indicate that the prevailing wind direction is from the southwest. This site data for wind speed, being most representative of the site, were used in the modeling.

Precipitation

The average annual precipitation for the Cincinnati area from 1960 through 1989 was 103 centimeters (40.6 inches). The highest precipitation typically occurs during the spring and early summer, the lowest in the late summer and fall. The average annual snowfall for 1960 through 1989 was 59.7 centimeters (23.5 inches). The total rainfall for the area in 1991 was 102 centimeters (40 inches), and the total snowfall was 23.6 centimeters (9.3 inches). The wettest months in 1991 were August and December, with 12.8 and 12.9 centimeters (5 and 5.1 inches) of rainfall, respectively.

Temperature

The regional climate is defined as continental, with average monthly temperatures ranging from -1.55°C (29.2°F) in January to 24.3°C (75.7°F) in July. The highest temperature recorded from 1961 through 1989 was 39.4°C (103°F) in July 1988, and the lowest was -32°C (-25.6°F) in January 1977.

I.2.1.2 Topography and Surface Water Hydrology

The site topography and drainage channels are shown in Figure I.2-1. Maximum elevation along the northern boundary of the FEMP property is slightly more than 213.4 meters (700 feet) above mean sea level (MSL). The production and waste storage areas are on a relatively level plain at about 176.8 meters (580 feet) MSL. The plain slopes from 183 meters (600 feet) MSL along the eastern edge of the FEMP to 173.7 meters (570 feet) MSL at the K-65 silos, and then drops off towards Paddys Run stream at 167.6 meters (550 feet) MSL. All drainage on the property is generally from east to west into Paddys Run.

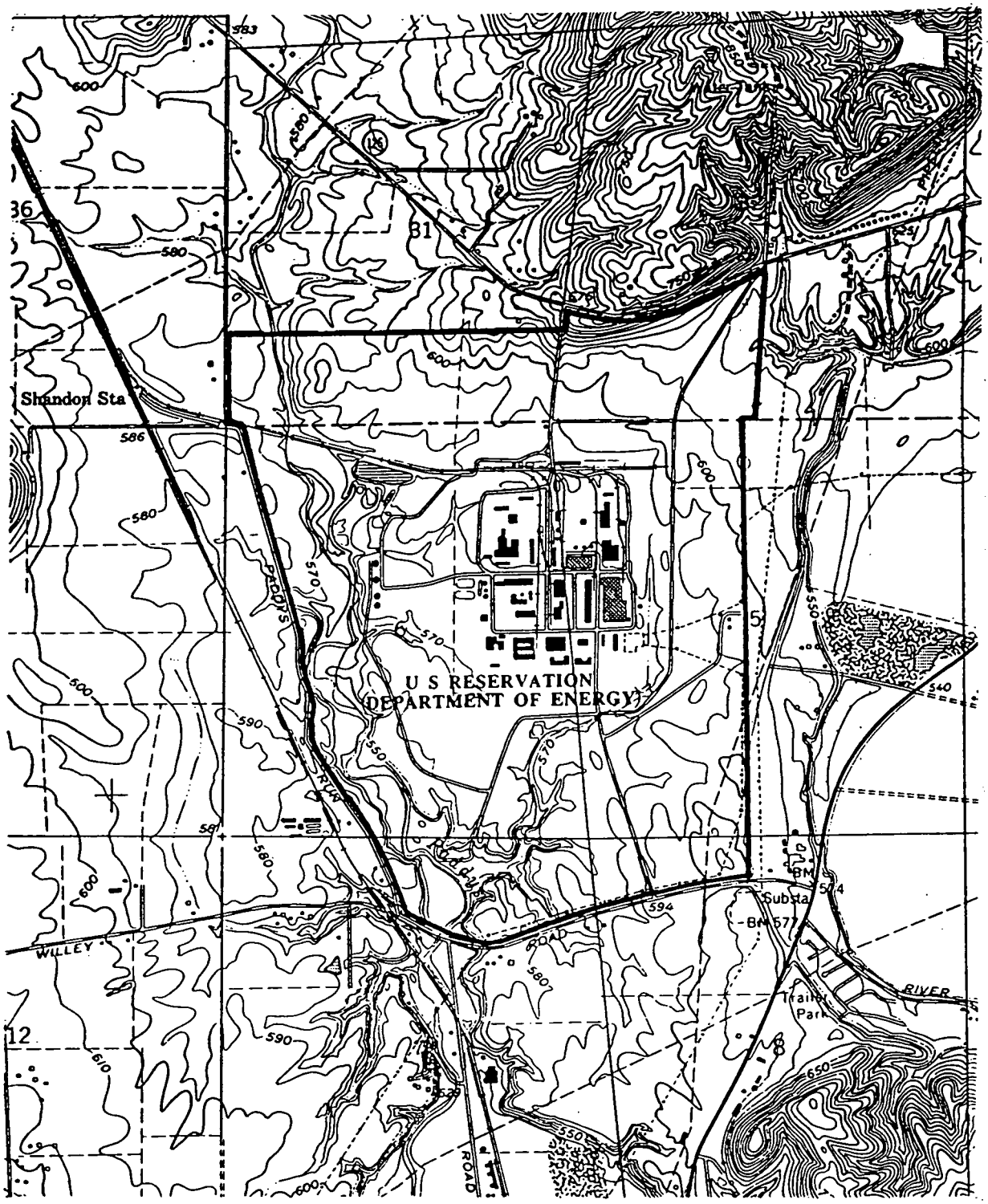
Paddys Run is a steep-sided intermittent stream that originates north of the FEMP and runs south along the western boundary of the facility. Paddys Run is approximately 14 kilometers (8.8 miles) long and drains an area of approximately 41 square kilometers (15.8 square miles). The stream is ungauged, but estimated flows for January through May range from 0.006 to 0.1 cubic meters per second (cms) or 0.2 to 4.0 cubic feet per second (cfs). The stream is a tributary of the Great Miami River, which is three-quarters of a mile from the facility's eastern boundary at its closest point.

The FEMP lies within the Great Miami River drainage basin but is above the river's present-day floodplain. The Great Miami River is the main surface water feature in the vicinity and is the receiving water for National Pollutant Discharge Elimination System (NPDES) permitted discharge from the facility. The river flows generally to the southwest and drains an area of approximately 8702 square kilometers (3360 square miles).

The average discharge for the Great Miami River, based on 55 years of records, is 936 cms (3305 cfs). The maximum discharge ever recorded for the river occurred on March 26, 1913 and was estimated to be 9969 cms (352,000 cfs). The 10-year flood discharge has been calculated to be 2307 cms (81,455 cfs). The minimum daily discharge of 4.4 cms (155 cfs) was recorded on September 27, 1941.

I.2.1.3 Geology and Hydrology

At the FEMP, groundwater occurs in the glacial overburden as perched water, in a sand and gravel aquifer (the Great Miami Aquifer), and to a lesser extent in the underlying bedrock.



SOURCE
USGS (1981)
SHANDON, OHIO
QUADRANGLE

SCALE
1:24,000

OU2 CRARE CADFILE: 424331\AU211-3 AUG 1994

FIGURE 1.2-1
TOPOGRAPHIC MAP OF THE FEMP

Perched water occurs when water sinking through the earth from the surface is retarded above a very dense stratum, in this case clay. This perched water either seeps slowly downward through the clay or flows horizontally to discharge sites in Paddys Run. At the FEMP, perched water is generally found between 0.3 and 3 meters (1 and 10 feet) below the surface (DOE 1993a).

The glacial overburden, which occurs under most of the FEMP property, is composed of the following: loess, fine-grained silt with small amounts of clay; lacustrine deposits, silt and clay with interbedded sand; till, heterogeneous mixture of silt, clay, sand, gravel, and boulder-sized materials; and glaciofluvial deposits, well-sorted sand and gravel. The thickness of the glacial overburden ranges from 1.5 to 15 meters (5 to 50 feet) within the FEMP study area, but most often averages between 6 and 9 meters (20 and 30 feet). With the exception of some scattered deposits, this material does not exist along the floodplain of the Great Miami River to the east and south of the FEMP. The only on-property areas that lack overburden are certain reaches of Paddys Run and the storm sewer outfall ditch, where the material has eroded away.

The presence of till and deposits of silt and clay classify the overburden as an aquitard in most locations. However, perched water zones are formed from the lenses, beds, and irregularly shaped deposits of sand and gravel interbedded within the till. A series of slug tests performed in the on-property wells screened in the perched-water zones found hydraulic conductivities ranging from 0.002 to 4.5 meters per day (0.0065 to 14.7 feet per day). Porosities range from 22 to 36.7 percent with a mean of 31 percent (Morris and Johnson 1967). Based on hydrography analyses, the perched-water zones may be interconnected and limited, indicating that the movement of water and contaminants within and among these units is limited. The till is considered to be saturated from the perched water zones down to the top of the glaciofluvial deposits.

Water seeping through the clay layer passes through the glacial overburden and collects in the underlying aquifer. The Great Miami Aquifer, is about 24 meters (80 feet) beneath the FEMP and ranges between 38 and 53 meters (125 and 175 feet) in thickness. Flow in the aquifer is to the southeast and south, toward the Great Miami River.

I.2.1.4 Ecology

Plant and wildlife communities within FEMP boundaries have been extensively characterized by Facemire et al. (1990), who provide detailed data on species abundances. Habitats include grazed and ungrazed pastures, pine plantations, deciduous woodlands, riparian woodlands, and a "reclaimed" flyash pile, which overlaps the inactive flyash pile and South Field. The inactive flyash pile and South Field have been colonized by American elm, eastern cottonwood, black locust, redbud, and box elder. Herbaceous species are also present. Common mammals include the white-tailed deer, eastern cottontail rabbit, coyote, red fox, and several smaller animals such as the white-footed mouse, short-tailed shrew, and eastern chipmunk.

I.2.1.5 Land Use

Most of the land surrounding the FEMP is devoted to farming and to raising dairy and beef cattle. Major crops include field corn, sweet corn, soybeans, and winter wheat. Other important commercial activities include sand and gravel mining and commercial water extraction from the adjacent Great Miami Aquifer. Many sand and gravel operations exist along the river, and the Southwest Ohio Water Company is 2 kilometers (1.25 miles) upstream of the FEMP discharge line to the river.

I.2.1.6 Demographics

Scattered residences and several villages, including Fernald, New Baltimore, Ross, New Haven, and Shandon, are located near the FEMP. Downtown Cincinnati is approximately 29 kilometers (18 miles) southeast, and the cities of Hamilton and Fairfield are approximately 9.7 to 13 kilometers (6 to 8 miles) to the northeast. More than 24,000 people live within 8 kilometers (5 miles) of the facility center, the nearest resident within 1.2 kilometers (0.75 miles). The Knollman Dairy Farm is on Willey Road, just outside the southeast corner of the FEMP property boundary. Several residences are located off Paddys Run Road, approximately 1.6 kilometers (1 mile) south of property boundaries.

I.2.2 ASSUMPTIONS

Throughout the course of the CRARE development, assumptions have been employed that have significant bearing on the interpretation of the resultant risk data. Assumptions concerning future site conditions, the completeness of data, future facility management, demographics, materials

containment, and risk assessment methods have been addressed. The following assumptions are specific to this version of the CRARE.

Future Site Conditions

- The designs for the on-property disposal facilities follow the concepts described in the SWCR (for Operable Units 3 and 5) and FS reports (for Operable Units 1, 2, and 4).

- Site soil under Operable Unit 5 would be remediated for U-238 to an activity level not exceeding 60 picocuries per gram (pCi/g), based on the expanded trespasser receptor (the recreational user in the SWCR Part III). The value of 60 pCi/g was selected as a target cleanup level and may change as the operable unit FSs are completed.

- The FEMP property boundaries and operable unit boundaries define the source areas for the CRARE analysis. Impacts from non-FEMP off-site contaminants and related contaminant transport, and FEMP off-site disposal locations are not included in this CRARE.

- All volatile organic compounds (VOCs) have been effectively removed to a level no longer warranting air dispersion modeling after remedial action is complete (short-term and long-term adverse impacts are addressed in the remedial action and residual risk assessment appendix for Operable Units 1, 2, and 4 FS report.

- VOCs and semivolatile organic compounds (SVOCs) would be reduced in the groundwater through the pump and treat operations of Operable Unit 5. This assumption is consistent with the Amended Consent Agreement relative to operable unit definitions. It is considered reasonable based on the low frequency of detection and low concentrations (ppb range) of these compounds, as reported in the SWCR. The SWCR evaluated COC concentrations in 85 off-site wells and identified 7 of them as containing elevated concentrations of VOCs or SVOCs. Five of these are located in the vicinity of the southern property boundary or the South Plume. Two wells are located along the northwestern, upgradient property boundary. Radionuclides are much more widespread in the South Plume and are the major focus of remediation there. Groundwater that is removed from the South Plume for treatment will eventually be discharged to the Great Miami River and not returned to the aquifer. It is probable that this process will reduce the existing VOC and SVOC concentrations to minimal levels as part of the effort to remediate the more extensive radionuclide contamination.

- Inorganic compounds would also be reduced in the groundwater, as described above. Because uranium is the most widespread COC and has the highest concentrations, uranium was assumed to be the most persistent COC during remediation. Groundwater was therefore assumed to still contain uranium at the drinking water standard at the end of FEMP remediation. All other inorganics were assumed to be reduced to minimal levels.

- The CRARE Site-Wide Conceptual Model describes site conditions immediately following and for up to 1000 years after remediation. The three land use scenarios are summarized in Section I.1.6 and detailed in Section I.5.0.

- The contaminated surface soils would be remediated to the cleanup levels for all COCs which exceed those levels.

- The surface soil not covered by disposal facilities is assumed to be 85 percent vegetated per Appendix E (Fate and Transport Modeling) of the Operable Unit 4 RI report.

Completeness of Data

- All "hot spots" (areas where COC concentrations exceed cleanup levels) have been identified as a result of sampling to date.

- All COCs considered for Operable Units 1, 2, and 4 are identified in the RI and FS reports for those units.

- COCs considered for Operable Units 3 and 5 are identified in Appendix R of the SWCR.

- The nature and extent of contamination for Operable Units 1, 2 and 4 are described in the RI reports for those units.

- The nature and extent of contamination for Operable Units 3 and 5 are described by the data contained in the SWCR and RI/FS database, as of March 1993. This database may contain nonvalidated data, which may have been used in this CRARE as the best data available at this time.

- Physical properties used for groundwater transport modeling were taken from fate and transport modeling assumptions contained in the RI/FS reports as primary sources as well as the SWCR, as needed, for secondary sources.

Future Facility Management

- For the Current Land Use scenario, maintenance would be performed on the fences, facility and storage areas for 70 years after remediation. The necessity and duration of this maintenance would be considered in future assessments.

- The government would own the FEMP for up to 1000 years under the Future Land Use With Federal Ownership scenario, and therefore will control land use to prohibit residences, farms, or other public land use.

- Under the Future Land Use Without Federal Ownership scenario, the FEMP would revert to private ownership and would become a resident farm immediately after the remediation is complete. No further facility maintenance or access control would occur for the 1000-year evaluation period.

Socioeconomics

- During the 1000-year evaluation period, the surrounding land use will remain primarily agricultural.

- Population density changes for the 1000-year evaluation period are assumed to be insignificant.

Demographics

- For the CRARE, the off-site resident farmer is located at the point of maximum exposure (on the fence line) for both air and groundwater COC modeling. Predicting the actual location of populations 1000 years into the future is acknowledged to be highly speculative. However, even if the FEMP were surrounded by residential housing, the risk would be no greater than that of the resident farmer, because a farmer's exposure would exceed that of a nonfarming resident. Note that the CRARE methodology is designed to assess site-wide exposure to the RME individual and is not conducive to the assessment of collective or population risks.

Material Containment

- All material left on-property, except the soils left in place, would be contained in permanent on-property disposal facilities or in covered areas for the duration of the 1000-year evaluation period.

- Soils would either be washed, covered, contained, or removed to meet cleanup levels.

- Containment structures would be effective for a period of not less than 1000 years in preventing direct contact with disposed materials.

- Containment structures may leak and seep during the period immediately following remediation for up to 1000 years after remediation. Anticipated moisture infiltration rates through the on-property disposal facilities are presented in Section I.6.1.3.3.

- The disposal cells would use a design that would function effectively for 1000 years.

- The disposal cell cap is assumed to meet Ohio state regulations as stipulated in OAC 3745-27.

Risk Assessment Methods

- Contaminants adsorbed to soils in which are carried downgradient in surface water runoff will remain adsorbed onto the stream sediment.

- Contaminants dissolved in surface water runoff will remain in the water column in the receiving stream.

- Inputs from individual source areas can be summed to obtain site-wide inputs to receiving surface water streams.

- This CRARE estimates long-term residual risks associated with the remediated FEMP site. Short-term risks, such as those related to remediation activities, are taken from the information in the Operable Unit 1, 2 and 4 FS reports.

- This CRARE addresses human health risks. A quantitative site-wide ecological risk assessment will be performed as part of the Operable Unit 5 RI in accordance with the Amended Consent Agreement.

- Some groundwater COCs (Section I.4.0) have been eliminated from quantitative risk assessment by transport screening calculations of contaminants in the vadose zone.

- This CRARE uses the LRAs for Operable Units 3 and 5 as identified in the SWCR, and the PRAs for Operable Units 1, 2, and 4 from their FS reports.

- New reference doses (RfDs) and cancer slope factors will not be developed as part of the CRAREs. The most current values developed for the Operable Unit 1, 2 and 4 RI and FS reports have been applied.

- Exposure parameters are taken from the values published in the Operable Unit 2 RI report and are presented in Section I.8.0.

- Validated data are the primary source of exposure concentration estimates. Where validated data are not available, the highest detected concentration of a contaminant in a medium is used.

- Based on the site operational history, it is assumed that 90 percent of the chromium that has been identified is not hexavalent; therefore, 10 percent would be carried over as hexavalent in the risk assessment. The rationale for the health-hazard approach used for chromium is presented in Section I.7.0. The associated uncertainties are discussed in Section I.10.0.

- Lifetime cancer risk was calculated for external exposure to radionuclides in contaminated surface soil, sediments, and airborne particulates.

I.2.3 REMEDIAL ALTERNATIVES

This section summarizes the PRAs for Operable Units 1, 2, and 4, which are developed in FS reports for those units. For Operable Units 3 and 5 (whose FS activities have not yet been completed), the LRAs may be changed in the future to represent updated plans. Figure I.2-2 has been provided to illustrate postremediation site conditions as projected based on the PRA/LRAs presented below.

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I.2.3.1 Operable Unit 1 PRA

The PRA for Operable Unit 1 includes removal, pretreatment drying, and off-property disposal of waste pit materials, covers, liners, and contaminated soils. The excavated areas will be backfilled with clean soil. Additional components of the PRA include construction of waste processing and loading facilities and equipment, and removal of water from open waste pits for treatment at the Advanced Waste Water Treatment (AWWT) facility.

I.2.3.2 Operable Unit 2 PRA

The PRA for Operable Unit 2 includes excavation of contaminated soil, flyash, lime sludge and debris with COCs above the PRLs, material processing for size reduction and moisture control (as required), on-site disposal in an engineered disposal cell, and off-site disposal of a small fraction of the excavated material that exceeds the WAC for the on-site disposal facility. Excavation activities and construction of the disposal facility would be coordinated with Operable Units 1, 3, 4, and 5.

At the North Lime Sludge Pond, free-standing water would be removed. Lime sludge would be stabilized as required, to improve its handling/compaction characteristics. Nonsoil material (e.g., concrete, steel, pallets, etc.) from all subunits would be visually segregated, hauled to the staging/ material preparation area, processed for size reduction, and placed in the on-site disposal cell.

Approximately 240,600 cubic meters (314,700 cubic yards) of contaminated material from Operable Unit 2 would be deposited in the on-site disposal facility. It is anticipated that up to 2350 cubic meters (3100 cubic yards) of material would exceed the WAC for the on-site facility and be transported to the representative off-site facility for disposal. In addition, approximately 230 cubic meters (300 cubic yards) of lead contaminated mixed waste from the Firing Range would be treated (assumed to be stabilization/solidification).

I.2.3.3 Operable Unit 3 LRA

For the Operable Unit 3 LRA, buildings will be decontaminated and demolished; contaminated material would be removed, treated and/or decontaminated, temporarily placed in storage, and finally disposed to reduce the potential for contaminant migration. Decontamination and

treatment residue would require further treatment and disposal. Contaminated material would be disposed in the vaults while clean material would be free-released for reuse or recycling.

I.2.3.4 Operable Unit 4 PRA

The PRA for Operable Unit 4 includes removing the waste stored in Silos 1, 2, and 3, stabilizing it via vitrification, and removing it to an off-site disposal facility. Silos 1, 2, 3 and 4 will be decontaminated to the extent practical and demolished. Contaminated soil and construction material from the silo berms, subsoil, and decant tank would be removed to the extent necessary based on cleanup levels and temporarily stored on-site for eventual treatment and disposal with Operable Unit 3 debris and/or Operable Unit 5 soil. These actions are presented in the Proposed Plan For Remedial Actions at Operable Unit 4 (DOE 1994e).

I.2.3.5 Operable Unit 5 LRA

Under the LRA for Operable Unit 5, contaminated groundwater would be extracted, treated at an on-property facility, and discharged to the Great Miami River through the newly constructed effluent line. Treatment residuals would be disposed in on-property disposal facilities. The LRA also involves excavating contaminated sediment and soil necessary to meet cleanup levels, transporting the contaminated material to an on-property location for treatment using soil-washing, and returning the treated material as backfill. For U-238, a 60-pCi/g target cleanup level was selected. This cleanup level and those for other COCs were defined in the SWCR. The soil-washing fluids would be recycled and the removed contaminants stabilized and disposed in on-property disposal facilities.

I.2.4 ON-PROPERTY DISPOSAL FACILITY DESIGN

As part of the RI/FS process, Comprehensive Environmental Response Compensation, and Liability Act (CERCLA) requires that remedial alternatives be developed and evaluated. For the FEMP, the proposed plan for each operable unit provides the recommendation of the most appropriate alternatives. In each case, an on-site disposal option has been included, under which some wastes or treated materials would be disposed in on-property disposal facilities. Several disposal facility designs have been developed for on-property disposal of FEMP contaminants. This CRARE assumes that the structures and debris from Operable Unit 3 (including the silos from Operable Unit 4) would be placed in sealed concrete vaults covered with an engineered cap.

A cover system would be constructed over Operable Unit 1 following remedial activities. The excavated soil and material from Operable Unit 2 would be placed in a disposal cell.

The following discussions describe the major features of the disposal facility (vaults) and cell designs assumed for this CRARE. Other alternatives, such as in-situ remediation and off-property disposal, will be identified and possibly implemented as part of the RI/FS process for each operable unit. Accordingly, the vault and cell designs may change.

I.2.4.1 Description of Operable Unit 3 Vault

Twenty-five vaults would provide long-term, on-property disposal of the radioactive, hazardous, and mixed waste generated during the FEMP remediation. The vaults would accommodate the different waste types, volumes, and generation rates for Operable Units 3 and 5, as noted in the SWCR.

There are two design concepts for the vaults. The structure of the wet and dry vaults is essentially the same, except that the wet vaults have access panels in their roofs through which slurry can be placed. Figure I.2-2 presents a typical vault system, showing both wet and dry vaults. For the wet vaults, access panels would be provided through the concrete roof to allow the grout to be placed and inspected. For the dry vaults, a service opening would be provided for each disposal cell along one side of the vault to allow access for placing the containers. A forklift would be used to stack waste containers in the dry vaults. Active areas of the vault would be ventilated to remove exhaust gases.

The vaults would be located on FEMP property near the eastern perimeter. Each vault would consist of an above-grade, reinforced concrete structure capable of storing approximately 90,000 cubic yards (68,814 cubic meters) of waste. The floors and roofs of the vaults would be sloped.

To facilitate leachate collection and leak detection, the vaults would contain 3 modules each, with 4 cells in each module, for a total of 12 cells per vault. One vault would have only two modules and eight cells. Each vault cell would contain a double-liner system with leachate collection and leak detection capability. The liners selected would be chemically resistant to waste and leachate.

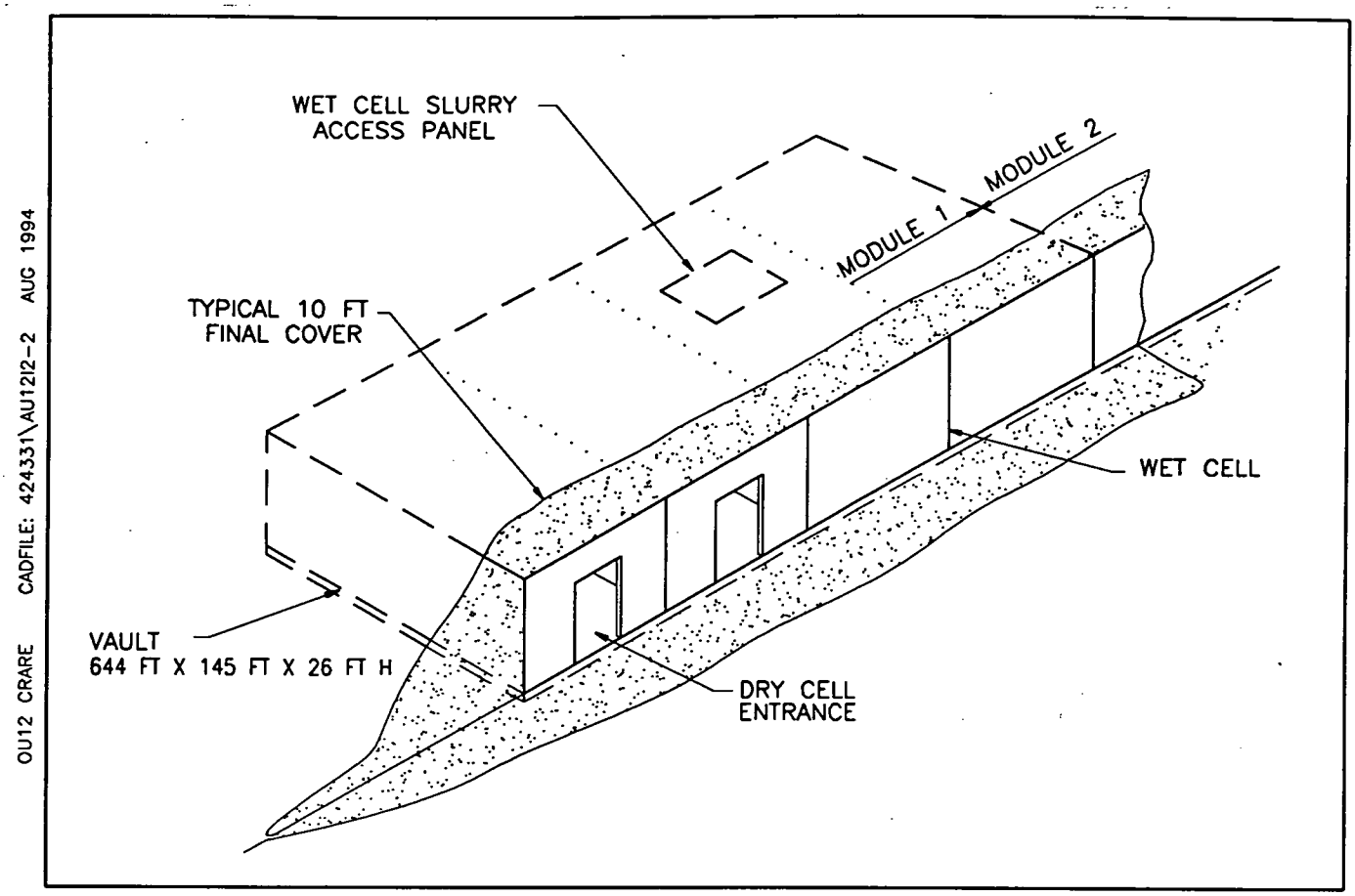

FIGURE I.2-2

TYPICAL VAULT

During remediation and for a 70-year period after remediation, if the Current Land Use scenario is implemented (with access controls), storm water runoff from the waste disposal operation areas, including the vaults, would be controlled by drainage ditches, culverts, sedimentation and retention basins, and lift stations. The system would be designed to handle peak discharge from a 24-hour, 25-year storm. To maintain the design capacity, provisions would be included to empty the storm water accumulating in the retention basin. The accumulated water would be pumped to a waste water treatment facility for treatment prior to discharge. Storm water runoff from closed

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and unregulated areas would be allowed to flow off-property via man-made and natural water courses. Erosion control structures would be used, if required. Under the Future Land Use scenarios, all retention basins are breeched and nonoperative.

I.2.4.2 Cover System Design

A cover system will be constructed over Operable Unit 1. This cover will consist of compacted fill with an infiltration limiting layer of clay which in turn will be covered by vegetated topsoil. This is described as the PRA in the Operable Unit 1 FS report.

I.2.4.3 Description of Operable Unit 2 Disposal Cell

An on-site disposal cell for contaminated material from Operable Unit 2 would be constructed in the southeast corner of the FEMP site east of the site access road (refer to Figure 5-21 in the FS Report). The location of the disposal cell was selected based on minimizing potential conflicts with the on-site disposal plans of other operable units. The proposed location is within the general area of potentially acceptable locations for on-site disposal. The disposal cell may be moved within this general area to meet the disposal needs of other operable units.

The contaminated material with COC concentrations exceeding the PRLs, as well as all of the flyash and lime sludge from the Operable Unit 2 subunits, would be consolidated and deposited in this disposal cell. The disposal cell would be constructed in accordance with applicable ARARs and DOE guidelines. The disposal cell would be designed for a minimum of 200 years design life with 1,000 years expected effective life with proper maintenance. Approximately 240,600 cubic meters (314,700 cubic yards) of contaminated soil, lime sludge, flyash, and debris from, and waste generated during remediation of, Operable Unit 2 would be placed in the disposal cell. This volume includes approximately 62,000 cubic meters (81,9000 cubic yards) of contaminated material from the subunits with COC concentrations below the PRLs for dermal contact would be used for constructing the interior portions of the disposal cell berms.

Construction of the disposal cell would include site preparation, a decontamination facility for personnel and equipment, a liner system, leachate collection and treatment system, disposal of the contaminated material, and a capping system (refer to Figures 5-22 and 5-23 in the FS Report).

Disposal Cell Liner System

The liner system (refer Appendix E of the FS Report for details) would be constructed before the contaminated material is excavated from the Operable Unit 2 subunits. The construction of the liner system would begin with site preparation, which would include clearing and grubbing; installation of erosion and sediment controls, a runoff control facility, and a security fence, construction of a decontamination facility and an access road; and subgrade preparation for the liner.

Subgrade for the liner would be graded and compacted to at least 95 percent of the maximum standard Proctor density. The components of the liner from top to bottom, include the following:

- Contouring layer;
- Infiltration/radon barrier;
- Drainage layer;
- Biotic barrier;
- Filter layer;
- Vegetative support soil layer; and,
- Topsoil layer.

Following placement of the capping materials, the cap surface would be finish graded with a minimum slope of four percent, seeded, and mulched in accordance with the approved Erosion and Sediment Control Plan. Fertilizing, seeding, and mulching for the grass cover would be performed to minimize surface erosion.

Operation of the Disposal Cell

Various activities would be performed at the disposal facility to maintain the integrity and effectiveness of the containment system. These activities would include the following:

- Collection and treatment of leachate and storm water runoff;
- Routine inspection of the capping system to identify subsidence, erosion, or weathering;
- Removal of dead vegetation that would threaten the integrity of the capping system;

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- Repair of portions of the capping system noted as defective; and,
- Five-year CERCLA reviews.

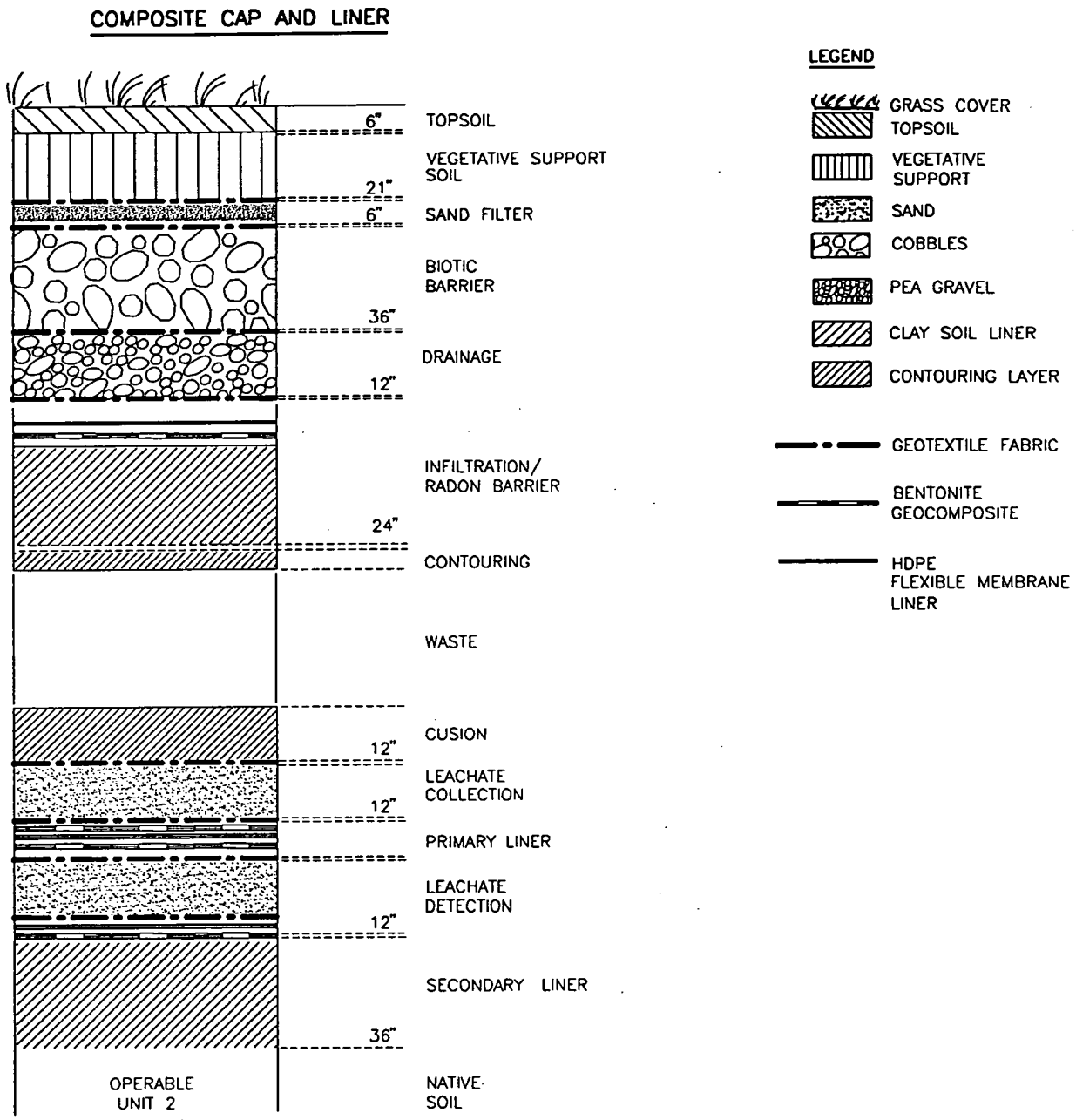
The liner construction would begin with subgrade preparation. Subgrade for the liner would be graded and compacted to at least 95 percent of the maximum standard Proctor density (for the typical liner detail, refer to Appendix E). The components of the liner from top to bottom, include a cushion layer, a leachate collection system layer, a primary liner system layer, a leachate detection system layer, and a secondary liner system layer. Contaminated material placed on top of the cushion layer would be pre-screened and would be free of sharp objects or other characteristics that could jeopardize the integrity of the nonwoven geotextile below the cushion layer. No heavy equipment would be operated over the liner until the cushion layer is placed.

The approximate area of the liner would be 52,000 sq m (560,000 sq ft). The leachate collection system would include perforated high-density polyethylene (HDPE) leachate collection piping in the drainage layer, two HDPE leachate collection sumps outside the liner area, double-walled diameter HDPE leachate discharge pipe from the sump to the AWWT facility, and six HDPE clean-out manholes on the leachate discharge pipe to the AWWT facility.

Capping System

The cap would be constructed after the consolidation of the contaminated material in the disposal cell. The total area of the cap would be approximately 52,700 sq m (567,000 sq ft) and would include a berm and composite cap.

The composite cap would be constructed in accordance with applicable regulations and DOE guidance. The cap would be graded to blend with the existing grade or blend in with the surrounding topography. Each cap would be constructed on top of the consolidated material consisting of the following components from bottom to top: a contouring layer, an infiltration barrier, a radon barrier, a drainage layer, a biotic barrier, a filter layer, a vegetative support soil layer, and a topsoil layer (for details, refer to Appendix E). Following placement of the capping materials, the cap surface would be graded with a minimum slope of 3 percent, seeded, and mulched in accordance with the approved Erosion and Sediment Control Plan. Fertilizing,



OU2 CRARE CADFILE: 424331/AU12I2-3 AUG 1994

FIGURE I.2-3
TYPICAL DISPOSAL CELL

seeding, and mulching for the grass cover would be performed in accordance with the approved erosion and sediment control plan to minimize surface erosion. The cap would be finish graded to a minimum slope of 5 percent.

Various activities would be performed at the disposal cell to maintain the integrity ad effectiveness of the capping system. These activities would include routine inspection of the capping system to identify subsidence, erosion, or weathering; removal of dead vegetation that would threaten the integrity of the capping system; and repairs. Five-year CERCLA reviews would also be conducted at the disposal cell.

I.3.0

I.3.0 OVERVIEW OF CRARE TECHNICAL APPROACH

This CRARE is based on projected site conditions after remediation has been completed. In the baseline risk assessment, actual site conditions, including contaminant concentrations, are used with modeling to project future concentrations, exposures, and risks to various receptors. For the CRARE, initial conditions are determined from the result of treatment and disposal alternatives described in each operable unit FS or the SWCR. Modeling must then be used to estimate future concentrations, exposures, and risks to receptors under various land use scenarios.

Groundwater fate and transport modeling was used as part of the CRARE methodology to predict future COC concentrations in groundwater resulting from migrations from residual soil contamination and the on-site disposal facilities. Future ambient air concentrations were predicted from air pathway transport modeling of soil and disposal area sources. Direct exposure (through air, soil, sediment, surface water, and groundwater pathways) and indirect exposure (via food pathways) from soils and water were modeled using projected soil and water contaminant concentrations. All of this was based on site physical conditions, topography, etc. projected from engineering estimates of the impact of the remedial alternatives. This section summarizes the CRARE methodology which is presented in greater detail in Sections I.4.0 through I.7.0.

I.3.1 TECHNICAL APPROACH

The basis of the CRARE is the Amended Consent Agreement, page 38, which states: "The cumulative residual risk contributions from the other operable units will be estimated based upon the selected alternative, or the Leading Remedial Alternative." The Addendum emphasizes the iterative nature of cleanup level selection. The CRARE does not select cleanup levels, but rather reports the risks calculated using the cleanup levels from each operable unit. The overall technical approach for the CRARE has been developed within the context of the RI/FS process for the FEMP to determine if the remedial alternatives for the operable units protect human health and the environment or, if they do not, to provide information useful in developing the best path forward.

This CRARE has been prepared in conjunction with the EPA, Ohio Environmental Protection Agency (OEPA), and DOE guidelines to assess the potential risk of exposure to radionuclides

and hazardous chemicals. It follows the methodology presented in the RAWPA, which derived much of its methodology from the EPA Risk Assessment Guidance for Superfund (RAGS). Deviations from the methodology discussed in the RAWPA are the result of: 1) FERMCO's response to EPA and OEPA review comments on the SWCR and Operable Unit 1 and 4 RI reports, 2) the release of additional guidance documents after the submittal of the Addendum and the SWCR, and 3) technical information attained from literature other than that cited in the Addendum and SWCR. These deviations are summarized below.

- Groundwater cleanup levels for radionuclides were developed from a 10^{-6} target risk level and/or from applicable, relevant, and appropriate requirements (ARARs) and those to be considered (TBC). The ARARs/TBCs include maximum contaminant levels (MCLs) and proposed MCLs.

- The soil ingestion rate for the on- and off-property resident farm adult was increased. The new rate of soil ingestion, 0.18g/day, was developed in response to EPA comments on the SWCR. This soil ingestion rate was based upon a standard adult soil ingestion rate of 100 mg/day and modified to account for farming activities (February 11, 1993 FERMCO memo). The derivation of the 180 mg/day soil ingestion rate is presented in detail in the Operable Unit 4 RI report (DOE 1993c).

- Skin surface area available for contact was increased for the child and adult receptors to comply with the Operable Unit 2 RI. This change reflects better characterization of the receptor's physical parameters and the availability of new data in the literature.

- EPA Region V guidance for beryllium is the gastrointestinal absorption factor of 1.00 (July 1994). Guidance from EPA Region V (Saunders, M. 1994) is to apply OSWER Directive No. 9355.4-02 (EPA 1989μ) to on-site soil lead contamination. This directive established a soil cleanup level for lead of 500 to 1000 ppm, based on recommendations by the Centers for Disease Control designed to protect children from blood lead concentrations above background, which are associated with lead-induced neorulogical effects.

In addition to the Operable Unit 1, 2 and 4 FS reports, information for this CRARE has been extracted from the SWCR for Operable Units 3 and 5. This CRARE reflects the Risk Information Data Quality Objectives and is sensitive to EPA's comments on the Operable Unit 1, 2 and 4 RI reports and the SWCR.

I.3.2 FATE AND TRANSPORT MODELING OF RESIDUAL CONTAMINANTS

Section I.1.5 describes the CRARE Site-Wide Conceptual Model, which was used to establish potential sources, pathways, and contaminant receptors. Section I.2.2 discusses the major assumptions used to estimate conditions. After developing the conceptual model, fate and transport computer models were used to simulate the transport processes. A discussion of the computer transport models follows.

I.3.2.1 Groundwater and Surface Water Modeling

The SWCR (Section II, Part 3.2.1) describes the development of specific conceptual models using source terms, release mechanisms, and receptors, and the selection of numerical computer codes for RI/FS work at the FEMP. The CRARE fate and transport models use the same approaches and codes where appropriate. The principal differences between the baseline and CRARE transport models are in the definition of source terms from the respective conceptual models. The same One-Dimensional Analytical Solute Transport (ODAST) and SWIFT III codes were used to model transport through the vadose zone and the aquifer, respectively. More detailed descriptions of ODAST and SWIFT III are presented in Section I.6.1.

COC Selection

The first step in defining source terms for groundwater numerical modeling is to establish the COCs to be evaluated in the assessment. Section I.4.0 describes how a site-wide list of potential COCs was compiled for possible inclusion in the CRARE and then reduced through three screening procedures.

Sources

As defined in Section I.6.1, the source terms for the various areas of the site are the leachate from the vaults, the residual soil, and the capped/covered areas. The ODAST results for these areas were used as direct inputs to the CRARE SWIFT III groundwater model.

Engineering studies of the vaults and capped/covered areas estimate leakage rates through the structures over time. Preliminary Toxicity Characteristic Leaching Procedures (TCLPs) were performed on various types of waste that would be stored on the FEMP. The results were used to estimate the COCs in the leachate and then used as input to the ODAST model to estimate

transport through the vadose zone (see Section I.6.1 for more detail). TCLP results were not available for all types of waste. Geochemical modeling or literature values were used to estimate leachate concentrations where the TCLP results were not available.

Contaminant Concentrations

For soil that is excavated, treated, and returned as backfill, U-238 was assumed to be at a concentration of 60 pCi/g and Ra-226 at 5 pCi/g. These values are defined in the SWCR, Part III. For Ra-226, Ra-228, Th-228, Th-230, and Th-232, an ARAR of 5 pCi/g (40 CFR 192) was established as the PRG. For U-238, a risk-based PRG of 60 pCi/g was selected based on recreational use and a 10^{-6} risk. Untreated residual soil was assumed to retain its current level of constituents. Leachate concentrations for surface soil were estimated from field data, Kd values, or literature values. The HELP model was used to estimate infiltration and runoff values for surface soil.

Transport

A simplified analytical approach was used to estimate runoff and contaminant transport from surface soils to Paddys Run. The flow in Paddys Run was used as a source term for groundwater in downstream areas where it recharges through coarse sediments (till is not present). The ODAST model was not used in these areas.

For all source terms, the total mass of available contaminants was initially estimated for the start of the model time frame. As contaminants were transported away or decayed over time, these source masses were depleted. If they were exhausted before completion of the 1000-year simulation, then the source was deleted from that time forward.

Receptor Locations

The flow and contaminant concentration data from all of the ODAST simulations were used by the SWIFT III model to calculate mass loadings of contaminants to the GMA. SWIFT III predicted the transport of the contaminants in the groundwater flow paths and developed contaminant concentration contours at specified times. From these data, specific receptor locations were selected as representative of the maximum potential risks to on- and off-property

residents. Plots of concentration versus time for these locations were then developed to use in estimating the potential risks from groundwater contaminants originating at the FEMP.

I.3.2.2 Site-Wide Air Pathway Analysis

The objectives of the air quality impact analysis were to calculate the risk from estimated ground-level air contaminant concentrations from the PRAs or LRAs. The ground-level air contaminant concentrations were then used in the exposure analysis.

Air Emission and Dispersion Modeling

Air dispersion modeling conducted for risk assessment calculations used an EPA air quality dispersion model, the Industrial Source Complex, Long-Term, Version 2 (ISCLT2). Rn-222 emission rates were estimated using the RAECOM model, which converts Ra-226 soil concentrations to Rn-222 emission rates, consistent with the natural decay of Ra-226. Airborne particulate emission rates were estimated using methods presented in *Rapid Assessment of Exposure to Particulate Emissions from Surface Contamination Sites* (EPA 1985b). Only nonvolatile organic compounds were assumed to remain on-property after remediation; therefore, nonvolatile organic compound soil concentrations were used to analyze organic emission rates.

Sources

The air emissions from the LRAs for Operable Units 3 and 5 (identified in the SWCR) and the PRAs for Operable Units 1, 2 and 4 (identified in their FS reports) were modeled as source areas for risk assessment calculations. Operable Unit 1 has 57 sources; Operable Unit 2, 286 sources; Operable Unit 4, 10 sources; and Operable Units 3 and 5, 894 sources; for a total of 1247 source areas. As shown in the Operable Unit 4 CRARE (DOE 1993d), post remediation current and future source terms are virtually the same. Therefore, only the future scenario source terms are analyzed in this CRARE. More specific information about these sources appears in Section I.6.2.

As indicated above, models and methods were used to estimate air contaminant emission rates. Radon emissions were calculated using the RAECOM model. The contaminant concentrations in surface soil were used to develop suspended contaminant emission rates from the total suspended particulate emission rate. Contaminants in wind-blown soil include radionuclides, inorganic compounds, and nonvolatile organic compounds.

Contaminant soil concentrations for Operable Units 1, 2, and 4 were obtained from their RI/FS reports, and for Operable Units 3 and 5 from the SWCR and Operable Unit 5 RI report. The SWCR and the existing sampling database were used to estimate soil contaminant concentrations for Operable Units 3 and 5. These reports were also used to estimate the Ra-226 concentration for waste disposed in on-property disposal facilities. The cleanup levels were used as concentration estimates for remediated soils, consistent with the groundwater modeling approaches presented in Section I.3.2.1.

Meteorological Data

Five years of meteorological data from the FEMP, in stability array (STAR) format, were used to model air quality impacts (1987, 1988, 1989, 1991, and 1992). The data collection efficiency for 1990 was below 90 percent and therefore was not used. The requirement of 90 percent efficiency for valid wind and stability data is defined in the U.S. EPA Quality Assurance Handbook for Air Pollution Measurements Systems (Section 4.2.6 EPA 1989b). Based on this guidance and the professional judgement that missing 10 percent of the meteorological data could significantly impact the results, the 1990 data set was not used.

Receptors

Air contaminant concentrations were modeled using a receptor grid, a system of fenceline receptors, and several discrete receptors. The receptor grid consists of 985 receptor points covering the site and extending approximately 300 meters (1000 feet) beyond the FEMP fenceline in each direction. The grid was used to develop airborne concentration isopleths for the FEMP and surrounding area. The maximum on-property impact location was determined from modeled results at these receptor grid points. The on-property residential and occupational worker exposures were developed from the grid point concentration values.

The fenceline receptor system (a subset of the grid system) consists of 36 receptor points located around the FEMP at the fenceline. The maximum off-property impact location was determined from modeled results at these receptor points. The off-property residential exposure was developed from this maximum impact location (the nearest off-property resident was assumed to be at the maximum off-property impact location).

Discrete receptor locations included the Elda School and Ross High School in Ross, and the Crosby Township Elementary School between Fernald and New Haven. These receptors were used to determine impacts at sensitive receptors in the surrounding community.

I.3.3 EXPOSURE AND INTAKE ASSESSMENT

Exposure assessment evaluates the amount of contaminants a potential receptor may experience from contact with FEMP residual contaminants and how much would be taken into the body to cause adverse effects. The exposure assessment involves four stages:

1. Characterization of the exposure setting
2. Identification of contaminant migration and receptor exposure pathways
3. Quantification of exposure
4. Assessment of contaminant intake doses

Section I.5.1 provides a detailed description of the exposure setting up to 1000 years after site remediation. Sections I.5.2 and I.5.3 characterize and identify the pathways in which site residual contaminants could reach human receptors. Section I.8.0 contains detailed presentations of the intake equations, data values, and sources of data used in the exposure assessment.

The exposure assessment data in this CRARE were selected according to the following hierarchy (in descending order of preference):

1. Site-specific data obtained from the site remediation database
2. RI/FS database and other regional and site-specific data from studies that complement the RI/FS characterization process
3. Generic exposure assessment data from EPA reference documents
4. Generic exposure assessment data from secondary sources, subject to EPA approval.

I.4.0 CONTAMINANTS OF CONCERN

The principal radioactive constituents found in environmental media at the FEMP are uranium, radium, strontium, technetium, thorium, and their progeny. Principal hazardous waste constituents include heavy metals, chlorinated and no-chlorinated solvents, polychlorinated biphenyls (PCBs), and polycyclic aromatic hydrocarbons (PAHs). The source areas of the nonradioactive constituents are typically smaller than those of the radioactive constituents.

I.4.1 COMPARISON OF LISTS

A listing of site-wide constituents of potential concern (CPCs) is presented in Appendix R of the SWCR. The list contains CPCs that may be present in the various media at the FEMP. The SWCR list, which is based on detection in on-property samples, was combined with the lists of CPCs from the RI/FS reports of Operable Units 1, 2, and 4. The combined list was then used for the initial screening of COCs in this CRARE. Those constituents which remain after baseline risks from government and private land uses have been calculated become the contaminants of concern (COCs). COCs are defined as an ILCR $>10^{-6}$ and an HI>0.2. Because the COCs for Operable Units 3 and 5 were obtained from the SWCR, it is important to note that SWCR data are subject to validation and will be supplemented with validated RI/FS data in the future.

I.4.2 COC SELECTION PROCESS

It was assumed that constituents evaluated in the CRARE are all COCs, since COC selection has occurred as part of the RIs and FSs. Because the CRARE addresses postremediation time frames, total potential COCs have been reduced to reflect the screening in both the RI and FS. Further, some contaminants will have been removed, treated or contained in the future such that exposure to humans and the environment is precluded. For this CRARE, the new site-wide list was screened three times as follows to eliminate contaminants that pose little or no risk to postremediation receptors (Figure I.4-1):

1. Initial screening:

   Eliminate nontoxic compounds, nutrients, and noncompound-specific analytical results.

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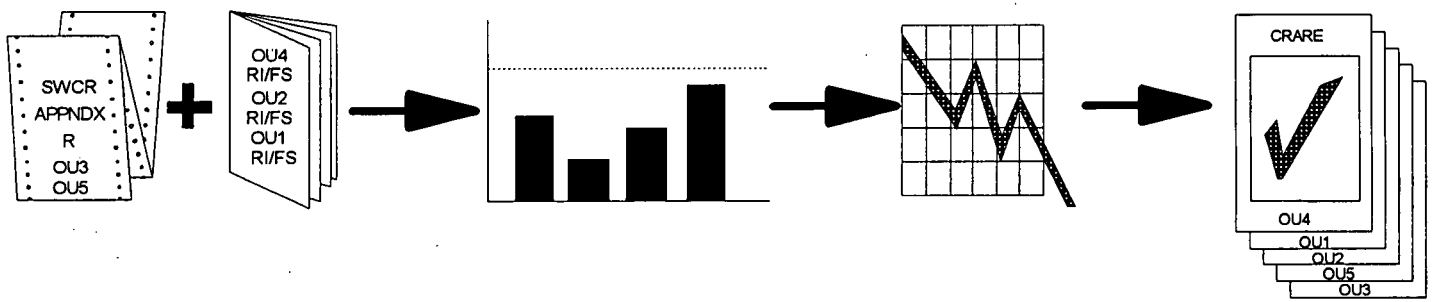

INITIAL CHEMICAL LISTING

FROM:

- SITE-WIDE LIST, SWCR APPENDIX R
- OU1 RI/FS
- OU2 RI/FS
- OU4 RI/FS

INITIAL SCREENING

REMOVE:

- NONTOXIC COMPOUNDS
- LAB ARTIFACTS
- ANALYTICAL RESULTS FOR GENERAL CLASSES OF COMPOUNDS
- NUTRIENTS

SECOND SCREENING

REMOVE:

- VOLATILES WITH VAPOR PRESSURE >10 mm HG

FINAL SCREENING

REMOVE:

- ORGANICS THAT DEGRADE IN SOIL BY 99.9% WITHIN 70 YEARS
- ORGANICS IN WATER THAT WILL BE REMOVED BY THE OU 5 GROUNDWATER PUMP AND TREAT SYSTEM

FIGURE I.4-1. COC SELECTION PROCESS

2. Second screening:

   Eliminate contaminants with vapor pressures above 10 millimeters (0.4 inches) of mercury at 20°C (68°F).

3. Final screening:

   Eliminate contaminants that would degrade sufficiently, based on their organic degradation rates in soil over time, or would be removed from the groundwater by pump and treat operations.

Inherent in the screening process are uncertainties based on how the COC's will interact in the environment over time. Section I.10.0 discusses these uncertainties associated with this process, and Section I.12.0 suggests an approach to validate the screening process during the 70-year remediation period.

I.4.2.1 Initial Screening of COCs

Three criteria were used during the initial screening to eliminate COCs from the initial lists:

1. Contaminant is a nontoxic, ubiquitous compound.

2. Analytical result is a general class of compounds unsuitable for use in a quantitative risk assessment (e.g., total petroleum hydrocarbons); these analyses do not identify individual contaminants.

3. Contaminant is a nutrient or dietary requirement.

Table I.4-1 presents contaminants eliminated during the initial screening and the corresponding screening criteria. Table I.4-2 presents the results of the initial screening process for radionuclides and chemicals.

TABLE I.4-1

CONTAMINANTS ELIMINATED DURING INITIAL SCREENING

Radionuclides	Chemicals (Screening Criteria)[a]	
None	Alkalinity as $CaCO_3$ (2)	Potassium (3)
	Ammonia (2)	Silicon (1)
	Calcium (3)	Sodium (3)
	Chloride (3)	Sulfate (1)
	Magnesium (3)	Sulfide (1)
	Nitrate (3)	Total dissolved solids (2)
	Oils and greases (2)	Total Kjeldahl nitrogen (2)
	Phosphate (2)	Total organic carbon (2)
	Phosphorous (2)	Total organic nitrogen (2)
		Total organic halides (2)

[a] The three screening criteria are indicated in parenthesis and are described in the first paragraph of Section I.4.3.

TABLE I.4-2

POTENTIAL COCs IN EACH MEDIUM FOR EACH OPERABLE UNIT (AFTER INITIAL SCREENING)[a]

Compound	OU1	OU2	OU3	OU4	OU5
Chemical					
2-Butanone			Surf, Sub	Berm, Surf	Sub, GW
4-Chloro-3-methylphenol			Sub		Sub
2-Chlorophenol					Sub
4,4-DDE		Surf			
1,2-Dichlorobenzene					GW
1,1-Dichloroethane			Surf,Sub	Sub,GW	
1,2-Dichloroethane			Sub		GW
1,1-Dichloroethylene			Surf, Sub		GW
1,2-Dichloroethylene			Surf, Sub		Sub, GW
2,4-Dimethylphenol					GW
4,6-Dinitro-2-methylphenol					GW
2,6-Dinitrotoluene					GW
1,4-Dioxane					Sub
2-Hexanone			Surf, Sub		Surf, Sub, GW
2-Methylnaphthalene		Surf	Surf, Sub		Sub
4-Methyl-2-pentanone			Surf, Sub		Surf, Sub, GW
4-Methylphenol					GW
3-Nitroaniline					GW
2-Nitrophenol					GW
4-Nitrophenol					GW
1,1,2,2-Tetrachloroethane			Surf, Sub		
2,3,4,6-Tetrachlorophenol					GW
1,1,1-Trichloroethane			Surf, Sub		Sub, GW
1,1,2-Trichloroethane			Surf, Sub		GW
Acenaphthene		Surf	Surf, Sub	Surf	Sub
Acetone			Surf, Sub	Berm, Surf	Surf, Sub, GW
Anthracene			Surf, Sub	Surf	Sub
Antimony	Surf		Surf, Sub	Berm, Surf	Surf, Sub, GW
Aroclor-1221			Sub		
Aroclor-1248	Surf		Sub		
Aroclor-1254	Surf	Sed, Surf	Surf, Sub		Surf, Sub
Aroclor-1260	Surf	Surf	Surf, Sub		Sub
Arsenic	SW, Surf, Sed	Sed, Surf, SW	Surf, Sub	Berm, Surf	Surf, Sub, GW
Barium		Surf, SW	Surf, Sub	Berm, Surf	Sub, GW
Benzene			Surf, Sub		GW
Benzoic acid			Surf, Sub	Surf	Sub, GW
Benzo(a)anthracene	Surf	Sed, Surf	Surf, Sub	Surf	Sub

See footnotes at end of table.

TABLE I.4-2
(Continued)

Compound	OU1	OU2	OU3	OU4	OU5
Benzo(a)pyrene	Surf	Sed, Surf	Surf, Sub	Surf	Sub
Benzo(b)fluoranthene	Surf	Sed, Surf	Surf, Sub	Surf	Sub
Benzo(g,h,i)perylene		Sed, Surf	Surf, Sub	Surf	Sub
Benzo(k)fluoranthene		Sed, Surf	Surf, Sub		Sub
Benzyl alcohol					GW
Beryllium	Sed, Surf	Sed, Surf, GW	Surf, Sub	Berm, Surf	Sub, GW
Beta-BHC			Surf, Sub		
Bis(2-ethylhexyl)phthalate		Sed, Surf, SW	Surf, Sub	Surf	Sub, GW
Boron	GW, Per				
Bromochloromethane					GW
Bromodichloromethane			Sub		Sub
Butylbenzyl phthalate			Sub		GW
Cadmium	Surf	Sed, Surf, SW		Berm, Surf	GW
Carbazole		Per, Sed, Surf			
Carbon disulfide			Surf, Sub		Sub, GW
Carbon tetrachloride			Sub		GW
Chlorobenzene			Surf, Sub		
Chloroethane			Sub		GW
Chloroform			Surf, Sub		Sub, GW
Chromium	Per, Surf	Sed, Surf		Berm	GW
Chrysene	Surf	Sed, Surf	Surf, Sub		Sub
Cobalt		Sed, Surf	Surf, Sub		Sub, GW
Copper	Per	Surf	Surf, Sub	Berm, Surf	Sub, GW
Cyanide		Surf	Surf, Sub	Berm, Surf	Surf, Sub, GW
Dibenzo(a,h)anthracene		Surf	Surf, Sub	Surf	Sub
Dibromochloromethane					Sub
Dieldrin		Surf			
Diethyl phthalate			Sub		Sub, GW
Di-n-butyl phthalate		Sed	Surf, Sub	Berm, Surf	Sub, GW
Di-n-octyl phthalate			Sub		
Endrin		Surf			
Ethylbenzene			Surf, Sub		Sub, GW
Fluoranthene		Sed	Surf, Sub	Surf	Sub
Fluorene			Surf, Sub		Sub
Heptachlorepoxide					GW
Heptachlorodibenzo-p-dioxin	Surf, GW	GW, Per			
Heptachlorodibenzofuran	Surf, GW				
Indeno(1,2,3-cd)pyrene	Surf	Sed, Surf	Surf, Sub	Surf	Sub
Isophorone					GW

See footnotes at end of table.

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TABLE I.4-2
(Continued)

Compound	OU1	OU2	OU3	OU4	OU5
Lead		Surf, Sed, SW, GW	Surf, Sub		Sub
Manganese	Per, GW, Surf	Sed, SW	Sub		GW
Mercury	Surf	GW	Surf, Sub		Sub, GW
Methylene chloride		Surf	Surf, Sub	Surf	Surf, Sub, GW
Molybdenum	Per, Surf	GW		Berm, Surf	Sub, GW
Naphthalene			Surf, Sub		Sub, GW
Nickel	Per, Surf	Surf	Surf, Sub	Berm, Surf	Surf, Sub, GW
N-Nitrosodiethylamine					GW
N-Nitroso-di-n-propylamine			Sub		
N-Nitrosodiphenylamine			Surf, Sub		GW
Octachlorodibenzo-p-dioxin	Surf, GW				
Pentachlorophenol	Surf				GW
Phenanthrene		Sed, Surf	Surf, Sub	Surf	Sub
Phenol			Surf, Sub	Berm, Surf	Sub, GW
Pyrene		Sed	Surf, Sub	Surf	Sub
Selenium		Surf, SW	Surf, Sub		Sub, GW
Silver	Surf, Per, SW				
Styrene			Surf, Sub		
Tetrachlorodibenzo-p-dioxin	Surf, GW	GW			
Tetrachlorodibenzofuran		Surf	Surf, Sub		Sub
Tetrachloroethane			Surf, Sub		Sub, GW
Thallium	Sed, Surf	Sed, Surf		Berm, Surf	GW
Thorium	Surf, GW, Per	Sed, Surf			
Toluene		Surf	Surf, Sub	Berm, Surf	Sub, GW
Total Xylenes			Surf, Sub	Berm	Sub, GW
Tributyl phosphate			Surf, Sub		GW
Trichloroethene			Surf, Sub		Sub, GW
Trichlorofluoromethane					GW
Uranium	Surf, GW, Per,	Sed, Surf, SW			
Vanadium	Surf	Surf		Berm, Surf	Sub, GW
Vinyl acetate					Sub, GW
Vinyl chloride			Sub		Sub, GW
Zinc					

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See footnotes at end of table.

TABLE I.4-2
(Continued)

Compound	OU1	OU2	OU3	OU4	OU5
Radionuclide					
Cs-137	Sed, SW, Surf	Surf, Sed	Surf, Sub		Surf, Sub
Np-237	Surf, Per	Surf, Sed, GW, SW	Sub		GW
Pa-231				Sub	
Pb-210				Berm	
Pu-238	Per, Surf, GW	Sed, Surf, SW	Surf, Sub		Surf
Pu-239	Sed, Surf	Surf, Sed, SW	Surf, Sub		Surf
Pu-240		Surf, Sed, SW	Surf, Sub		Surf
Ra-226		Sed, Surf, GW, SW	Surf, Sub	Berm, Surf	Surf, Sub, GW
Ra-228	Per, Surf, GW	Sed, Surf, GW, SW	Surf, Sub	Berm, Surf	Surf, Sub, GW
Rn-222[b]	A	A	A	A	A
Ru-106		Sed			
Sr-90	SW, Surf, Per	Sed, Surf	Surf, Sub	Surf	Surf, Sub, GW
Tc-99	Surf, SW, GW, Per	Surf, GW, Per, Sed	Surf, Sub	Surf	Surf, Sub, GW
Th-228	Surf, Per, GW, Sed	Sed, Surf	Surf, Sub	Berm, Surf	Surf, Sub, GW
Th-230	Surf, Per, GW	Sed, Surf, SW	Surf, Sub	Berm, Surf	Surf, Sub
Th-232	Surf, Per, Sed	Sed, Surf	Surf, Sub	Berm, Surf	Surf, Sub, GW
U-234	Surf, SW, Per, GW	Sed, GW, Surf, SW	Surf, Sub	Berm, Surf	Surf, Sub, GW
U-235	Surf, SW, Per, GW, Sed	Sed, Surf, GW, SW	Surf, Sub		Surf, Sub, GW
U-236		Sed, Surf, GW, SW	Surf, Sub		Surf, Sub, GW
U-238	Surf, SW, Per, Sed, GW	Sed, GW, Surf, SW	Surf, Sub	Berm, Surf	Surf, Sub, GW

[a]Abbreviations used in this table:

A = Air
Berm = Berm fill
GW = Groundwater
Sed = Sediment
Per = Perched Groundwater
Sub = Subsurface soil
Surf = Surface soil
SW = Surface water

[b]Radon was the only COC detected in on-site air samples. However, all surface soil COC exposures through particulate inhalation are evaluated quantitatively in the CRARE.

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I.4.2.2 Second Screening of COCs: Volatile Losses

This section details the second COC screening procedure employed for each of the five operable units. The CRARE time frames for all scenarios begin after completion of all remedial actions at the FEMP. The time period needed to complete the remedial actions is assumed to be 70 years. This value is derived from the assumption in the Operable Unit 5 RI report (DOE 1994fc) that the remediation of the South Groundwater Contamination Plume will continue for 70 years. The remediation of on-site groundwater contamination will probably require a similar time period. Therefore, volatile chemicals for all operable units were eliminated because they would be lost to the atmosphere prior to the 70- or 1000-year postremediation time frames. Volatile chemicals are defined as those chemicals with a vapor pressure greater than 10 millimeters (0.4 inches) of mercury at 20°C (68°F). This concept is based on the *Air/Superfund National Technical Guidance Series, Volumes II and III* (EPA 1985a).

The most important chemical parameters to consider when evaluating volatility from a hazardous waste site are vapor pressure and Henry's Law Constant. Vapor pressure is a useful screening indicator of the potential of a chemical to volatilize from soil. Henry's Law Constant is a more relevant parameter to estimate the tendency of a chemical to volatilize from a surface impoundment or water (Walker 1984, EPA 1984, and EPA 1994e). In the above EPA document series, volatile chemicals are defined as chemicals having a vapor pressure greater than 1 millimeter of mercury. As a conservative approach, a factor of 10 was applied to this vapor pressure to define volatile chemicals. Additionally, remediation activities implemented before the time frame considered in the CRARE would be expected to disturb, expose, and mix many of the areas with VOC contamination and thereby hasten the evaporation of these contaminants.

Each operable unit is at a different stage of the remediation process and therefore requires a different degree of contaminant screening. Table I.4-3 presents the remaining COCs following the secondary screening as applied to each of the operable units.

Operable Units 1, 2 and 4

The data for Operable Units 1, 2 and 4 (Table I.4-3) have been analyzed in recent RI and FS reports, and are not expected to change significantly.

TABLE I.4-3

POTENTIAL COCs IN EACH MEDIUM FOR EACH OPERABLE UNIT (AFTER SECOND SCREENING)[a]

Compound	OU1	OU2	OU3	OU4	OU5
Chemical					
4-Chloro-3-methylphenol			Sub		Sub
2-Chlorophenol					Sub
4,4-DDE		Surf			
1,2-Dichlorobenzene					GW
6-Dinitrotoluene					GW
2-Hexanone			Surf, Sub		Surf, Sub, GW
4-Methyl-2-pentanone			Surf, Sub		Surf, Sub, GW
2-Methylnaphthalene		Surf	Surf, Sub		Sub
3-Nitroaniline					GW
1,1,2,2-Tetrachloroethane			Surf, Sub		
Acenaphthene		Surf	Surf, Sub	Surf	Sub
Anthracene			Surf, Sub	Surf	Sub
Antimony	Surf		Surf, Sub	Berm, Surf	Surf, Sub, GW
Aroclor-1221			Sub		
Aroclor-1248	Surf		Sub		
Aroclor-1254	Surf	Sed, Surf	Surf, Sub		Surf, Sub
Aroclor-1260	Surf	Surf	Surf, Sub		Sub
Arsenic	SW, Surf, Sed	Sed, Surf, SW, GW	Surf, Sub	Berm, Surf	Surf, Sub, GW
Barium		Surf, SW	Surf, Sub	Berm, Surf	Sub, GW
Benzoic acid			Surf, Sub	Surf	Sub, GW
Benzo(a)anthracene	Surf	Sed, Surf	Surf, Sub	Surf	Sub
Benzo(a)pyrene	Surf	Sed, Surf	Surf, Sub	Surf	Sub
Benzo(b)fluoranthene	Surf	Sed, Surf	Surf, Sub	Surf	Sub
Benzo(g,h,i)perylene		Sed, Surf	Surf, Sub	Surf	Sub
Benzo(k)fluoranthene		Sed, Surf	Surf, Sub		Sub
Benzyl alcohol					GW
Beryllium	Sed, Surf	Sed, Surf, GW	Surf, Sub	Berm, Surf	Sub, GW
Beta-BHC			Surf, Sub		
Bis(2-ethylhexyl)phthalate		Sed, Surf, SW	Surf, Sub	Surf	Sub, GW
Boron	GW, Per				
Butylbenzyl phthalate			Sub		GW
Cadmium	Surf	Sed, Surf, SW		Berm, Surf	GW
Carbazole		Per, Sed, Surf			
Chlorobenzene			Surf, Sub		
Chromium	Per, Surf	Sed, Surf		Berm	GW
Chrysene	Surf	Sed, Surf	Surf, Sub		Sub
Cobalt		Sed, Surf	Surf, Sub		Sub, GW
Copper	Per	Surf	Surf, Sub	Berm, Surf	Sub, GW
Cyanide		Surf	Surf, Sub	Berm, Surf	Surf, Sub, GW
Dibenzo(a,h)anthracene		Surf	Surf, Sub	Surf	Sub
Dieldrin		Surf			
Diethyl phthalate			Sub		Sub, GW
Di-n-butyl phthalate		Sed	Surf, Sub	Berm, Surf	Sub, GW

See footnotes at end of table

TABLE I.4-3
(Continued)

Compound	OU1	OU2	OU3	OU4	OU5
Di-n-octyl phthalate			Sub		
Endrin		Surf			
Ethylbenzene			Surf, Sub		Sub, GW
Fluoranthene		Sed	Surf, Sub	Surf	Sub
Fluorene			Surf, Sub		Sub
Heptachlorodibenzofuran	Surf, GW				
Heptachlorodibenzo-p-dioxin	Surf, GW	GW, Per			
Indeno(1,2,3-cd)pyrene	Surf	Sed, Surf	Surf, Sub	Surf	Sub
Lead		Surf, Sed, SW, GW	Surf, Sub		Sub
Manganese	Per, GW, Surf	Sed, SW	Sub		GW
Mercury	Surf	GW	Surf, Sub		Sub, GW
Molybdenum	Per, Surf	GW		Berm, Surf	Sub, GW
Naphthalene			Surf, Sub		Sub, GW
Nickel	Per, Surf	Surf	Surf, Sub	Berm, Surf	Surf, Sub, GW
N-Nitrosodiethylamine					GW
N-Nitroso-di-n-propylamine			Sub		
N-Nitrosodiphenylamine			Surf, Sub		GW
Octachlorodibenzo-p-dioxin	Surf, GW				
Pentachlorophenol	Surf				GW
Phenanthrene		Sed, Surf	Surf, Sub	Surf	Sub
Phenol			Surf, Sub	Berm, Surf	Sub, GW
Pyrene		Sed	Surf, Sub	Surf	Sub
Selenium		Surf, SW	Surf, Sub		Sub, GW
Silver	Surf, Per, SW				
Styrene			Surf, Sub		
Tetrachlorodibenzofuran		Surf	Surf, Sub		Sub
Tetrachlorodibenzo-p-dioxin	Surf, GW	GW			
Thallium	Sed, Surf	Sed, Surf		Berm, Surf	GW
Thorium	Surf, GW, Per	Sed, Surf			
Total Xylenes			Surf, Sub	Berm	Sub, GW
Tributyl phosphate			Surf, Sub		GW
Uranium	Surf, GW, Per, SW	Sed, Surf, SW			
Vanadium	Surf	Surf		Berm, Surf	Sub, GW
Zinc	Surf, Per, SW	Surf	Surf, Sub	Berm, Surf	Sub, GW
Radionuclide					
Cs-137	Sed, SW, Surf	Surf, Sed	Surf, Sub		Surf, Sub
Np-237	Surf, Per	Surf, Sed, GW, SW	Sub		GW
Pa-231				Sub	
Pb-210				Berm	
Pu-238	Per, Surf, GW	Sed, Surf, SW	Surf, Sub		Surf
Pu-239	Sed, Surf	Surf, Sed, SW	Surf, Sub		Surf
Pu-240		Surf, Sed, SW	Surf, Sub		Surf

See footnotes at end of table

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TABLE I.4-3
(Continued)

Compound	OU1	OU2	OU3	OU4	OU5
Ra-226		Sed, Surf, GW, SW	Surf, Sub	Berm, Surf	Surf, Sub, GW
Ra-228	Per, Surf, GW	Sed, Surf, GW, SW	Surf, Sub	Berm, Surf	Surf, Sub, GW
Rn-222[b]	A	A	A	A	A
Ru-106		Sed			
Sr-90	SW, Surf, Per	Sed, Surf	Surf, Sub	Surf	Surf, Sub, GW
Tc-99	Surf, SW, GW, Per	Surf, GW, Per, Sed	Surf, Sub	Surf	Surf, Sub, GW
Th-228	Surf, Per, GW, Sed	Sed, Surf	Surf, Sub	Berm, Surf	Surf, Sub, GW
Th-230	Surf, Per, GW	Sed, Surf, SW	Surf, Sub	Berm, Surf	Surf, Sub
Th-232	Surf, Per, Sed	Sed, Surf	Surf, Sub	Berm, Surf	Surf, Sub, GW
U-234	Surf, SW, Per, GW	Sed, GW, Surf, SW	Surf, Sub	Berm, Surf	Surf, Sub, GW
U-235	Surf, SW, Per, Sed, GW	Sed, Surf, GW, SW	Surf, Sub		Surf, Sub, GW
U-236		Sed, Surf, GW, SW	Surf, Sub		Surf, Sub, GW
U-238	Surf, SW, Per, Sed, GW	Sed, GW, Surf, SW	Surf, Sub	Berm, Surf	Surf, Sub, GW

[a]Abbreviations used in this table:

A = Air
Berm = Berm fill
GW = Groundwater
Per = Perched Groundwater
Sed = Sediment
Sub = Subsurface soil
Surf = Surface soil
SW = Surface water

[b]Radon was the only COC detected in on-site air samples. However, all surface soil COC exposures through particulate inhalation are evaluated quantitatively in the CRARE.

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Operable Unit 3

At this time, these contaminants (Table I.4-3) are considered potential COCs. In the future, analysis and screening, including frequency-of-detection and concentration-toxicity analysis, shall be employed to further eliminate contaminants when the CRARE for Operable Unit 3 is prepared.

Operable Unit 5

Operable Unit 5 is defined as those environmental media at the site that are not being addressed by the other operable units. According to the implementation schedule, the Operable Unit 5 remedial actions would be completed after finishing the actions for the other operable units. All COCs from the other operable units are assumed to be present in some residual concentration following remediation. Contaminants having passed the initial and second screening were combined to produce the Operable Unit 5 COC list (Table I.4-3). Both validated and invalidated data were used to compile this list. In the future, fate and transport modeling efforts will refine the Operable Unit 5 COCs.

I.4.2.3 Final Screening of COCs

To reflect the forward-looking nature of the CRARE, the final screening addressed elimination of organic chemicals that would degrade or be removed from the site prior to the time period considered in the CRARE. The half-lives of organic constituents remaining in the soil were examined, and those constituents were screened out for which the original concentration would degrade by three orders of magnitude (99.9 percent) or greater during the 70-year remediation period. For this final screening the concentration decay rate of organic constituents in soil, over time, was calculated using the formula below:

$$C/C_o = e^{-(\ln 2/T)t} \qquad \text{(I.4-1)}$$

where

C = the concentration at time t,
C_o = the initial concentration (UCL),
T = the half-life in days, and
t = time in days.

Except where otherwise noted, half-life values for constituents in soil were obtained from the *Handbook of Environmental Degradation Rates* (Howard et al. 1991), which was the result of work performed for the EPA. The highest half-life values were used. For example, using the half-life in soil from Howard et al. for benzo(k)fluoranthene:

$$T = 2140 \text{ days}$$

where

$$t = 25{,}550 \text{ days (70 years) during remediation, and}$$

$$C/C_o = 2.55 \times 10^{-4} \text{ or a 99.97 percent reduction.}$$

Therefore, benzo(k)fluoranthene was eliminated.

The models used for the assessment of risks to soil exposures in the Operable Unit 1, 2 and 4 baseline risk assessments and the SWCR report establish a linear relationship between soil concentrations and risks. Therefore, the reduction in concentration due to degradation is directly equivalent to the reduction in risk from soil exposures.

To confirm that the soil concentrations remaining after half-life based screening were health-protective, a three-step procedure was followed:

1. The reduction in soil concentration after 70 years was calculated using equation (1) for each contaminant screened.
2. Maximum risk levels from soil exposures for each contaminant were compiled from baseline risk assessments (Operable Unit 1, 2, and 4 RI reports and the SWCR).
3. Baseline risk was multiplied by the reduction in soil concentration.

All contaminants screened by this procedure were found to be below 10^{-7} residual risk. Additionally, it was observed that all COCs with a vapor pressure greater than 10 mmHg screened in this step also had a Henry's Law Constant greater than 1×10^{-5} $atm^3/gmole$ (EPA 1991a, RAGS, PtB, pg 20) Table I.4-4 summarizes this screening process and the projected risks.

090093

TABLE I.4-4

HALF-LIFE SCREENING RISK ESTIMATION

Organic Chemical	Half-life (days)	Number of Half-Lives in 70 Days	Reduction Factor	Baseline Risk	Post-Degradation Risk
4-Chloro-3-methylphenol[a]	14[d]	1825			
-hlorophenol	1[f]	25550			
2-Dichlorobenzene	180	142			
6-Dinitrotoluene	180	142			
2-Hexanone[a]	14[b]	1825			
4-Methyl-2-pentanone[a]	7	3650			
3-Nitroaniline[a]	No Data[c]	NA			
1,1,2,2-Tetrachloroethane	44	581			
Acenaphthene[a]	102	250			
Anthracene[a]	460	56			
Benzoic acid[a]	7	3650			
Benzo(a)anthracene	680	38	4.9×10^{-12}	2.2×10^{-3}	1.1×10^{-14}
Benzo(a)pyrene	693.5	37	3.8×10^{-34}	7.7×10^{-3}	2.9×10^{-36}
Benzo(b)fluoranthene	610	42	2.5×10^{-13}	1.0×10^{-2}	2.5×10^{-15}
Benzo(g,h,i)perylene[a]	650	39			
Benzo(k)fluoranthene	2140	12	2.5×10^{-4}	2.6×10^{-6}	6.5×10^{-10}
Benzyl alcohol	No Data[c]	NA			
Beta-BHC[a]	124	206			
Bis (2-ethylthexyl) phthalate	23	1111	0	1.7×10^{-6}	0
Butylbenzyl phthalate[a]	7	3650			
Chlorobenzene[a]	150	170			
Chrysene	1000	26	2.0×10^{-8}	1.6×10^{-3}	3.2×10^{-11}
Dibenzo(a,h)anthracene	940	27	6.6×10^{-9}	4.7×10^{-4}	3.1×10^{-12}
Dieldrin	1095	23	9.5×10^{-8}	1.2×10^{-6}	1.14×10^{-13}
Diethyl phthalate[a]	56	456			
Di-n-butyl phthalate[a]	23	1111			
Di-n-octyl phthalate[a]	28	912			
Ethylbenzene[a]	10	2555			
Fluoranthene[a]	440	58			
Fluorene[a]	60	426			
Indeno(1,2,3-cd)pyrene	730	35	2.9×10^{-11}	4.4×10^{-2}	1.3×10^{-12}
Naphthalene[a]	48	532			
N-Nitroso-di-n-propylamine	180	142	1.9×10^{-43}	6.7×10^{-7}	1.3×10^{-49}
N-Nitrosodiphenylamine[a]	34	751			
Pentachlorophenol	178	144	6.2×10^{-44}	1.7×10^{-6}	1.1×10^{-49}
Phenanthrene[a]	200	128			
Phenol[a]	10	2555			
Pyrene[a]	1900	13			
Styrene[a]	28	912			
Total xylenes[a]	28	912	0	6.7×10^{-3}	0
Tributyl phosphate[a]	140[e]	182			

[a]Baseline risks were not available for these compounds (DOE 1993c, 1993a, 1993f, 1994d)

Organic constituents present in the groundwater were assumed to be removed from the site through a groundwater pump and treat operation. Thus, organics that were identified as COCs only in groundwater were eliminated from further consideration in the CRARE. Organic constituents which were COCs in media other than groundwater were not eliminated solely based on the pump and treat operation. Table I.4-5 lists the organic chemicals that were addressed in the final screening process. The table presents the half-life in soil of each compound and identifies those retained as COCs.

It should be noted that this screening assumption will be reevaluated for Operable Units 3 and 5 as additional information concerning COCs becomes available. These Operable Units may propose specific methods for remediation of these organic contaminants. Table I.4-6 shows the contaminants retained after implementing the final screening process.

TABLE I.4-5

FINAL SCREENING OF ORGANIC CHEMICALS[a]

Organic Chemical	Half-life (days)[g]	Retained or Screened Out
4-Chloro-3-methylphenol	14[d]	Screened out
-hlorophenol[a]	1[f]	Screened out
4,4-DDE	5694	Retained
2-Dichlorobenzene[a]	180	Screened out
6-Dinitrotoluene[a]	180	Screened out
2-Hexanone	14[b]	Screened out
4-Methyl-2-pentanone	7	Screened out
2-Methylnaphthalene	No Data	Retained
3-Nitroaniline	No Data[c]	Screened out
1,1,2,2-Tetrachloroethane[a]	44	Screened out
Acenaphthene	102	Screened out
Anthracene	460	Screened out
Aroclor-1221	No Data	Retained
Aroclor-1248	No Data	Retained
Aroclor-1254	No Data	Retained
Aroclor-1260	No Data	Retained
Benzoic acid	7	Screened out
Benzo(a)anthracene	680	Screened out
Benzo(a)pyrene	693.5[f]	Screened out
Benzo(b)fluoranthene	610	Screened out
Benzo(g,h,i)perylene	650	Screened out
Benzo(k)fluoranthene	2140	Screened out
Benzyl alcohol	No Data[c]	Screened out
Beta-BHC	124	Screened out
Bis (2-ethylthexyl) phthalate	23	Screened out
Butylbenzyl phthalate	7	Screened out
Carbazole	No Data	Retained
Chlorobenzene	150	Screened out
Chrysene	1000	Screened out
Dibenzo(a,h)anthracene	940	Screened out
Dieldrin	1095	Screened out
Diethyl phthalate	56	Screened out
Di-n-butyl phthalate	23	Screened out
Di-n-octyl phthalate	28	Screened out
Endrin	No Data	Retained
Ethylbenzene	10	Screened out
Fluoranthene	440	Screened out
Fluorene	60	Screened out
Heptachlorodibenzo-p-dioxin	No Data	Retained
Heptachlorodibenzofuran	No Data	Retained
Indeno(1,2,3-cd)pyrene	730	Screened out

See footnotes at end of table.

TABLE I.4-5
(Continued)

Organic Chemical	Half-life (days)[g]	Retained or Screened Out
Naphthalene	48	Screened out
N-Nitroso-di-n-propylamine	180	Screened out
N-Nitrosodiphenylamine	180	Screened out
Octachlorodibenzo-p-dioxin	No Data	Retained
Pentachlorophenol	178	Screened out
Phenanthrene	200	Screened out
Phenol	10	Screened out
Pyrene	1900	Screened out
Styrene	28	Screened out
Tetrachlorodibenzofuran	No Data	Retained
Tetrachlorodibenzo-p-dioxin	No Data	Retained
Total xylenes	28	Screened out
Tributyl phosphate	140[e]	Screened out

[a]The soil degradation rates for most PAHs were obtained from the Handbook of Environmental Degradation Rates by P.H. Howard et al. (1991). This monograph was produced for the EPA to specifically develop Chemical Fate Rate Constants for the Superfund Amendments and Reauthorization Act (SARA), Section 313, Chemicals and Superfund Health Evaluation Manual Chemicals. Therefore, DOE assumes that these half-lifes are correct since they are promulgated by EPA. The soil degradation rates were presented in the monograph as a range of soil half-lifes. To be health-conservative, the maximum soil half-lifes were used in the CRARE for purposes of calculating percent soil concentrations remaining after 70 years.

Recently the ATSDR (October 1993) released an updated draft Toxicological Profile for the PAHs: "Section 104(i)(5) of CERCLA, as amended, directs the Administrator of ATSDR (in consultation with the Administrator of EPA and agencies and programs of the Public Health Service) to assess whether adequate information on the health effects of PAHs is available. Where adequate information is not available, ATSDR, in conjunction with the NTP (National Toxicology Program), is required to assure the initiation of a program of research designed to determine the health effects (and techniques for developing methods to determine such health effects) of PAHs." The adequacy of the database on the environmental fate of PAHs was specifically evaluated "by a joint team of scientists form ATSDR, NTP and EPA." The findings of this team included the following: "The environmental fate of PAHs is well characterized." "PAHs are transported in and partitioned to the air, water, and soil. Transformation and degradation processes of PAHs in the air, water, and soil have been well studied." "Microbial metabolism is the major process for degradation of PAHs in soil environments." "No further studies are needed."

[b]Half-life in soil assumed to be twice the value for 2-Butanone.
[c]Compounds removed from groundwater during pump and treat operation, not considered in CRARE.
[d]Half-life in soil assumed to be twice the value for 2-Methylphenol.
[e]Half-life in soil assumed to be 10 times its half-life in surface water/sediment (Montgomery 1991).
[f]EPA (1994c).
[g]Source: Howard et al. 1991, unless otherwise indicated.

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TABLE I.4-6

COCs RETAINED AFTER FINAL SCREENING FOR ALL OPERABLE UNITS

Radionuclide	Chemical	
Cs-137	2-Methylnaphthalene	Cyanide
Np-237	4,4-DDE	Endrin
Pa-231	Antimony	Lead
Pb-210	Aroclor-1221	Manganese
Pu-238	Aroclor-1248	Mercury
Pu-239	Aroclor-1254	Molybdenum
Pu-240	Aroclor-1260	Nickel
Ra-226	Arsenic	Selenium
Ra-228	Barium	Silver
Rn-222	Beryllium	Tetrachlorodibenzo-p-dioxin[a]
Ru-106	Boron	Thallium
Sr-90	Cadmium	Thorium
Tc-99	Carbazole	Uranium
Th-228	Chromium	Vanadium
Th-230	Cobalt	Zinc
Th-232	Copper	
U-234		
U-235		
U-236		
U-238		

[a]All isomers of dioxins and furans were evaluated using toxicity equivalency factors (TEFs) to 2, 3, 7, 8-tetrachlorodibenzo-p-dioxin.

I.5.0 EXPOSURE SCENARIOS

This section discusses the steps taken to identify, screen, and develop the CRARE exposure scenarios. The exposure scenarios were defined by assuming implementation of the LRAs described in the SWCR for Operable Units 3 and 5 and the PRAs presented in the Operable Unit 1, 2, and 4 RI/FS reports. This approach is consistent with the Amended Consent Agreement. A quantitative risk analysis is presented in Section I.8.0.

The exposure scenarios developed for this CRARE describe three sets of land use conditions:

1. The Current Land Use scenario assumes government ownership, maintenance, and access control for 70 years after completion of all FEMP remedial actions.

2. The Future Land Use With Federal Ownership scenario describes the site up to 1000 years after remedial actions are complete, and assumes continued government ownership and land use control with access control (fencing).

3. The Future Land Use Without Federal Ownership scenario also describes the site up to 1000 years after remedial actions are complete, but assumes occupation by a resident farm.

These scenarios provide a basis for evaluating the potential exposures in the environment following the completion of remedial actions. However, the accuracy of the scenarios depends on the ability to predict site conditions well into the future. It should be recognized that projected land uses, as well as a description of the FEMP up to 1000 years hence, are speculative.

In general, each exposure scenario is made up of the same components: a source of contaminants, mechanisms that facilitate the transport of contaminants from the source through various environmental media, receptors in the local environment, and a route or mechanism of exposure for those receptors. Based on these components, three steps were involved in developing the exposure scenarios:

1. Characterization of the exposure setting

2. Identification of potential exposure pathways

3. Selection of site-specific exposure pathways to be quantitatively evaluated.

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In the development of the exposure scenarios, the environmental setting of the FEMP years after the completion of remediation was evaluated.

I.5.1 CHARACTERIZATION OF EXPOSURE SETTING

The characterization of the exposure setting relied on the definition of the operable units, the actions proposed in the remedial alternatives, and the existing characterization information from the RIs to establish the nature of changes caused by each remedial action to each operable unit. The source areas of contamination considered for each operable unit were the original areas plus new areas associated with the on-property disposal facilities. Material moved off-property during remediation was not considered in the compilation of risks.

I.5.1.1 Physical Environment

This section describes the future physical environment of the site for up to 1000 years after remediation as it relates to the individual release mechanisms and pathways to be screened. This information was developed from the Operable Unit 1, 2, and 4 RI/FS reports and from the SWCR for Operable Units 3 and 5.

Surface Topography

The topography of the FEMP may be substantially altered after remediation. Man-made above ground structures would be removed, and areas would be excavated, graded, and in some cases capped or covered and revegetated. On-property disposal facilities may be erected. Additionally, surface drainage ponds would be maintained during and possibly immediately after remediation, and then left unattended or backfilled for the remainder of the 1000-year evaluation period. In general, the overall FEMP in the future would have fewer man-made obstructions and would eventually revert to woods and perhaps a mature forest.

Surface Hydrology

Surface water drainage would change on the FEMP due to the removal of man-made structures and nonporous areas. The addition of new, impervious areas have the potential to create new channels of surface water runoff. Wetlands have been identified on the FEMP and may continue to emerge, depending on climate and perched-water conditions. Paddys Run would be a potential

source of exposure, as would newly formed and existing wetlands, ponds, and channel creeks. The storm water treatment system is a significant feature for the Current Land Use scenario.

Demographics

Regardless of the land use scenario chosen for the final disposition of the FEMP site, it is assumed that land use within a five-mile radius will remain constant. Three primary factors will influence the change in local land use: final disposition of the FEMP (DOE 1994d) site, future zoning easements, and economic activity in nearby communities. Historically, areas surrounding the FEMP have exhibited limited industrial and residential fluctuations; however, change to one of the dominant land use features, could trigger an increase or decrease in one or both of these areas. Consequently, areas surrounding the FEMP site are expected to remain primarily rural (i.e., agricultural) with a potential for industrial and residential growth, depending on the level of economic activity generated by nearby communities. For the purposes of this analysis, the same potentially exposed populations (see Section I.5.1.3) were assumed to exist in the future scenarios.

Historical Significance

Known sites of archaeological significance within the boundaries of the FEMP, if any, will be identified during the on-going RI/FS process. The sites will be managed appropriately, pursuant to the National Historic Preservation Act (36 CFR 800, Section 106).

Geology and Hydrogeology

The geological and hydrological characteristics of the FEMP and its surrounding areas have been numerically modeled to reflect the proposed FEMP remediation plans. The assumptions that support this modeling appear in Section I.2.1. Descriptions of site conditions and the development of the computer models are in the SWCR and individual RI/FS document. Postremediation groundwater conditions are summarized in Section I.6.1.6 of this CRARE.

Ecological Setting

In the Current Land Use scenario, 70 years after remediation, vegetation planted at the operable unit residual footprints will be approaching successional maturity. The deciduous forest vegetation would be invading the site. Wildlife would progress from grassland species to an increasing abundance of deciduous forest species. In the northern region of the FEMP, the

wetland is assumed to expand further with the increased runoff from the on-property disposal facilities. This loss of runoff area and the subsequent filling of the drainage and sedimentation ponds would eventually lead to the emerging wetland becoming a recipient drainage area.

In the Future Land Use scenarios, up to 1000 years after remediation, many types of forests or other ecological settings may occur. The deciduous forest invasions are assumed to have grown to a mature forest. In some areas, roots from trees may invade the former footprints of the operable units. The emerging wetlands may be fully developed, fluctuating with natural changes in the shallow water table. Contamination would potentially be available to vegetation, terrestrial and aquatic species.

I.5.1.2 Land Use

Because of the uncertainty associated with future sociopolitical activities, three potential exposure scenarios have been evaluated. The Current Land Use scenario assumes that the government would control the FEMP for up to 70 years after site remediation. Under this assumption, access controls at the FEMP would remain in effect. At a minimum, a security fence would surround the entire FEMP property and would be regularly patrolled by a security force. Access controls are assumed to be effective in restricting intruders' access and short-term forays. Two Future Land Use scenarios (with and without federal ownership) have been evaluated for a period of up to 1000 years after remediation.

I.5.1.3 Potentially Exposed Populations

This section evaluates the relevance to this CRARE of human receptors on or in the vicinity of the FEMP who have been presented in the Operable Unit 1, 2 and 4 RI/FS reports (Table I.5-1). These populations have been examined to determine if they have the potential for significant exposure to contaminants under future site conditions for both the 70-years and 1000 year post-remediation periods. Those populations determined to present a reasonable possibility of significant exposure based on postremediation site conditions have been retained for examination in this CRARE. The following paragraphs provide details on the nature of the receptors and their respective pertinent exposure pathways.

I.5.1.3.1 Screening of Receptors and Exposure Pathways

The location of fixed point and mobile receptors varies for each media as the receptor location is dependent upon modeled air as gas, and particulate, external radiation, surface water, and groundwater concentrations. As such, figures presented throughout Sections I.6.1 and I.6.2 of this CRARE indicate receptor locations.

Groundskeeper. A worker is assumed to be present on the property conducting groundskeeping and maintenance throughout the FEMP (not just for Operable Units 1 and 2). This is consistent with future postremediation site conditions, and therefore the groundskeeper has been evaluated in this CRARE. No groundwater would be used by this receptor. Exposure pathways include inhalation of fugitive dusts, organics, and gases, dermal contact with and incidental ingestion of site soil, and external radiation exposure while on site.

TABLE I.5-1

RECEPTORS EVALUATED FOR THE OU2 CRARE

Receptor	Retained	Eliminated
Groundskeeper	X	
Trespassing Child	X	
Expanded Trespasser	X	
Off-Property Farm Residents:		
Adult	X	
Child	X	
On-Property Farm Residents:		
Adult (Ingests Great Miami Aquifer Water)	X	
Adult (Ingests Perched Groundwater)	X	
Adult (Central Tendency)		X
Child	X	
Homebuilder		X
Homebuilder/Resident		X
Great Miami River User:		
Agricultural	X	
Residential	X	
Recreational	X	
Visitor		X
Consumer of Animal Products		X

Trespassing Child. This hypothetical receptor addresses the potential exposures incurred by a child (age 7 through 18) who lives off-property but regularly trespasses onto the FEMP site and roams about the FEMP. Relevant exposure pathways include inhalation of fugitive dusts, organics, and gases, dermal contact with and incidental ingestion of site soil, incidental ingestion of contaminated surface water while wading, and external radiation exposure while on site. This receptor has been included in this CRARE.

Expanded Trespasser. The expanded trespasser is a composite adult/child who illegally uses the site for recreational purposes. This hypothetical individual is assumed to visit the site despite continued government ownership. Exposure pathways include inhalation of fugitive dusts, volatile organics, and radon, dermal contact with and incidental ingestion of site soil, incidental ingestion of surface water in Paddys Run, and external radiation exposure while on site. For these reasons, this receptor has been evaluated in this CRARE. The expanded trespasser wanders over the entire FEMP, with the exception of the caps and vaults to be conservative and maximize exposure to all pathways.

For the purposes of establishing a cleanup level for the Future Land Use With Federal Ownership scenario, an on-property receptor was employed assuming a trespassing exposure scenario that includes both adult and child age groups. This expanded trespassing scenario was employed because it represents an upper bound estimate of the exposures a receptor could reasonably be expected to receive. This assumes the federal government would continue to own the site, thus precluding site development for residential, farm, industrial/commercial, or recreational use (e.g., ball fields, jogging trails, and biking trails). This assumption will be re-evaluated in the Operable Unit 5 CRARE.

It was assumed that Paddys Run fish are not considered a pathway for chemical or radiological intake by this receptor because of the composition of the fish populations. Paddys Run is a small, intermittent tributary of the Great Miami River running north to south along the western edge of the FEMP. Surveys of the Paddys Run fish population concluded that the stream does not support any sport fish in most of the stream sections. Surveys completed by Facemire et al. (1990), Miller et al. (1990), and those completed for the RI/FSs in general, concluded the majority of the stream population was composed of members of the darter, minnow, and sunfish

families. In Paddys Run, these fish are too small or undesirable for human consumption. Some sport fish can be found in Paddys Run at the confluence of the Great Miami River. However, because of fish movement and feeding patterns, these fish are considered only in conjunction with the Great Miami River. This is not expected to change in the future. Crayfish, which are present in Paddys Run, are primarily consumed by animals such as raccoons and as such will be addressed in the Ecological Risk Assessment for the Operable Unit 5 RI.

On-Property Resident Farm Adult (Ingests Great Miami Aquifer Water). Consistent with the RME concept and to ensure the estimated risk values protect human health and the environment, it was assumed that the remediated FEMP site could revert to residential and agricultural uses in the future and that an adult farmer could reside on the site after it is remediated. Potential exposures to this receptor may result from external radiation residual contamination from remediated site footprints, and/or waste leaking from vaults.

Exposure pathways examined for this receptor include residential, growing food, tending livestock, and performing general farm work. These activities may result in direct exposure to residual site contamination, consumption of contaminated produce, dairy products, and meat, ingestion of contaminated water from the Great Miami Aquifer, dermal absorption through contact with residually contaminated soil, inhalation of radon, vapors, and dust, and incidental ingestion of soil. This receptor has been evaluated in this CRARE; the selected RME location is presented in Sections I.6.1.6.2 and I.6.2.10.

On-Property Resident Farm Adult (Ingests Perched Groundwater). This receptor addresses the potential additional exposure incurred by the on-property resident farm adult if the drinking water source is the perched groundwater. This receptor has been evaluated in this CRARE; the selected RME location is presented in Section I.6.1.6.2.

On-Property Resident Farm Adult (Central Tendency). This receptor addresses the potential exposure incurred by the on-property resident farm adult using slightly less conservative, central-tendency exposure parameters. Exposure pathways examined include residential, growing food, tending livestock, and performing general farm work. These activities may result in direct exposure to residual site contamination, consumption of contaminated produce, dairy products,

and meat, ingestion of contaminated water from the Great Miami Aquifer, dermal absorption through contact with residually contaminated soil, inhalation of radon, direct radiation, and incidental ingestion of soil.

The inclusion of a central-tendency analysis will not significantly reduce the overall health risks for the adult farm receptor. An examination of the impact of including central-tendency parameters in the calculation of on-property farm adult risks has indicated that a reduction of approximately a factor of 3 can be achieved. This reduction is mainly due to the slight reduction in exposure duration (350 versus 275 days) and minor reductions in the individual pathway contact rate.

The CRARE is designed to evaluate a wide range of pathways and exposures. The CT on-property farmer has the same source terms, pathways, and exposure point concentrations as the on-property farmer. The CT on-property farmer varies only in the exposure parameters, such as exposure durations. This receptor adds no information pertinent to the site-wide evaluation of possible health risks associated with varying site development (i.e., farming, recreational, industrial etc.). On this basis, the CT on-property farmer was eliminated from further consideration

On-Property Resident Farm Child. Young children (age 1 through 6) living on the property would form a subpopulation of concern, because they may be more sensitive to a given exposure than are adults. For these reasons, this receptor has been evaluated in this CRARE. A young child residing on the remediated FEMP could be exposed directly to residual site contaminants remaining in soils, and could inhale gases, vapors, and dust. In the CRARE risk calculations, this hypothetical child of the on-property resident farm adult is assumed to drink Great Miami Aquifer water from an on-property well and to consume vegetables, fruit, meat, and dairy products produced on the property. The selected RME location of this receptor is presented in Sections I.6.1.6.2 and I.6.2.10.

Off-Property Resident Farm Adult. The inclusion of a farmer, assumed to live immediately adjacent to the remediated FEMP property boundary, was determined to be highly likely based on future conditions and has therefore been included in this CRARE. The major concern for this receptor is the exposure received from regular use of water from the Great Miami Aquifer

(drinking and agricultural uses). This farmer could also be exposed to COCs from remote on-property residual sources, and/or other COCs carried by the wind as radon and dust. However, he would not be exposed to on-property soil from dermal contact or receive external radiation from on-site soil. The selected RME location of this receptor is presented in Sections I.6.1.6.2 and I.6.2.10.

Off-Property Resident Farm Child. This hypothetical child (age 1 through 6) of the off-property resident farmer is assumed to have the same diet as the adult, including ingestion of GMA water. This child could also be exposed to COCs from remote on-property residual sources, and/or other contaminants carried by the wind as radon and dust. For these reasons, this receptor has been evaluated in this CRARE; the selected RME location is presented in Sections I.6.1.6.2 and I.6.2.10.

Homebuilder and Homebuilder/Resident. The homebuilder receptor was originally considered for evaluation based on exposure to subsurface soils during the construction of a residence. These receptors were eliminated from further evaluation in this CRARE, based on the proposed postremediation site conditions. Post remediation, the subsurface soil concentrations (PRGs) do not exceed surface soils.

The home builder scenario is actually a subchronic exposure over a period of less than one year. Based on guidance from Region V, a homebuilder would be expected to have a typical exposure of 500 hours during homebuilding activities. Half of the exposure would be inside the structure (wiring, plumbing, flooring, drywall installation). The acute exposure experienced by the homebuilder is far less than that of the farmer. Acute exposures are not evaluated in the CRAREs.

Great Miami River User. This scenario was designed to evaluate the exposures incurred during the activities of a receptor who frequently uses the Great Miami River for recreational, residential, and agricultural purposes. This receptor has been evaluated in the Operable Unit 1 and 2 RI/FS reports. The Great Miami River User is evaluated in this CRARE.

Visitor. This scenario is intended to evaluate exposures incurred by the activities of a regular visitor to the postremediated FEMP. An example of this receptor would be a delivery person making regular deliveries to a given building on the site. The major concern for this receptor is the exposure to COCs transported by the wind in the form of radon and dusts generated during remedial activities. This receptor is not further developed in the CRARE, since the CRARE evaluates postremediation hazards and risks.

Consumer of Animal Products. This receptor was evaluated in the baseline risk assessment (DOE 1992d) and considered the hazards and risks associated with the use of animal products produced by cattle grazing on the FEMP site. This exposure has been evaluated and quantified for the on- and off-property resident farm receptors in this CRARE, and has therefore been eliminated as a separate receptor.

I.5.1.3.2 Selected Receptors and Scenarios

In this CRARE, four hypothetical receptors were selected for the Current Land Use scenario, which assumes government ownership for 70 years after remediation. Each receptor represents a unique population and exposure scenario. As a whole, they cover a wide range of exposure scenarios for potentially impacted human receptors. The four receptors are:

1. Groundskeeper
2. Trespassing child
3. Off-property resident farm adult
4. Off-property resident farm child

For the Future Land Use With Federal Ownership scenario, which assumes government ownership for up to 1000 years after the remediation, five receptors were selected:

1. Trespassing child
2. Expanded Trespasser
3. Off-property resident farm adult
4. Off-property resident farm child
5. Great Miami River user

For the Future Land Use Without Federal Ownership scenario, which assumes private ownership for up to 1000 years after the remediation, six receptors were selected:

1. On-property resident farm adult (who ingests perched groundwater)

2. On-property resident farm adult (who ingests Great Miami Aquifer water)
3. On-property resident farm child
4. Off-property resident farm adult
5. Off-property resident farm child
6. Great Miami River user

I.5.1.3.3 Locations of Reasonable Maximum Exposure

Receptor locations were selected based on the graphical representation of modeled air, soil, and water COC concentrations from remediated conditions. In keeping with the philosophy of evaluating the RME individual, the locations of highest on- and off-property exposures were assessed.

The RME locations were determined for fixed point receptors by first locating areas on and off the FEMP property which would receive elevated levels of COCs. The estimated COC concentrations in the environment were developed using computer modeling, as described in detail in Section I.6.0. Time-weighted exposure concentrations at these areas, along with exposure parameters, were then considered to define exposure pathways and to quantify the potential COC intake by the receptor. Mobile receptors such as the trespassing scenarios wander about the site.

The resulting intakes by potential receptors at various locations were then compared, and the location producing the highest intake was designated as the RME location. In the case of multiple pathways and COCs, the resulting risks and hazard values were considered in the selection of the RME location.

Due to the multiple sources of COCs, the different patterns of COC fate and transport in the environment, and the variety of COC release mechanisms at the FEMP, a complex matrix of interdependent effects was found to exist among COCs, exposure pathways, and the resulting exposure concentrations. Consequently, the selection of the site-wide RME locations required careful comparison of dispersion concentrations for air and maximum groundwater concentrations and estimated risk values.

I.5.2 DETAILED CONCEPTUAL EXPOSURE MODEL

A detailed conceptual exposure model is presented here which builds upon the CRARE Site-Wide Conceptual Model presented in Section I.1.6. This model has been developed to provide the basis for identifying and evaluating the potential risk to human health after the FEMP is remediated. The key objective of the model is to facilitate the analysis of exposure routes and receptors, focus on those pathways and sources that drive the potential impacts on human health risk, and screen out other exposure pathways that are likely to pose minor risks.

The model provides a consistent and comprehensive evaluation of the risk to human health by creating a framework for identifying the mechanisms by which human health may be affected by the remediated site. The elements necessary to construct a complete exposure pathway, and thus develop the conceptual model, are as follows:

- Sources of residual contaminants
- Release mechanisms
- Transport pathways
- Exposure pathways
- Receptors

The model traces the exposure pathways from the sources through the release mechanisms and exposure routes to the affected receptors. The model also indicates which exposure routes are carried through the quantitative risk assessment for each receptor under the Current and two Future Land Use scenarios.

The CRARE detailed conceptual exposure model is depicted in Figures I.5-1 through I.5-4 (these figures are based on Figures I.1-10 through I.1-13 as presented in Section I.1.6).

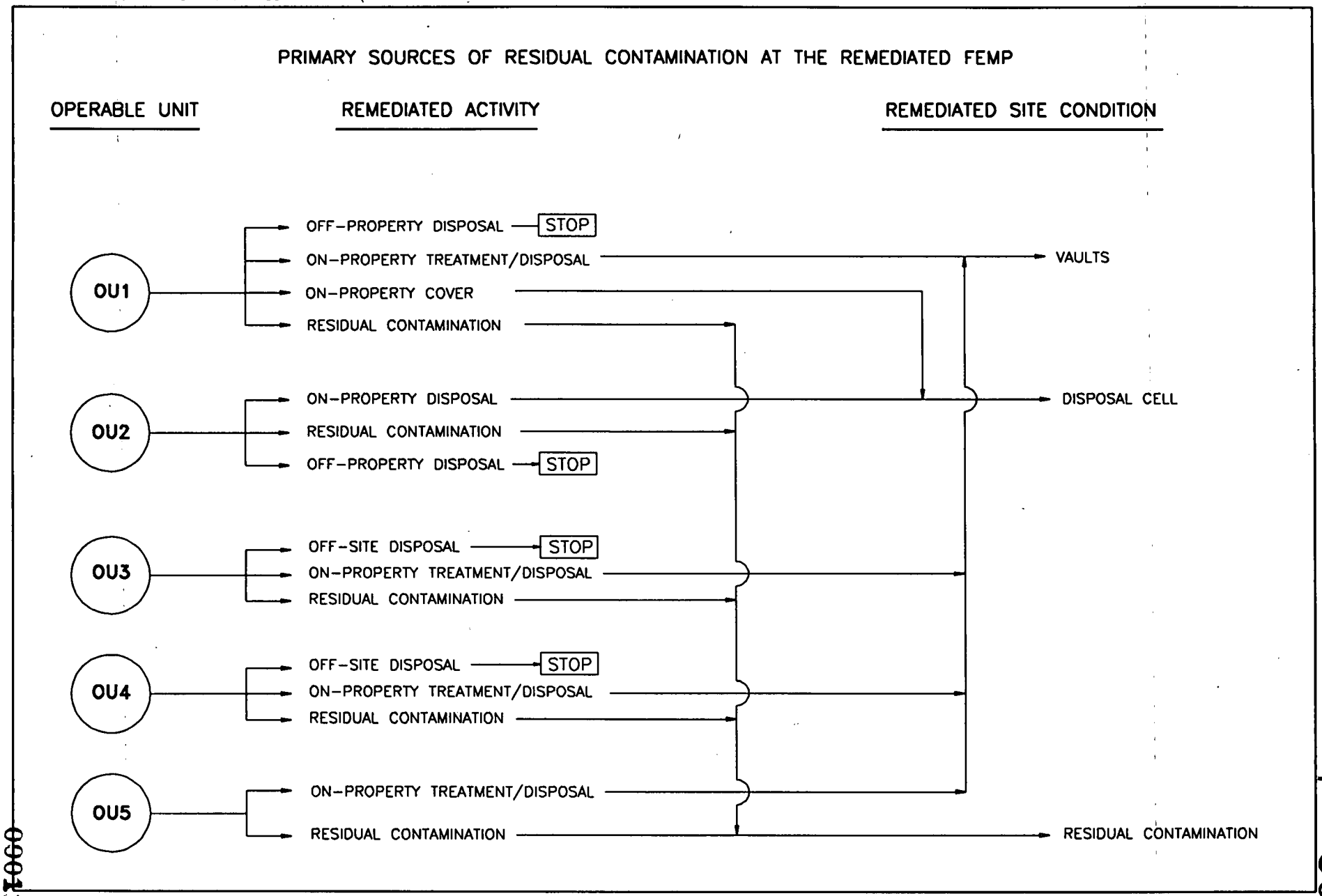

FIGURE 1.5-1

PRIMARY SOURCES OF FEMP RESIDUAL CONTAMINATION

I.5.2.1 Sources of Residual Contaminants

This CRARE evaluates the residual human-health risk of the five operable units after remediation, with the focus on Operable Units 1 and 2. Figure I.5-1 presents the post-remediation sources of contaminants and provides a basis for developing the exposure pathways in the conceptual model. The sources, which are described in detail in Sections I.2.2 and I.2.3, include:

- Residual contamination in the remediated areas of each operable unit, including contaminated soil, surface water, sediment, groundwater, and vegetation.
- Leachate from disposal facilities for other operable unit material.
- Leachate from the disposal cell for Operable Units 2.
- Remediated surface soils.

The conceptual model addresses these sources as reservoirs of residual contaminants that can migrate to other environmental compartments or serve as a direct source of exposure.

I.5.2.2 Release Mechanisms of Contained Wastes and Soils

Figure I.5-1 outlines the five operable units, and identifies the residual on-property COC sources following the completion of remedial actions. Under the current disposal alternatives, the remediated site will have a disposal cell, disposal vaults and operable unit footprints with residual wastes left in place that have met the cleanup levels (see Figure I.2-1 in Section I.2.0).

Wastes and soils with acceptably, low residual contaminant concentrations will be left within the Operable Unit 1, 2, 4, and 5 footprints (Figure I.5-1). Several mechanisms could allow these latter source contaminants to be accessed directly by a receptor or dispersed and made available for transport in the environment. The following paragraphs describe the hypothetical release mechanisms considered in the CRARE conceptual exposure model (Figures I.5-2 through I.5-4).

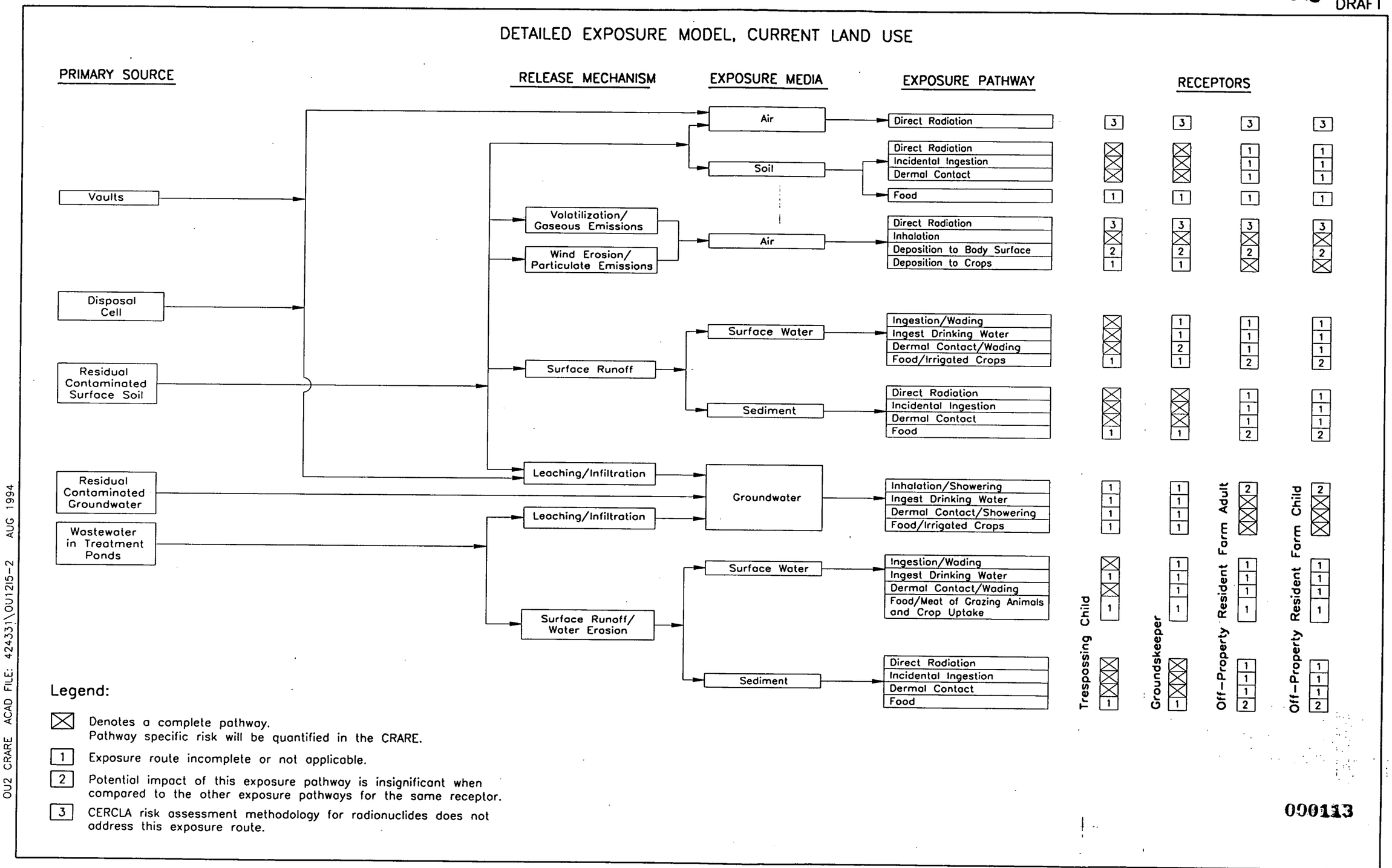

FIGURE 1.5-2 DETAILED EXPOSURE MODEL, CURRENT LAND USE

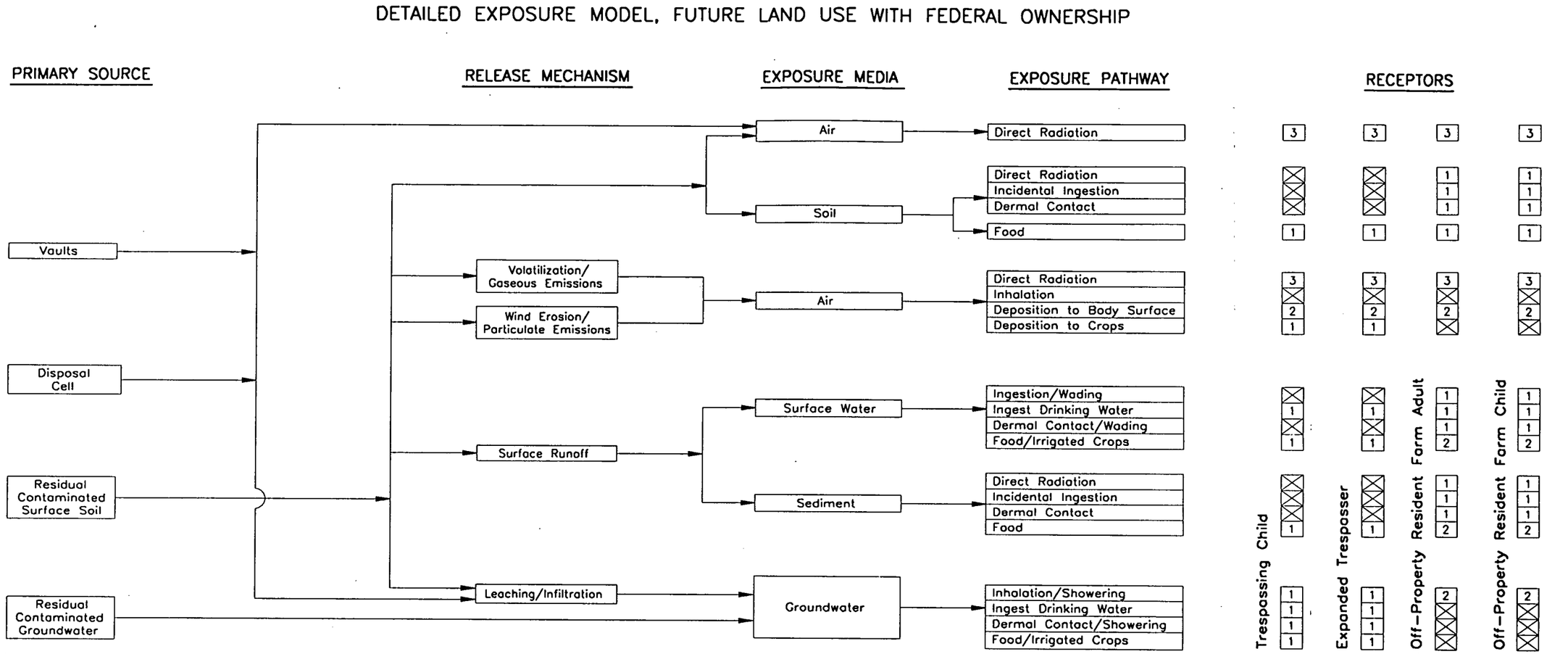

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FIGURE 1.5-3 DETAILED EXPOSURE MODEL, FUTURE LAND USE WITH FEDERAL OWNERSHIP

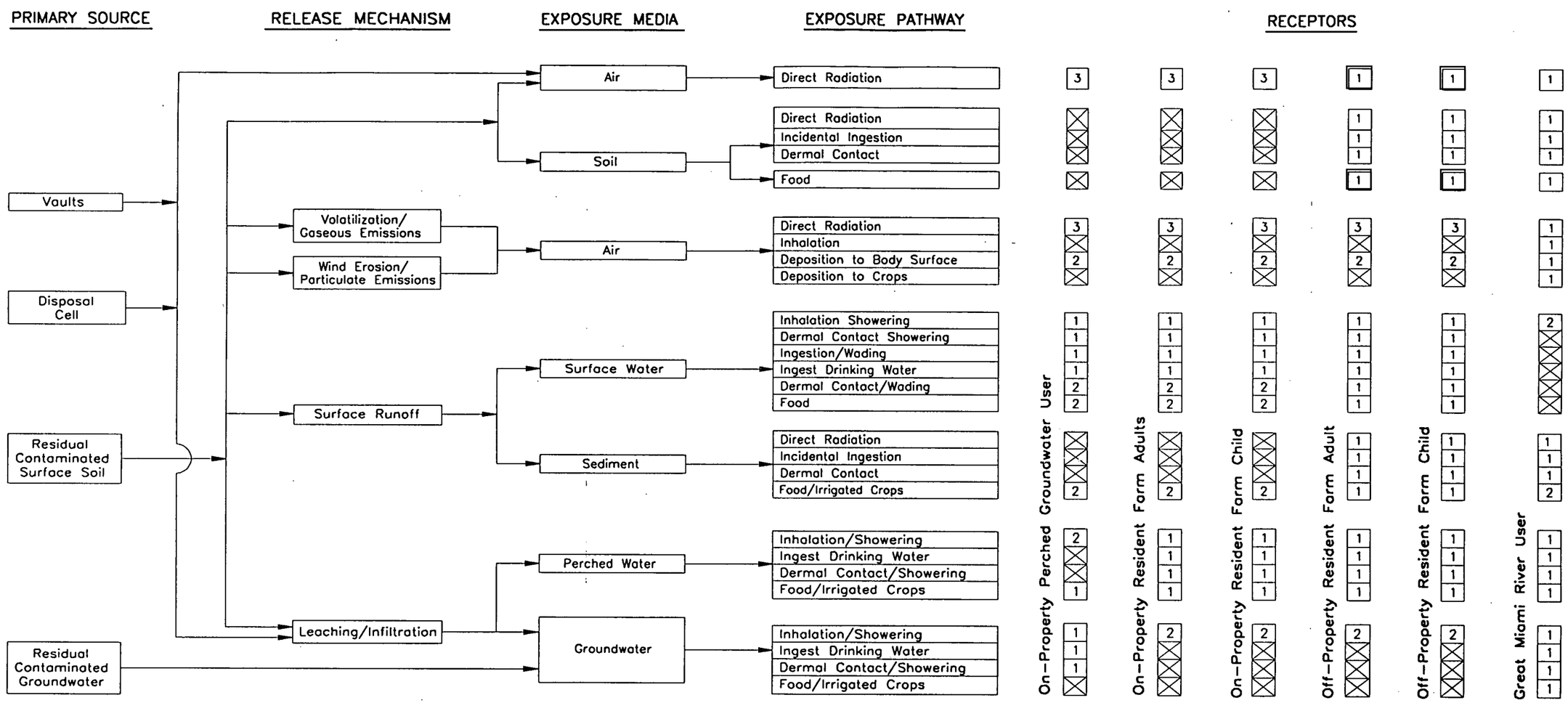

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FIGURE 1.5-4 DETAILED EXPOSURE MODEL, FUTURE LAND USE WITHOUT FEDERAL OWNERSHIP

Failure of On-Property Disposal Vaults or Cells

This hypothetical release mechanism postulates a failure of the disposal structures holding the treated wastes or a fracture of the cell materials. If the integrity of these structures is breached, the wastes in or beneath them can be exposed to the environment and subjected to wind erosion, surface runoff, and water infiltration (Figures I.5-2 through I.5-4). Possible forces that could induce structural failure include physical impact or natural weathering forces. These forces could weaken, damage, and/or destroy the integrity of the structures, thus exposing treated or buried materials to the environment. The disposal cell and vaults selected for evaluation in this CRARE is designed to remain intact for 1000 years. Also during this period, infiltration and leachate generation were assumed to occur, but only in small amounts as man-made materials can fail over long periods of time. An analysis of the proposed disposal facility design was completed and water infiltration/exfiltration and emission venting was calculated due to eventual deterioration.

Surface Water Overflow

Although the wastewater will be treated at the FEMP during the first 70 years after remediation has been completed (as indicated in the Current Land Use scenario), it is possible that surface water runoff may carry COCs from the designated treatment areas and make it available for human uptake. Specifically, this release mechanism primarily affects water being treated at the wastewater treatment plant or contained in the retaining ponds. These collection structures may overflow during periods of heavy rainfall. The liquid spilling over the top of the treatment plant or ponds can flow overland and contaminate surface soil, sediments, or any water bodies that come in contact with the liquid or receive it.

I.5.2.3 Transport of Source Emissions

Contaminated materials from those sources not contained (residual soils and waste materials, residual groundwater contamination, contaminated vegetation) may be released from the site without the failure of containment structures. Uncontained and contained COCs, if released from the disposal facilities can travel by several transport pathways to reach various environmental media to which potential receptors may be exposed (Figures I.5-2 through I.5-4). This section briefly discusses the four transport pathways.

Air

Releases to air may occur through the generation of particulates by wind or surface soil disturbance. In addition, gaseous phase contaminants may be released through volatilization or radioactive decay (e.g., radon). Transport through the air is expected to be a major pathway for contaminants in residual soils and waste materials left on-property after remediation.

Surface Water and Sediment Runoff

Surface water transports waste material by conveying dissolved and suspended solids to receptors as it flows across the surface of the ground and along any surface drainage features. It is assumed that no wastes in the disposal facilities will be exposed to permit surface sediment runoff. COCs in the surface soils will be subject to transport in surface water/sediment runoff. Runoff can transport contaminants to receiving surface water bodies to which receptors may come in contact directly (through wading, etc.) or indirectly (through stock or irrigation water).

Leaching and Infiltration

The FEMP has a humid climate with an average annual rainfall of about 102 centimeters (40 inches). A portion of this water percolates through subsurface soil and recharges the underlying aquifer. Percolation would also occur through the waste storage structures as a result of the natural weathering process. COCs in waste and soil would be dissolved and transported in this flow. However, degradation, retardation, and radioactive decay may reduce the concentrations that eventually reach the aquifer. Dilution would also occur in the groundwater flow. Eventually, the groundwater would complete the pathway with transport to a well from which a receptor can take water for home and farm use.

I.5.2.4 Exposure Media

The transport pathways just discussed would result in the occurrence of site-related contaminants in the various exposure media identified in Figures I.5-2 through I.5-4. The media to which receptors may be exposed include soil (either in-place residuals or materials transported from source areas by various mechanisms), groundwater, surface water, sediment, and air. Indirect human exposures to contaminants in one or more of these media may occur through the ingestion of crops or livestock and related products (meat, milk) which have been exposed to contaminated

soil or water. In the case of on-property residual soil, no intermediate transport mechanism is necessary for on-property receptors; humans may be exposed directly to in-place materials.

I.5.3 EXPOSURE PATHWAYS

There are numerous potential exposure pathways at the FEMP by which receptors can come in contact with contaminants. These pathways include ingestion, inhalation, and dermal contact with chemical contaminants and radionuclides. In the case of radionuclides, external exposures to radiation may also occur. On the right-hand side of Figures I.5-2 through I.5-4, the various combinations of exposure pathways and exposure media are tabulated. Each pathway and medium are evaluated for each of the exposed receptors under the different exposure scenarios. Pathways identified as being complete and significant are denoted with an "X," while those not expected to result in significant exposures for a given receptor are noted, along with an explanation of why these pathways were not included in the quantitative risk analysis for the CRARE.

I.5.3.1 Air Exposure Pathways

A receptor's exposure via these pathways begins with wastes being transported by the ambient air, eventually reaching the receptor either by inhalation or external radiation. Inhalation of airborne gases (such as radon) and resuspended particulate is a typical example of this type of exposure. The air exposure pathways are applicable to all on- and off-property receptors examined.

The significance of the air exposure pathway depends on the different characteristics of the receptor's daily activities. These pathways very often are receptor-specific. The significant air exposure pathways identified in this CRARE include inhalation of gases, radon, and resuspended particulate (Figures I.5-2 through I.5-4).

I.5.3.2 Exposure Pathways Attributable to Dermal Contact

This group of pathways encompasses all of the receptor's activities that would result in direct contact with contaminated soil, sediment, and water. Potential sources of contamination for these exposures include exposed waste, soil, groundwater, and sediment.

Exposure pathways via dermal contact included in the quantitative risk assessment are dermal contact with contaminated soil and sediment (Figures I.5-2 through I.5-4). As in the air exposure pathways described in Section I.5.3.1, many dermal contact exposure routes are receptor-specific.

I.5.3.3 Ingestion Exposure Pathways

Direct ingestion of soil, sediment, drinking water, and food are considered plausible for many receptors. Ingestion of substances containing waste can come from direct or indirect routes. For example, a receptor may ingest COCs from the aquifer in the drinking water, while wading in contaminated surface water, or by ingesting vegetation irrigated with contaminated water.

Eating meat or drinking milk from animals that have ingested contaminated soil, stock water, or foliage while grazing on FEMP property is included in this CRARE risk analysis. Exposure pathways such as ingestion of contaminated soil, surface water, sediment, groundwater, and crops are significant for the receptors investigated in this CRARE (Figures I.5-2 through I.5-4).

I.5.3.4 Exposure to External Radiation

This pathway may be significant for receptors who come into close proximity to residual soils or wastes, such as the trespassing child or groundskeeper under the Current Land Use scenario and the on-property residents or expanded trespasser under the Future Land Use scenarios. Significant external radiation pathways identified for one or more of the receptors include exposure to radiation originating from contaminated soil and sediment.

I.6.0

I.6.0 FATE AND TRANSPORT MODELING

Fate and transport computer models were used to predict the movement of residual COCs through various media from the remediated FEMP to receptor locations. This CRARE employs model selection approaches, criteria, and modeling parameter values based on those specified in the RAWPA and subsequent FS documents.

This section describes the methodology used to predict contaminant concentrations in different media for the FEMP Operable Unit 2 CRARE. Included are discussions of:

- Technical approaches used to select the appropriate model for each potential exposure assessment
- Fate and transport models used
- Required data and default parameter values
- Modeling results

The models were selected based on their appropriateness for a specific application in the CRARE process and the availability of required input information as described in Section 6.1 of the RAWPA. The principal results from the modeling efforts are predicted concentrations for each COC over a future time period, at specified time intervals, at selected receptor locations. These results are then used as the basis for the risk calculations presented in Section I.9.0. Additional information on the modeling results is also included in the following sections, to supplement the receptor results and increase understanding of the modeling process.

The CRARE models also included assumptions on future FEMP site conditions. These assumed changes were derived primarily from the anticipated remedial actions for each operable unit. Due to the uncertainties associated with these models, all results have been carefully reviewed before including them in this CRARE.

CRARE modeling is similar to the approach of the SWCR modeling. However, the SWCR modeling is intended to evaluate baseline conditions and does not account for changes in site conditions due to remedial actions. Each operable unit FS is planned to model the effects of all

of the remedial alternatives for that operable unit in detail. The CRARE models are consistent with these efforts by using the same modeling parameters as the FS, but will only address the anticipated PRA or LRA for each operable unit.

One key goal of the CRARE modeling effort is to ensure that all CRAREs use the same input parameters and default values, and that these data are consistent with EPA recommendations. Assumptions and parameters presented in this report may change, subject to EPA approval, as new information becomes available. As discussed in Section I.2.2, the remedial alternatives for some operable units may change in future CRARE documents.

Due to the large number of potential exposure pathways at the FEMP (see Section I.5.0, Figures I.5-1 through I.5-4), the CRARE models have been grouped by transport medium as presented in the RAWPA. Detailed information on the model selection and parameters employed in quantifying fate and transport of contaminants in water are presented in Section I.6.1. This includes vadose zone, surface water and groundwater models. Section I.6.2 presents the air emission and transport models. Section I.6.3 presents modeling methodologies and results for the concentrations of residual contaminants in vegetables, meat, and dairy products.

I.6.1 WATER TRANSPORT MODELING

This section includes a conceptual description of the process of evaluating the groundwater and surface water contaminant transport pathways from source areas to receptors. Detailed discussions then follow on the selection of COCs, the development of source terms for modeling, and the use of vadose-zone, surface-water, and groundwater transport models.

I.6.1.1 Description of Approach

The purpose of water transport modeling was to provide a predictive methodology for simulating the movement of contaminants in surface water, vadose zone water, and groundwater from source areas to receptors. Of the multiple pathways identified in the CRARE Site-Wide Conceptual Model (Section I.1.6), two are described here, surface water and groundwater. The key elements of these and other pathways are:

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- Sources of residual contamination
- Release mechanisms
- Transport pathways
- Exposure pathways
- Receptors

This section provides detailed descriptions of the contaminant sources, release mechanisms and transport pathways, for both the surface water and the groundwater transport pathways, as well as the selection of receptor locations and the development of contaminant concentrations with time at these locations.

Surface water is an exposure medium because receptors were assumed to be located in Paddys Run downstream of the source areas. Surface water in Paddys Run also represents a portion of the groundwater pathway, since COCs in this surface water were assumed to infiltrate to groundwater, and then may be transported in the groundwater to potential receptors. Transport through the vadose zone is also considered to be part of the groundwater pathway. However, perched water is present in the vadose zone beneath some areas of the FEMP, and this water is considered a potential future drinking water supply at some locations.

The source areas of groundwater and surface water contamination projected to remain at the FEMP include elements from all operable units. As discussed in Section I.2.2, this CRARE assumed that the PRAs for Operable Units 1, 2, and 4 and the LRAs for Operable Units 3 and 5 would be implemented. When FEMP remediation is complete, the only structures planned to remain on the site are the vaults, the Operable Unit 1 covered area, and the Operable Unit 2 Disposal Cell, as described in Section I.2.3 (Figure I.2-1). In addition, a water treatment facility was assumed to be present in the Current Land Use scenario. The vaults along the eastern boundary of the FEMP (the Eastern Vaults) were assumed to contain Operable Unit 3 waste plus soil and rubble from Operable Unit 4. The Solid Waste Landfill, Lime Sludge Ponds, Inactive Flyash Pile, Active Flyash Pile, and South Field areas of Operable Unit 2 were assumed to be excavated to PRG/PRL levels, and the waste disposed in the Disposal Cell. Other source areas include the site-wide soil under Operable Unit 5, the residual soils within the Operable Unit 4 boundary, and the covered and residual Operable Unit 1 areas.

Figure I.6-1 shows the process, in conceptual terms, of evaluating the surface water and groundwater pathways. The CRARE Site-Wide Conceptual Model is described in Section I.1.6 and throughout this CRARE. The FEMP Conceptual Flow Model is the current, comprehensive, and consistent description of the hydrogeologic environment at the FEMP. This conceptual model is described in the SWCR and most recently in the Operable Unit 5 RI report (DOE 1994f). The conceptual model is an approximation and simplification of actual field conditions and is subject to modification as additional field data are developed. The data and interpretations presented in the SWCR and Operable Unit RI reports are briefly described and referenced below.

The CRARE Site-Wide Conceptual Model (Section I.1.6, Figures I.1-11 through 13) includes leachate as a release mechanism of concern for all of the primary sources. Figure I.6-1 presents the steps involved in estimating the flow rates and COC concentrations with time of the leachate from each of the source areas. Rainwater was the only source of inflowing water considered in the CRARE for the formation of leachate. Agricultural irrigation, residential watering, or industrial discharges were assumed not to occur at contaminated areas at the FEMP within the modeled period. The HELP Infiltration Model (as described in the SWCR) was used to estimate soil infiltration and runoff rates. Previous geochemical studies (using a geochemical model, EQ3/6), literature research, and a limited amount of bench-scale laboratory leach test data were used to estimate COC concentrations in the leachate.

The leachate data was then used as input to the vadose zone transport modeling. The ODAST model was used to mathematically simulate flow and transport through the vadose zone from each of the source areas. The time-variant output from ODAST was used as input to the SWIFT III groundwater model, which had previously been calibrated to simulate the current flow and contaminant characteristics at the site. Model calibration is discussed in ASI/IT (1990) and IT (1990).

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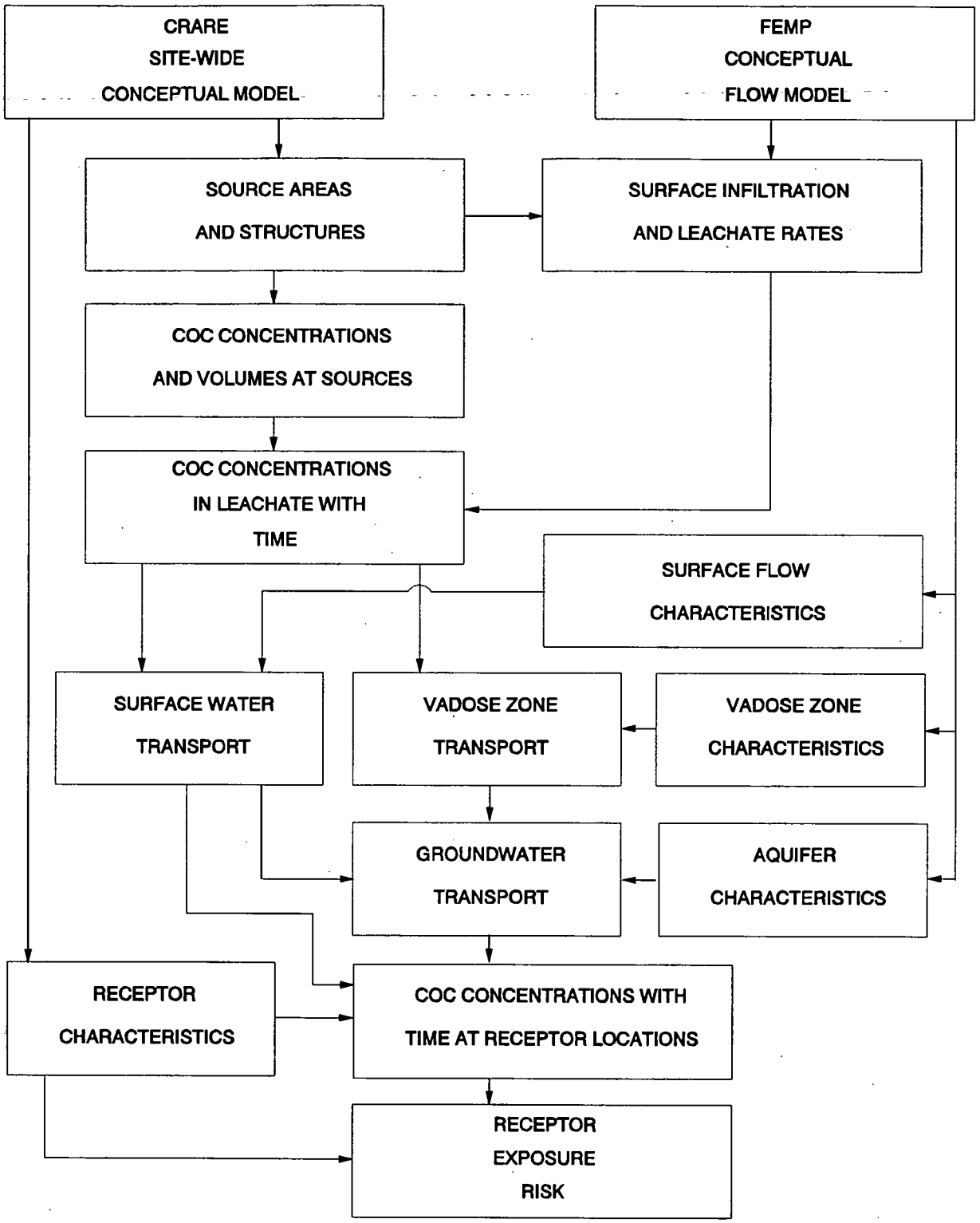

FIGURE I.6-1

EVALUATION OF SURFACE WATER AND GROUNDWATER PATHWAYS

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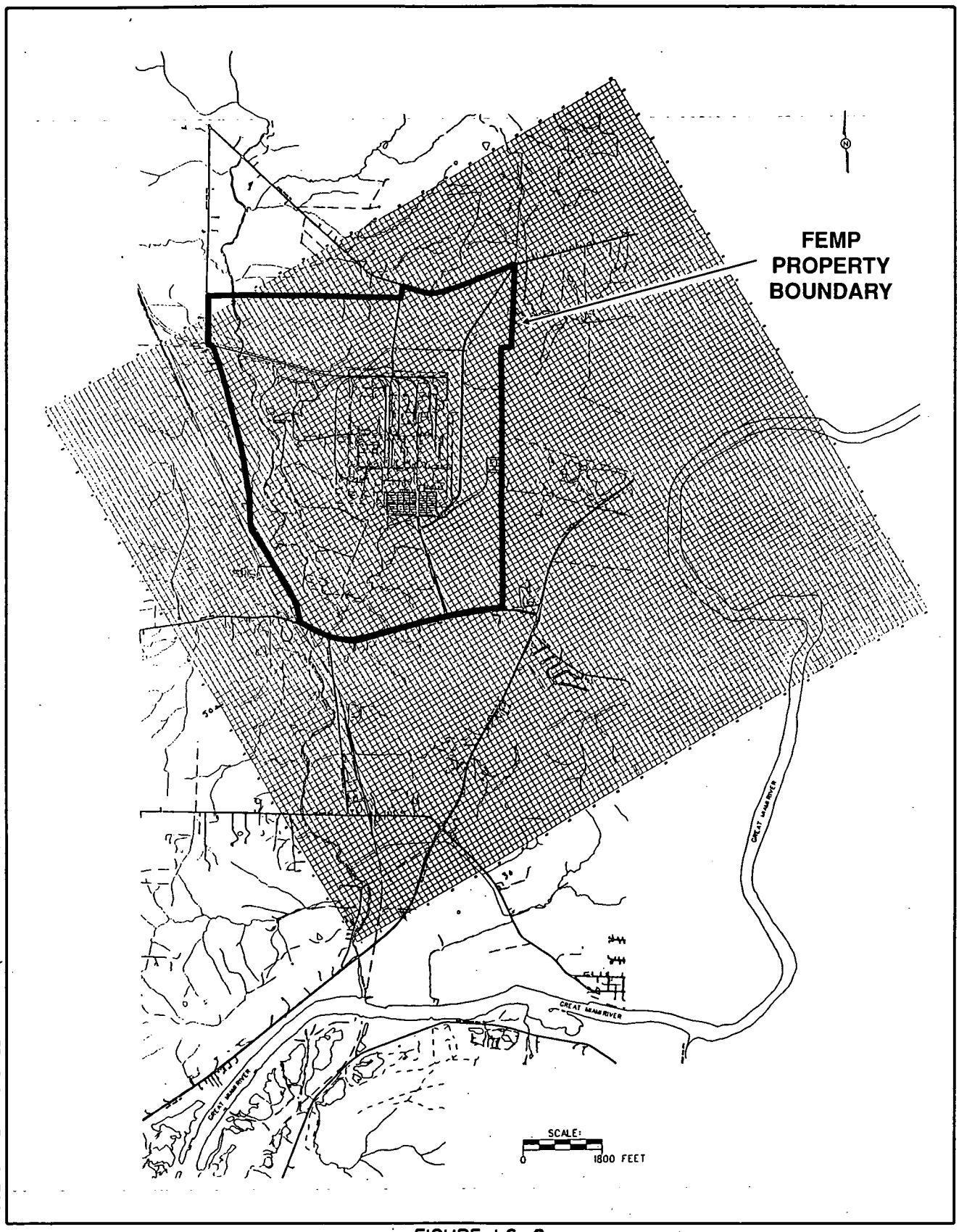
Contaminant transport was simulated in the SWIFT III model over a rectangular area that is a subset of the area covered by the groundwater flow portion of the model. A grid system subdivides the transport area into 112 by 120 cells that are each 38 meters (125 feet) square (Figure I.6-2). This grid system is also projected down through six layers in the SWIFT III model that represent the full depth of the aquifer. A smaller grid was originally established in the SWCR to simulate the currently existing uranium plume in the groundwater. The new grid was developed to expand the coverage for all of the RI/FS study areas.

The transport grid cells were used in this CRARE to define the areas of source terms and vadose zone transport modeling. This made the process of defining the COC input terms for the groundwater model more efficient, since the same area definitions were carried through the multiple modeling steps.

I.6.1.2 Selection of COCs for the Groundwater Pathways

The method of selecting COCs for the Operable Unit 1, 2, and 4 areas involved a review of the groundwater modeling and risk assessment results for the PRA in the FS for each operable unit. There may be variations in the methods used by each operable unit as time progresses. As such, the CRARE reflects these variations for each operable unit. The FS for Operable Unit 1 identified the uranium isotopes, Np-237, Aroclor-1254, antimony, and cadmium as representing potential post-remediation risks by the groundwater pathway above Operable Unit 1 screening levels of 1×10^{-7} for ILCR or 1×10^{-1} for HI. A subsequent review of the modeling data for Operable Unit 1 determined that "Aroclor-1254" is a misprint in the FS, and the correct compound is Aroclor-1221. The FS documents for Operable Units 2 and 4 found that only the uranium isotopes were of concern.

For the Operable Unit 3 and 5 areas, the remedial analyses that are conducted for FS studies are not available. However, Section I.4.0 describes how a site-wide list of potential COCs was compiled for possible inclusion in the CRARE and then reduced through three screening procedures. Table I.4-6 (Section I.4.5) presents the final site-wide list of COCs retained after the screenings. This list was then reduced further by comparing it to the results of the Operable Unit 5 RI baseline risk assessment (DOE 1994f Section A.5.0). This is a very conservative, health-



OU2 CRARE CADFILE: 424331\OU12I6-2 AUG 1994

FIGURE 1.6-2
REVISED FLOW AND SOLUTE GRID

based approach, since this risk assessment does not incorporate any assumptions of future remediation. The future land use scenario, which involves an on-property RME farmer in the OU5 baseline risk assessment was selected for this screening. This scenario incorporates the maximum potential exposure that could be experienced by an individual pursuing an agricultural lifestyle on the FEMP. COCs with an ILCR of 1×10^{-6} or greater, or an HQ of 1.0 or greater, for the ingestion of groundwater from any area for the on-property RME farmer were selected.

The groundwater COCs for Operable Units 3 and 5 that passed this screening are Np-237, Ra-226, Sr-90, Tc-99, U-234, U-235/236, U-238, arsenic, beryllium, and antimony. These COCs encompass 100 percent of the total ILCR and 95 percent of the total HQ for groundwater ingestion under the on-property RME farmer. However, the previous CRARE found that Sr-90 did not make a significant contribution to risk.

Therefore the COCs retained for ODAST and then SWIFT III modeling are the uranium isotopes, Tc-99, Np-237, Ra-226, Aroclor-1221, antimony, cadmium, arsenic, and beryllium. Because of their chemical similarity, all of the uranium isotopes were assumed to be transported by water in approximately the same manner. Therefore, U-238 is the only uranium isotope that has been modeled for this CRARE, since it is the most abundant isotope. The other uranium isotopes were assumed to also be transported in the same ratios to U-238 as they are present in the source areas. The relative abundances of the uranium isotopes at the FEMP are as follows, in decreasing order:

- U-238 99.3 percent
- U-235 0.685 percent
- U-236 9.63×10^{-3} percent
- U-234 8.96×10^{-3} percent

These values were estimated from the uranium isotope distributions found in the RI/FS database.

I.6.1.3 Descriptions of Source Terms

Section I.6.1.1 describes how this CRARE uses the PRAs for Operable Units 1, 2, and 4 and the LRAs from the SWCR for Operable Units 3 and 5 to identify the source areas assumed to remain after remediation. These assumptions provide the basis for determining the locations and source terms for the release of COCs to the water pathways. Descriptions of the Operable Unit 1, 2,

and 4 source areas are not included in this section, since they are described in the FS reports for those units. Operable Unit 2 subdivided the South Field and Inactive Flyash areas into a complex pattern of eight zones that define groundwater source terms. Detailed information on these zones is presented in the Operable Unit 2 FS report (Appendix D, Table D.3-8). The individual source terms and results for these zones are only summarized in this CRARE.

I.6.1.3.1 COC Masses and Leachate Concentrations

The determination of COC masses, initial concentrations, and the derived leachate concentrations for each of the Operable Unit 3 and 5 source areas is described below. The estimation of infiltration rates as part of the source terms is described in Section I.6.1.3.2 and I.6.1.3.3. The calculation of rainfall runoff as a source term to surface water flow is described in Section I.6.1.5.

Under Operable Unit 5, the area of potential soil contamination includes the entire FEMP (Section I.2.2, Figure I.2-1). The areas for Operable Units 1, 2, and 4 were not included in the CRARE site-wide soils area because they are described separately as sources of COCs. Operable Unit 1 intends to transfer approximately 58,645 cubic meters (76,700 cubic yards) of potentially contaminated soil to Operable Unit 5 for treatment and eventual disposal in an Operable Unit 5 area. Possible COC concentrations in this soil have not been included in the Operable Unit 5 totals because these concentrations have not been estimated by Operable Unit 1, the soil will be treated, and the volume is small compared to the total volume of soil within Operable Unit 5. This transferred soil will be addressed in the Operable Unit 5 CRARE.

Operable Unit 5 subdivided the FEMP into 28 subareas that have similar soil and uranium-concentration characteristics. These areas are shown on Figure I.6-3. The average concentrations and total masses in each area for U-238, Ra-226, and arsenic were calculated in the Operable Unit 5 RI. Beryllium is not included in these calculations because it is not a COC by the vadose zone pathway for Operable Unit 5.

For U-238, all areas with concentrations above 100 ppm were assigned that value to represent the results of the soil-washing remediation of Operable Unit 5. This cleanup level for U-238 was developed by Operable Unit 5. Similarly, soil washing cleanup levels of 36,600 pCi/g for Tc-99, 5 pCi/g for Np-237, 0.4 pCi/g for Ra-226, 16 mg/kg for beryllium, and 15.6 mg/kg for arsenic were

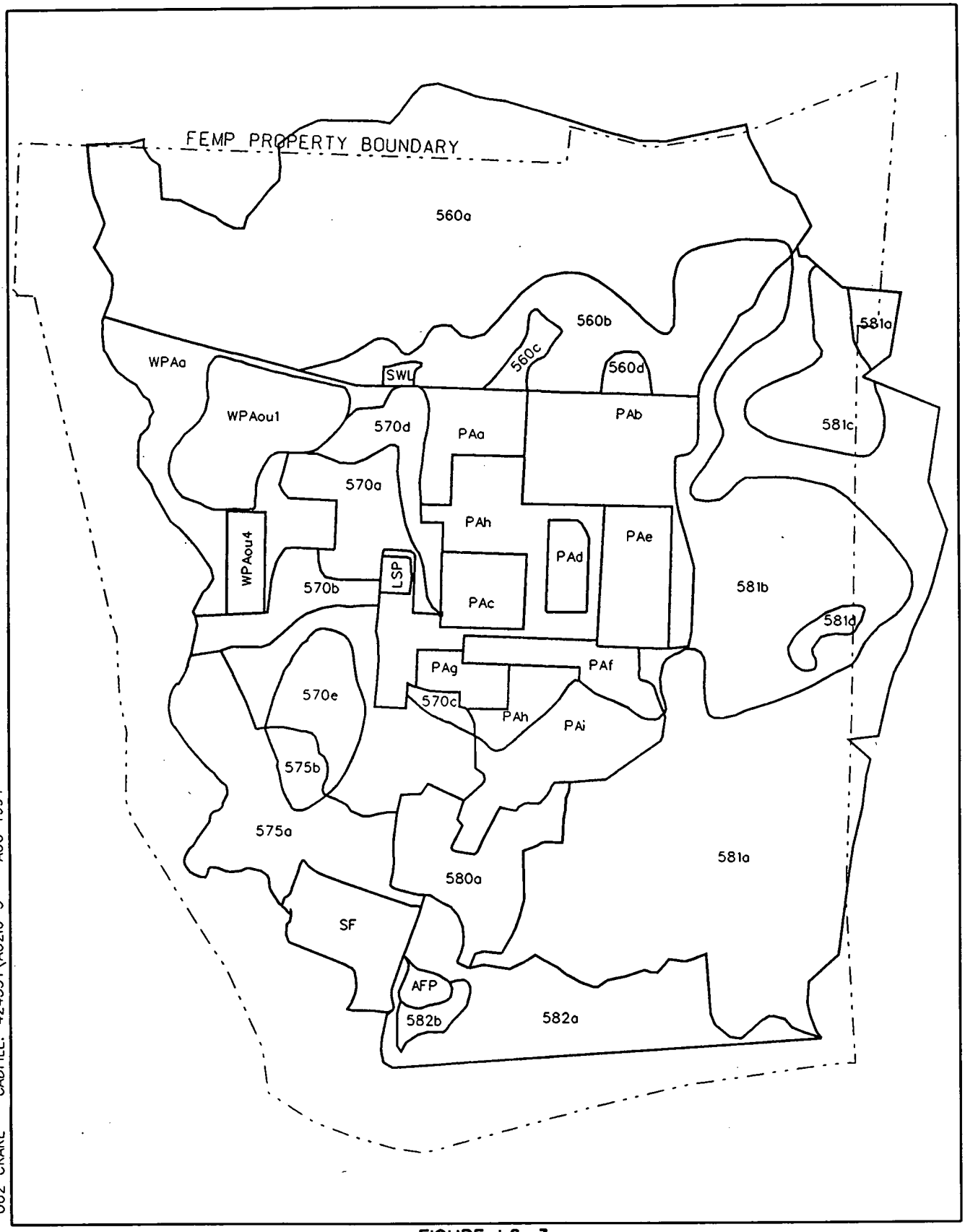


FIGURE 1.6-3
AREAS OF SOIL CONTAMINATION

selected by Operable Unit 5 based on data in the SWCR plus more recent data on arsenic. However, these values may be changed in future CRARE documents, depending on the results of treatability tests being conducted for the Operable Unit 5 soil-washing process. Concentrations below 100 ppm for U-238 were assumed to remain the same (unwashed soil).

Data on the concentrations and extent of the COCs other than U-238, Ra-226 and arsenic in soils were obtained from the RI/FS database. The data for each COC was then divided into two groups: 1) "surface results," which are analytical results from soil samples collected from the surface to 15.2 centimeters (6 inches) in depth and 2) "subsurface results," which are analytical results from below 15.2 centimeters (6 inches). The 0-to-15.2 centimeter (0-to-6 inch) depth was selected because many of the surface soil samples in the database had been collected within that range. The surface soil databases were used to estimate COC source locations, soil concentrations, and masses for the surface water modeling. The subsurface soil databases were used for the same purposes for the vadose zone modeling. For each database the soil concentrations were averaged over depth and gridded on the SWIFT transport grid to obtain cell by cell concentrations. Within the soil-washing areas defined for U-238, any soil concentration value for the other COCs, as mentioned above, that exceeded the cleanup levels defined above was set to the cleanup level. If analytical results were not available for soils in a cell, then the COC concentrations in that cell were assumed to be negligible.

The process of evaluating the areas where there is soil data for the COCs followed four steps:

1. Take the arithmetic average of all sample results at each particular location over depth.
2. Take the arithmetic average of the depths over which contamination penetrated.
3. Grid the average results over the desired portion of the SWIFT solute transport grid. Use the "inverse distance second power" algorithm of SURFER (Golden Software, Inc. 1990). Use the 8 closest neighboring data points for fitting at each grid point. Using only 8 neighbor points avoids undue influence by local hot spots and, along with second-power fitting, provides reasonably accurate estimates of the total mass.
4. Take the arithmetic average of the gridded results.

The leachate concentrations from the averaged soil results were obtained by dividing the soil concentration by the soil partitioning coefficient (K_d) for the COC. For U-238 the K_d value used

for this calculation was either 222 ml/g or 15 ml/g, depending on the specific area. This approach is described further in the Operable Unit 5 RI report. A K_d of 15 was used for areas 560C, 581D, PAA, PAB, PAC, PAD and PAE. All other site-wide soils area used a K_d of 222. For all other COCs the K_d for Layer 1 (see Section I.6.1.4.1) was used. K_d is defined as the mass of solute on the soil solid per unit mass of solid, divided by the concentration of solute in solution. As an example, for a COC that has an average soil concentration of 10 mg/kg, and a K_d of 5.0, the leachate concentration (C_L) would be:

$$C_L = \frac{10\frac{mg}{kg}}{5\frac{l}{kg}} = 2 \text{ mg/l} \qquad (I.6\text{-}1)$$

This approach assumes that the soil and the water passing through it are in reversible linear equilibrium with each other (the same assumption that SWIFT makes). This assumption does not take into account the effects of variations in pH, anions, and mineralogical composition on COC partitioning. The lower the flow of water, the more accurate is this assumption. Variations in the soil moisture are also assumed to have no significant effect on the partitioning process. Accuracy is also improved by having dilute concentrations well below solubility limits. K_d values used for the CRARE modeling are discussed further in Sections I.6.1.4.1 and I.6.1.6.1, and in Attachment I.IV. A comprehensive list of K_d values for the FEMP appears in the RAWPA, which also describes their derivation. The leachate concentrations and masses of COCs for the Operable Unit 3 wastes in the vaults were taken from the SWCR.

To summarize the results of this section, the mass values and initial leachate concentrations for each COC at each of the source areas are listed in Table I.6-1. These source terms were used as input to the vadose-zone transport modeling described in Section I.6.1.4. The input to the surface water transport modeling is listed separately in Section I.6.1.5. Residual uranium projected to remain in groundwater at the end of remediation is discussed in Section I.6.1.6.1. Masses for uranium isotopes other than U-238 are not shown in Table I.6-1 but were estimated by multiplying the U-238 masses by the ratios provided in Section I.6.1.2.

TABLE I.6-1

SOURCE TERMS FOR COC MASSES AND CONCENTRATIONS

Source Area	Total Initial Mass (mg)	Initial Leachate Concentration (mg/l)	Calculation Method
U-238			
Eastern Vaults	2.635×10^{12}	3.289×10^{-3}	SWCR
OU4 Contaminated Soils	1.083×10^{7}	1.500×10^{0}	OU4 FS
OU1 Contaminated Soils	2.876×10^{10}	7.440×10^{-1}	OU1 FS
OU2			
SWLF	9.410×10^{8}	1.982×10^{-3}	OU2 FS
LSP	1.362×10^{8}	2.083×10^{-3}	OU2 FS
AFP	4.260×10^{7}	1.984×10^{-2}	OU2 FS
IFP: Fill over GMA	8.600×10^{7}	1.984×10^{-2}	OU2 FS
SF: Fill over GMA	6.990×10^{8}	4.167×10^{-6}	OU2 FS
SF: Impacted Till	3.104×10^{8}	4.167×10^{-6}	OU2 FS
SE Disposal Cell Interior	1.992×10^{11}	7.143×10^{1}	OU2 FS
SE Disposal Cell Berm	1.402×10^{11}	7.143×10^{1}	OU2 FS
Site-Wide Soils			
560A	1.205×10^{10}	6.982×10^{-2}	Database K_d
560B	1.846×10^{10}	4.503×10^{-1}	Database K_d
560C	1.163×10^{9}	6.667×10^{0}	Database K_d
560D	1.017×10^{9}	4.506×10^{-1}	Database K_d
570A	5.320×10^{9}	3.509×10^{-1}	Database K_d
570B	5.087×10^{9}	4.505×10^{-1}	Database K_d
570C	4.238×10^{9}	1.622×10^{-1}	Database K_d
570D	4.942×10^{9}	4.505×10^{-1}	Database K_d
570E	3.415×10^{9}	2.860×10^{-1}	Database K_d
575A	4.011×10^{9}	1.081×10^{-1}	Database K_d
575B	1.367×10^{9}	2.649×10^{-1}	Database K_d
580A	1.712×10^{9}	8.423×10^{-2}	Database K_d
581A	1.588×10^{10}	9.595×10^{-2}	Database K_d
581B	2.573×10^{10}	4.504×10^{-1}	Database K_d
581C	3.943×10^{9}	2.144×10^{-1}	Database K_d
581D	8.719×10^{8}	6.667×10^{0}	Database K_d
582A	2.323×10^{9}	5.180×10^{-2}	Database K_d
582B	1.163×10^{9}	4.505×10^{-1}	Database K_d
PAA	5.088×10^{9}	6.667×10^{0}	Database K_d
PAB	1.221×10^{10}	6.667×10^{0}	Database K_d
PAC	5.233×10^{10}	6.665×10^{0}	Database K_d
PAD	1.386×10^{10}	6.667×10^{0}	Database K_d

TABLE I.6-1
(Continued)

Source Area	Total Initial Mass (mg)	Initial Leachate Concentration (mg/l)	Calculation Method
PAE	6.047×10^{10}	6.666×10^{0}	Database K_d
PAF	4.070×10^{9}	4.505×10^{-1}	Database K_d
PAG	2.471×10^{9}	4.503×10^{-1}	Database K_d
PAH	1.532×10^{10}	4.477×10^{-1}	Database K_d
PAI	3.697×10^{9}	1.878×10^{-1}	Database K_d
WPAA	1.410×10^{10}	4.505×10^{-1}	Database K_d
Tc-99			
Eastern Vaults	2.615×10^{4}	1.055×10^{-3}	SWCR
OU1 Contaminated Soils	8.220×10^{4}	4.337×10^{-3}	OU1 FS
Site-Wide Soils			
Main Plant Area	1.818×10^{5}	1.055×10^{-3}	Database K_d
East Plant Area	2.383×10^{3}	1.055×10^{-3}	Database K_d
West Plant Area	5.107×10^{3}	1.055×10^{-3}	Database K_d
Np-237			
OU1 Contaminated Soils	1.140×10^{5}	1.289×10^{-5}	OU1 FS
Site-Wide Soils			
Plant 2/3	2.248×10^{5}	4.681×10^{-4}	Database K_d
Plant 6	1.241×10^{5}	5.579×10^{-4}	Database K_d
Ra-226			
Site-Wide Soils			
560A	3.142×10^{2}	5.806×10^{-10}	Database K_d
560B	7.470×10^{1}	5.805×10^{-10}	Database K_d
560C	4.707×10^{0}	5.805×10^{-10}	Database K_d
560D	4.106×10^{0}	5.805×10^{-10}	Database K_d
570A	2.762×10^{1}	5.804×10^{-10}	Database K_d
570B	2.048×10^{1}	5.804×10^{-10}	Database K_d
570C	4.751×10^{1}	5.804×10^{-10}	Database K_d
570D	1.991×10^{1}	5.805×10^{-10}	Database K_d
570E	2.167×10^{1}	5.806×10^{-10}	Database K_d
575A	6.754×10^{1}	5.803×10^{-10}	Database K_d
575B	9.403×10^{0}	5.805×10^{-10}	Database K_d
580A	2.775×10^{1}	4.353×10^{-10}	Database K_d
581A	3.002×10^{2}	5.804×10^{-10}	Database K_d
581B	1.039×10^{2}	5.805×10^{-10}	Database K_d
581C	3.338×10^{1}	5.804×10^{-10}	Database K_d
581D	3.522×10^{0}	5.805×10^{-10}	Database K_d

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TABLE I.6-1
(Continued)

Source Area	Total Initial Mass (mg)	Initial Leachate Concentration (mg/l)	Calculation Method
582A	8.146×10^{1}	5.804×10^{-10}	Database K_d
582B	4.694×10^{0}	5.805×10^{-10}	Database K_d
PAA	2.055×10^{1}	5.804×10^{-10}	Database K_d
PAB	4.928×10^{1}	5.805×10^{-10}	Database K_d
PAC	9.726×10^{1}	5.805×10^{-10}	Database K_d
PAD	5.121×10^{1}	5.805×10^{-10}	Database K_d
PAE	3.786×10^{2}	5.804×10^{-10}	Database K_d
PAF	1.639×10^{1}	5.806×10^{-10}	Database K_d
PAG	9.986×10^{0}	5.804×10^{-10}	Database K_d
PAH	6.233×10^{1}	5.805×10^{-10}	Database K_d
PAI	3.584×10^{1}	5.805×10^{-10}	Database K_d
WPAA	5.691×10^{1}	5.804×10^{-10}	Database K_d
Cadmium			
Eastern Vaults	8.895×10^{8}	$1.167 \times 10^{+2}$	SWCR
OU1 Contaminated Soils	9.319×10^{8}	1.160×10^{-2}	OU1 FS
Site-Wide Soils			
Plant 2/3	1.835×10^{8}	7.800×10^{-3}	Database K_d
Plant 9	1.435×10^{8}	1.220×10^{-2}	Database K_d
Remainder	4.176×10^{9}	8.142×10^{-3}	Database K_d
Antimony			
Eastern Vaults	4.618×10^{9}	1.451×10^{0}	SWCR
OU1 Contaminated Soils	4.371×10^{9}	1.088×10^{-1}	Database K_d
Site Wide Soils			
Plant 6	3.215×10^{8}	4.085×10^{-2}	Database K_d
Plant 9	7.985×10^{7}	1.015×10^{-2}	Database K_d
Remainder	8.539×10^{9}	2.489×10^{-2}	Database K_d
Aroclor-1221			
Eastern Vaults	1.322×10^{7}	8.112×10^{-2}	SWCR
Site-Wide Soils			
Plant 2/3	2.200×10^{8}	1.222×10^{-2}	Database K_d
Plant 9	1.163×10^{7}	1.292×10^{-3}	Database K_d
Remainder	2.701×10^{8}	6.880×10^{-4}	Database K_d
Arsenic			
Site-Wide Soils			
560A	9.411×10^{9}	6.050×10^{-2}	Database K_d
560B	1.628×10^{9}	4.410×10^{-2}	Database K_d
560C	6.582×10^{7}	2.830×10^{-2}	Database K_d

TABLE I.6-1
(Continued)

Source Area	Total Initial Mass (mg)	Initial Leachate Concentration (mg/l)	Calculation Method
560D	7.427×100^{7}	3.650×10^{-2}	Database K_d
570A	1.065×10^{9}	7.800×10^{-2}	Database K_d
570B	7.938×10^{8}	7.800×10^{-2}	Database K_d
570C	7.335×10^{8}	3.115×10^{-2}	Database K_d
570D	3.079×10^{8}	3.115×10^{-2}	Database K_d
570E	8.392×10^{8}	7.800×10^{-2}	Database K_d
575A	1.220×10^{9}	3.650×10^{-2}	Database K_d
575B	8.605×10^{7}	1.850×10^{-2}	Database K_d
580A	5.952×10^{8}	3.250×10^{-2}	Database K_d
581A	7.336×10^{9}	4.920×10^{-2}	Database K_d
581B	1.585×10^{9}	3.080×10^{-2}	Database K_d
581C	2.734×10^{8}	1.650×10^{-2}	Database K_d
581D	6.018×10^{7}	3.450×10^{-2}	Database K_d
582A	1.736×10^{9}	4.295×10^{-2}	Database K_d
582B	1.814×10^{8}	7.800×10^{-2}	Database K_d
PAA	3.903×10^{8}	3.835×10^{-2}	Database K_d
PAB	1.904×10^{9}	7.800×10^{-2}	Database K_d
PAC	4.228×10^{9}	4.040×10^{-2}	Database K_d
PAD	7.537×10^{8}	2.720×10^{-2}	Database K_d
PAE	2.745×10^{9}	2.270×10^{-2}	Database K_d
PAF	4.721×10^{8}	5.800×10^{-2}	Database K_d
PAG	3.014×10^{8}	6.100×10^{-2}	Database K_d
PAH	9.383×10^{8}	3.045×10^{-2}	Database K_d
PAI	5.674×10^{8}	3.200×10^{-2}	Database K_d
WPAA	9.700×10^{8}	3.440×10^{-2}	Database K_d

I.6.1.3.2 Soil and Capped Area Infiltration Rates

Section I.2.3.3 describes the type of cover to be constructed over the Operable Unit 1 area. A HELP model simulation of this design was run by Operable Unit 1, as described in their FS, and the resulting infiltration rate is listed in Table I.6-2. Similarly, Appendix D of this Operable Unit 2 FS describes how HELP modeling was used to determine the infiltration rates for the Operable Unit 2 residual areas and disposal cell. The infiltration rate for the Operable Unit 4 residual area was determined by Operable Unit 4.

For the site-wide soils, information regarding the major portion of Production Area soils in the SWCR was used. The percolation rate of 19.1 cm/year (7.5 in./year) was determined from the seepage velocities given in Appendix O of the SWCR. This rate was originally developed by HELP modeling of surface soils. Operable Unit 5 has made the assumption that the infiltration rate through the washed and back-filled soil will be reduced by up to one order of magnitude, if determined necessary (NUS 1994). This reduction of infiltration can be achieved by vegetation, compacting the back-filled soil, and mixing the back-filled soil with low permeability materials. Therefore, the infiltration rate for these areas was set at 1.9 cm/year (0.75 in./year). This assumed rate represents a target value for the backfill/soil capping design for these localized areas. The actual design and resulting hydrologic parameters will be developed by Operable Unit 5 and presented in the Operable Unit 5 FS.

I.6.1.3.3 Vault Infiltration Rates

This section estimates infiltration rates through the proposed Eastern Vault. Since the Eastern Vault design was not available at the time this report was prepared, information from studies conducted on similar cap designs as well as information from literature were used to evaluate the leakage rate of the proposed vault design. Additionally, a study to evaluate the degradation of a concrete vault was conducted and is also summarized in this section.

As discussed in Section I.2.3.1, the proposed typical vault cover would consist of a multi-layered composition of compacted soil, clay, sand, and gravel, designed to divert water away from the vault. The proposed vault cover will range in thickness from about 8.5 feet to 11.5 feet consisting of 5 layers and 11 sublayers. The first layer (vegetative layer) is about 3.5 feet thick, made up of

TABLE I.6-2
INFILTRATION RATES

Source Area	Infiltration Rate (in./yr)
Eastern Vaults	5.118×10^{-1}
OU4 Residual Area	6.00
OU1 Covered Area	9.1×10^{-1}
Remainder	7.5
OU2	
Solid Waste Land Field	9.61
Lime Sludge Pond	9.61
Active Fly Ash Pile	9.61
Inactive Fly Ash Pile :	
Grid Block 28 66	1.77×10^{1}
Grid Block 28 65	9.61
Grid Block 29 63	1.77×10^{1}
Grid Block 30 62	3.388×10^{1}
South Field : Fill/Debris over GMA	
Grid Block 29 60	9.61
Grid Block 30 58	3.388×10^{1}
Grid Block 30 63	3.388×10^{1}
Grid Block 28 59	9.61
South Field : Impacted Till over GMA	
Grid Block 29 59	1.77×10^{1}
Grid Block 30 64	1.73
Grid Block 30 60	2.017×10^{1}
Disposal Cell	1.22
Site-Wide Soils	
560A	7.50
560B	7.5×10^{-1}
560C	7.5×10^{-1}
560D	7.5×10^{-1}
570A	7.50
570B	7.5×10^{-1}
570C	7.50
570D	7.5×10^{-1}
570E	7.50
575A	7.50
575B	7.50
580A	7.50
581A	7.50
581B	7.5×10^{-1}
581C	7.50

TABLE I.6-2
(Continued)

Source Area	Infiltration Rate (in./yr)
581D	7.5×10^{-1}
582A	7.50
582B	7.5×10^{-1}
PAA	7.5×10^{-1}
PAB	7.5×10^{-1}
PAC	7.5×10^{-1}
PAD	7.5×10^{-1}
PAE	7.5×10^{-1}
PAF	7.5×10^{-1}
PAG	
Grid Block 57 70	7.50
Grid Block 57 71	7.50
Grid Block 57 72	7.50
Remaining Grid Blocks	7.5×10^{-1}
PAH	7.50
PAI	7.50
WPAA	7.5×10^{-1}

top soil, common soil, and geotextile. The second layer (drainage layer) is about 1 foot thick, made up of sand. The infiltration and radon barrier is about 2 feet thick and is comprised of membrane composites and compacted clay soils.

The fourth layer consists of 2 feet of common soil which lays directly over the concrete vault (layer 5).

Because the Eastern Vault design has not been initiated, it is difficult to characterize the physical properties of the vault cover (e.g., leakage rates, permeability, resistance to degradation, etc.). Therefore, an investigation of concrete vault degradation was conducted for this CRARE. A literature review found that groundwater flow through concrete vaults has been the subject of several studies, and that a wide range of modeling procedures based on many parameters are available.

Studies conducted by Walton and Seitz (1991) on the performance of intact and partially degraded concrete barriers in limiting fluid flow indicate that the leakage rate through a well designed cover is about 0.5 cm/yr (0.2 in/yr). Studies further indicate that an engineered cover over the vault will only improve waste isolation performance if leakage rates can be reduced below 0.1 cm/yr (0.04 in/yr). As the concrete vault degrades and permeability increases, the moisture flux rate becomes dependent upon the cover performance at higher leakage rates.

Typical hydraulic conductivity values of a concrete vault with no cover are given in some of the literature. Walton and Seitz (1991) approximate the hydraulic conductivity at 3.2×10^{-3} to 3.2×10^{-5} cm/yr (1.26×10^{-3} to 1.26×10^{-5} in/yr) for a vault in good condition. A degraded vault would have a conductivity of approximately 3.2×10^{-2} cm/yr 1.26×10^{-2} in/yr). The effect of cracking was specifically excluded because Walton and Seitz (1991) indicate that concrete vaults can be designed to minimize the impact of cracks. This data was used for a preliminary assessment of the potential leakage rate through a concrete vault. In order to represent average values for a 1000-year period, the hydraulic conductivity for a degraded vault was used in this assessment.

Give the hydraulic conductivity, it is necessary to establish the pressure head for perched water above a vault. For the purposes of this study, an average pressure head was assumed to be 10 centimeters (4 inches) throughout the year.

The equation for one-dimensional flow is (Freeze and Cherry 1979):

$$q = K\Delta h/\Delta l \qquad (7)$$

where

- q = leakage (specific discharge),
- K = hydraulic conductivity,
- Δh = difference in head between top and bottom surfaces of vault ceiling, and
- Δl = thickness of vault ceiling.

The thickness of the vault ceiling is not known, so the $\Delta h/\Delta l$ term was set to equal the 10-centimeter (4-inch) assumed head. This is a conservative assumption, since the ceiling thickness would probably range from 5 to 50 centimeters (2 to 20 inches). The calculated leakage rate is 0.32 cm/yr (0.13 in/yr).

Another approach for evaluating the proposed Eastern Vault cover is a comparison with the modeling efforts presented in Appendix E of this Operable Unit 2 FS for a range of cap covers. The cap designs in Appendix E were compared to the design proposed for the Eastern Vault. Four types of caps were evaluated in Appendix E: 1) tumulus cover, 2) concrete vault, 3) exempt waste, and 4) solid waste disposal. The caps ranged in thickness from 3.5 feet (exempt waste cover) to 11 feet (tumulus cover). Estimated infiltration rates through these caps ranged from 0.006 in/yr for the concrete vault and 0.073 in/yr for the tumulus cover, to 2.03 in/yr for the solid waste disposal cap.

In evaluating the proposed Eastern Vault cover, the proposed thickness of this cover is between 7 to 10 feet. This proposed thickness is within the range of the thickness of the concrete vault cover (7 feet) and the tumulus cover (11 feet). In comparison to both covers, the Eastern Vault cover can be assumed to contain similar design features. A vegetative cover over compacted soil

over drainage layers over at least two feet of recompacted clay are common elements in these designs. The infiltration rate for the Eastern Vault would also be similar to the rates for these designs.

Other information on disposal facility design can be found under Alternatives 4A and 4B (on-property waste disposal options) of the Operable Unit 1 FS. HELP modeling by Operable Unit 1 of a 1000-year design period showed that an infiltration rate of 1.3 cm/yr (0.5 in/yr) was a reasonable estimate.

The information presented in this section shows that a range of infiltration values can be considered in setting the infiltration rate for the Eastern Vaults. To be conservative, this rate was set at 1.3 cm/yr (0.5 in/yr) to match the approved rate in the Operable Unit 1 FS. All of the designs discussed in this section focus primarily on the structure of the cap over waste materials. As with the Operable Unit 1 design, the assumption has been made that the exfiltration rate from the vault liner is identical to the infiltration rate. This is reasonable because the leachate collection system in and beneath the floor of the vaults will be constructed of the same concrete as the vault roof, but probably thinner. A much greater head of water could also build up in the leachate sumps, as compared to the sloping roof. This would increase the leakage rate into the subsurface soil.

The infiltration rate for the Eastern Vault is combined with leachate concentration data (Table I.6-1) to provide input data to the vadose zone modeling described in the next section. The conservative assumption is also made that there is no time delay associated with the infiltration of rainwater through the vaults.

I.6.1.4 Vadose Zone Modeling

The source terms that are defined for the groundwater pathway in Section I.6.1.3 were used as input to the vadose zone model. The development of this model is described in the next section, followed by the model results.

I.6.1.4.1 Vadose Zone Model Development

The vadose zone is defined as the unsaturated zone above the groundwater table of the aquifer. In this zone, the interstices are occupied partially by water and partially by air. At the FEMP, two distinct deposits, or layers, have been identified that constitute the vadose zone. The uppermost layer (Layer 1) consists of dense, fine-grained glacial overburden that overlie the unsaturated outwash deposits. Within these till deposits, there are numerous water-bearing zones that have limited interconnection, the majority of which are of glaciofluvial origin and consist of small beds of highly sorted sands and gravels. These beds are probably the result of small meltwater streams that occurred along the ice margin and within the glacier itself. Movement of water and contaminants within these units may be limited due to their limited extent and interconnection. Overlying the Great Miami Aquifer at the FEMP are approximately 4.6 to 11 meters (15 to 35 feet) of unsaturated sand and gravel outwash deposits (Layer 2). These deposits are assumed to have the same hydraulic characteristics as the underlying saturated material since the deposits are essentially the same. Additional information on the hydrogeology of the FEMP is in the SWCR and the RI documents for each operable unit.

Vadose zone modeling was performed to estimate contaminant loading rates to the Great Miami Aquifer from a given source as a function of time. The overburden has a capacity for immobilization and retardation of contaminants due to adsorption, precipitation, biodegradation, and radioactive decay. This capacity to prevent or slow the movement of contaminants to the aquifer has been evaluated with respect to future risk.

A one-dimensional analytical model was selected to evaluate the flow in the vadose zone, ODAST, Version 2 (Javendel et al. 1984). The model was previously selected for use, as discussed in the SWCR, based upon the following factors:

- Analytical methods are the most efficient alternative when data necessary for the characterization of the system is sparse and uncertain.
- These methods are consistent with approaches used for similar radionuclide assessment models such as the flow portions of PRESTO (EPA 1987a and other site studies).
- The basis of the solution is well documented and the software code has been extensively verified.

ODAST was used for determining the fate and transport of the constituents in the unsaturated zone that were retained for study after the screening process of Section I.6.1.2. Based on the solution originally developed by Ogata and Banks (1961), ODAST calculates the normalized concentrations of a given constituent in a uniform flow field from a source having a constant or varying concentration in the initial layer. It evaluates the basic one-dimensional analytical solute transport equation as a function of seepage velocity, dispersion coefficient, source decay, retardation factor, depletion time, and source rate. ODAST has been extensively verified against the model STRIP1B (Batu 1989).

The input flow rates and COC concentrations with time to the ODAST model are the source terms described in Section I.6.1.3 for Operable Units 3 and 5, plus the source terms described for the PRAs in the Operable Unit 1, 2, and 4 FS documents. Two other sets of source terms, from Paddys Run and the storm sewer outfall ditch (SSOD), were input directly to the SWIFT III groundwater model. These are described in Section I.6.1.5. The vadose zone is thinner and consists primarily of coarse material in the areas of surface water recharge to groundwater; therefore, it is reasonable to assume that the contaminant retardation would be minimal.

A utility code, SWIFTLOAD, was written to run ODAST on cell-by-cell or specified-area input. Input files for the ODAST modeling were developed to represent the same 38-by-38 meter (125-by-125-foot) grid cell layout of the SWIFT III model. This allowed the ODAST output to be used as input directly to SWIFT without additional manipulation.

The thickness of each soil layer was gridded and provided to SWIFTLOAD on a cell-by-cell basis. The conductivities used for Layers 1 and 2 were 0.008 and 13.7 m/day (0.0264 and 45 ft/day), respectively. The Layer 1 conductivity was estimated by log averaging the 1000 series-well slug test results (as of February 1993) and dividing by 20 to account for the horizontal-to-vertical ratio. At the direction of Operable Unit 5, three grid cells in the Plant 6 area (PAG on Figure I.6-3) were set to a hydraulic conductivity of .305 m/day (1 ft/day) for Layer 1. This was done to incorporate the effect of building foundations that penetrate this layer in the Plant 6 area.

Because the FEMP site has two distinct layers in the vadose zone, ODAST was run for each to calculate the normalized concentration at the bottom of each layer for each time step. In general, dispersion through the lower layer did not come into effect until the constituent reached the bottom of the adjacent upper layer.

ODAST requires the input of a retardation factor (R_f), which is derived from the K_d by the equation:

$$R_f = 1 + K_d \rho_b/\theta \qquad \text{(I.6-2)}$$

where

R_f = retardation factor
ρ_b = bulk density
θ = moisture content
K_d = soil partitioning coefficient

The SWCR estimates that the bulk densities of Layers 1 and 2 are 1.78 and 1.60 g/cc, respectively, and the moisture contents are 28 and 14 percent, respectively. The Operable Unit 2 FS and Operable Unit 5 RI has re-evaluated the K_d values for uranium that were originally provided in the SWCR. An analysis is presented in *Groundwater Model Improvement Task Objectives and Technical Approach, Zonation and Values of Geochemical Parameters*, which is included in Attachment I.V. Operable Units 1, 2, and 4 have also developed some site-specific K_d and R_f values for uranium. Most of the K_d values for COCs other than uranium remained the same as those listed in the SWCR.

Table I.6-3 lists the specific K_d and R_f values for the groundwater pathway COCs, and also the radioactive decay constants. A biodegradation coefficient is not available for the only organic compound among these COCs, Aroclor-1221. The decay constants are also taken from the SWCR.

Operable Unit 5 is currently planning to fully remediate the perched water within the vadose zone beneath the central portion of the FEMP. Therefore, this perched water is not included in the vadose zone modeling as a source of contaminants.

TABLE I.6-3
VADOSE ZONE MODEL PARAMETERS

COC	Layer 1 K_d (ml/g)	Layer 1 R_f (unitless)	Layer 2 K_d (ml/g)	Layer 2 R_f (unitless)	Radioactive Decay Constant (day^{-1})
U-238					
OU1 Area	240	1257	1.78	11.75	4.25×10^{-13}
OU4 Area	12	63.82	1.78	11.75	4.25×10^{-13}
OU2					
SWL	24	109.3	1.78	38.38	4.25×10^{-13}
LSP	24	109.3	1.78	51.77	4.25×10^{-13}
AFP	24	109.3	1.78	37.75	4.25×10^{-13}
IFP/SF :					
Cell (28,66)	24	109.3	1.78	36.82	4.25×10^{-13}
Cell (28,65)	24	109.3	1.78	36.82	4.25×10^{-13}
Cell (29,63)	24	109.3	1.78	39.85	4.25×10^{-13}
Cell (30,62)	24	109.3	1.78	36.82	4.25×10^{-13}
Cell (29,60)	24	109.3	1.78	36.82	4.25×10^{-13}
Cell (30,58)	24	109.3	1.78	36.82	4.25×10^{-13}
Cell (30,63)	24	109.3	1.78	36.82	4.25×10^{-13}
Cell (28,59)	24	109.3	1.78	39.85	4.25×10^{-13}
Cell (29,59)	24	109.3	1.78	39.85	4.25×10^{-13}
Cell (30,64)	24	109.3	1.78	48.87	4.25×10^{-13}
Cell (30,60)	24	109.3	1.78	49.44	4.25×10^{-13}
Disposal Cell	3.1	14.99	1.78	48.50	4.25×10^{-13}
Site-Wide Soils	24	263.9	1.78	11.75	4.25×10^{-13}
Tc-99					
OU1 Area	0.12	1.75	0.07	1.80	8.92×10^{-9}
Site-Wide Soils	0.12	1.75	0.07	1.80	8.92×10^{-9}
Np-237	55	289	2.69	31.8	8.87×10^{-10}
Ra-226					
Site-Wide Soils	696	7.62×10^{3}	106	9.65×10^{2}	1.19×10^{-6}
Cadmium					
OU1 Area	500	2618	12	74.85	NA
Site-Wide Soils	500	3180	12	138	NA
Antimony					
OU1 Area	250	1310	45	278	NA
Site-Wide Soils	250	1590	45	515	NA
Aroclor-1221	235	1500	101	1160	NA

TABLE I.6-3
(Continued)

COC	Layer 1 K_d (ml/g)	Layer 1 R_f (unitless)	Layer 2 K_d (ml/g)	Layer 2 R_f (unitless)	Radioactive Decay Constant (day^{-1})
Arsenic					
Site-Wide Soils	200	2.19×10^3	200	1.82×10^3	NA
Beryllium					
Site-Wide Soils	1300	1.42×10^4	250	2.27×10^3	NA

NA = Not Applicable. COC does not radioactively decay.
SOURCES: SWCR (DOE 1993a)
OU1 FS Report (DOE 1994b)
OU2 FS Report (DOE 1994a)
OU4 FS Report (DOE 1993b)
Groundwater Model Improvement Task Objectives and Technical Approach Zonation and Values of Geochemical Parameters (Attachment I.V)

Section I.5.0 describes how exposure scenarios have been developed for this CRARE. ODAST runs were completed for each COC, to simulate the Current Land Use and both Future Land Use scenarios. The Current Land Use scenario included only a 70-year period and assumed that leachate from the vaults and disposal cell were captured and not allowed to infiltrate the vadose zone. The Future Land Use scenarios included 1000 years and assumed that all source areas were releasing COCs as described in this section.

I.6.1.4.2 Vadose Zone Model Results

Loading rates to the Great Miami Aquifer were estimated for each COC for the SWIFT cells at each source area using ODAST. Attachment I.I provides a listing of the mass loading rates for U-238 to the Great Miami Aquifer for 1000 years from each waste area. Table I.6-4 provides summaries of the total mass loading from the vadose zone modeling for the Current and Future Land Use scenarios. Figure I.6-4 provides a graphical representation of the data in the column labeled Mass Transport to Groundwater After 1000 Years. COCs, or specific areas under each COC, that did not have significant loading are not shown. In the table, the values in the Mass Transport to Groundwater columns are generally less than the mass of the COC removed from the source area, because some of the COC remains in transit through the vadose zone at the end of the specified time period. The time at which the remaining mobile mass becomes zero is also provided. A value of either 1 gram or 1 billionth (10^{-9}) of the Initial Mobile Mass for each area (whichever is smaller) is assumed to be equivalent to a zero mass value.

Figure I.6-5 depicts the source depletion rate of U-238 from the soils of all operable units. This does not include the U-238 associated with the Operable Unit 3 building rubble in the Eastern Vaults. In SWCR studies, loading rates were found to be sensitive to changes in the leach rate of the waste, thickness of the vadose zone, dispersion coefficient, interstitial water velocity, retardation factor, radioactive decay factor, biodegradation, and depletion time of the source. The loading rates were used as input for SWIFT III to model the groundwater movement and solute transport in the Great Miami Aquifer. Section I.10.3 analyzes the uncertainties related to modeling the groundwater pathway.

TABLE I.6-4
SUMMARY OF VADOSE ZONE MODELING RESULTS

Source Area	Initial Mass (mg)	Current Land Use Scenario Mass Transport to Groundwater After 70 Years (mg)	Future Land Use Scenarios Mass Transport to Groundwater After 1000 Years (mg)	Future Land Use Scenarios Remaining Mass At 1000 Years (mg)	Time at Which Remaining Mass Becomes Zero (Years)[a]
U-238					
Eastern Vaults	2.635×10^{12}	0.000×10^{0}	0.000×10^{0}	2.635×10^{12}	4.665×10^{9}
OU4 Contaminated Soils	1.083×10^{7}	0.000×10^{0}	1.030×10^{7}	0.000×10^{0}	7.0×10^{1}
OU1 Contaminated Soils	2.876×10^{10}	0.000×10^{0}	0.000×10^{0}	1.567×10^{10} and 5.919×10^{9}[b]	5.686×10^{4} and 4.673×10^{5}[b]
OU2					
SWLF	9.410×10^{8}	0.000×10^{0}	6.022×10^{5}	9.359×10^{8}	3.968×10^{6}
LSP	1.362×10^{8}	5.059×10^{-41}	2.072×10^{7}	7.504×10^{6}	1.396×10^{4}
AFP	4.260×10^{7}	3.195×10^{-54}	7.246×10^{6}	1.333×10^{8}	5.464×10^{5}
IFP: Fill over GMA	8.600×10^{7}	6.841×10^{5}	2.302×10^{7}	6.200×10^{7}	6.242×10^{4}
SF: Fill over GMA	6.990×10^{8}	9.116×10^{1}	6.911×10^{3}	6.990×10^{8}	1.935×10^{9}
SF: Impacted Till	3.104×10^{8}	1.103×10^{1}	5.913×10^{2}	3.104×10^{8}	5.051×10^{9}
SE Disp Cell Interior	1.992×10^{11}	0.000×10^{0}	9.534×10^{4}	1.289×10^{11}	4.763×10^{4}
SE Disposal Cell Berm	1.402×10^{11}	0.000×10^{0}	2.375×10^{5}	8.664×10^{10}	4.111×10^{4}
Site-Wide Soils					
560A	1.205×10^{10}	0.000×10^{0}	3.747×10^{7}	5.104×10^{9}	2.413×10^{4}
560B	1.846×10^{10}	0.000×10^{0}	0.000×10^{0}	1.694×10^{10}	2.418×10^{5}
560C	1.163×10^{9}	0.000×10^{0}	0.000×10^{0}	0.000×10^{0}	7.886×10^{2}
560D	1.017×10^{9}	0.000×10^{0}	0.000×10^{0}	9.338×10^{8}	2.418×10^{5}
570A	5.320×10^{9}	0.000×10^{0}	2.327×10^{3}	2.252×10^{9}	2.413×10^{4}
570B	5.087×10^{9}	0.000×10^{0}	1.904×10^{-14}	4.673×10^{9}	2.420×10^{5}
570C	4.238×10^{9}	0.000×10^{0}	1.831×10^{8}	1.794×10^{9}	2.420×10^{5}
570D	4.942×10^{9}	0.000×10^{0}	1.046×10^{-54}	4.536×10^{9}	2.418×10^{5}
570E	3.415×10^{9}	0.000×10^{0}	9.506×10^{6}	1.446×10^{9}	2.413×10^{4}
575A	4.011×10^{9}	8.013×10^{-56}	6.087×10^{8}	1.699×10^{9}	2.413×10^{4}
575B	1.367×10^{9}	7.287×10^{-71}	1.220×10^{8}	5.789×10^{8}	2.413×10^{4}

See footnotes at end of table.

000148

5862

TABLE I.6-4
(Continued)

Source Area	Initial Mass (mg)	Current Land Use Scenario Mass Transport to Groundwater After 70 Years (mg)	Future Land Use Scenarios Mass Transport to Groundwater After 1000 Years (mg)	Future Land Use Scenarios Remaining Mass At 1000 Years (mg)	Time at Which Remaining Mass Becomes Zero (Years)[a]
580A	1.712×10^{9}	0.000×10^{0}	2.366×10^{8}	7.251×10^{8}	2.413×10^{4}
581A	1.588×10^{10}	0.000×10^{0}	1.174×10^{8}	6.725×10^{9}	2.413×10^{4}
581B	2.573×10^{10}	0.000×10^{0}	3.681×10^{-19}	2.361×10^{10}	2.418×10^{5}
581C	3.943×10^{9}	0.000×10^{0}	1.683×10^{-25}	1.670×10^{9}	2.413×10^{4}
581D	8.719×10^{8}	0.000×10^{0}	1.446×10^{-63}	0.000×10^{0}	7.880×10^{2}
582A	2.323×10^{9}	1.310×10^{2}	3.367×10^{8}	9.833×10^{8}	2.413×10^{4}
582B	1.163×10^{9}	3.216×10^{4}	6.993×10^{6}	1.067×10^{9}	2.418×10^{5}
PAA	5.088×10^{9}	0.000×10^{0}	0.000×10^{0}	0.000×10^{0}	7.886×10^{2}
PAB	1.221×10^{10}	0.000×10^{0}	5.059×10^{-18}	0.000×10^{0}	7.880×10^{2}
PAC	5.233×10^{10}	0.000×10^{0}	1.664×10^{-20}	4.671×10^{10}	2.180×10^{5}
PAD	1.386×10^{10}	0.000×10^{0}	2.292×10^{-18}	1.166×10^{10}	1.199×10^{5}
PAE	6.047×10^{10}	0.000×10^{0}	1.048×10^{9}	5.095×10^{10}	1.743×10^{5}
PAF	4.070×10^{9}	0.000×10^{0}	2.401×10^{-16}	3.738×10^{9}	2.420×10^{5}
PAG	2.471×10^{9}	0.000×10^{0}	2.556×10^{-13}	2.268×10^{9}	2.418×10^{5}
PAH	1.532×10^{10}	0.000×10^{0}	3.284×10^{8}	6.487×10^{9}	2.680×10^{4}
PAI	3.697×10^{9}	0.000×10^{0}	2.440×10^{8}	1.566×10^{9}	2.680×10^{4}
WPAA	1.410×10^{10}	6.036×10^{-43}	4.048×10^{6}	1.294×10^{10}	2.418×10^{5}
Tc-99					
Eastern Vaults	2.615×10^{4}	7.849×10^{2}	2.599×10^{4}	0.000×10^{0}	7.0×10^{1}
OU1 Contaminated Soils	8.220×10^{4}	3.804×10^{4}	8.218×10^{4}	0.000×10^{0}	7.0×10^{1}
Site-Wide Soils					
Main Plant Area	1.818×10^{5}	1.081×10^{5}	1.818×10^{5}	0.000×10^{0}	7.0×10^{1}
East Plant Area	2.383×10^{3}	1.166×10^{3}	2.383×10^{3}	0.000×10^{0}	7.0×10^{1}
West Plant Area	5.107×10^{3}	2.935×10^{3}	5.107×10^{3}	0.000×10^{0}	7.0×10^{1}

See footnotes at end of table.

TABLE I.6-4
(Continued)

Source Area	Initial Mass (mg)	Current Land Use Scenario Mass Transport to Groundwater After 70 Years (mg)	Future Land Use Scenarios Mass Transport to Groundwater After 1000 Years (mg)	Future Land Use Scenarios Remaining Mass At 1000 Years (mg)	Time at Which Remaining Mass Becomes Zero (Years)[a]
Np-237					
OU1 Contaminated Soils	1.140×10^5	0.000×10^0	0.000×10^0	3.837×10^4	1.299×10^4 and 1.069×10^5 [b]
Site-Wide Soils					
Plant 2/3	2.248×10^5	0.000×10^0	0.000×10^0	1.766×10^4	1.085×10^3
Plant 6	1.241×10^5	0.000×10^0	0.000×10^0	7.246×10^2	1.006×10^3
Ra-226					
560A	3.142×10^2	0.000×10^0	0.000×10^0	2.527×10^2	2.927×10^4
560B	7.470×10^1	0.000×10^0	0.000×10^0	7.301×10^1	3.659×10^4
560C	4.707×10^0	0.000×10^0	0.000×10^0	4.599×10^0	3.659×10^4
560D	4.106×10^0	0.000×10^0	0.000×10^0	4.023×10^0	3.659×10^4
570A	2.762×10^1	0.000×10^0	0.000×10^0	2.221×10^1	3.659×10^4
570B	2.048×10^1	0.000×10^0	0.000×10^0	2.012×10^1	3.659×10^4
570C	4.751×10^1	0.000×10^0	0.000×10^0	3.826×10^1	3.659×10^4
570D	1.991×10^1	0.000×10^0	0.000×10^0	1.954×10^1	3.659×10^4
570E	2.167×10^1	0.000×10^0	0.000×10^0	1.748×10^1	3.659×10^4
575A	6.754×10^1	0.000×10^0	0.000×10^0	5.433×10^1	3.659×10^4
575B	9.403×10^0	0.000×10^0	0.000×10^0	7.557×10^0	3.659×10^4
580A	2.775×10^1	0.000×10^0	0.000×10^0	2.230×10^1	3.659×10^4
581A	3.002×10^2	0.000×10^0	0.000×10^0	2.423×10^2	3.659×10^4
581B	1.039×10^2	0.000×10^0	0.000×10^0	1.017×10^2	3.659×10^4
581C	3.338×10^1	0.000×10^0	0.000×10^0	2.692×10^1	2.927×10^4
581D	3.522×10^0	0.000×10^0	0.000×10^0	3.449×10^0	3.659×10^4
582A	8.146×10^1	0.000×10^0	0.000×10^0	6.565×10^1	2.927×10^4

See footnotes at end of table.

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TABLE I.6-4
(Continued)

Source Area	Initial Mass (mg)	Current Land Use Scenario Mass Transport to Groundwater After 70 Years (mg)	Future Land Use Scenarios Mass Transport to Groundwater After 1000 Years (mg)	Future Land Use Scenarios Remaining Mass At 1000 Years (mg)	Time at Which Remaining Mass Becomes Zero (Years)[a]
582B	4.694×10^{0}	2.789×10^{-33}	2.550×10^{-6}	4.598×10^{0}	3.659×10^{4}
PAA	2.055×10^{1}	0.000×10^{0}	0.000×10^{0}	2.012×10^{1}	3.659×10^{4}
PAB	4.928×10^{1}	0.000×10^{0}	0.000×10^{0}	4.827×10^{1}	3.659×10^{4}
PAC	9.726×10^{1}	0.000×10^{0}	0.000×10^{0}	2.077×10^{2}	3.659×10^{4}
PAD	5.121×10^{1}	0.000×10^{0}	0.000×10^{0}	5.586×10^{1}	3.659×10^{4}
PAE	3.786×10^{2}	0.000×10^{0}	0.000×10^{0}	2.437×10^{2}	3.659×10^{4}
PAF	1.639×10^{1}	0.000×10^{0}	0.000×10^{0}	1.609×10^{1}	3.659×10^{4}
PAG	9.986×10^{0}	0.000×10^{0}	0.000×10^{0}	9.772×10^{0}	3.659×10^{4}
PAH	6.233×10^{1}	0.000×10^{0}	0.000×10^{0}	5.007×10^{1}	2.927×10^{4}
PAI	3.584×10^{1}	0.000×10^{0}	0.000×10^{0}	2.882×10^{1}	2.927×10^{4}
WPAA	5.691×10^{1}	0.000×10^{0}	0.000×10^{0}	5.575×10^{1}	3.659×10^{4}
Cadmium					
Eastern Vaults	8.895×10^{8}	0.000×10^{0}	0.000×10^{0}	0.000×10^{0}	7.0×10^{1}
OU1 Contaminated Soils	9.319×10^{8}	0.000×10^{0}	0.000×10^{0}	8.100×10^{8}	1.181×10^{5} and 9.735×10^{5} [b]
Site-Wide Soils					
Plant 2/3	1.835×10^{8}	0.000×10^{0}	0.000×10^{0}	1.800×10^{8}	5.317×10^{4}
Plant 9	1.435×10^{8}	0.000×10^{0}	0.000×10^{0}	1.408×10^{8}	5.317×10^{4}
Remainder	4.176×10^{9}	0.000×10^{0}	0.000×10^{0}	3.460×10^{8}	1.102×10^{5}
Antimony					
Eastern Vaults	4.618×10^{9}	0.000×10^{0}	0.000×10^{0}	0.000×10^{0}	8.829×10^{2}
OU1 Contaminated Soils	4.371×10^{9}	0.000×10^{0}	0.000×10^{0}	3.316×10^{9}	5.906×10^{4} and 4.865×10^{5} [b]

See footnotes at end of table.

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TABLE I.6-4
(Continued)

Source Area	Initial Mass (mg)	Current Land Use Scenario Mass Transport to Groundwater After 70 Years (mg)	Future Land Use Scenarios Mass Transport to Groundwater After 1000 Years (mg)	Future Land Use Scenarios Remaining Mass At 1000 Years (mg)	Time at Which Remaining Mass Becomes Zero (Years)[a]
Site-Wide Soils					
Plant 6	3.215×10^{8}	0.000×10^{0}	0.000×10^{0}	3.126×10^{8}	7.374×10^{5}
Plant 9	7.985×10^{7}	0.000×10^{0}	0.000×10^{0}	7.764×10^{7}	7.374×10^{5}
Remainder	8.539×10^{9}	0.000×10^{0}	0.000×10^{0}	6.445×10^{9}	7.371×10^{4}
Aroclor-1221					
Eastern Vaults	1.322×10^{7}	0.000×10^{0}	0.000×10^{0}	0.000×10^{0}	7.0×10^{1}
Site-Wide Soils					
Plant 2/3	2.200×10^{8}	0.000×10^{0}	0.000×10^{0}	2.135×10^{8}	7.803×10^{5}
Plant 9	1.163×10^{7}	0.000×10^{0}	0.000×10^{0}	1.129×10^{7}	7.803×10^{5}
Remainder	2.701×10^{8}	0.000×10^{0}	0.000×10^{0}	2.004×10^{8}	7.801×10^{4}
Arsenic					
560A	9.411×10^{9}	0.000×10^{0}	0.000×10^{0}	3.626×10^{9}	2.174×10^{4}
560B	1.628×10^{9}	0.000×10^{0}	0.000×10^{0}	1.628×10^{9}	1.051×10^{4}
560C	6.582×10^{7}	0.000×10^{0}	0.000×10^{0}	6.582×10^{7}	1.051×10^{4}
560D	7.427×10^{7}	0.000×10^{0}	0.000×10^{0}	7.427×10^{7}	1.051×10^{4}
570A	1.065×10^{9}	0.000×10^{0}	0.000×10^{0}	4.104×10^{8}	2.174×10^{4}
570B	7.938×10^{8}	0.000×10^{0}	0.000×10^{0}	7.938×10^{8}	1.051×10^{4}
570C	7.335×10^{8}	0.000×10^{0}	0.000×10^{0}	2.825×10^{8}	2.174×10^{4}
570D	3.079×10^{8}	0.000×10^{0}	0.000×10^{0}	3.079×10^{8}	1.051×10^{4}
570E	8.392×10^{8}	0.000×10^{0}	0.000×10^{0}	3.233×10^{8}	2.174×10^{4}
575A	1.220×10^{9}	0.000×10^{0}	0.000×10^{0}	4.700×10^{8}	2.174×10^{4}
575B	8.605×10^{7}	0.000×10^{0}	0.000×10^{0}	3.315×10^{7}	2.174×10^{4}
580A	5.952×10^{8}	0.000×10^{0}	0.000×10^{0}	2.293×10^{8}	2.174×10^{4}

See footnotes at end of table.

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TABLE I.6-4
(Continued)

Source Area	Initial Mass (mg)	Current Land Use Scenario Mass Transport to Groundwater After 70 Years (mg)	Future Land Use Scenarios Mass Transport to Groundwater After 1000 Years (mg)	Future Land Use Scenarios Remaining Mass At 1000 Years (mg)	Time at Which Remaining Mass Becomes Zero (Years)[a]
581A	7.336×10^{9}	0.000×10^{0}	0.000×10^{0}	2.826×10^{9}	2.174×10^{4}
581B	1.585×10^{9}	0.000×10^{0}	0.000×10^{0}	1.585×10^{9}	1.051×10^{4}
581C	2.734×10^{8}	0.000×10^{0}	0.000×10^{0}	1.053×10^{8}	2.174×10^{4}
581D	6.018×10^{7}	0.000×10^{0}	0.000×10^{0}	6.018×10^{7}	1.051×10^{4}
582A	1.736×10^{9}	0.000×10^{0}	0.000×10^{0}	6.690×10^{8}	2.174×10^{4}
582B	1.814×10^{8}	1.619×10^{-46}	9.395×10^{0}	1.814×10^{8}	1.051×10^{4}
PAA	3.903×10^{8}	0.000×10^{0}	0.000×10^{0}	3.903×10^{8}	1.051×10^{4}
PAB	1.904×10^{9}	0.000×10^{0}	0.000×10^{0}	1.904×10^{9}	1.051×10^{4}
PAC	4.228×10^{9}	0.000×10^{0}	0.000×10^{0}	4.100×10^{9}	2.907×10^{6}
PAD	7.537×10^{8}	0.000×10^{0}	0.000×10^{0}	7.440×10^{8}	1.598×10^{6}
PAE	2.745×10^{9}	0.000×10^{0}	0.000×10^{0}	2.704×10^{9}	2.325×10^{6}
PAF	4.721×10^{8}	0.000×10^{0}	0.000×10^{0}	4.721×10^{8}	1.051×10^{4}
PAG	3.014×10^{8}	0.000×10^{0}	0.000×10^{0}	3.014×10^{8}	1.051×10^{4}
PAH	9.383×10^{8}	0.000×10^{0}	7.914×10^{-74}	3.615×10^{8}	2.174×10^{4}
PAI	5.674×10^{8}	0.000×10^{0}	0.000×10^{0}	2.186×10^{8}	2.174×10^{4}
WPAA	9.700×10^{8}	0.000×10^{0}	0.000×10^{0}	9.700×10^{8}	1.051×10^{4}

[a]The time at which the mobile mass becomes negligibly small is defined as the smaller of 1 gram or 10^{-9} times the original mass.
[b]The values given are for surface soil without cover and surface soil with cover, respectively.

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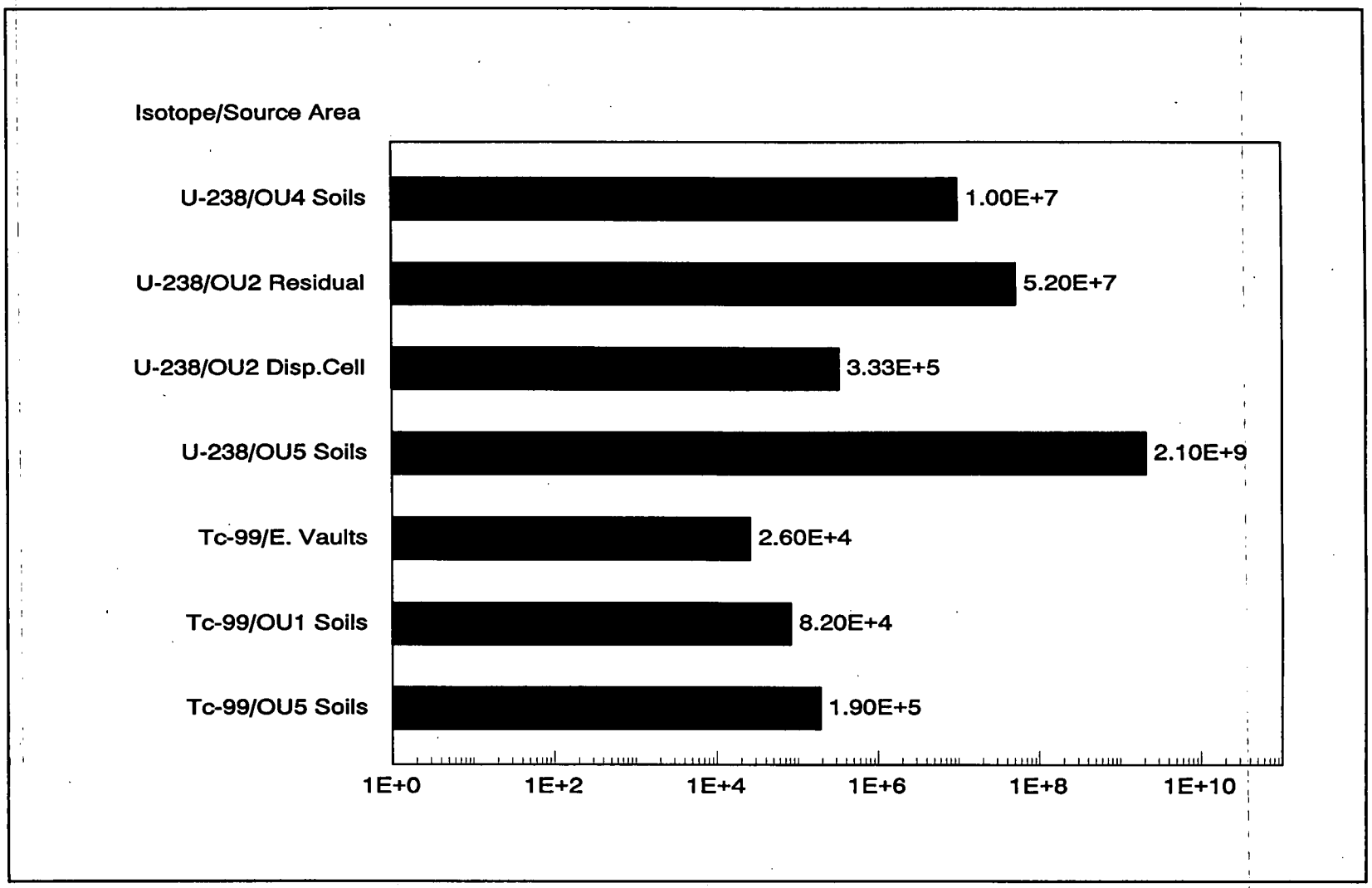

FIGURE I.6-4
MASS TRANSPORTED TO GROUNDWATER AFTER 1000 YEARS (mg)

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The loading rates of a constituent traveling to the aquifer from a given source vary over time. Typically, loading rates increase sharply during an initial time period and then stabilize or decrease, depending on the depletion time of the source. For longer depletion times, the source remains active longer during the simulation, and may approach a steady-state condition within the 1000-year simulation time of the Future Land Use scenarios.

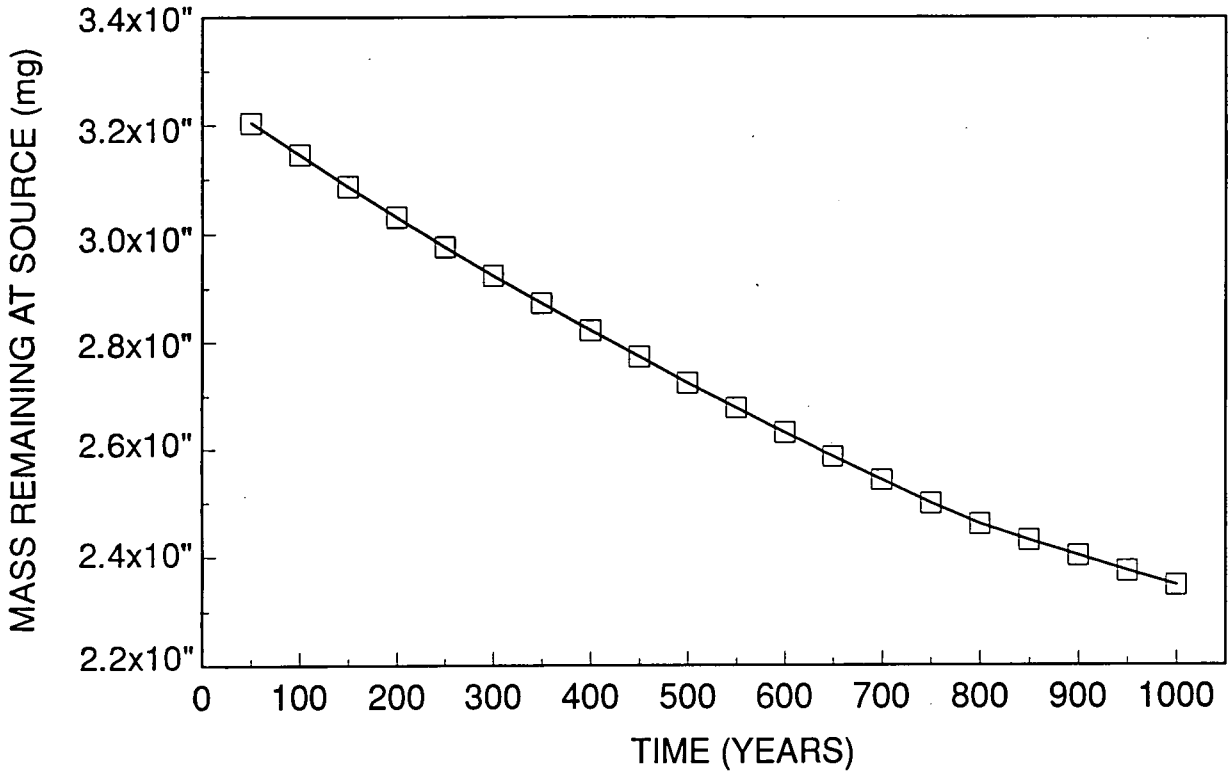

FIGURE I.6-5

DEPLETION RATE OF U-238 FROM THE RESIDUAL SOILS

I.6.1.5 Surface Water Modeling

Surface water modeling was used for two purposes: to define source terms for the SWIFT III groundwater model and to estimate contaminant concentrations in surface water bodies as an exposure medium. Potential exposures for a future recreational use of surface water include dermal contact and incidental ingestion. Additional exposures include residential and agricultural uses of the Great Miami River.

I.6.1.5.1 Surface Water Model Development

Surface soil was estimated to be the only source of surface water contamination for this CRARE. The Operable Unit 3 vaults were not included as sources because they have been designed with floors recessed below ground level and leachate collection systems located beneath the floors. Leachate that contacts the waste will collect in these subsurface systems rather than exit to surface runoff. At the end of any maintenance period, the subsurface collection systems are expected to develop leaks such that all leachate will escape downward to groundwater. The capped areas of Operable Unit 1 and the Operable Unit 2 disposal cell are expected to maintain their integrity so that no wastes are exposed to surface runoff.

Only the COCs that passed the screening of Section I.6.1.2 were evaluated for surface water transport. The same soil retention effects (characterized by R_f) that delay the release of COCs from the vadose zone soils also delay the release of the COCs from surface soils to surface water. Additional COCs may be evaluated for surface water transport in future versions of the CRARE. Only U-238, Tc-99, Np-237, Ra-226, antimony, arsenic, and beryllium were modeled for surface water transport. Aroclor-1221, and cadmium were screened out because they are not Constituents of Potential Concern in surface water (Baseline and Future conditions) in the Operable Unit 5 RI report.

The SWCR conducted surface water modeling for a wide range of COCs and reported that, with the exception of uranium, concentrations in the receiving streams were predicted to be generally very low. The SWCR estimates that future surface water concentrations in the Great Miami River are below 1 pCi/l for all radionuclides except the uranium isotopes. Activity concentrations for U-234, U-235/236, and U-238 are estimated at 24, 1.3, and 28 pCi/l, respectively. Modeled concentrations for organic compounds range from 4.9×10^{-11} to 1.1×10^{-4} mg/l and are all below

usual analytical detection levels. Modeled concentrations for inorganics except uranium range from 3.8×10^{-7} to 1.4×10^{-5} mg/l, also below analytical detection levels. The SWCR also includes risk assessments for surface water concentrations.

The FEMP is located on a gently sloping plateau bounded on the north and east sides by distinct drainage divides and on a third side by Paddys Run, a small intermittent stream. A topographic map of the FEMP is shown in Figure I.1-3 (Section I.1.3.2). Surface water transport of contaminants at the FEMP occurs intermittently, principally during rainstorms. Free-flowing surface water on the FEMP eventually flows down one of three drainage features to the Great Miami River. Two of these are Paddys Run and the SSOD, the primary drainage features on the property. The third, a small watershed in the northeast corner of the FEMP which drains to the east, was eliminated from further study because it contains no discernable sources.

Several areas are currently served by a system of engineered drainage features, such as ditches and runoff collection basins, as described in further detail by WEMCO (1991). The two most significant areas drained by this system are the production and the waste storage areas. Runoff from the Production Area, plus the incinerator area was assumed to continue to flow into the SSOD after FEMP remediation. Runoff from the silo area, waste storage area, and South Field was assumed to continue to enter Paddys Run. To be conservative, the assumption has been made that stormwater runoff patterns in the future will be similar to present conditions. The same assumption was used for surface water runoff modeling in the SWCR.

Modeling of surface water flow and transport was modified from the Operable Unit 4 CRARE approach. This approach is described in the *Surface Water Flow and Infiltration Model Summary Report* (SWF&IM report) and is briefly described here. The primary purpose of the SWF&IM report is to provide information concerning the hydrology and hydraulics of the Paddys Run drainage basin needed to conduct modeling of future containment transport in the surface water at the FEMP. The technical approach used for the fate and transport modeling is also described in the report.

The Surface Water Flow and Infiltration Model (SWF&IM) was applied first in the process of modeling surface water flow and transport. It is a subset of the larger, overall approach to this

modeling, and provides results to be used in contaminant transport calculations. In general, the SWF&IM is only concerned with the movement of water and does not consider contaminant transport. The SWF&IM consists of the following components. The rainfall and runoff are simulated with the HEC-1 modeling code (U.S. Army Corps of Engineers 1990). Rating curves for cross-sections along Paddys Run and the SSOD are generated using Manning's equation (Henderson 1966). Manning's equation is applied along Paddys Run and the SSOD to determine the elevation of water in the stream (stage) at each cross section for a given flow rate (discharge). This relationship between stage and discharge at a cross section of a stream is called a rating curve. Drainage basins at the FEMP and the cross-section locations are shown in Figure I.6-6.

To calculate infiltration from surface water to the Great Miami Aquifer, the computer code VS2DT (Healy 1990) was applied at each cross section. A time-varying depth of water was input into the VS2DT program for the infiltration calculations to simulate the fluctuation of flow depths in the streams during a storm. The stream water depth was based on the runoff hydrographs from HEC-1 combined with the rating curves developed with Manning's equation. The output from VS2DT provided the infiltration volumes to the Great Miami Aquifer along the length of Paddys Run and the SSOD. The runoff hydrographs and infiltration information were then used in calculating contaminant concentrations and loadings.

The calculations of the contaminant concentrations in the surface water bodies required estimates of the surface water flow rates and volumes, and estimates of the amount of contaminants being transported from the source soil with the runoff. The contaminant can move with the runoff in two phases: absorbed to sediment eroded from the land surface or dissolved in the runoff itself. The amount of contaminant absorbed to the sediment and the amount dissolved in the surface water runoff were estimated with partitioning equations presented in the Superfund Exposure Assessment Manual (EPA 1988). The amount of sediment generated from a single storm was estimated with the Modified Universal Soil Loss Equation (MUSLE), which is also presented in the manual.

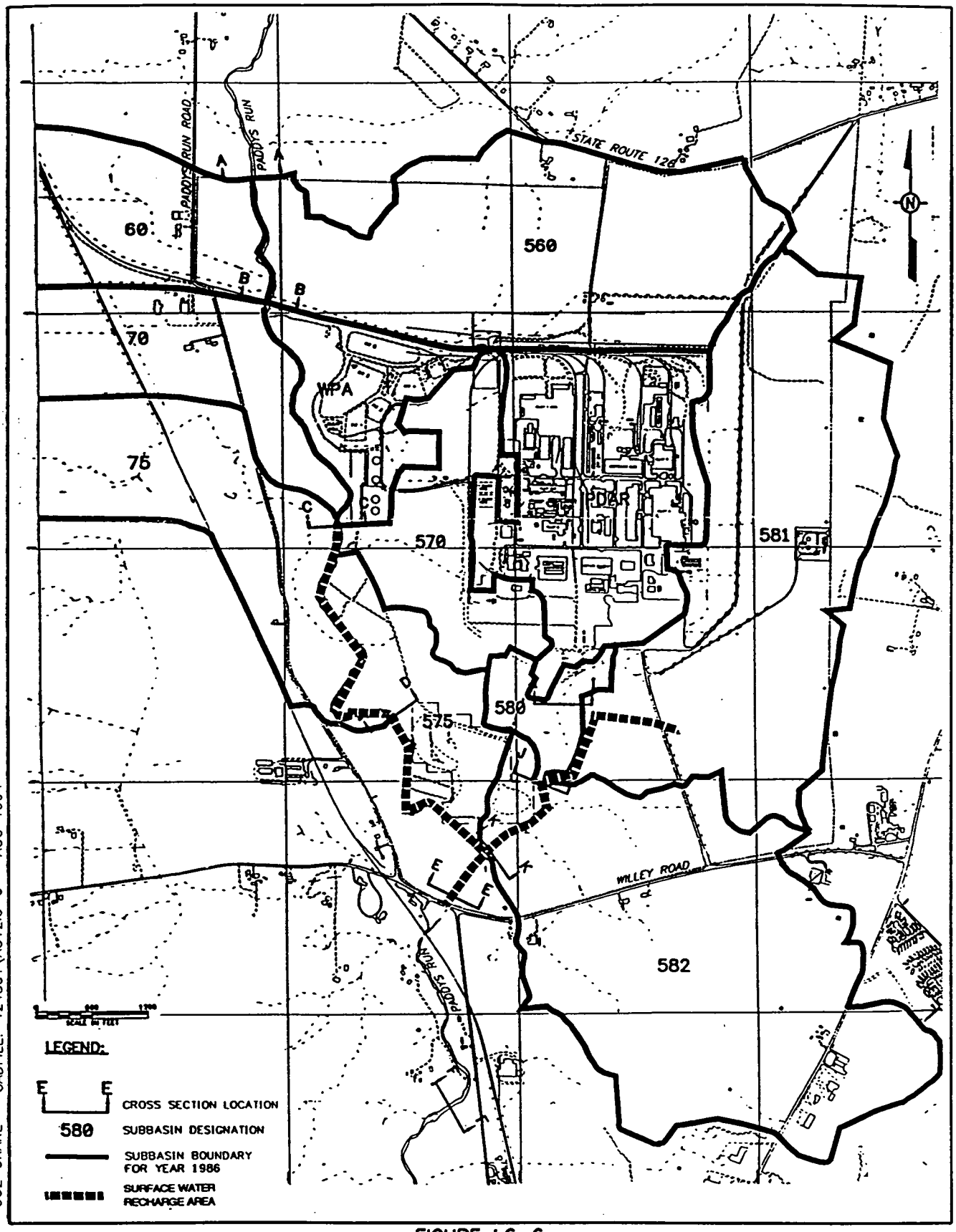

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FIGURE 1.6-6
PADDYS RUN DRAINAGE SUBBASINS
FOR HEC-1 MODEL CONTAMINATION CALCULATIONS

The 1000-year duration of the Future Land Use scenario could make depletion of the source soil an important consideration in determining surface water concentrations and the contaminant loadings to the Great Miami Aquifer. The annual soil depletion was calculated in the Operable Unit 5 RI using the Universal Soil Loss Equation (USLE) presented in the Superfund Exposure Assessment Manual (EPA 1988). The preliminary results of the USLE calculations indicated that the source soil would not erode completely during the 1000-year time frame. Because the contaminated source soils would still be present during the time frame of the study, the depletion of the source soil by erosion was not significant and was not used in the procedure. Therefore, the loadings were assumed to be constant over the 1000 years.

The contaminant concentrations in Paddys Run and the SSOD were calculated by combining runoff from contaminated subbasins with runoff from uncontaminated subbasins. This mixing is based on dilution factors between the subbasin flow and the receiving stream (Paddys Run, the SSOD or the Great Miami River). These calculations were performed using the dilution factors and dissolved contaminant masses from the partitioning equations.

To be conservative, the procedure for estimating concentrations in the surface water assumed that no mass of contaminant is lost to infiltration through the streambeds. This assumption would represent a worst-case scenario for concentrations in the surface water. If a storm occurred when the streambeds are saturated (i.e., immediately following a previous storm or in the spring when storms occur frequently), little or no dissolved contaminant would infiltrate through the streambeds. If the storm occurred at any other time, more contaminant would likely infiltrate, leaving less contaminant for the concentration in the surface waters.

Two contaminant loading rates were calculated to simulate the loading to the Great Miami Aquifer for the entire year: the loading due to a single representative storm, and an average loading for six months of the year. The assumption of loading only for six months per year is based on the concept that flow in Paddys Run, and hence the contaminant loading, does not occur continually throughout the year since Paddys Run and its tributaries are often dry for extended periods. The single representative storm loading rate was used to simulate the relatively few number of large storms per year that create substantial amounts of runoff. The average loading was used to represent the common storms that occur during the year.

To be conservative, the procedure for estimating contaminant loadings to the groundwater due to infiltration through the streambeds of Paddys Run and the SSOD was based on infiltration calculations that assume the streambeds are initially unsaturated. This establishes conservatively high rates of infiltration and contaminant transport through the streambed to the Great Miami Aquifer.

Stormwater management is not included as an ongoing activity for site-wide soils in the remedial alternatives (Section I.2.2) after FEMP remediation. However, several stormwater retention structures are assumed to remain after remediation, as discussed in Section I.2.3. Section I.5.0 describes how exposure scenarios have been developed for this CRARE. Model runs were completed for each COC to simulate the Current Land Use and both Future Land Use scenarios. The first run covered a 70-year period and assumed that stormwater discharge to the SSOD from the Production Area was first captured in stormwater retention basins and then treated to remove the COCs. The second run, which addressed both Future Land Use scenarios, covered 1000 years and assumed that there was no capture and treatment of stormwater.

I.6.1.5.2 Surface Water Model Results

COC concentrations in surface water predicted to occur under the Current Land Use and Future Land Use scenarios are listed in Table I.6-5. The surface water modeling results as a source to groundwater are summarized in Table I.6-6. The locations of the surface water recharge to groundwater are shown in Figure I.6-6. Concentrations and loading rates for all COCs were assumed to be constant over the full 70- or 1000-year duration of each scenario.

I.6.1.6 Aquifer Modeling

This section describes the prior development of the SWIFT III groundwater model as a standard approach for the FEMP site. The specific use of the model for this CRARE is also described, as are the modeling results.

TABLE I.6-5

ESTIMATED COC CONCENTRATIONS (μg/l) IN SURFACE WATER

	Current Land Use				Future Land Use			
COC	C[a]	D[a]	E[a]	GMR[b]	C[a]	D[a]	E[a]	GMR[b]
U-238	7.38	2.24	4.73	6.33×10^{-1}	7.52	3.31	35.8	3.24
Tc-99	4.84×10^{-3}	1.59×10^{-3}	1.98×10^{-2}	1.68×10^{-3}	3.57×10^{-3}	1.71×10^{-3}	5.16×10^{-2}	5.59×10^{-3}
Np-237	0.0	0.0	5.07×10^{-5}	4.34×10^{-6}	0.0	0.0	1.81×10^{-4}	1.64×10^{-5}
Ra-226	8.89×10^{-8}	8.89×10^{-8}	8.89×10^{-8}	5.50×10^{-9}	1.16×10^{-7}	1.16×10^{-7}	1.16×10^{-7}	1.02×10^{-8}
Antimony	4.07×10^{-1}	2.01×10^{-1}	3.90×10^{-2}	3.37×10^{-3}	5.51×10^{-1}	2.75×10^{-1}	7.64×10^{-2}	7.11×10^{-3}
Arsenic	1.10	5.17×10^{-1}	8.16×10^{-1}	9.42×10^{-2}	1.09	6.25×10^{-1}	1.18	1.07×10^{-1}
Beryllium	3.80×10^{-2}	3.80×10^{-2}	3.80×10^{-2}	3.15×10^{-3}	3.77×10^{-2}	3.77×10^{-2}	3.77×10^{-2}	3.30×10^{-3}

[a] Letters designate cross-section locations shown on Figure I.6-6.
[b] GMR = Great Miami River at Paddys Run

TABLE I.6-6

ESTIMATED COC TRANSPORT (g/year) FROM SURFACE WATER TO GROUNDWATER

	Current Land Use		Future Land Use	
COC	Paddys Run	SSOD	Paddys Run	SSOD
U-238	1.60×10^{3}	2.82×10^{3}	2.51×10^{3}	2.56×10^{4}
Tc-99	4.78×10^{0}	1.38×10^{1}	5.52×10^{0}	4.50×10^{1}
Np-237	9.97×10^{-4}	3.76×10^{-2}	2.97×10^{-3}	1.38×10^{-1}
Ra-226	2.04×10^{-5}	2.95×10^{-5}	3.13×10^{-5}	5.23×10^{-5}
Antimony	4.23×10^{2}	1.10×10^{-1}	5.23×10^{2}	5.21×10^{-1}
Arsenic	3.54×10^{2}	5.61×10^{2}	4.16×10^{2}	9.99×10^{2}
Beryllium	1.41×10^{1}	1.76×10^{1}	1.53×10^{1}	3.00×10^{1}

I.6.1.6.1 Aquifer Model Development

CRARE groundwater modeling was performed with the previously-calibrated SWIFT groundwater flow model for the FEMP. This model uses the SWIFT III code, Version 2.52, compiled using optimizing Fortran compilation parameters. The SWIFT III model was previously calibrated using groundwater elevations obtained during the April 1986 monitoring period.

The site-wide groundwater modeling program was initiated to define groundwater transport in and around the FEMP. The selection, verification, calibration, and results of groundwater modeling are presented in two reports (IT 1990 and ASI/IT 1990). SWIFT III is a finite-difference computer model of groundwater flow and solute transport. A detailed presentation of the model, its development, and the baseline input data was issued as part of the overall modeling report prepared under the RI/FS (ASI/IT 1990). Only the most pertinent information is presented here. A comprehensive verification study of the SWIFT III code has also been completed and a report issued (IT 1990).

More recent modifications to the SWIFT III model are described in the following reports:

- Groundwater Modeling Report - Summary of Model Development (DOE 1993a)
- Groundwater Model Evaluation Report and Improvement Plan (DOE 1993b)
- Glacial Overburden/Upper Great Miami Aquifer System Model Report (DOE 1994d)
- Groundwater Modeling Report - Summary of Model Improvement (DOE 1994a).

Improvements made to the SWIFT model include: (1) increasing the vertical resolution, i.e., adding layers, (2) recalibrating of the flow and transport portions of the model based on the results of the South Plume Pump Test Study and Kriging analysis, respectively, and (3) incorporating a larger model area to the south and east to include the Great Miami River and the collector wells of the Southern Ohio Water Company (SOWC).

The regional SWIFT model covers an area of 74.3 km^2 (28.7 mi^2), including the FEMP, the SOWC collector wells, and a portion of the Great Miami River. The regional model's grid spacing varies between 76 and 610 meters (250 and 2000 feet), and has the closest grid spacing in the area of the SOWC collector wells. It was calibrated against field data using a steady-state flow condition, and calibration results were incorporated into the SWIFT local area model.

The local model covers a smaller area than the regional model and uses a tighter grid spacing, with grid cells 38 meters (125 feet) on a side. The grid size was selected based on the need to simulate a dispersivity of 30 meters (100 feet) longitudinally, which was the preferred value, based on the solute transport calibration for uranium and also the literature review (IT 1990). Using

this dispersivity value, the grid size was selected to accommodate dispersivity values as low as 19 meters (62.5 feet), or half the distance of the local grid area of 38 meters (125 feet). Dispersivity is a constant value related to aquifer characteristics and not the solute being modeled. A smaller grid area was originally established to include the existing uranium plume. An expanded grid area is now in use that covers 112 by 120 cells, as shown on Figure I.6-2. The new grid was developed to expand the solute transport coverage for all of the RI/FS studies. The relationship between the local and regional SWIFT models was established by imposing the steady-state flow field predicted by the regional model onto the local solute transport model.

The regional and local models each contain six layers. These model layers were designed to coincide with the depth of Type 2 (2000-series), Type 3 (3000-series), and Type 4 (4000-series) monitoring wells, the clay interbed, and the top of bedrock contours. In regions where the clay interbed is not present, the middle layer has the same characteristics as the two upper layers. The layers extend laterally into bedrock at the edges of the buried valley that contains the aquifer. The number of aquifer cells in each layer was decreased with depth in the aquifer to simulate the narrowing bedrock valley. This was done using bedrock topography maps of the region and simulated the U-shaped buried valley that contains the Great Miami Aquifer.

The pumping wells in the area are spanned by both the regional and local models. These include (in both models) a FEMP production well, three industrial wells south of the FEMP, and two large-capacity collector wells owned by the SOWC and located by the Great Miami River. The FEMP well was assumed to be shut down after the completion of remediation. Pumping from each of the industrial and collector wells was assigned to the proper cell and layer in the model.

The SWIFT groundwater flow model was previously calibrated by comparing hydraulic heads calculated by the model against heads measured in numerous monitoring wells throughout the FEMP and surrounding areas. This calibration was performed using the regional flow model. Reasonable estimates of hydraulic conductivity and recharge were initially input into the model and then varied within an acceptable range to adjust model-computed heads into agreement with observed monitoring well heads.

Recharge rates set as a result of the regional model calibration were assigned to several different zones. In areas where the sand and gravel aquifer is overlain by glacial overburden, a recharge rate of 15 cm/year (6 in./year) was used. Regions where the Great Miami Aquifer is exposed at the surface use 36 cm/year (14 in./year), with Paddys Run channel being assigned a value of 81 cm/year (32 in./year) in the local model to simulate its increased infiltration. The calibrated recharge rate of 5 cm/year (2 in./year) for the area covered by the FEMP was used in the SWCR, and was also used in this CRARE. The loading rates of COCs with time to the SWIFT III model were determined by the ODAST vadose zone modeling or the surface water modeling.

Initial background concentrations of each compound in the aquifer were set at zero, with the exception of uranium. Because it is the most widespread COC and has the highest concentrations, uranium was assumed to be the most persistent COC during remediation. The Great Miami Aquifer groundwater in an area beneath the current sources is assumed to still contain uranium at the drinking water standard (7 pCi/l or 20.77 μg/l) at the end of FEMP remediation. This area is depicted in Figure I.6-7. K_d values for the COCs in the aquifer are presented in Table I.6-7.

TABLE I.6-7

SWIFT III Kd VALUES

COC	K_d
U-238	1.78
Tc-99	0.07
Np-237	2.69
Ra-226	106
Aroclor-1221	101
Antimony	45
Cadmium	12
Arsenic	200
Beryllium	250

000165

I.6.1.6.2 Aquifer Model Results and Receptor Selection

Groundwater transport modeling with the SWIFT III code was first run with U-238 as the COC. U-238 was selected because the baseline modeling in the SWCR had identified it as potentially the most widespread contaminant in groundwater that represented the greatest risk. This conclusion was supported in the Operable Unit 4 CRARE. Figure I.6-8 presents the projected COC concentration contours at 70 years after the end of remediation for the Current Land Use scenario. Figure I.6-9 presents the concentration contours at 1000 years after the end of remediation for the Future Land Use scenario.

The peak concentrations for U-238 occur at 70 years for the Current Land Use scenario due to the increasing concentrations in the Operable Unit 1 area, up to the end of the 70-year period. For the Future Land Use scenario the peak groundwater concentrations occur at 1000 years due to increasing input from Operable Unit 5 soils adding to the constant loading from surface water. The elevated concentrations adjacent to the Eastern Vaults are due to the higher conductivity in Layer 1 beneath Plant 6. The impact of U-238 transport from the Operable Unit 1 area can also be seen in both of these figures. Results for U-234, U-235, and U-236 were developed by applying the abundance ratios of these isotopes to the U-238 results, and not by separate modeling.

Tc-99 was modeled next because it appeared to represent the second-highest potential risk in groundwater. Figures I.6-10 and I.6-11 present the projected Tc-99 concentration contours at 70 and 1000 years after the end of remediation for the Future Land Use scenarios. Site-wide Tc-99 concentrations are lower for the Current Land Use scenario, and are not shown separately. Tc-99 reaches its peak concentrations at approximately 40 years for all scenarios, and does not decline from these peaks for the remainder of the 1000 years. This is because the most significant source of contamination is surface water recharge, although impacts from the Operable Unit 1 area and site-wide soils can also be seen. When compared to the Operable Unit 4 CRARE modeling, both U-238 and Tc-99 show significant increases in groundwater concentrations that are primarily due to the assumption of constant COC loading from surface water over time.

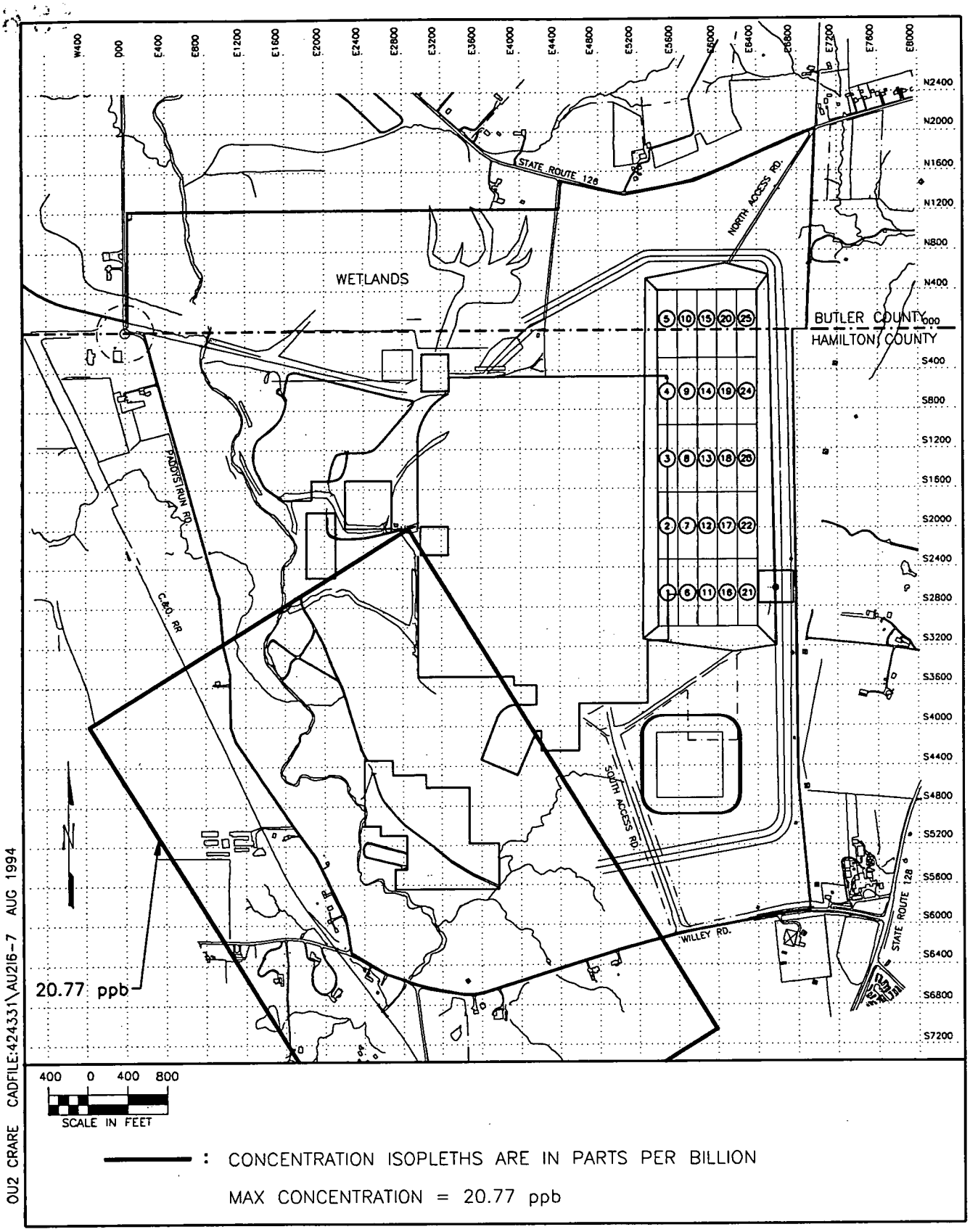

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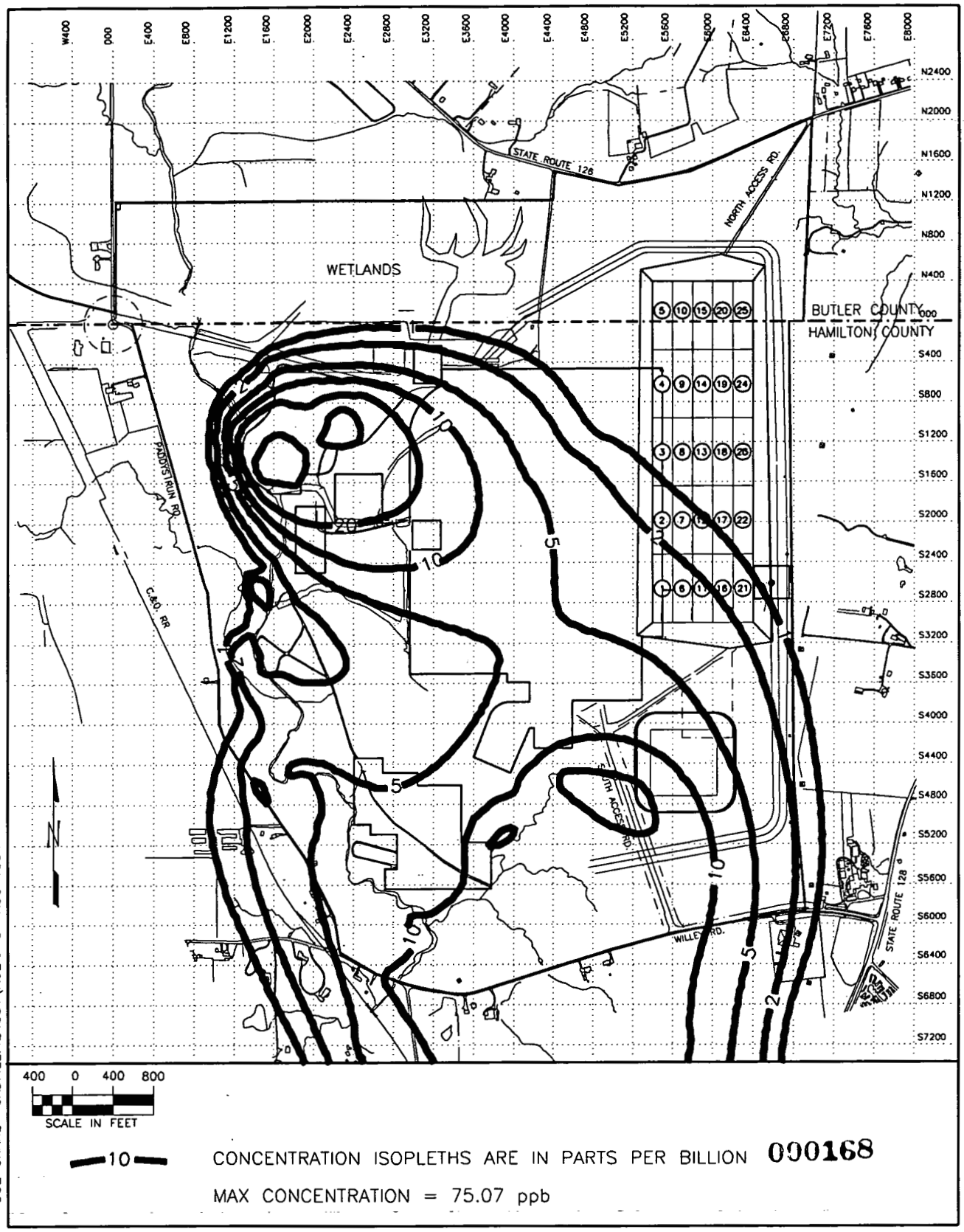
FIGURE 1.6-7
INITIAL CONCENTRATIONS OF U-238 IN AQUIFER AFTER REMEDIATION



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090168

FIGURE 1.6-8
U-238 GROUNDWATER CONCENTRATIONS AT 70 YEARS
FOR CURRENT LAND USE SCENARIO

400 0 400 800

SCALE IN FEET

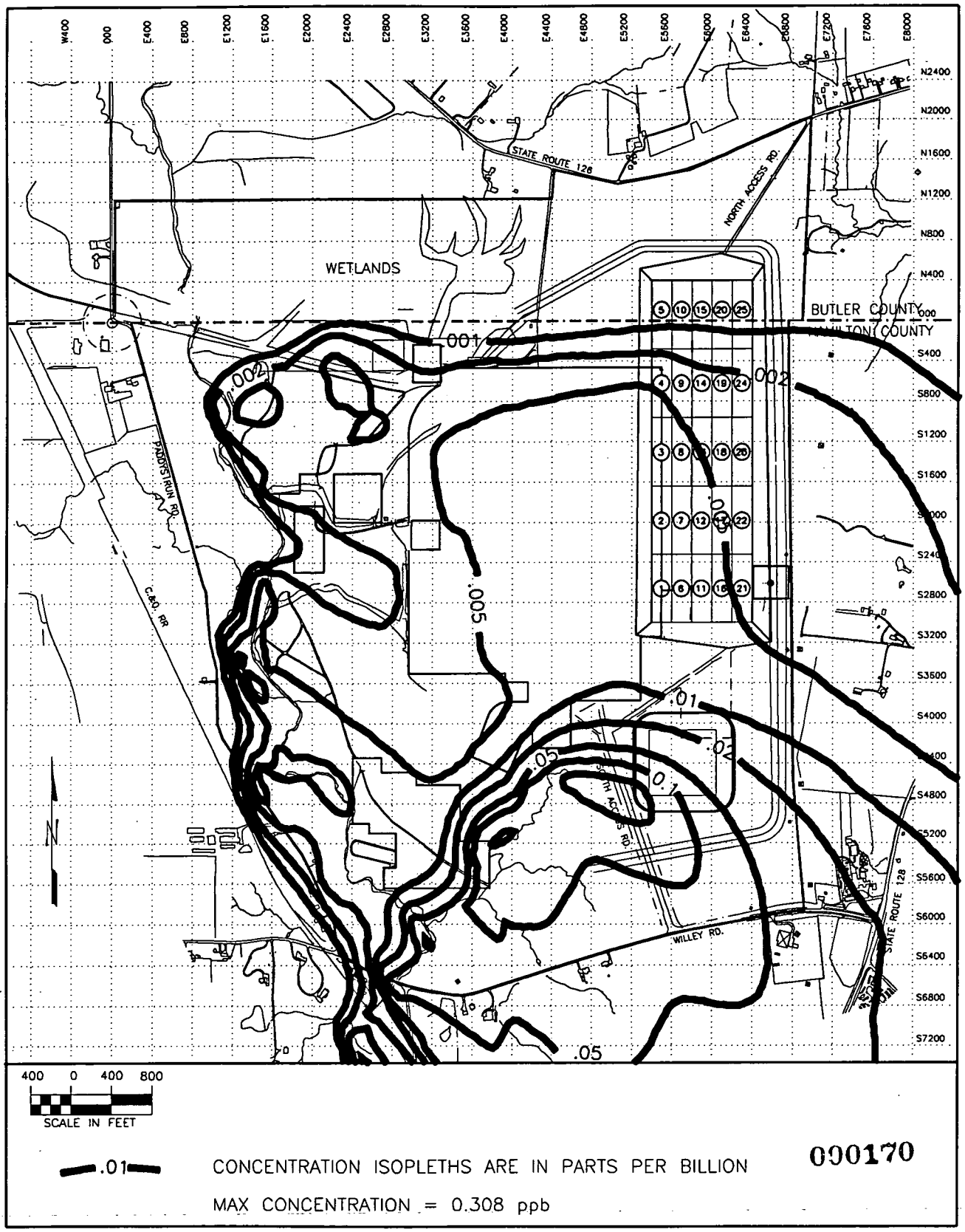
090169

10 CONCENTRATION ISOPLETHS ARE IN PARTS PER BILLION

MAX CONCENTRATION = 183.5

OU2 CRARE CADFILE:424331\AU216-9 AUG 1994

FIGURE 1.6-9
U-238 AT 1000 YEARS



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000170

FIGURE 1.6-10
TC-99 GROUNDWATER CONCENTRATIONS AT 70 YEARS
FOR FUTURE LAND USE SCENARIO

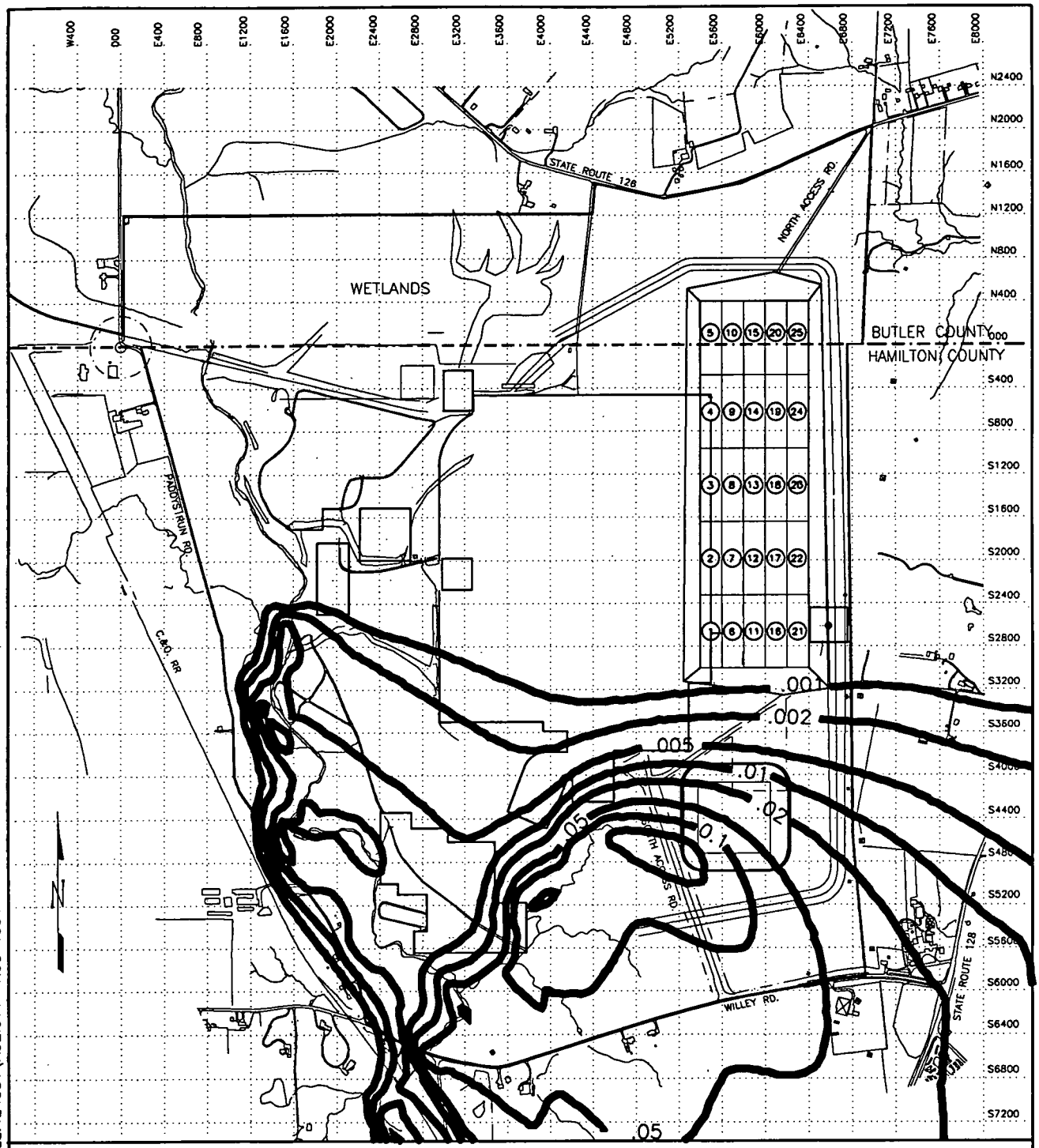

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FIGURE 1.6-11
TC-99 GROUNDWATER CONCENTRATIONS AT 1000 YEARS

Figures I.6-12 through I.6-18 present the concentration contours for Ra-226, Np-237, Aroclor-1221, antimony, cadmium, arsenic and beryllium at the 1000-year point for the Future Land Use scenario. This is the time when each of these COCs reaches its maximum concentration at any point in the aquifer. Operable Unit 1 is the principal source for Aroclor-1221 and cadmium; and a significant source for Np-237 and antimony. Surface water recharge is the principal source for Ra-226, arsenic and beryllium; and a significant source for Np-237 and antimony. These COCs are not expected to contribute significantly to the site-wide risk when compared to the impact of the uranium isotopes and Tc-99.

The general process for selecting receptor locations is described in Section I.5.1.4. For the specific locations of groundwater receptors, the U-238 and Tc-99 contour plots were reviewed and a limited number of potential locations were selected for both on- and off-property receptors. These potential receptor locations were selected in areas where both U-238 and Tc-99 reached maximum values. COC concentrations with time were listed at each of these points. Then, to be conservative, a method was developed to determine both the location and the 10-year interval over which the greatest ILCR was estimated, for an adult RME receptor who ingested 2 liters of groundwater per day over a 70-year lifetime. For each 10-year interval of the groundwater modeling output, and for each potential receptor location, the ILCR was estimated for each modeled COC (which had an appropriate cancer slope factor). The resulting individual cancer risks were summed for each location over the 10-year interval. The single location where the RME receptor would experience the greatest total ILCR for all COCs for the groundwater (over each 70 or 1000 years of groundwater modeling output) was chosen as the representative receptor location for each scenario. One receptor location was selected for the maximum on-property risk, and one for the maximum off-property risk. These locations are shown on Figure I.6-19.

Figure I.6-20 presents the changes in estimated groundwater U-238 concentrations with time for the off-property receptor under the Current Land Use scenario. The process for locating a perched-water receptor was similar to that of the groundwater receptor. The initial leachate concentrations in Table I.6-1 (Section I.6.1.3.1) were assumed to represent potential perched-zone concentrations for the COCs after remediation. Several potential receptor locations were selected in the central portion of the FEMP, where the perched zone is known to exist. Locations were selected where the listed COC concentrations are at the highest values. The total ILCR was then

calculated for each location. The Plant 2/3 area (area PAC on Figure I.6-3) was found to have the highest total ILCR for perched-water concentrations derived from the initial leachate concentrations. A perched-water receptor has been located in this area, as shown in Figure I.6-19.

The estimated contaminant concentrations in perched water and groundwater at each receptor point are evaluated further in Section I.8.0 to quantify the exposure values they represent. The risks represented by these and other COC exposures are then characterized in Section I.9.0.

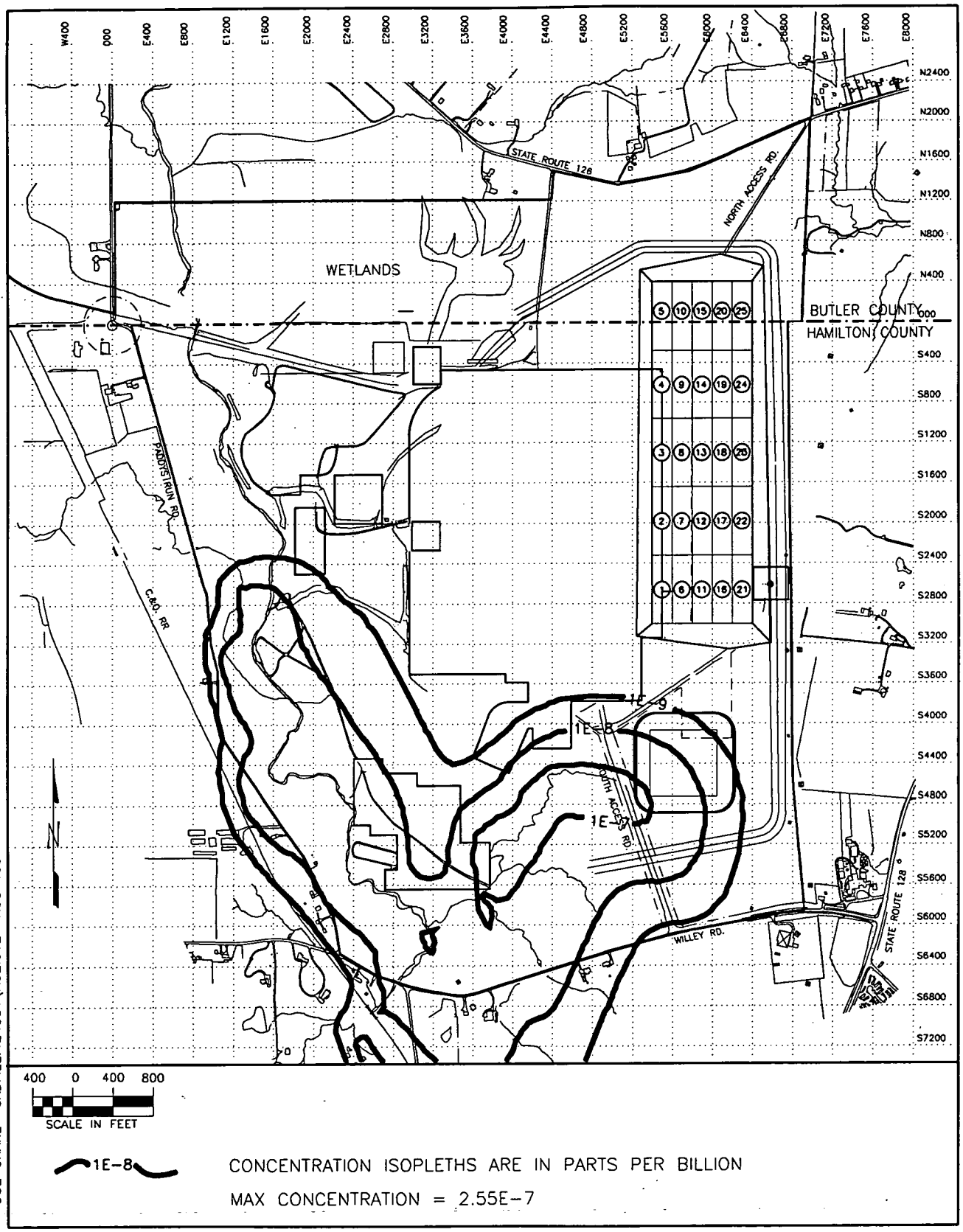

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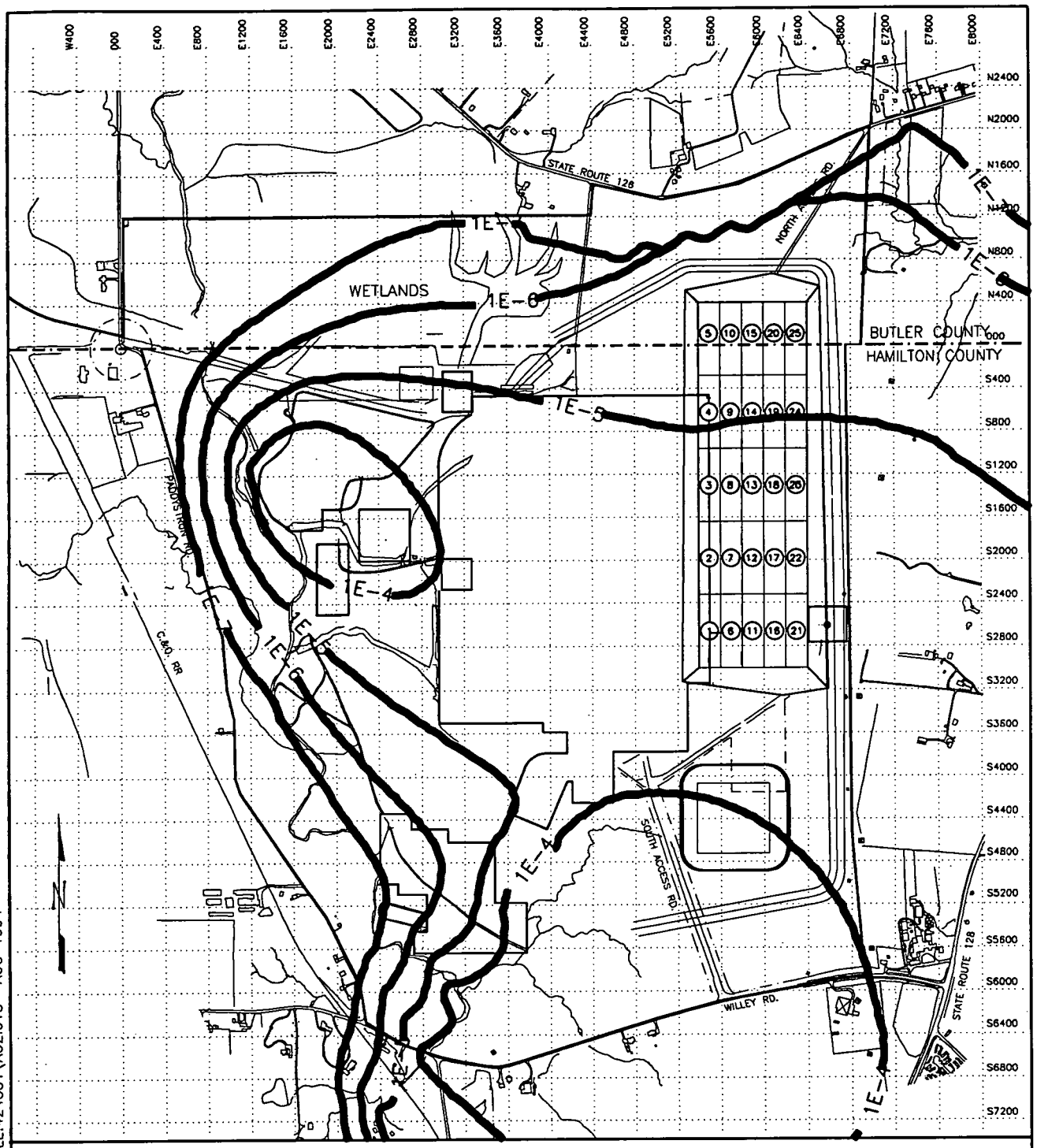
FIGURE 1.6-12
RADIUM-226 AT 1000 YEARS



1E-5 CONCENTRATION ISOPLETHS ARE IN PARTS PER BILLION

MAX CONCENTRATION = 9.063E-04 ppb

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FIGURE 1.6-13
NP-237 GROUNDWATER CONCENTRATIONS AT 1000 YEARS

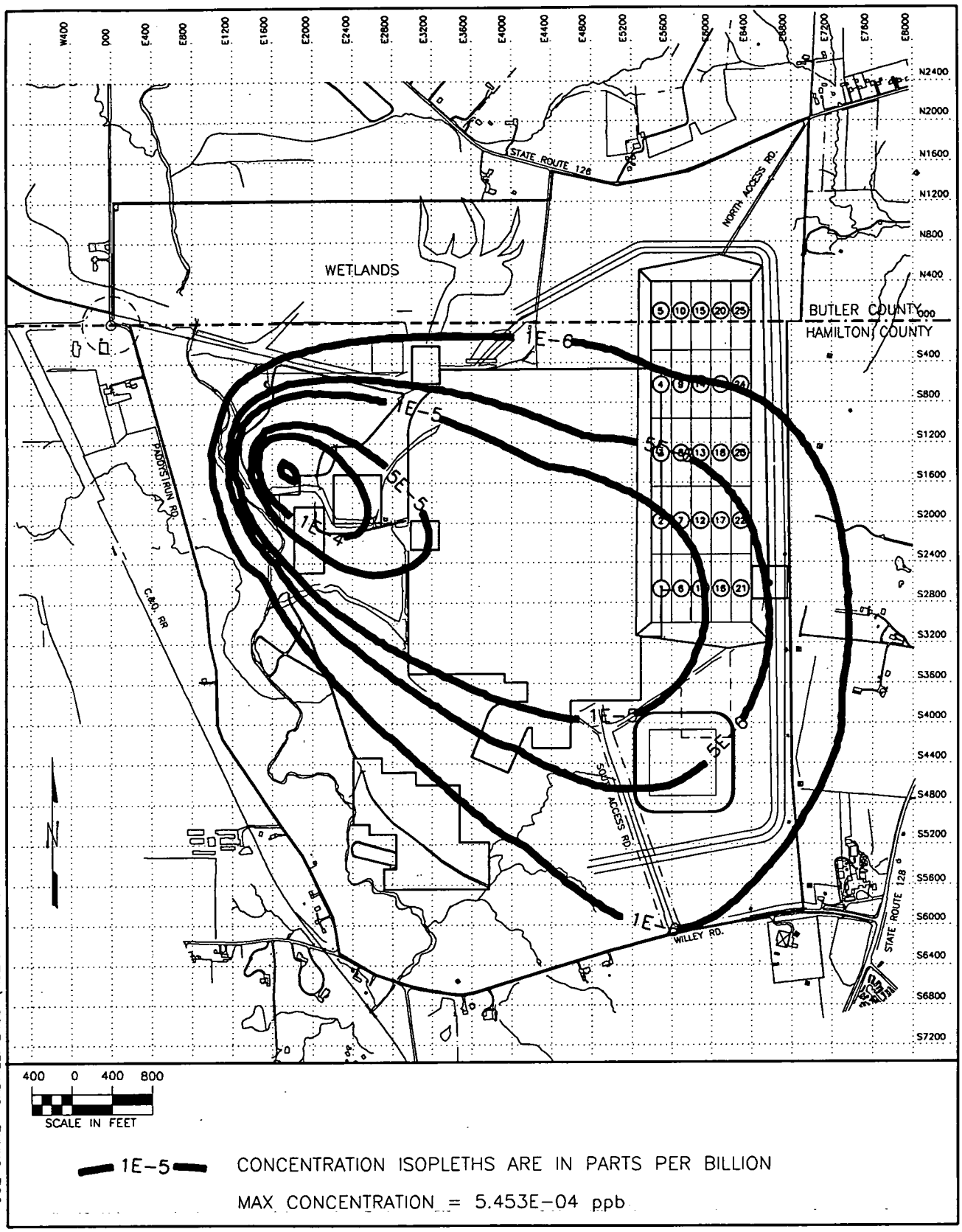

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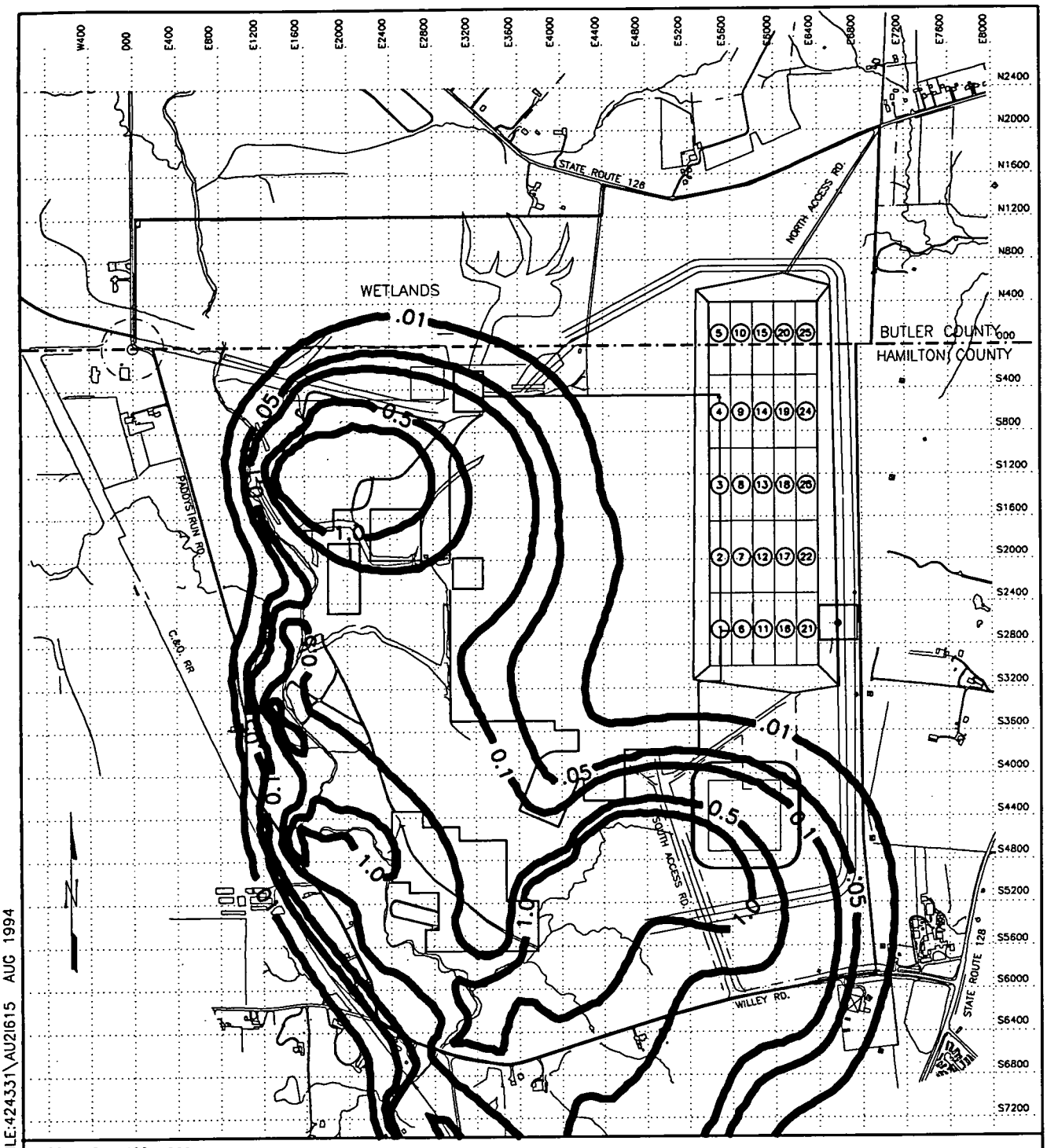
FIGURE 1.6-14
AROCLOR-1221 GROUNDWATER CONCENTRATIONS AT 1000 YEARS



400 0 400 800
SCALE IN FEET

.01 CONCENTRATION ISOPLETHS ARE IN PARTS PER BILLION

MAX CONCENTRATION = 3.435 ppb

OU2 CRARE CADFILE:424331\AU21615 AUG 1994

FIGURE 1.6-15
ANTIMONY GROUNDWATER CONCENTRATIONS AT 1000 YEARS

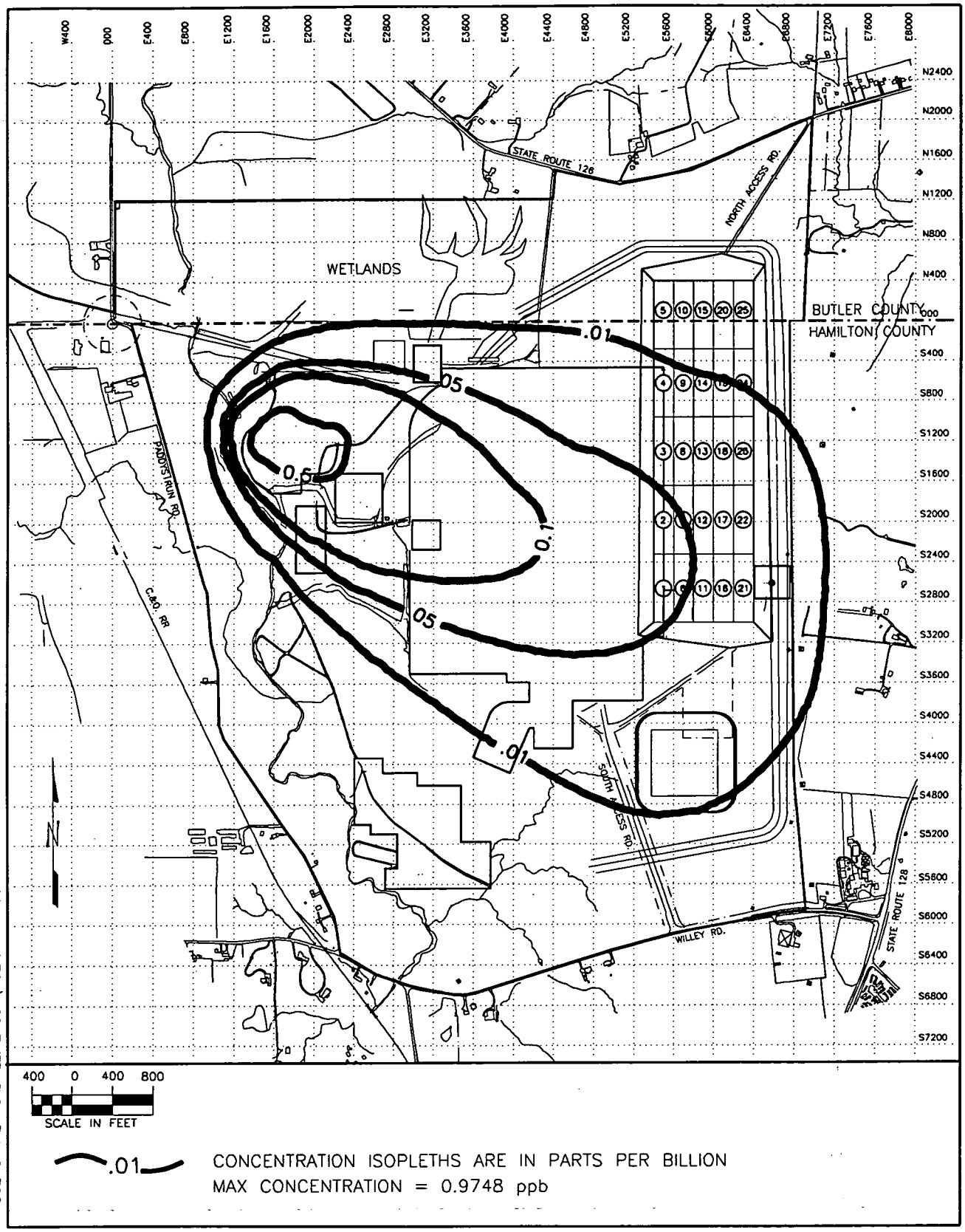


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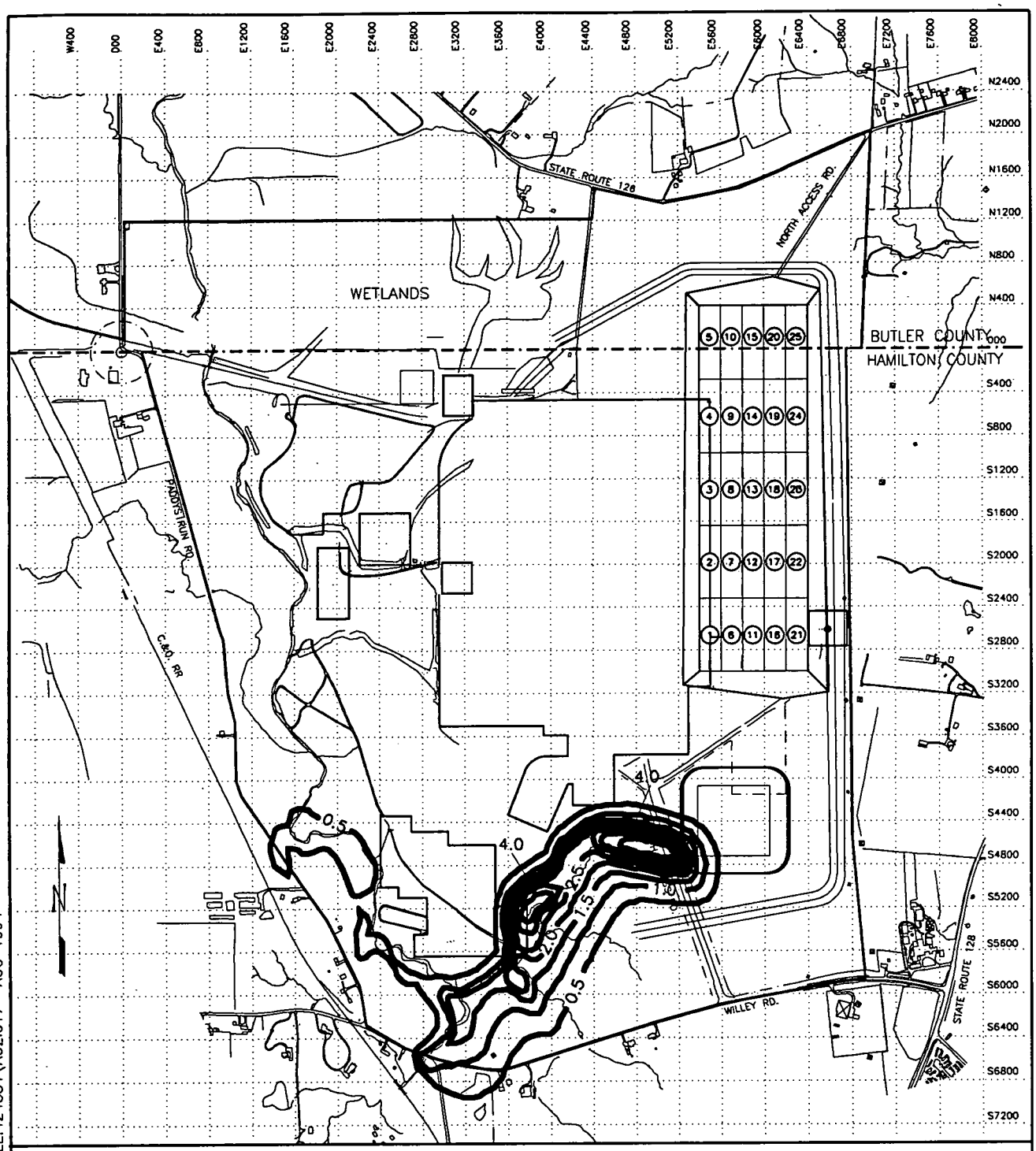
FIGURE 1.6-16
CADMIUM GROUNDWATER CONCENTRATIONS AT 1000 YEARS



400 0 400 800

SCALE IN FEET

.01 CONCENTRATION ISOPLETHS ARE IN PARTS PER BILLION

MAX CONCENTRATION = 4.341 ppb

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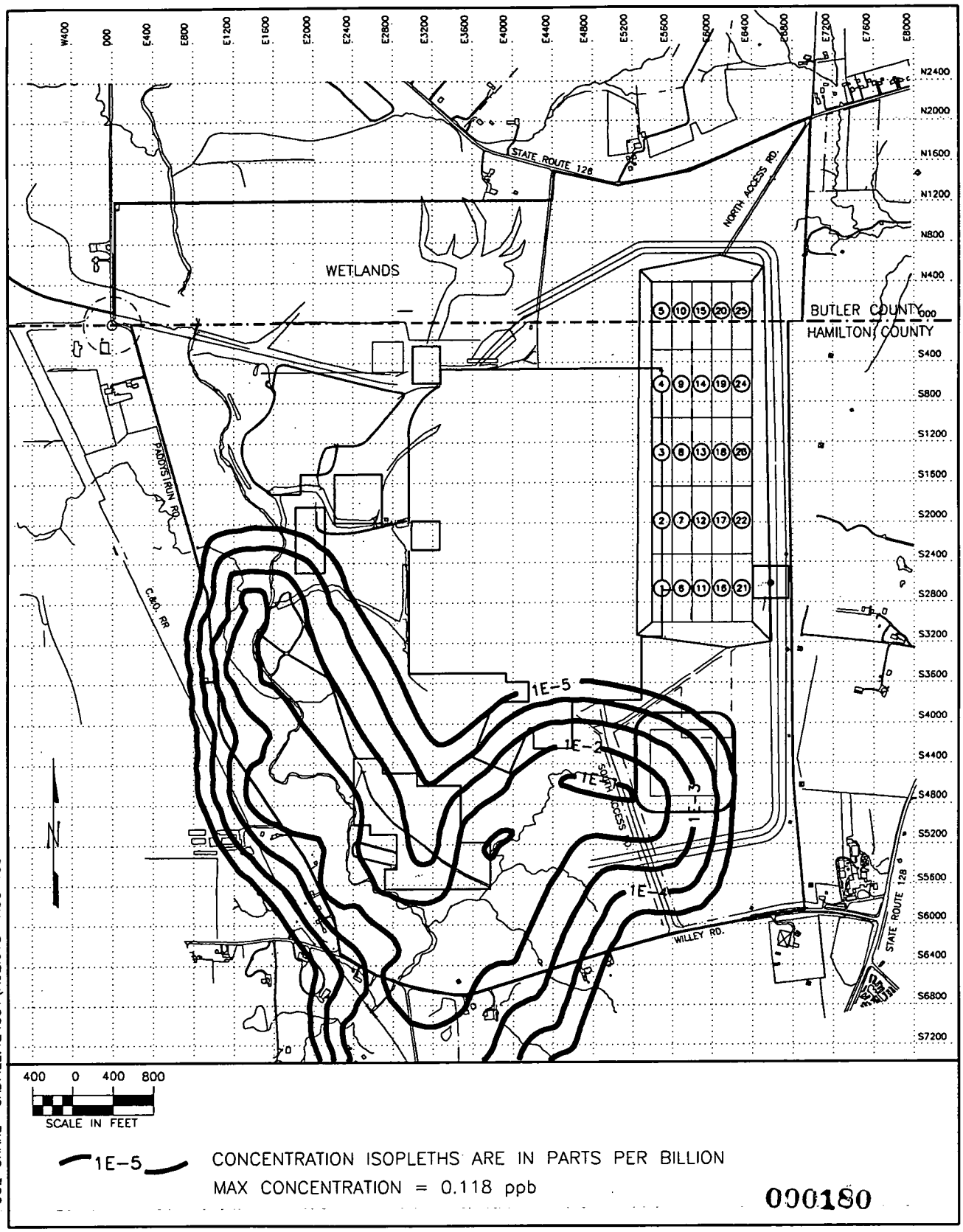
FIGURE 1.6-17
ARSENIC CONCENTRATIONS AFTER 1000 YEARS



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000180

FIGURE I.6-18
BERYLLIUM CONCENTRATION AT 1000 YEARS

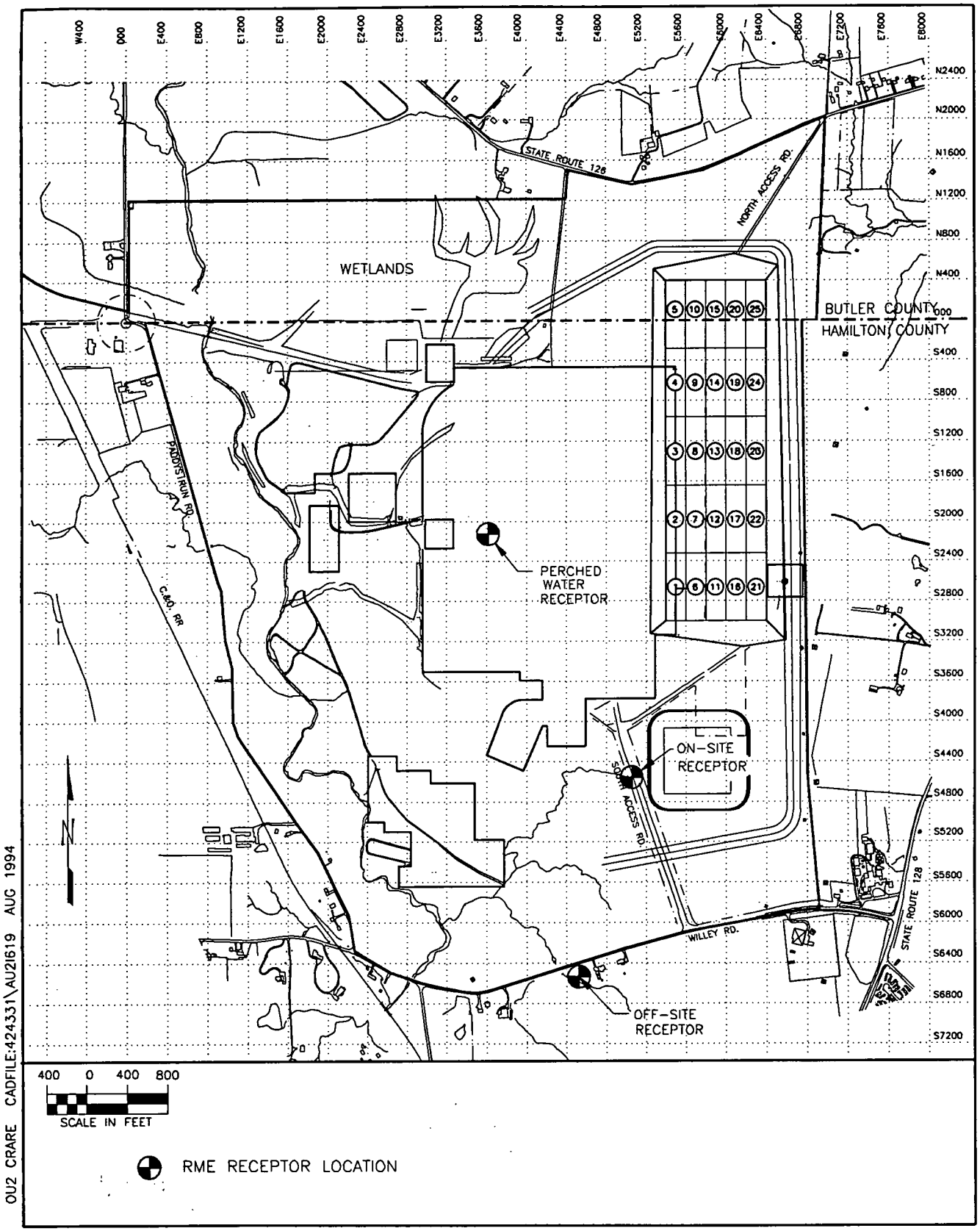

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FIGURE 1.6-19
GROUNDWATER RECEPTOR LOCATIONS

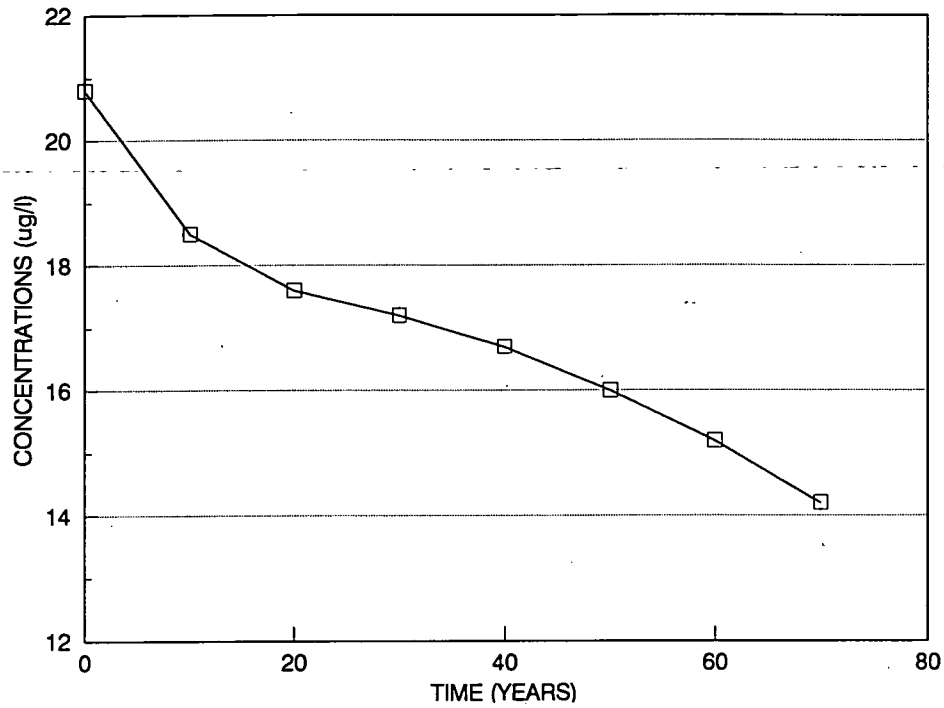

FIGURE I.6-20
U-238 GROUNDWATER CONCENTRATIONS VS TIME FOR CURRENT LAND USE RECEPTORS

I.6.2 AIR TRANSPORT MODELING

This section presents the approach, methodology, and results of the CRARE air transport analysis. The objective of this analysis was to determine the maximum on- and off-property annual average ground-level air concentrations of contaminants released to the atmosphere from the remediated FEMP. These concentrations were used for the CRARE residual risk assessment.

The analysis was conducted in accordance with EPA guidance (EPA 1989c). Two emission models and an air dispersion model were used to estimate air emissions from each source and to calculate annual average concentrations at several preselected receptor locations. One emission model predicted the quantity of exposed soil that would be resuspended by the wind, and the other emission model estimated the flux of Rn-222 gas from soil containing Ra-226. Particulate-phase contaminants examined include radionuclides, inorganic compounds, and semivolatile and nonvolatile organic compounds. The only gas-phase contaminant evaluated in this analysis was Rn-222. VOCs were not analyzed as they would be lost to the atmosphere prior to the start of the postremediation periods analyzed in the CRARE. The air dispersion model accounted for dispersion and dilution of the contaminants under defined meteorological conditions, such as wind speed and direction, atmospheric stability, and mixing height. All data were collected from an on-property meteorological station, except mixing heights, which are from the National Weather Service in Dayton, Ohio.

Five major steps were required to achieve the objective of this analysis:

1. Scenarios for the air transport analysis were defined.
2. Sources of air emissions and contaminants released were identified based on site-specific information.
3. The appropriate EPA regulatory air dispersion model was selected which best represented the site characteristics and the objective of the analysis.
4. Particulate or gaseous air emissions were estimated from site-specific soil contaminant concentrations, and additional inputs to the model such as meteorological data and receptor locations were determined.
5. Results of the air dispersion model were processed to determine the maximum on- and off-property annual average concentration for residual risk.

Figure I.6-21 presents the sequence of these steps and the sections below that describe them.

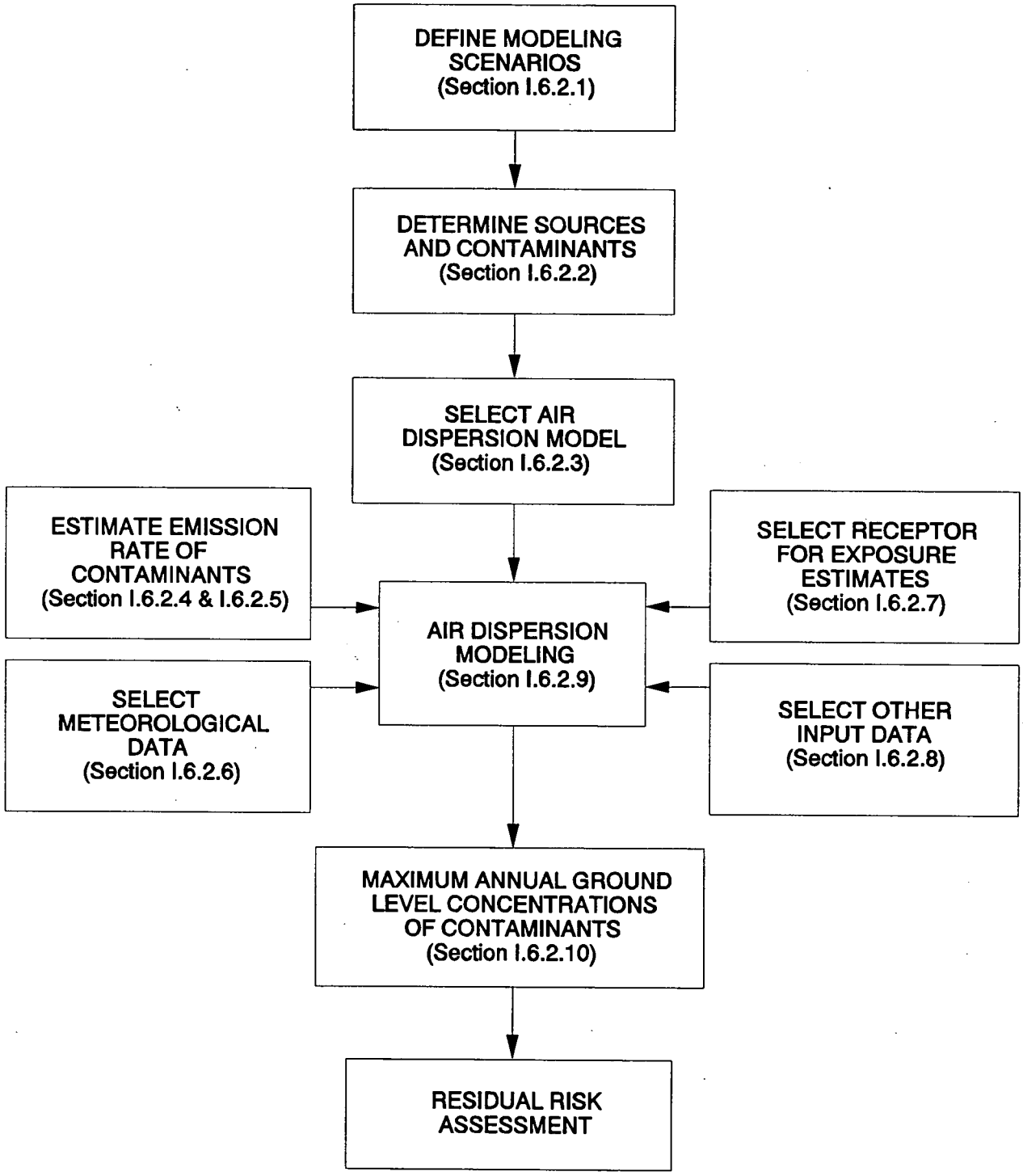

FIGURE I.6-21

SEQUENTIAL BLOCK DIAGRAM OF AIR TRANSPORT ANALYSIS

090184

Throughout the analysis, site-specific data were used where available. When such data were not available, conservative assumptions were made. Regulatory default options and values were used where applicable in the air emission and dispersion models. The intent of the assumptions was to make the results relevant to the site so that the risk associated with the air exposure pathway was realistic.

I.6.2.1 Source Term Assumptions for Air Transport Analysis

The air pathway fate and transport analysis was conducted assuming that exposed soil contaminant concentrations were less than or equal to the Expanded Trespasser PGS. Each was based on the COC PRG developed to meet and ILCR of 10^{-6} or an HQ of 0.2.

A number of assumptions were made to develop source term emission rates for each operable unit. From the air transport analysis previously performed for the Operable Unit 4 CRARE (DOE 1993d), one can determine that no significant emissions occur from the disposal facilities or capped/covered areas compared to emissions from exposed soil with residual contamination. Therefore, no air emission source terms are included for the Operable Unit 1 covered area, the Operable Unit 2 Disposal Cell cap or the Operable Unit 3 Disposal Vaults. The erosion of caps and cover soils caused by wind is less than 4 inches over the 1000-year period. Combined with the erosion rate from surface water runoff, the total loss of caps and cover soils would not cause exposure of the contaminated layers in these areas.

Particulate matter and radon emissions were estimated for exposed soil in Operable Units 1, 2, 4, and 5. For Operable Unit 1, this soil included approximately 11 acres of ground within the battery limits but not covered with the cap. For Operable Unit 2, this soil included the upper GMA and till layers exposed after remedial excavation in the South Field, Inactive Flyash Pile, and Active Flyash Pile as well as the exposed fill layer in the South Field. Also included in Operable Unit 2 were the till layers in the Solid Waste Landfill and Lime Sludge Ponds exposed after loss of clean cover soil. For Operable Unit 4, this soil included subsurface soil which was assumed to be exposed following the loss of 6 inches of clean cover soil. For Operable Unit 5,

this soil included existing surface soil for the remainder of the FEMP. The materials and soil imported for cap layers and cover soil were assumed to be uncontaminated and would have contaminant concentrations at background levels.

I.6.2.2 Sources and Contaminants

All sources considered for this study were analyzed as ground-level area sources. The particulate emission sources included the exposed soils in Operable Units 1, 2, 4, and 5. To analyze emission impacts, 1,247 area sources were evaluated in 47 source groups. Figure I.6-22 shows the source group locations and sizes used in the air dispersion model for areas associated with Operable Units 1 through 5. Note that soil beneath Operable Unit 3 is considered part of Operable Unit 5.

I.6.2.3 Air Transport Models

The annual average contaminant concentrations were determined using ISCLT2 (EPA 1992a), the model recommended by the EPA for air pathway analysis of Superfund sites (EPA 1989c). The ISCLT2 model was designed by the EPA to assess the air quality impact of emissions from a wide variety of sources. It incorporates a steady-state gaussian plume equation that is applicable in flat or gently rolling terrain, for multiple point, area, and volume sources. The ISCLT2 model calculates the annual average concentration due to airborne emissions at user-selected receptors, based on sector-averaged statistical wind summaries. Data required for input to the model include source emission rates, the locations and configurations of sources, statistical summaries of wind speed, wind direction, and atmospheric stability, and the locations of the selected receptors.

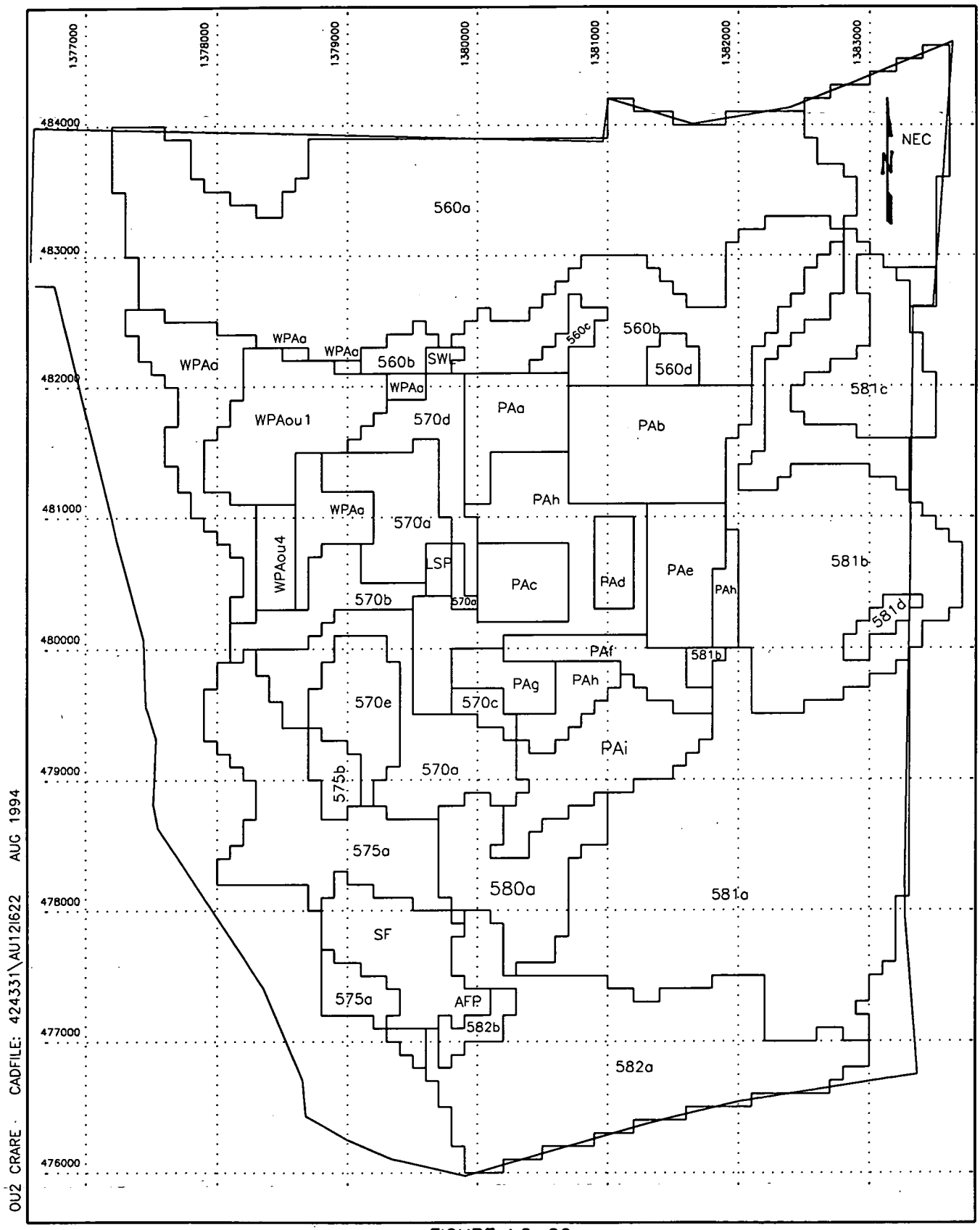

FIGURE 1.6-22

SOURCE LOCATIONS FOR AIR DISPERSION MODELING

I.6.2.4 Particulate Contaminant Emission Rates

Radionuclide, inorganic, and nonvolatile organic contaminants were assumed to be present in the suspended particulate matter emitted from the site. The emission rate for each contaminant in this particulate matter was calculated from the concentration of the contaminant in the exposed soil and from the estimated site-wide average emission rate of particulate matter less than 10 micrometers in diameter (PM_{10}). The emission rate of total suspended particulates (TSP) was estimated by assuming that PM_{10} emissions represented 50 percent of TSP emissions (EPA 1993a). The TSP emission rate was used to estimate deposition rates of contaminants onto soils and crops.

I.6.2.4.1 Contaminated Soil Concentrations

The estimated radionuclide contaminant concentrations used for development of emission source terms are presented in Attachment I.II-1. Contaminant soil concentrations were selected from data in the RI/FS database and data presented in the following documents:

- *Site-Wide Characterization Report* (DOE 1993a)
- *Feasibility Study Report for Operable Unit 1* (DOE 1994b)
- *Remedial Investigation Report for Operable Unit 2* (DOE 1994d)
- *Feasibility Study Report for Operable Unit 2* (DOE 1994a)
- *Remedial Investigation Report for Operable Unit 4* (DOE 1993c)
- *Feasibility Study Report for Operable Unit 4*, Appendix A (DOE 1993b)
- *Proposed Plan for Remedial Actions at Operable Unit 4* (DOE 1994e)
- *Remedial Investigation Report for Operable Unit 5 (DOE 1994f)*

In this CRARE, cleanup levels were based on PRLs developed for each operable unit. The PRLs presented in the Proposed Plans for Operable Units 1 and 4 were used to set the upper limit on contaminant levels in those operable units. The PRLs presented in Section 2 of the Operable Unit 2 FS Report were used in that operable unit. The PRGs presented in the Site-Wide Characterization Report were used to develop PRLs for Operable Unit 5. For compounds included in this CRARE which were not included in the Site-Wide Characterization Report, the Operable Unit 5 cleanup levels were obtained from the Draft Feasibility Study for Operable Unit 5. Because this analysis assumed that the site has been remediated, any soil concentrations exceeding an applicable PRL was reset to the PRL.

For this CRARE, the residual concentration of uranium isotopes and total uranium was based on the average uranium composition on the site and the residual U-238 concentration in each source area. The approximate compositions are 0.00896, 0.685, 0.0093, and 99.3 percent (by weight) of U-234, U-235, U-236, and U-238, respectively.

For COCs which did not exceed the cleanup level, the UCL contaminant concentration in a given area or operable unit was used for that area or operable unit. This approach assumed that FEMP contamination after remediation will not be worse than currently measured levels. This approach is also extremely conservative, because no credit was taken for the effect of soil treatment, and the highest values used would not typically represent the average concentration for the modeled sources.

I.6.2.4.2 Suspended Particulate Emission Estimate

The method used to estimate PM_{10} emission rates for the FEMP is based on EPA guidance for estimating wind erosion rates from flat soil surfaces at hazardous waste sites (EPA 1985b). This guidance has also been adopted by EPA for Superfund sites. (EPA 1992f). The EPA methodology assumes that a minimum wind speed is required for the suspension of respirable dust, and the emission rate is a nonlinear function of the "threshold friction velocity" (TFV) and the erosion potential of the site, which depends on the particle size distribution of the soil. Very fine soils (those with small modal diameters) have low TFVs and high potential for erosion by wind.

In addition to modal diameter, other factors such as the amount of nonerodible elements (gravel and pebbles with diameters greater than approximately 1 centimeter), rustiness of the surface soil, and the amount of vegetative cover affect the quantity of soil that can be resuspended by the wind.

A review of the EPA method for determining the aerodynamic modal diameter of surface soil (EPA 1985b) indicated that additional laboratory sieve analyses needed to be conducted on FEMP soil to estimate this diameter. Therefore, a sampling protocol was developed based on the

EPA guidance and surface soil samples were collected and analyzed during May 1994. The sampling protocol and analysis results are presented in Attachment I.II-2. The measured aerodynamic modal diameters ranged from 2 to 4 mm.

The method used to estimate FEMP PM_{10} emission rates is based on EPA guidance for estimating wind erosion rates from flat soil surfaces at hazardous waste sites (EPA 1985b and EPA 1992f). The EPA methodology assumes that a minimum wind speed is required for the suspension of respirable dust, and the emission rate is a nonlinear function of the "Threshold Friction Velocity" (TFV) and the erosion potential of the site, which depends on the particle size distribution of the soil. Very fine soils (those with small modal diameters) have low TFVs and high potential for wind erosion.

Using an exposed soil modal diameter of 2 to 4 mm, the TFV can be determined from the EPA guidance document (EPA 1985b, Figure 3-4). The relationship between the modal diameter and the TFV can be represented by the equation:

$$\log (TFV) = 1.812 + 0.4161 \log (d_p) \qquad (I.6\text{-}3)$$

where

TFV	=	threshold friction velocity (cm/s) near the soil surface
d_p	=	modal diameter of soil sample (mm)

The calculated TFV ranges from 86.5 to 115 cm/s based on modal diameters of 2 to 4 mm. The calculated TFV should be corrected based on the surface roughness, rustiness, and quantity of nonerodible elements. The ratio of the corrected TFV to the uncorrected TFV is a nonlinear function of the ratio of the silhouette area of the roughness elements to the total area of bare loose soil (EPA 1985b). For this CRARE, no correction was applied to the calculated TFV based on the assumption that the exposed surface would behave in the same manner as dry, loose silt. This assumption is obviously conservative since the site has enough clay in the soil to form a nonerodible crust, the surface contains nonerodible elements, and the vegetation present will significantly increase the TFV necessary to resuspend surface soil.

The calculated TFV is greater then the 75 cm/s (30 in./s); therefore, the FEMP surface soil was considered to have a "limited" erosion potential (EPA 1985b). The equation for respirable particulate emissions from erosion of soils with limited erosion potential takes the following form:

$$E_{10} = 0.83 \times f \times P(u^+) \times (1 - V) / (PE/50)^2 \qquad \text{(I.6-4)}$$

where

E_{10}	=	annual average PM_{10} emission rate per unit area of contaminated surface ($g/hr/m^2$)
f	=	frequency of disturbance per month
$P(u^+)$	=	erosion potential, the quantity of erodible particles present on the surface prior to the onset of wind erosion (g/m^2)
u^+	=	observed (or probable) fastest mile of wind for the period between disturbances (m/s)
V	=	fraction of soil covered by vegetation
PE	=	Thornwaite's Precipitation Index (a measure of average soil moisture content)

The erosion potential in Equation I.6-4 depends on the fastest mile as follows (EPA 1985b):

$$P(u^+) = 6.7 \times (u^+ - u_t), \text{ for } u^+ \geq u_t, \qquad \text{(I.6-5)}$$
$$= 0, \text{ for } u^+ < u_t.$$

A typical fastest mile for the region is 24 m/s (EPA 1985b) at 7 meters above ground. The TFV must be corrected to the anemometer height (7 meters) used to collect the fastest mile data. The corrected TFV is calculated from the following equation (EPA 1985b):

$$u_t/TFV = (1/0.4) \ln (Z/Z_o) \qquad \text{(I.6-6)}$$

where

Z	=	anemometer height (m)
Z_o	=	surface roughness height (m)

The surface at the FEMP is now, and will be, covered with grass and other vegetation after completion of remedial actions. Using an approximated value of 0.03 meters (0.1 feet) for grassland (EPA 1985b) as Z_o, the value of u_t was calculated to be 11.8 to 15.7 m/s. The calculated values for $P(u^+)$ range from 81.8 down to 55.4 g/m^2 for aerodynamic modal diameters of 2 to 4mm, respectively.

The frequency of disturbance represents the frequency that the surface crust is broken by mechanical means, such as agricultural tilling. Under the Future Land Use With Federal Ownership Scenario, the only disturbance caused by the expanded trespasser was assumed to be from walking across the site. Over a 44-year period, the trespasser spends 3920 hours on-site. The trespasser was assumed to walk at a pace of 3 miles/hr and was assumed to disturb a path 1 foot wide. Therefore, the total area disturbed over the 44-year period is approximately 1425 acres, or approximately 33 acres per year. Dividing this area by the total area of the site (1050 acres) results in a value for f of 0.0309.

Currently, the FEMP is 80 to 85 percent covered with vegetation. After remediation, the site will be planted with appropriate vegetation for erosion control and aesthetics. The region easily supports plant life, and a 100 percent vegetative cover is expected over the postremediated site, with or without continued maintenance. For this air transport analysis, the site was conservatively assumed to be 85 percent covered with vegetation. The 85 percent value is in line with EPA estimates of control efficiencies for vegetative covers (EPA 1987b).

The erosion potential of PM_{10} for the FEMP under the Future Land Use With Federal Ownership scenario ranged from 1.40×10^{-8} to 2.06×10^{-8} g/s/m^2 for aerodynamic modal diameters of 4 mm and 2 mm, respectively. The larger value was used in contaminant emission rate calculations.

The contaminant surface soil concentration in each area is multiplied by the annual average PM_{10} emission flux to determine the contaminant-specific emission rate used in the model for calculating airborne concentrations. The contaminant surface soil concentration is multiplied by the annual average TSP emission flux to determine the contaminant-specific emission rate used for calculating total deposition rates. Particulate matter contaminant emissions for each source group are presented in Attachment I.II-3.

I.6.2.5 Gaseous Contaminant Emission Rates

Emissions of Rn-222 were estimated for all exposed soil areas. No other gaseous emissions were estimated. Volatile organics were assumed to have decayed to negligible levels prior to the time

period studied by this analysis. Radionuclides, semivolatile organics, nonvolatile organics, and inorganics were assumed to be transported with the particulates emitted from the site.

Rn-222 emissions were determined from the Ra-226 concentrations in the contaminated soil using the RAECOM model algorithms developed for the NRC (NRC 1984). The model accounts for the half-lives of radon and radium as well as the density, porosity, moisture content, and depth of contaminated layers and cover layers in estimating Rn-222 emission rates. The model converts Ra-226 soil concentrations (in pCi/g) to Rn-222 fluxes (in pCi/s/m^2). The basic equations for estimating Rn-222 emissions from bare soil is presented below:

$$J_t = 10^4 R\rho E\sqrt{\lambda D_t} \tanh\left(X_t\sqrt{\frac{\lambda}{D_t}}\right) \qquad \text{(I.6-5)}$$

where:
- J_t = radon flux from the soil surface (pCi/s/m^2),
- R = activity concentration of Ra-226 in soil (pCi/g),
- ρ = dry bulk density of soil (g/cm^3),
- E = radon emanation coefficient (assumed to be 0.22 from NRC 1984),
- λ = decay constant of radon (= 2.1 x 10^{-6} 1/s),
- D_t = diffusion coefficient of radon in the total pore space (cm^2/s),
- X_t = thickness of contaminated soil (assumed to be 300 cm for surface soil), and
- 10^4 = conversion factor for m^2 to cm^2.

The RAECOM model input parameters and output tables are presented in Attachment I.II-4.

I.6.2.6 Meteorological Data

Meteorological data characterizing the transport and dispersion conditions of an area are needed as input to the ISCLT2 model. These data include wind speed, wind direction, atmospheric stability, ambient air temperature, and mixing height. Measurements for all of these meteorological parameters, except mixing height, have been recorded at the FEMP site as part of a comprehensive environmental monitoring program since August 1986.

Direct measurements of wind speed, wind direction, and ambient air temperature were taken at a height of 10 meters (33 feet) above the ground. Atmospheric stability was derived from direct

measurements of the standard deviation of the horizontal wind direction (σ_θ) during the day and the low-level temperature difference (ΔT) at night. Measurements of σ_θ were taken at a height of 60 meters (180 feet) above the ground. The temperature difference was calculated from air temperature measurements taken at 60 and 10 meters (180 and 30 feet) above the ground. Site-specific hourly measurements were obtained for 1987 through 1992 excluding 1990 due to poor data recovery. A five-year composite joint frequency distribution of windspeed, wind direction, and atmospheric stability is presented in Attachment I.II-5. The composite distribution was used in the ISCLT2 dispersion model.

Mixing heights were determined from twice daily atmospheric soundings made by the National Weather Service. The nearest station is in Dayton, Ohio.

I.6.2.7 Receptor Locations

As previously stated, the objective of the air transport analysis was to determine the maximum on- and off-property contaminant concentrations for risk assessment calculations. Two rectangular receptor grid systems were used to determine the maximum on-property concentrations and approximate locations. The first grid consisted of 625 receptor points in a 121.9 x 121.9 meter (400 x 400 foot) pattern which extended over the entire FEMP property. The FEMP coordinate system was used for origin and location. The second grid consisted of 360 receptor points also in a 121.9 x 121.9 meter (400 x 400 foot) pattern located over the center of the FEMP. The second grid was offset 60 meters (200 feet) north and 60 meters (200) feet east of the first grid, resulting in an effective 86.2 x 86.2 meter (283 x 283 foot) pattern over the center of the FEMP.

Thirty-six fenceline receptor points located around the FEMP were included in the air transport analysis to identify the maximum off-property receptor. These fenceline receptor locations were determined from the intersection of the FEMP fenceline and imaginary lines extending in 36 directions at 10-degree intervals from a point along the centerline and halfway between Silos 1 and 2 in Operable Unit 4. The analysis results for the fenceline receptor with the highest air quality impacts are reported as the maximum off-property concentrations in Section I.6.2.10. In

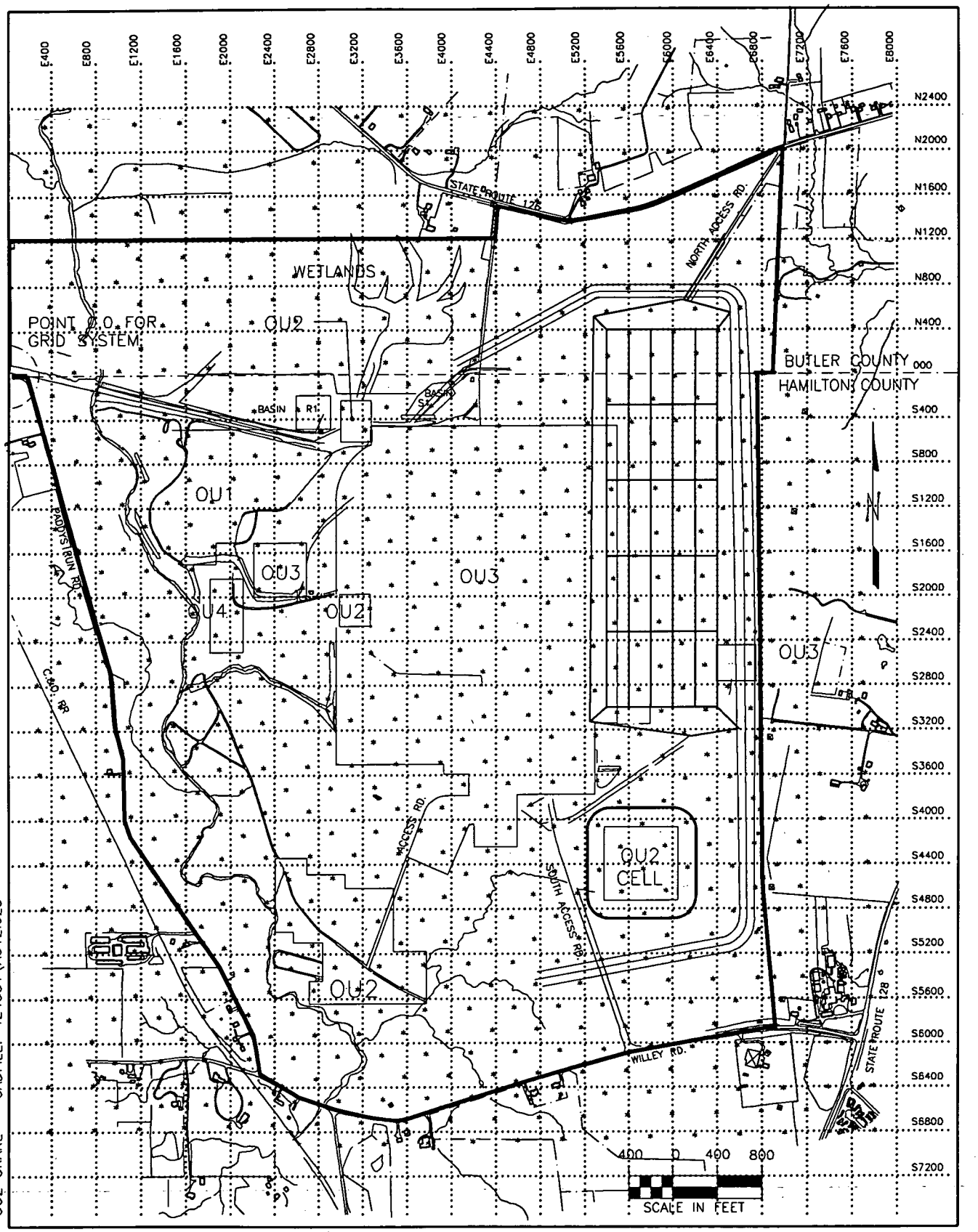

FIGURE 1.6-23

RECEPTOR GRIDS FOR AIR DISPERSION MODELING

addition, seven discrete locations were identified to represent sensitive receptors. These locations included: Crosby, Elda, Morgan, and St. John Elementary Schools, Ross Middle and High School, Ross County Day Nursery, and Venice Presbyterian Pre-School.

Figure I.6-23 shows the layout of the receptor grid considered in the air dispersion modeling. Because the concentrations were used primarily to estimate inhalation pathway risk for outdoor activities, the receptors were assumed to be 1.5 meters (5 feet) above the ground to simulate a typical person's breathing height for outdoor activities (EPA 1989a). The variation of ground level concentration within 0 to 1.5 meters (5 feet) is negligible.

I.6.2.8 Dispersion Coefficients

The selection of rural or urban dispersion coefficients for use in the ISCLT2 model was based on a land-use typing procedure to determine whether the characteristics of the area around the FEMP are primarily rural or urban. The procedure involved classifying the land use within an area circumscribed by a 3-kilometer (1.9-mile) radius about the site. Urban dispersion coefficients were recommended for use if land-use types of heavy industrial, light-to-moderate industrial, commercial, single-compact residential, and multi-compact residential account for 50 percent or more of the area. Otherwise, rural dispersion coefficients were recommended.

A review of U.S. Geological Survey (USGS) maps and a site survey of the area indicated that industrial, commercial, and compact residential land use comprise no more than 10 percent of the area within a 3-kilometer (1.9-mile) radius of the site. Therefore, the area was classified as rural for the purpose of air dispersion modeling, indicating the use of rural dispersion coefficients would be appropriate.

I.6.2.9 Model Output Processing

The air dispersion modeling analysis was simplified by running the ISCLT2 model with an assumed emission rate of 1.0 $g/s/m^2$ or 1.0 $pCi/s/m^2$ for each area source. The source group and plot file options of the ISCLT2 program were used to group sources with identical emission rates and write the grouped results to a plot file. The ISCLT2 source group results were multiplied by the contaminant emission rates listed in Attachment I.II-3 to determine the contaminant-specific

annual concentrations presented in Section I.6.2.10. Spreadsheets were used to calculate the contaminant-specific concentrations from the ISCLT2 model output and emissions data in Attachment I.II-3.

The 1247 area sources were combined into 47 source groups:

1. Former Production Area PAa (8 sources)
2. Former Production Area PAb (16 sources)
3. Former Production Area PAc (10 sources)
4. Former Production Area PAd (5 sources)
5. Former Production Area PAe (15 sources)
6. Former Production Area PAf (15 sources)
7. Former Production Area PAg (10 sources)
8. Former Production Area PAh (61 sources)
9. Former Production Area PAi (43 sources)
10. OU5 Surface Area 560a (108 sources)
11. OU5 Surface Area 560b (51 sources)
12. OU5 Surface Area 560c (8 sources)
13. OU5 Surface Area 560d (5 sources)
14. OU5 Surface Area 570a (55 sources)
15. OU5 Surface Area 570b (14 sources)
16. OU5 Surface Area 570c (6 sources)
17. OU5 Surface Area 570d (18 sources)
18. OU5 Surface Area 570e (22 sources)
19. OU5 Surface Area 575a (56 sources)
20. OU5 Surface Area 575b (11 sources)
21. OU5 Surface Area 580a (27 sources)
22. OU5 Surface Area 581a (140 sources)
23. OU5 Surface Area 581b (93 sources)
24. OU5 Surface Area 581c (47 sources)
25. OU5 Surface Area 581d (13 sources)
26. OU5 Surface Area 582a (62 sources)
27 OU5 Surface Area 582b (16 sources)
28. OU5 Surface Area WPAa (49 sources)
29. Waste Pit 1 (1 source)
30. Waste Pit 2 (1 source)
31. Waste Pit 3 (1 source)
32. Waste Pit 4 (1 source)
33. Waste Pit 5 (1 source)
34. Waste Pit 6 (1 source)
35. Burn Pit (1 source)
36. Clearwell (1 source)
37. Active Flyash Pile - Exposed GMA (26 sources)
38. Active Flyash Pile - Exposed Till, (57 sources)
39. Inactive Flyash Pile - Exposed GMA (32 sources)
40. Inactive Flyash Pile - Exposed Till (22 sources)

41. South Field - Exposed GMA (40 sources)
42. South Field - Exposed Till (43 sources)
43. South Field - Exposed Fill (58 sources)
44. Solid Waste Landfill (4 sources)
45. Lime Sludge Ponds (4 sources)
46. OU4 Surface Soil (10 sources)
47. FEMP Northeast Corner Surface Soil (50 sources)

The majority of these surface areas are the same as those used for surface water runoff modeling in the Operable Unit 5 RI Report (DOE 1994f). The surface areas for Operable Unit 2 are based on the air dispersion modeling areas presented in the Operable Unit 2 FS Report (DOE 1994a).

I.6.2.10 Results of Air Dispersion Modeling

This section presents the modeled air concentration for each contaminant. In addition, the modeled concentrations of several radionuclides are compared to the monitored air concentrations from previous years to determine the effectiveness of mitigation measures and to identify the magnitude of uncertainties in the analysis.

I.6.2.10.1 Modeled Air Concentrations

The modeled maximum annual average contaminant air concentrations are presented in Table I.6-9. The values presented are the maximum on-property concentration and maximum off-property (fenceline) concentration for each contaminant. Based on the results presented in the Operable Unit 4 CRARE, the maximum off-property concentrations were used to represent average on-property concentrations for receptors that were assumed to roam or wander over the property.

Gaseous Rn-222 emissions resulted in the highest activity concentrations of any radionuclide analyzed by at least two orders of magnitude. The maximum on-property and fenceline concentrations of Rn-222 were modeled at 12.8 and 12.6 pCi/m^3, respectively. Isopleths of Rn-222 concentrations are shown on Figure I.6-24. The maximum value is between two and three orders of magnitude below the EPA action level of 4000 pCi/m^3 (4 pCi/l) for indoor radon concentrations. The maximum value is also two orders of magnitude below the annual average U.S. residential radon concentration of 1250 pCi/m^3 (Marcinowski and Napolitano 1993).

TABLE I.6-9

CONTAMINANT CONCENTRATIONS IN AIR

Contaminant	On-Property Maximum	Off-Property Maximum
Radionuclides (pCi/m^3):		
Cesium-137	5.66×10^{-7}	4.34×10^{-7}
Lead-210	1.55×10^{-5}	1.14×10^{-5}
Neptunium-237	4.39×10^{-7}	1.98×10^{-7}
Plutonium-238	1.46×10^{-5}	1.19×10^{-5}
Plutonium-239	1.20×10^{-6}	3.94×10^{-7}
Plutonium-240	4.34×10^{-6}	1.43×10^{-6}
Proactinium-231	1.16×10^{-6}	4.11×10^{-7}
Radium-226	9.31×107^{-6}	9.13×10^{-7}
Radium-228	1.24×10^{-6}	1.14×10^{-6}
Ruthinium-106	5.35×10^{-7}	7.77×10^{-8}
Strontium-90	1.82×10^{-6}	1.40×10^{-6}
Technetium-99	3.29×10^{-5}	2.31×105^{-6}
Thorium-228	1.02×10^{-6}	9.45×107^{-6}
Thorium-230	3.65×10^{-6}	3.27×10^{-6}
Thorium-232	2.83×10^{-6}	2.70×10^{-6}
Uranium-234	5.06×10^{-6}	4.64×10^{-5}
Uranium-235	1.34×10^{-6}	1.23×10^{-6}
Uranium-236	5.53×10^{-7}	5.09×10^{-7}
Uranium-238	3.02×10^{-5}	2.78×10^{-5}
Radon-222	1.28×10^{1}	1.26×10^{-1}

TABLE I.6-9 (Continued)

Contaminant	On-Property Maximum	Off-Property Maximum
Inorganics (ug/m^3):		
Antimony	9.16×10^{-6}	7.54×10^{-6}
Arsenic	9.96×10^{-6}	5.31×10^{-6}
Barium	1.31×10^{-4}	8.16×10^{-5}
Beryllium	1.06×10^{-6}	7.83×10^{-7}
Boron	8.97×10^{-6}	8.48×10^{-6}
Cadmium	2.92×10^{-6}	1.30×10^{-6}
Chromium	1.83×10^{-5}	1.24×10^{-5}
Cobalt	7.70×10^{-6}	6.34×10^{6}
Copper	4.80×10^{-5}	3.75×10^{-5}
Cyanide	5.09×10^{-7}	4.62×10^{-7}
Lead	1.25×10^{-3}	1.28×10^{-3}
Manganese	4.32×10^{-7}	2.42×10^{-7}
Mercury	4.32×10^{-7}	2.42×10^{-7}
Molybdenum	5.83×10^{-6}	4.06×10^{-6}
Nickel	1.90×10^{-5}	1.52×10^{-5}
Selenium	7.57×10^{-7}	3.37×10^{-7}
Silver	4.45×10^{-6}	2.67×10^{-6}
Thallium	3.35×10^{-7}	3.30×10^{-7}
Thorium	2.14×10^{-4}	7.50×10^{-5}
Uranium	3.48×10^{-3}	1.00×10^{-3}
Vanadium	1.98×10^{-5}	1.98×10^{-5}
Zinc	6.15×10^{-5}	5.14×10^{-5}

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TABLE I.6-9 (Continued)

Contaminant	On-Property Maximum	Off-Property Maximum
Organics (ug/m^3):		
2-Methylnaphthalene	2.51×10^{-7}	6.02×10^{-8}
4,4'-DDE	5.29×10^{-9}	4.28×10^{-9}
Aroclor-1221	0.00	0.00
Aroclor-1248	0.00	0.00
Aroclor-1254	1.54×10^{-6}	2.65×10^{-7}
Aroclor-1260	4.05×10^{-7}	6.39×10^{-8}
Carbazole	1.05×10^{-7}	1.66×10^{-8}
Endrin	0.00	0.00
2,3,7,8-TCDD (Equiv.)	5.40×10^{-13}	8.79×10^{-14}

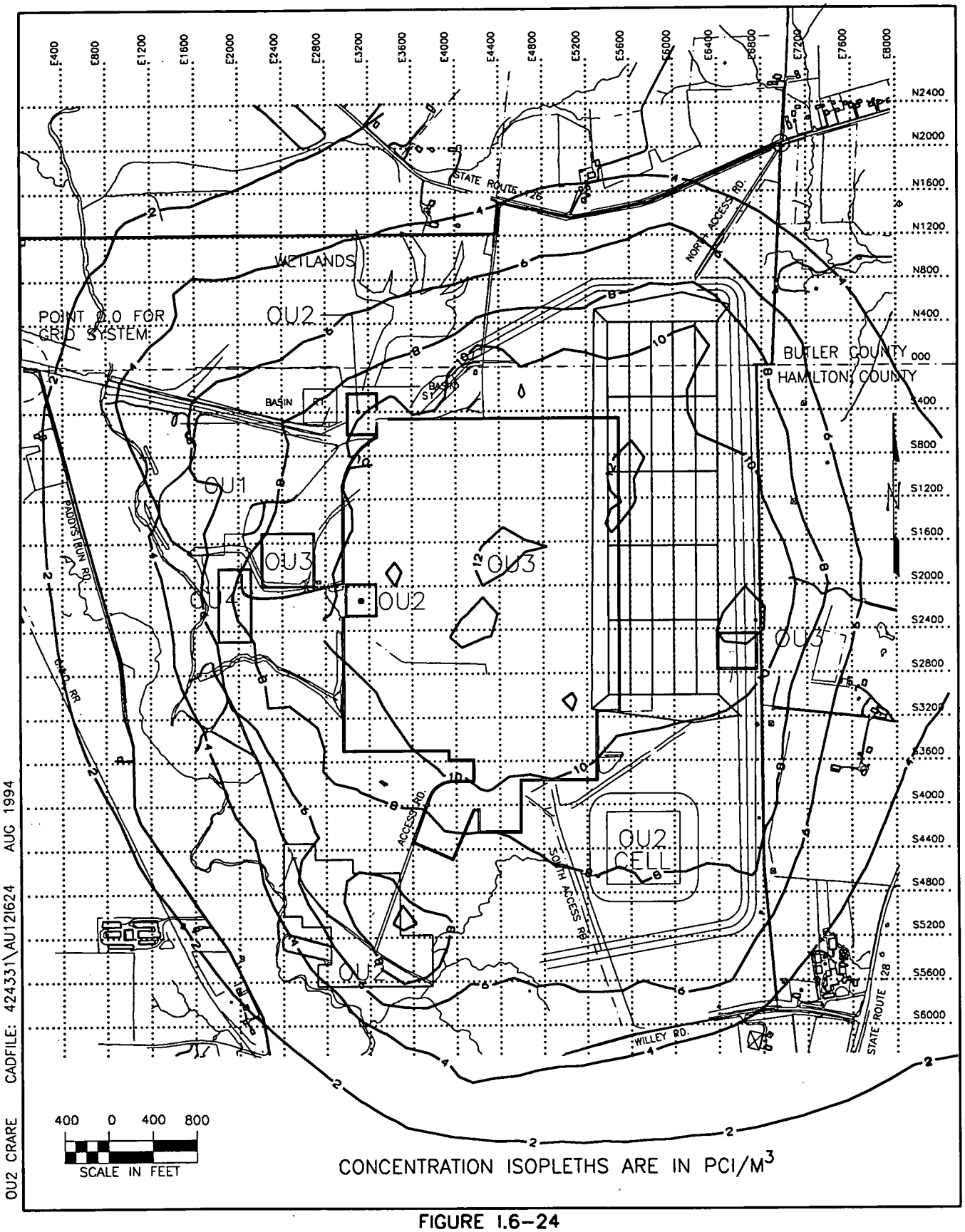

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FIGURE 1.6-24

Rn-222 CONCENTRATIONS IN AIR

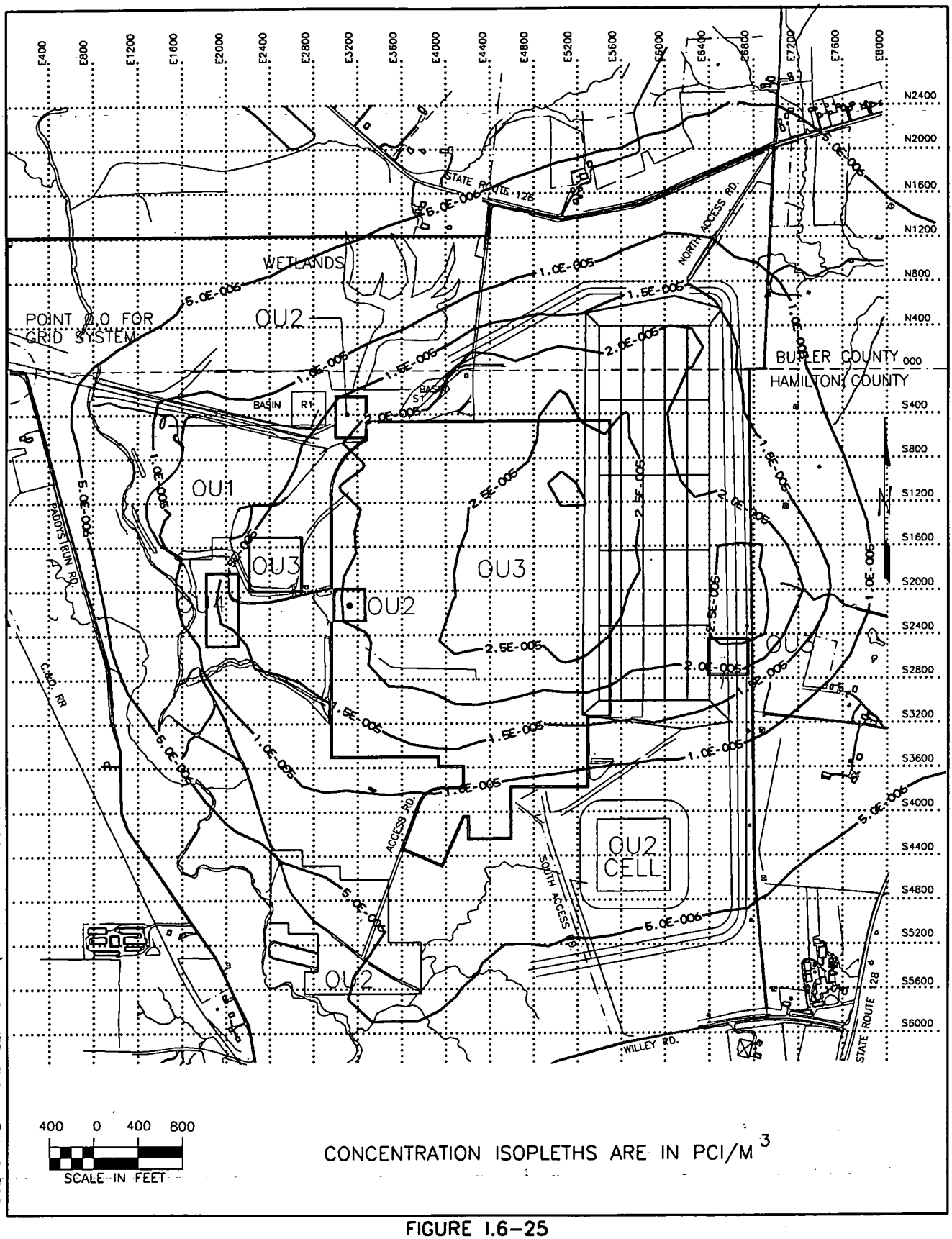

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FIGURE 1.6-25

U-238 CONCENTRATIONS IN AIR

Modeled concentrations of U-238 represented typical, particulate phase, radionuclide activity concentrations. The maximum on-property and fenceline concentrations of U-238 were modeled at 3.02×10^{-5} and 2.78×10^{-5} pCi/m^3, respectively. Isopleths of U-238 concentrations are presented on Figure I.6-25.

I.6.2.10.2 Comparison to Monitored Air Concentrations

The average monitored fenceline concentrations of Rn-222 were approximately 240, 230, and 310 pCi/m^3 (corrected for background levels) during 1989, 1990, and 1991, respectively (DOE 1991 and 1992b). This analysis indicates that implementing the remedial alternatives would result in mitigating approximately 95 percent of existing Rn-222 emission impacts.

The maximum monitored fenceline concentration of U-238 was approximately 0.00012 pCi/m^3 during 1990 (DOE 1991). Comparison of modeled future fenceline concentrations with currently measured values indicates that remediation of the site would result in mitigating approximately 77 percent of existing U-238 emission impacts.

Monitored and modeled fenceline results for several radionuclides are presented in Table I.6-10. These results indicate that the modeled future concentrations are less than concentrations currently monitored at the FEMP, except for Pu-238 and Pu-240. The plutonium isotopes have relatively high are concentrations due to elevated levels in the former production area and existing sewage treatment plant (located near the eastern fenceline) coupled with high PRLs presented in the Site-Wide Characterization Report.

000204

TABLE I.6-10
MODELED AND MONITORED RADIONUCLIDE FENCELINE CONCENTRATIONS IN AIR (pCi/m^3)

Radionuclide	Modeled Value	1990 Monitored Values
Cs-137	4.34×10^{-7}	$<5.9 \times 10^{-5}$
Np-237	1.98×10^{-7}	$<1.4 \times 10^{-6}$
Pu-238	1.19×10^{-5}	$<1.2 \times 10^{-6}$
Pu-239	3.94×10^{-7}	$<1.1 \times 10^{-6}$
Pu-240	1.43×10^{-6}	$<1.1 \times 10^{-6}$
Ra-226	9.13×10^{-7}	$<1.6 \times 10^{-6}$
Ra-228	1.14×10^{-6}	$<1.2 \times 10^{-5}$
Sr-90	1.40×10^{-6}	3.8×10^{-6}
Tc-99	2.31×10^{-5}	$<1.1 \times 10^{-4}$
Th-228	9.45×10^{-7}	$<5.8 \times 10^{-6}$
Th-230	3.27×10^{-6}	6.9×10^{-6}
Th-232	2.70×10^{-6}	$<5.8 \times 10^{-6}$
U-234	4.64×10^{-5}	1.3×10^{-4}
U-235	1.23×10^{-6}	4.8×10^{-6}
U-236	5.09×10^{-7}	1.7×10^{-6}
U-238	2.78×10^{-5}	1.2×10^{-4}

SOURCE: DOE 1991 for monitored values.

I.6.3 FARM PRODUCTS FATE MODELING

This section describes the equations used to estimate exposure to chemicals and radionuclides from ingestion of contaminated farm products.

I.6.3.1 Ingestion of Vegetables

The equations used to estimate exposure to chemicals and radionuclides via ingestion of vegetables irrigated with contaminated water are from the NRC (NRC 1977) and the EPA (EPA 1989d). This process involves estimating the concentration of the contaminant on and in the plant as a result of foliar deposition and root uptake. The model used to estimate the concentration in and on vegetation irrigated with contaminated water is (NRC 1977):

$$C_{ivw} = d_w \left[\frac{r_w (1 - e^{-\lambda_{Ei} t_e})}{Y \lambda_{Ei}} + \frac{f_w B_{iv} (1 - e^{-\lambda_{di} t_{bw}})}{\rho \lambda_{di}} \right] e^{-\lambda_{ri} t_h} \qquad \text{(I.6-6)}$$

For vegetation exposed to atmospheric fallout of dust, the equation becomes (NRC 1977):

$$C_{ivd} = d_d \left[\frac{r_d (1 - e^{-\lambda_{Ei} t_e})}{Y \lambda_{Ei}} + \frac{f_d B_{iv} (1 - e^{-\lambda_{di} t_{bd}})}{\rho \lambda_{di}} \right] e^{-\lambda_{ri} t_h} \qquad \text{(I.6-7)}$$

where

λ_{Ei}	=	effective depletion constant of ith contaminant on the plant surface (hr^{-1}),
λ_{di}	=	effective depletion constant from root zone of soil (hr^{-1}),
λ_{ri}	=	radioactive or chemical decay constant of ith contaminant (hr^{-1}), from Howard 1991,
B_{iv}	=	dry soil to wet plant (vegetables, forage, and fruit) transfer coefficient of ith contaminant,
C_{ivd}	=	concentration of ith contaminant in plants as a result of deposition of contaminated dust on plants (pCi/kg or mg/kg),
C_{ivw}	=	concentration of ith contaminant in plants as a result of irrigating plants with contaminated water (pCi/kg or mg/kg),
d_d	=	dust deposition rate (pCi/m^2-hr or mg/m^2-hr),
d_w	=	irrigation deposition rate (pCi/m^2-hr or mg/m^2-hr),
f_w	=	fraction of year plant is irrigated (unitless),
f_d	=	fraction of year plant is downwind (unitless),
ρ	=	effective dry surface density of the soil (kg/m^2),
r_d	=	fraction of deposited dust retained on plant surface (unitless),
r_w	=	fraction of water borne material retained on plant surface (unitless),

t_{bd} = period soil is exposed to airborne emissions (hr),
t_{bw} = period soil is exposed to contaminated water (hr),
t_e = growing season (hr),
t_h = duration of period between harvest and consumption (hr), and
Y = agricultural yield (kg/m^2),

$$\lambda_{di} = \lambda_{ri} + \lambda_{Li} \qquad \text{(I.6-8)}$$

and

$$\lambda_{Li} = \frac{V_w}{Z\theta\left[1 + \sigma\,\frac{K_d}{\theta}\right]} \qquad \text{(I.6-9)}$$

$$d_w = (C_{iw})(I) \qquad \text{(I.6-10)}$$
$$d_d = (C_{id})(v_d) \qquad \text{(I.6-11)}$$

where

C_{iw} = concentration of ith contaminant in irrigation water (pCi/l or mg/l),
I = irrigation rate (l/m^2/hr),
C_{id} = concentration of ith contaminant in dust (pCi/g or mg/g),
K_d = water to soil partioning coefficient of constituent (cm^3/g),
λ_{Li} = leachate removal constant (hr^{-1})
θ = moisture fraction of soil in root zone (unitless),
σ = density of soil in root zone (g/cm^3),
v_d = deposition velocity for dust (g/m^2/hr), Attachment I.III,
V_w = percolation rate (cm/hr), and
Z = depth of root zone (cm).

In addition to exposure to contaminated irrigation water and dust, vegetables and livestock feed may be contaminated by root uptake from contaminated soil. The contribution by this pathway is estimated by the irrigation model; however, this pathway is also considered for areas that are not irrigated with contaminated water but that exhibit surface soil contamination from historical deposition on the soil by other means. The following equation was used to estimate the contaminant concentration in the plant from root uptake of contaminants in the soil.

$$C_{ivs} = (C_s)(B_{iv})(e^{-\lambda_{di} t_h}) \qquad \text{(I.6-12)}$$

where

C_{ivs} = concentration of ith contaminant in plants as a result of root uptake from contaminated soil (pCi/kg or mg/kg), and
C_s = concentration of ith contaminant in dry soil at harvest time (pCi/kg or mg/kg).

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The total concentration of contaminants in vegetables (C_{iv}) is estimated using the following equation:

$$C_{iv} = C_{ivw} + C_{ivd} + C_{ivs} \qquad \text{(I.6-13)}$$

Equations of the same form were used to estimate the contaminant concentration in livestock feed, substituting concentration factors for livestock feed in place of those for vegetables ingested by man.

A summary of parameters used in the vegetable and forage uptake models is presented in Table I.6-11. Radioactive or chemical decay constants are presented in Table I.6-12. Transfer coefficients of contaminants from dry soil to wet plant material are presented in Table I.6-13. Source concentrations for farm product fate modeling are presented in Table I.6-14.

I.6.3.2 Ingestion of Meat and Dairy Products

Prior to the determination of intake following ingestion of animal products by humans, the concentration of chemicals and radionuclides in animal products must be estimated. The concentration of a contaminant in animal products, such as beef or milk, was estimated using the following equation (NRC 1977):

$$C_{iA} = F_{iA}[(C_{if})(Q_f) + (C_{iAw})(Q_{Aw})]\, e^{(-\lambda_{ri} t_{iA})} \qquad \text{(I.6-14)}$$

where

C_{iA}	=	concentration of ith contaminant in the animal product (pCi/l for milk, pCi/kg for beef or mg/l for milk, mg/kg for beef),
F_{iA}	=	element (stable) transfer coefficient that relates the daily intake by an animal to the concentration of ith contaminant in an edible portion of the animal product (day/l for milk, day/kg for beef),
C_{if}	=	concentration of ith contaminant in forage (pCi/kg or mg/kg),
Q_f	=	consumption rate of contaminated forage by an animal (kg/day),
C_{iAw}	=	concentration of ith contaminant in livestock water (pCi/l or mg/l),
Q_{Aw}	=	consumption rate of contaminated water by an animal (l/day),
λ_{ri}	=	decay constant of ith contaminant (hr^{-1}), and
t_{iA}	=	delay between harvest of animal product (milk or meat) and consumption (hr).

Transfer coefficients of contaminants to milk or beef (F_{iA}) are presented in Table I.6-13. Contaminant concentrations in forage are presented in Table I.6-15.

TABLE I.6-11

SUMMARY OF PARAMETERS FOR VEGETABLE/FORAGE UPTAKE MODELS

Parameter[a]	Value	Units	Reference
Typical Dust Settling Velocity (1/d)	6.48	m/h	USDA 1970
Irrigation Rate (I)	0.081	$l/m^2/hr$	USDA 1970
Percolation Rate (Vw)	1.28×10^{-3}	cm/h	DOE 1994a
Depth to Root Zone (Z)	15	cm	DOE 1994a
Density of Soil (σ)	1.5	g/cm^3	DOE 1994a
Moisture Fraction in Root Zone (θ)	0.17	unitless	DOE 1994a
Fraction of Deposited Dust Retained on Crops (r_d)	0.25	unitless	NRC 1977
Fraction of Water Borne Material Retained on Crops (r_w)	0.20	unitless	NRC 1977
Effective Depletion Constant of Contaminant on Plant Surface (λ_{Ei})	0.0021	hr^{-1}	NRC 1977
Growing Season for Vegetables and Fruit Crops (t_{ec})	1440	hr	NRC 1977
Growing Season for Forage (t_{eg})	720	hr	NRC 1977
Agricultural Yield of Vegetables and Fruit Crop (Y)	1.5	kg/m^2	USDA 1979
Agricultural Yield of Forage (Y)	0.8	kg/m^2	USDA 1979
Fraction of Year Plants are Downwind (f_d)	MD[b]	unitless	—
Fraction of Year Plans are Irrigated (f_w)	1.0[c]	unitless	NRC 1977
Period Soil is Exposed to Contaminated Water (t_{bw})	8,760,000	hr	Assumed
Period Soil is Exposed to Airborne Emissions (t_{bd})	8,760,000	hr	Assumed
Effective Dry Surface Density of the Soil (ρ)	150[d]	kg/m^3	USDA 1982
Delay between Harvest and Consumption of Vegetables (t_{hv})	24	hr	NRC 1977
Delay between Harvest and Consumption of Vegetables and Fruit (t_{hc})	720	hr	Assumed
Delay between Harvest and Consumption of Forage (t_{hg})	0	hr	NRC 1977
Delay between Milking and Consumption (t_{iA})	48	hr	NRC 1977
Delay between Slaughter and Consumption	480	hr	NRC 1977

[a] See the uncertainty analysis (Section I.10.0) for more information on these parameters.
[b] CRARE modeled RME location.
[c] The fraction of time plants are irrigated is implicitly included in the irrigation rate. To avoid using this parameter twice in Equation 7-9, f_d has been set to 1.0.
[d] Corresponds to a density of 1.5 g/cm^3 and a depth of 10 cm. Moist bulk densities of surface soil range from 1.4 to 1.55 g/cm^3 at the FEMP (USDA 1982).

TABLE I.6-12

CHEMICAL AND RADIOACTIVE COC DECAY CONSTANTS

Chemical	Decay Constant (λ_{ri}) (hr^{-1})	Source	Radionuclide	Decay Constant (λ_{ri}) (hr^{-1})	Source
Antimony	1.00×10^{-14}	a	Cs-137	2.62×10^{-6}	b
Aroclor-1221	1.00×10^{-14}	a	Np-237	3.70×10^{-11}	b
Aroclor-1248	1.00×10^{-14}	a	Pa-231	2.42×10^{-9}	a
Aroclor-1254	1.00×10^{-14}	a	Pb-210	3.55×10^{-6}	a
Aroclor-1260	1.00×10^{-14}	a	Pu-238	9.02×10^{-7}	b
Arsenic	1.00×10^{-14}	a	Pu-239	3.28×10^{-9}	b
Barium	1.00×10^{-14}	a	Pu-240	3.28×10^{-9}	b
Beryllium	1.00×10^{-14}	a	Ra-226	4.95×10^{-8}	a
Boron	1.00×10^{-14}	a	Ra-228	1.37×10^{-5}	a
Cadmium	1.00×10^{-14}	a	Rn-222	NA	
Carbazole	1.00×10^{-14}	a	Ru-106	7.84×10^{-5}	b
Chromium	1.00×10^{-14}	a	Sr-90	2.77×10^{-6}	b
Cobalt	1.00×10^{-14}	a	Tc-99	3.71×10^{-10}	b
Copper	1.00×10^{-14}	a	Th-228	4.14×10^{-5}	a
Cyanide	1.00×10^{-14}	a	Th-230	1.03×10^{-9}	a
4,4-DDE	1.00×10^{-14}	a	Th-232	5.63×10^{-15}	a
Endrin	1.00×10^{-14}	a	U-234	3.24×10^{-10}	a
Lead	1.00×10^{-14}	a	U-235	1.12×10^{-13}	a
Manganese	1.00×10^{-14}	a	U-236	1.12×10^{-13}	b
Mercury	1.00×10^{-14}	a	U-238	1.77×10^{-14}	a
2-Methylnaphthalene	1.00×10^{-14}	a			
Molybdenum	1.00×10^{-14}	a			
Nickel	1.00×10^{-14}	a			
Selenium	1.00×10^{-14}	a			
Silver	1.00×10^{-14}	a			
Thallium	1.00×10^{-14}	a			
Thorium	1.00×10^{-14}	a			
Uranium	1.00×10^{-14}	a			
Vanadium	1.00×10^{-14}	a			
Zinc	1.00×10^{-14}	a			

[a]DOE (1993c)
[b]Grove Engineering (1991)
NA = Non Applicable

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TABLE I.6-13

K_d AND TRANSFER COEFFICIENTS

COC	K_d(cm³/g)	Beef $_{Fla}$(d/kg)	Source	Milk $_{Fla}$(d/l)	Source	Vegetable B $_{(IV2)}$	Source	Forage B $_{(IV1)}$	Source	Fish G (l/kg)	Source
Chemical											
Antimony	4.50×10^{1}	1.00×10^{-3}	a	6.00×10^{-5}	c	1.28×10^{-2}	d	3.00×10^{-2}	a	1.00×10^{0}	d
Aroclor-1221	1.29×10^{1}	3.08×10^{-4}	b	9.75×10^{-5}	c	3.98×10^{-1}		9.32×10^{-1}	e	7.54×10^{2}	d
Aroclor-1248	4.65×10^{3}	1.41×10^{-2}	a	4.46×10^{-3}	c	9.42×10^{-3}	d	2.20×10^{-2}	a	1.38×10^{4}	d
Aroclor-1254	8.86×10^{3}	2.69×10^{-2}	a	8.50×10^{-3}	c	3.04×10^{-3}	d	7.10×10^{-3}	a	2.25×10^{4}	d
Aroclor-1260	1.07×10^{4}	3.02×10^{-1}	a	1.11×10^{-1}	c	4.71×10^{-3}	d	1.10×10^{-2}	a	1.59×10^{5}	d
Arsenic	2.00×10^{2}	2.00×10^{-3}	a	6.00×10^{-5}	d	1.71×10^{-2}	d	4.00×10^{-2}	a	4.40×10^{1}	d
Barium	2.00×10^{2}	1.50×10^{-4}	a	3.50×10^{-4}	d	6.42×10^{-2}	d	1.50×10^{-1}	a	NA	
Beryllium	2.50×10^{2}	1.00×10^{-3}	a	9.00×10^{-7}	d	4.28×10^{-3}	d	1.00×10^{-2}	a	1.90×10^{1}	d
Boron		8.00×10^{-4}	d	1.50×10^{-3}	d	1.71×10^{0}	d	4.00×10^{0}	d	NA	
Cadmium	1.2×10^{1}	5.50×10^{-4}	a	1.00×10^{-3}	d	2.35×10^{-1}	d	5.50×10^{-1}	a	8.10×10^{1}	d
Carbazole		8.14×10^{-5}		2.57×10^{-5}		1.55×10^{-1}		3.62×10^{-1}		2.74×10^{2}	d
Chromium iv	7.0×10^{1}	5.50×10^{-3}	d	1.50×10^{-3}	d	3.21×10^{-3}	d	7.50×10^{-3}	d	1.60×10^{1}	d
Cobalt	6.0×10^{1}	2.00×10^{-2}	a	2.00×10^{-3}	d	8.56×10^{-3}	d	2.00×10^{-2}	a	NA	
Copper	3.5×10^{1}	1.00×10^{-2}	a	1.50×10^{-3}	d	1.71×10^{-1}	d	4.00×10^{-1}	a	2.00×10^{2}	d
Cyanide		5.6×10^{-8}		1.80×10^{-8}		1.50×10^{-1}		3.50×10^{-1}	a	NA	
4,4-DDE		1.26×10^{-2}	a	3.98×10^{-3}	d	7.70×10^{-3}	d	1.80×10^{-2}	a	1.26×10^{4}	d
Endrin		9.12×10^{-4}	d	2.88×10^{-4}	d	3.83×10^{-2}	d	8.96×10^{-2}	d	1.72×10^{3}	d
Lead	3.80×10^{1}	3.00×10^{-4}	a	2.50×10^{-4}	d	1.93×10^{-2}	d	4.50×10^{-2}	a	4.90×10^{1}	d
Manganese	5.0×10^{1}	4.00×10^{-4}	a	3.50×10^{-4}	d	1.07×10^{-1}	d	2.50×10^{-1}	a	NA	
Mercury	1.00×10^{1}	2.50×10^{-1}	a	4.50×10^{-4}	d	3.85×10^{-1}	d	9.00×10^{-1}	a	5.50×10^{3}	d

See footnotes at end of table.

TABLE I.6-13
(Continued)

COC	K_d(cm³/g)	Beef $_{Fia}$(d/kg)	Source	Milk $_{Fia}$(d/l)	Source	Vegetable B $_{(IV2)}$	Source	Forage B $_{(IV1)}$	Source	Fish G (l/kg)	Source
Chemical (cont.)											
2-Methylnaphthalene	5.98×10^{1}	1.82×10^{-4}	a	5.75×10^{-5}	c	9.74×10^{-2}		2.28×10^{-1}		5.05×10^{2}	d
Molybdenum	1.00×10^{1}	6.00×10^{-3}	a	1.50×10^{-3}	d	2.57×10^{-2}	d	6.00×10^{-2}	d	NA	
Nickel	4.00×10^{2}	6.00×10^{-3}	a	1.00×10^{-3}	d	2.57×10^{-2}	d	6.00×10^{-2}	a	4.70×10^{1}	d
Selenium	1.50×10^{2}	1.50×10^{-2}	a	4.00×10^{-3}	d	1.07×10^{-2}	d	2.50×10^{-2}	a	1.60×10^{1}	d
Silver	9.00×10^{1}	3.00×10^{-3}	d	2.00×10^{-2}	d	1.71×10^{-1}	d	4.00×10^{-1}	d	3.10×10^{3}	d
Tetrachlorodibenzo-p-dioxin		1.58×10^{-1}		5.01×10^{-2}		1.95×10^{-3}		4.55×10^{-3}		8.67×10^{4}	d
Thallium	1.50×10^{3}	4.00×10^{-2}	a	2.00×10^{-3}	d	1.71×10^{-3}	d	4.00×10^{-3}	a	NA	
Thorium	3.20×10^{3}	6.00×10^{-6}	a	5.00×10^{-6}	d	3.64×10^{-4}	d	8.50×10^{-4}	a	3.00×10^{1}	d
Uranium		2.00×10^{-4}	a	6.00×10^{-4}	d	3.64×10^{-3}	d	8.50×10^{-3}	a	2.00×10^{0}	d
Vanadium	1.00×10^{3}	2.50×10^{-3}	a	2.00×10^{-5}	d	2.35×10^{-3}	d	5.50×10^{-3}	a	NA	
Zinc	2.40×10^{3}	1.00×10^{-1}	a	1.00×10^{-2}	d	6.42×10^{-1}	d	1.50×10^{0}	a	4.70×10^{1}	d
Radionuclide											
Cs-137	1.37×10^{3}	2.00×10^{-2}	a	7.00×10^{-3}	d	3.42×10^{-2}	d	8.00×10^{-2}	a	2.00×10^{3}	d
Np-237	5.00×10^{0}	5.50×10^{-5}	a	5.00×10^{-6}	d	4.28×10^{-3}	d	1.00×10^{-2}	a	1.00×10^{1}	d
Pa-231	5.50×10^{2}	1.0×10^{-5}	a	5.00×10^{-4}	d	1.07×10^{-4}	d	2.50×10^{-4}	a	1.10×10^{4}	d
Pb-210	3.80×10^{1}	3.0×10^{-4}		2.50×10^{-4}		1.93×10^{-2}		4.50×10^{-2}	a	1.00×10^{2}	d
Pu-238	1.00×10^{2}	5.00×10^{-7}	a	1.00×10^{-7}	d	1.93×10^{-4}	d	4.50×10^{-4}	a	2.50×10^{1}	d
Pu-239	1.00×10^{2}	5.00×10^{-7}	a	1.00×10^{-7}	d	1.93×10^{-4}	d	4.50×10^{-4}	a	2.50×10^{1}	d
Pu-240	1.00×10^{2}	5.00×10^{-7}	a	1.00×10^{-7}	d	1.93×10^{-4}	d	4.50×10^{-4}	a	2.50×10^{1}	d
Ra-226	1.06×10^{2}	2.50×10^{-4}	a	4.50×10^{-4}	d	6.42×10^{-3}	d	1.50×10^{-2}	a	5.00×10^{1}	d
Ra-228	1.06×10^{2}	2.50×10^{-4}	a	4.50×10^{-4}	d	6.42×10^{-3}	d	1.50×10^{-2}	a	5.00×10^{1}	d

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See footnotes at end of table.

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TABLE I.6-13
(Continued)

COC	K_d(cm³/g)	Beef $_{Fia}$(d/kg)	Source	Milk $_{Fia}$(d/l)	Source	Vegetable B $_{(IV2)}$	Source	Forage B $_{(IV1)}$	Source	Fish G (l/kg)	Source
Radionuclide (cont.)											
Rn-222		NA		NA		NA		NA		NA	
Ru-106	5.50×10^{1}	2.00×10^{-3}		6.00×10^{-7}	d	8.56×10^{-3}	d	2.00×10^{-2}	a	1.00×10^{1}	d
Sr-90	2.50×10^{0}	3.00×10^{-4}	a	1.50×10^{-3}	d	1.07×10^{0}	d	2.50×10^{0}	a	3.00×10^{1}	d
Tc-99	7.00×10^{-2}	8.50×10^{-3}	a	1.00×10^{-2}	d	4.07×10^{0}	d	9.50×10^{0}	a	1.50×10^{1}	d
Th-228	3.20×10^{3}	6.00×10^{-6}	a	5.00×10^{-6}	d	3.64×10^{-4}	d	8.50×10^{-4}	d	3.00×10^{1}	d
Th-230	3.20×10^{3}	6.00×10^{-6}	a	5.00×10^{-6}	d	3.64×10^{-4}	d	8.50×10^{-4}	d	3.00×10^{1}	d
Th-232	3.20×10^{3}	6.00×10^{-6}	a	5.00×10^{-6}	d	3.64×10^{-4}	d	8.50×10^{-4}	d	3.00×10^{1}	d
U-234	1.48×10^{0}	2.00×10^{-4}	a	6.00×10^{-4}	d	3.64×10^{-3}	d	8.50×10^{-3}	d	2.00×10^{0}	d
U-235	1.48×10^{0}	2.00×10^{-4}	a	6.00×10^{-4}	d	3.64×10^{-3}	d	8.50×10^{-3}	d	2.00×10^{0}	d
U-236	1.48×10^{0}	2.00×10^{-4}	a	6.00×10^{-4}	d	3.64×10^{-3}	d	8.50×10^{-3}	d	2.00×10^{0}	d
U-238	1.48×10^{0}	2.00×10^{-4}	a	6.00×10^{-4}	d	3.64×10^{-3}	d	8.50×10^{-3}	d	2.00×10^{0}	d

[a]SWCR (DOE 1993a)
[b]Log of bioconcentration factor in beef (Log Bb) calculated from geometric mean regression model: Log Bb = -7.6 + Log Kow (RAWPA; DOE 1992a)
[c]Log of Biotransfer factor in milk (Log Bm) calculated from geometric mean regression model: Log Bm = -8.10 + Log Kow (RAWPA; DOE 1992a)
[d]Operable Unit 2 RI Report (DOE 1994a)
[e]Log of bioconcentration factor in vegetation (Log Bv) calculated from geometric mean regression model: Log Bv = 1.588 - 0.578 Log Kow (RAWPA; DOE 1992a)
[f]Not Available

In addition to intake from irrigated forage and water, cows may receive a significant intake from soil ingestion if the soil is also a source of contamination (Zach and Mayoh 1984). The following equation was used to estimate the concentration in the animal product from soil ingestion (EPA 1989d):

$$C_{iA} = F_{iA}[(C_s)(Q_s)]e^{(-\lambda_{di}t_{iA})} \qquad \text{(I.6-15}$$

where

C_s = concentration ofcontaminant in soil (pCi/kg or mg/kg), and
Q_s = consumption rate of soil by livestock (kg/day).

Animal Consumption Rates

The following parameters were used to quantify the intake of contaminants in food and water by beef and milk cattle at or near the FEMP:

Animal	Q_f Feed or Forage[a] (kg wet weight/day)	Q_{Aw} Water[a] (l/day)	Q_s Soil[b] (kg/day)
Milk cow	50	60	0.5
Beef cattle	50	50	0.5

[a]NCR 1977
[b]Zach and Mayoh (1984)

Radionuclide and Nonradioactive Transfer Coefficients

Transfer coefficients for radioelements and nonradioactive metals were taken from Baes et al. (1984), Till and Meyer (1983) and EPA (1989e). The radiological properties of atoms do not effect their elemental transfer in the environment. The soil-to-plant transfer coefficient for edible plants ingested by humans and forage ingested by cattle used in intake models, in the absence of site-specific information, are listed in Table I.6-13. These factors are the ratios of the dry-weight concentration of an element in the reproductive or vegetative portions of the plant to the dry-weight concentration of the element in soil. Edible portions of the plant include grain kernels, fruits, and tubers. These portions are most representative of the plant foods ingested by humans. The list of elements is not all inclusive. The cited references were used to obtain values for additional constituents of concern in individual risk assessments as needed.

Transfer coefficients for organic chemicals were taken from Travis and Arms (1988). If a transfer coefficient was not readily available, the following regression equations based on the relationship between transfer and the octanol-water partition coefficient (K_{ow}) were used to estimate transfer coefficients (Travis and Arms 1988):

$B_{iv(2)}$ (vegetables)	$\log B_{iv} = 1.588 - 0.578 \log K_{ow}$
F_{iA} (milk)	$\log F_{iA} = -8.10 + \log K_{ow}$
F_{iA} (beef)	$\log F_{iA} = -7.6 + \log K_{ow}$

Chemical-specific K_{ow} values are available from several sources. The major source used for K_{ow} values was Hansch and Leo (1979).

Concentrations in the aboveground vegetative part of plants were estimated using the following equation (Baes et al. 1984):

$$C_{iv} = (C_s)(B_{iv(1)}) \qquad \text{(I.6-16)}$$

where

C_{iv} = concentration of the ith contaminant in vegetation (mg/kg dry wt),
C_s = maximum concentration in soil (mg/kg dry wt), and
$B_{iv(1)}$ = soil to plant transfer factor of the ith contaminant (mg/kg dry wt plant per mg/kg dry wt soil).

I.6.3.3 Results of Farm Product Fate Modeling

Tables I.6-16 through I.6-18 present a summary of modeling results for the contaminant concentrations in vegetables, meat, and dairy products under the Current Land Use and two Future Land Use scenarios. These values have been incorporated into Section I.8.0.

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TABLE I.6-14

SOURCE CONCENTRATIONS FOR FARM PRODUCTS FATE MODELING

	C_{id} (mg/m^3)		C_{iw} (mg/l)			
Chemical	Off-Property	On-Property	Current Off-Property	Future Off-Property	Future On-Property	C_s (mg/kg)
Antimony	7.54×10^{-9}	9.16×10^{-9}	3.05×10^{-7}		1.24×10^{-3}	5.35×10^{0}
Arsenic	5.31×10^{-9}	9.96×10^{-9}	NA		4.26×10^{-3}	5.09×10^{0}
Barium	8.16×10^{-8}	1.31×10^{-7}	NA		NA	9.72×10^{2}
Beryllium	7.83×10^{-10}	1.06×10^{-9}	NA		1.15×10^{-4}	7.55×10^{-1}
Boron	8.48×10^{-9}	8.97×10^{-9}	NA		NA	1.12×10^{2}
Cadmium	1.30×10^{-9}	2.92×10^{-9}	4.0×10^{-31}		NA	3.48×10^{0}
Chromium vi	1.24×10^{-8}	1.83×10^{-9}	NA		NA	1.64×10^{1}
Cobalt	6.34×10^{-9}	7.70×10^{-9}	NA		NA	1.21×10^{1}
Copper	3.75×10^{-8}	4.80×10^{-8}	NA		NA	2.02×10^{1}
Cyanide	4.62×10^{-10}	5.09×10^{-8}	NA		NA	2.50×10^{-1}
Lead	1.28×10^{-6}	1.25×10^{-6}	NA		NA	2.35×10^{1}
Manganese	2.42×10^{-10}	4.32×10^{-10}	NA		NA	9.76×10^{2}
Mercury	2.42×10^{-10}	4.32×10^{-10}	NA		NA	2.14×10^{-1}
Molybdenum	4.06×10^{-9}	5.83×10^{-9}	NA		NA	6.49×10^{0}
Nickel	1.52×10^{-8}	1.90×10^{-8}	NA		NA	2.26×10^{1}
Selenium	3.37×10^{-10}	7.57×10^{-10}	NA		NA	6.31×10^{-1}
Silver	2.67×10^{-9}	4.45×10^{-9}	NA		NA	6.49×10^{0}
Thallium	3.30×10^{-10}	3.35×10^{-10}	NA		NA	2.26×10^{1}
Thorium-total	7.50×10^{-8}	2.14×10^{-10}	NA		NA	6.31×10^{-1}
Uranium-total	1.00×10^{-6}	3.48×10^{-6}	5.58×10^{-3}		1.82×10^{-1}	6.03×10^{0}
Vanadium	1.98×10^{-8}	1.98×10^{-8}	NA		NA	5.58×10^{-1}
Zinc	5.14×10^{-8}	6.15×10^{-8}	NA		NA	NA
2-Methylnaphthalene	6.02×10^{-11}	2.51×10^{-10}	NA		NA	NA
4,4-dde	4.28×10^{-12}	5.29×10^{-12}	NA		NA	2.60×10^{1}
Arcoclor-1221	NA	NA	2.21×10^{-34}		NA	6.41×10^{1}
Aroclor-1248	NA	NA	NA		NA	NA
Aroclor-1254	2.65×10^{-10}	1.54×10^{-9}	NA		NA	NA
Aroclor-1260	6.39×10^{-11}	4.05×10^{-10}	NA		NA	NA
Carbazole	1.66×10^{-11}	1.05×10^{-10}	NA		NA	NA
Endrin	NA	NA	NA		NA	NA
2,3,7,8-tcdd	8.79×10^{-17}	5.4×10^{-16}	NA		NA	NA

TABLE I.6-14
(Continued)

Radionuclides	C_{id} (mg/m^3) Off-Property	C_{id} (mg/m^3) On-Property	C_{iw} (mg/l) Current Off-Property	C_{iw} (mg/l) Future Off-Property	C_{iw} (mg/l) Future On-Property	C_s (mg/kg)
Cs_{137}	4.34×10^{-7}	5.66×10^{-7}	NA		NA	7.93×10^{2}
Pb_{210}	1.14×10^{-5}	1.55×10^{-5}	NA		NA	1.05×10^{-3}
Np_{237}	1.98×10^{-7}	4.39×10^{-7}	7.68×10^{-3}		5.68×10	8.36×10^{-5}
Pu_{238}	1.19×10^{-5}	1.46×10^{-5}	NA		NA	9.07×10^{-5}
Pu_{239}	3.94×10^{-7}	1.20×10^{-6}	NA		NA	1.25×10^{-5}
Pu_{240}	1.43×10^{-6}	4.34×10^{-6}	NA		NA	4.55×10^{-5}
Pa_{231}	4.11×10^{-7}	1.16×10^{-6}	NA		NA	NA
Ra_{226}	9.13×10^{-7}	9.31×10^{-7}	NA		2.5×10^{-1}	3.99×10^{-4}
Ra_{228}	1.14×10^{-6}	1.24×10^{-6}	NA		NA	7.00×10^{-4}
Ru_{106}	7.77×10^{-8}	5.35×10^{-7}	NA		NA	1.33×10^{-4}
Rn_{222}	1.26×10^{1}	1.28×10^{1}	NA		NA	NA
Sr_{90}	1.40×10^{-6}	1.82×10^{-6}	NA		NA	8.33×10^{-4}
Tc_{99}	2.31×10^{-5}	3.29×10^{-5}	4.06×10^{2}		5.24×10^{-3}	1.87×10^{-3}
Th_{228}	9.45×10^{-7}	1.02×10^{-6}	NA		NA	4.00×10^{-4}
Th_{230}	3.27×10^{-6}	3.65×10^{-6}	NA		NA	5.92×10^{-5}
Th_{232}	2.70×10^{-6}	2.83×10^{-6}	NA		NA	5.95×10^{-4}
U_{234}	4.64×10^{-5}	5.06×10^{-5}	9.27×10^{0}		1.02×10^{2}	2.06×10^{-2}
U_{235}	1.23×10^{-6}	1.34×10^{-6}	2.46×10^{-1}		2.7×10^{0}	9.34×10^{-4}
U_{236}	5.09×10^{-7}	5.53×10^{-7}	1.01×10^{-1}		1.12×10^{0}	6.86×10^{-3}
U_{238}	2.78×10^{-5}	3.02×10^{-5}	5.54×10^{0}		6.12×10^{1}	1.38×10^{-2}

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TABLE I.6-15

CONTAMINANT CONCENTRATION IN FORAGE

	C_{ir} (mg/kg)	
Chemical	**Off-Property**	**On-Property**
Antimony	1.9×10^{-5}	2.2×10^{-1}
Arsenic	3.76×10^{-5}	4.32×10^{-1}
Barium	3.10×10^{-4}	$1.71 \times 10^{+1}$
Beryllium	2.46×10^{-6}	1.34×10^{-2}
Boron	1.57×10^{-5}	$5.40 \times 10^{+1}$
Cadmium	8.53×10^{-6}	$1.40 \times 10^{+0}$
Chromium vi	2.36×10^{-5}	1.38×10^{-1}
Cobalt	1.53×10^{-5}	2.20×10^{-1}
Copper	4.56×10^{-4}	$1.58 \times 10^{+1}$
Cyanide	1.82×10^{-6}	$1.40 \times 10^{+1}$
Lead	3.59×10^{-3}	$1.72 \times 10^{+1}$
Manganese	2.67×10^{-6}	$3.30 \times 10^{+2}$
Mercury	2.04×10^{-6}	3.15×10^{-1}
Molybdenum	7.97×10^{-6}	3.60×10^{-1}
Nickel	2.20×10^{-4}	$1.31 \times 10^{+0}$
Selenium	1.43×10^{-6}	1.74×10^{-2}
Silver	7.68×10^{-5}	$2.06 \times 10^{+0}$
Thallium	9.21×10^{-7}	2.05×10^{-3}
Thorium-total	1.35×10^{-4}	4.58×10^{-2}
Uranium-total	1.50×10^{-3}	$9.10 \times 10^{+0}$
Vanadium	4.49×10^{-5}	1.42×10^{-1}
Zinc	1.08×10^{-2}	$9.50 \times 10^{+1}$
2-Methylnaphthalene	7.14×10^{-7}	2.55×10^{-2}
4,4-dde	6.44×10^{-9}	5.99×10^{-5}
Arcoclor-1221	NA	NA
Aroclor-1248	NA	NA
Aroclor-1254	1.09×10^{-6}	3.49×10^{-3}
Aroclor-1260	3.56×10^{-7}	1.40×10^{-3}
Carbazole	2.55×10^{-8}	9.56×10^{-3}
Endrin	NA	NA
2,3,7,8-tcdd	1.32×10^{-13}	5.01×10^{-10}

TABLE I.6-15
(Continued)

	C_{tf} (mg/kg)	
Radionuclides	**Off-Property**	**On-Property**
Cs	1.22×10^{-3}	$6.34 \times 10^{+1}$
Pb	2.15×10^{-2}	$5.54 \times 10^{+1}$
Np	3.05×10^{-4}	$2.75 \times 10^{+0}$
Pu_{238}	1.80×10^{-2}	$1.07 \times 10^{+0}$
Pu_{239}	6.06×10^{-4}	2.57×10^{-1}
Pu_{240}	NA	9.32×10^{-1}
Pa_{231}	6.43×10^{-4}	4.03×10^{-2}
Ra_{226}	2.38×10^{-3}	$1.91 \times 10^{+1}$
Ra_{228}	1.77×10^{-3}	$2.73 \times 10^{+1}$
Ru_{106}	1.18×10^{-4}	$3.74 \times 10^{+0}$
Rn_{222}	NA	NA
Sr_{90}	8.27×10^{-3}	$4.23 \times 10^{+3}$
Tc_{99}	6.53×10^{-2}	$7.02 \times 10^{+4}$
Th_{228}	1.42×10^{-3}	$1.29 \times 10^{+0}$
Th_{230}	4.92×10^{-3}	$3.42 \times 10^{+0}$
Th_{232}	4.06×10^{-3}	$2.02 \times 10^{+0}$
U_{234}	6.98×10^{-2}	$3.70 \times 10^{+2}$
U_{235}	1.85×10^{-3}	$9.86 \times 10^{+0}$
U_{236}	7.66×10^{-4}	$4.06 \times 10^{+0}$
U_{238}	4.18×10^{-2}	$2.21 \times 10^{+2}$

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TABLE I.6-16

MODELED FARM PRODUCT COC CONCENTRATIONS: OFF-SITE RESIDENT FARM RECEPTORS, CURRENT LAND USE

Chemical	Meat Concentration (mg/kg)	Dairy Product Concentration (mg/l)	Vegetable Concentration (mg/kg)
Antimony	9.69×10^{-7}	9.73×10^{-8}	1.22×10^{-5}
Arsenic	3.76×10^{-6}	1.13×10^{-7}	1.79×10^{-5}
Barium	2.32×10^{-6}	5.42×10^{-6}	1.60×10^{-4}
Beryllium	1.23×10^{-7}	1.11×10^{-10}	1.32×10^{-6}
Boron	6.27×10^{-7}	1.18×10^{-6}	9.55×10^{-6}
Cadmium	2.35×10^{-7}	4.27×10^{-7}	4.09×10^{-6}
Chromium vi	6.49×10^{-6}	1.77×10^{-6}	1.43×10^{-5}
Cobalt	1.53×10^{-5}	1.53×10^{-6}	8.68×10^{-6}
Copper	2.28×10^{-4}	3.42×10^{-5}	2.08×10^{-4}
Cyanide	5.12×10^{-12}	1.62×10^{-12}	9.33×10^{-7}
Lead	5.39×10^{-5}	4.49×10^{-5}	1.97×10^{-3}
Manganese	5.33×10^{-8}	4.67×10^{-8}	1.22×10^{-6}
Mercury	2.55×10^{-5}	NA	9.53×10^{-7}
Molybdenum	2.39×10^{-6}	5.98×10^{-7}	4.77×10^{-6}
Nickel	6.61×10^{-5}	1.10×10^{-5}	9.93×10^{-5}
Selenium	1.07×10^{-6}	2.86×10^{-7}	7.26×10^{-7}
Silver	1.15×10^{-5}	7.68×10^{-5}	3.38×10^{-5}
Thallium	1.84×10^{-6}	9.21×10^{-8}	5.05×10^{-7}
Thorium-total	4.05×10^{-9}	3.38×10^{-8}	8.30×10^{-5}
Uranium-total	7.08×10^{-5}	2.46×10^{-4}	2.83×10^{-2}
Vanadium	5.62×10^{-6}	4.49×10^{-8}	2.59×10^{-5}
Zinc	5.41×10^{-2}	5.41×10^{-3}	4.65×10^{-3}
2-Methylnaphthalene	6.49×10^{-9}	2.05×10^{-9}	3.26×10^{-7}
4,4-dde	4.05×10^{-9}	1.28×10^{-9}	4.19×10^{-9}
Arcoclor-1221	3.41×10^{-36}	1.29×10^{-36}	1.10×10^{-33}
Aroclor-1248	NA	NA	NA
Aroclor-1254	1.47×10^{-6}	4.64×10^{-7}	5.56×10^{-7}
Aroclor-1260	6.26×10^{-6}	NA	1.74×10^{-7}
Carbazole	1.04×10^{-10}	3.28×10^{-11}	1.65×10^{-8}
Endrin	NA	NA	NA
2,3,7,8-tcdd	9.24×10^{-13}	3.27×10^{-13}	8.55×10^{-14}

TABLE I.6-16
(Continued)

Radionuclides	Meat Concentration (mg/kg)	Dairy Product Concentration (mg/l)	Vegetable Concentration (mg/kg)
Cs_{137}	1.21×10^{-3}	4.25×10^{-4}	6.66×10^{-4}
Pb_{210}	3.22×10^{-4}	2.69×10^{-4}	1.30×10^{-2}
Np_{237}	2.20×10^{-5}	2.38×10^{-6}	3.78×10^{-2}
Pu_{238}	4.51×10^{-7}	9.02×10^{-8}	1.17×10^{-2}
Pu_{239}	1.51×10^{-8}	3.03×10^{-9}	3.91×10^{-4}
Pu_{240}	NA	NA	1.42×10^{-3}
Pa_{231}	3.22×10^{-7}	1.61×10^{-5}	4.13×10^{-4}
Ra_{226+8d}	2.97×10^{-5}	5.35×10^{-5}	1.32×10^{-3}
Ra_{228+1d}	2.19×10^{-5}	3.97×10^{-5}	1.14×10^{-3}
Ru_{106}	1.13×10^{-5}	3.52×10^{-9}	7.63×10^{-5}
Rn_{222+4d}	NA	NA	NA
Sr_{90+1d}	1.24×10^{-4}	6.20×10^{-4}	4.01×10^{-3}
Tc_{99}	$1.73 \times 10^{+2}$	2.44×10^{-2}	$2.24 \times 10^{+3}$
Th_{228+7d}	4.18×10^{-7}	3.55×10^{-7}	9.24×10^{-4}
Th_{230}	1.47×10^{-6}	1.23×10^{-6}	3.62×10^{-3}
$Th_{232+10d}$	1.22×10^{-6}	1.01×10^{-6}	2.99×10^{-3}
U_{234}	6.98×10^{-4}	2.09×10^{-3}	4.56×10^{-2}
U_{235+1d}	1.85×10^{-5}	5.55×10^{-5}	1.21×10^{-3}
U_{236}	7.66×10^{-6}	2.30×10^{-5}	5.00×10^{-4}
U_{238+2d}	4.18×10^{-4}	1.25×10^{-3}	2.73×10^{-2}

TABLE I.6-17

MODELED FARM PRODUCT COC CONCENTRATIONS:
OFF-SITE RESIDENT FARM RECEPTORS, FUTURE LAND USE

Chemical	Meat Concentration (mg/kg)	Dairy Product Concentration (mg/l)	Vegetable Concentration (mg/kg)
Antimony	9.58×10^{-7}	9.58×10^{-8}	1.10×10^{-5}
Arsenic	3.94×10^{-6}	1.19×10^{-7}	2.66×10^{-5}
Barium	2.32×10^{-6}	5.42×10^{-6}	1.60×10^{-4}
Beryllium	1.24×10^{-7}	1.11×10^{-10}	1.36×10^{-6}
Boron	6.27×10^{-7}	1.18×10^{-6}	9.55×10^{-6}
Cadmium	2.35×10^{-7}	4.27×10^{-7}	4.09×10^{-6}
Chromium vi	6.49×10^{-6}	1.77×10^{-6}	1.43×10^{-5}
Cobalt	1.53×10^{-5}	1.53×10^{-6}	8.68×10^{-6}
Copper	2.28×10^{-4}	3.42×10^{-5}	2.08×10^{-4}
Cyanide	5.12×10^{-12}	1.62×10^{-12}	9.33×10^{-7}
Lead	5.39×10^{-5}	4.49×10^{-5}	1.97×10^{-3}
Manganese	5.33×10^{-8}	4.67×10^{-8}	1.22×10^{-6}
Mercury	2.55×10^{-5}	NA	9.53×10^{-7}
Molybdenum	2.39×10^{-6}	5.98×10^{-3}	4.77×10^{-6}
Nickel	6.61×10^{-5}	1.10×10^{-5}	9.93×10^{-5}
Selenium	1.07×10^{-6}	2.86×10^{-7}	7.26×10^{-7}
Silver	1.15×10^{-5}	7.68×10^{-5}	3.38×10^{-5}
Thallium	1.84×10^{-6}	9.21×10^{-8}	5.05×10^{-7}
Thorium-total	4.05×10^{-8}	3.38×10^{-8}	8.30×10^{-5}
Uranium-total	4.65×10^{-4}	1.67×10^{-3}	2.21×10^{-1}
Vanadium	5.62×10^{-6}	4.49×10^{-8}	2.59×10^{-5}
Zinc	5.41×10^{-2}	5.41×10^{-3}	4.65×10^{-3}
2-Methylnaphthalene	6.49×10^{-9}	2.05×10^{-9}	3.26×10^{-7}
4,4-dde	4.05×10^{-9}	1.28×10^{-9}	4.19×10^{-9}
Arcoclor-1221	1.59×10^{-29}	6.02×10^{-30}	5.11×10^{-27}
Aroclor-1248	NA	NA	NA
Aroclor-1254	1.47×10^{-6}	4.64×10^{-7}	5.56×10^{-7}
Aroclor-1260	6.26×10^{-6}	NA	1.74×10^{-7}
Carbazole	1.04×10^{-10}	3.28×10^{-11}	1.65×10^{-8}
Endrin	NA	NA	NA
2,3,7,8-tcdd	9.24×10^{-13}	3.27×10^{-13}	8.55×10^{-14}

TABLE I.6-17
(Continued)

Radionuclides	Meat Concentration (mg/kg)	Dairy Product Concentration (mg/l)	Vegetable Concentration (mg/kg)
Cs_{137+1d}	1.21×10^{-3}	4.25×10^{-4}	6.66×10^{-4}
Pb_{210+2d}	3.22×10^{-4}	2.69×10^{-4}	1.30×10^{-2}
Np_{237+1d}	2.22×10^{-4}	2.42×10^{-5}	3.94×10^{-1}
Pu_{238}	4.51×10^{-7}	9.02×10^{-8}	1.17×10^{-2}
Pu_{239}	1.51×10^{-8}	3.03×10^{-9}	3.91×10^{-4}
Pu_{240}	NA	NA	1.42×10^{-4}
Pa_{231}	3.22×10^{-7}	1.61×10^{-5}	4.13×10^{-4}
Ra_{226+8d}	6.92×10^{-5}	1.39×10^{-4}	1.68×10^{-2}
Ra_{228+1d}	2.19×10^{-5}	3.97×10^{-5}	1.14×10^{-3}
Ru_{106}	1.13×10^{-5}	3.52×10^{-9}	7.63×10^{-5}
Rn_{222+4d}	NA	NA	NA
Sr_{90+1d}	$1.83 \times 10^{+1}$	6.20×10^{-4}	4.01×10^{-3}
Tc_{99}	2.77×10^{-2}	$7.32 \times 10^{+2}$	$6.74 \times 10^{+3}$
Th_{228+7d}	4.18×10^{-7}	3.55×10^{-7}	9.24×10^{-4}
Th_{230}	1.47×10^{-6}	1.23×10^{-6}	3.62×10^{-3}
$Th_{232+10d}$	1.22×10^{-6}	1.01×10^{-6}	2.99×10^{-3}
U_{234}	6.98×10^{-4}	2.09×10^{-3}	4.56×10^{-2}
U_{235+1d}	1.85×10^{-5}	5.55×10^{-5}	1.21×10^{-3}
U_{236}	7.66×10^{-6}	2.30×10^{-5}	5.00×10^{-4}
U_{238+2d}	4.18×10^{-4}	1.25×10^{-3}	2.73×10^{-2}

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TABLE I.6-18

MODELED FARM PRODUCT COC CONCENTRATIONS: ON-SITE RESIDENT FARM RECEPTORS, FUTURE LAND USE WITHOUT FEDERAL OWNERSHIP

Chemical	Meat Concentration (mg/kg)	Dairy Product Concentration (mg/l)	Vegetable Concentration (mg/kg)
Antimony			
Arsenic	4.87×10^{-2}	1.64×10^{-3}	2.25×10^{-1}
Barium	1.36×10^{-1}	3.19×10^{-1}	$1.46 \times 10^{+1}$
Beryllium	1.05×10^{-3}	1.21×10^{-6}	8.12×10^{-3}
Boron	$2.20 \times 10^{+0}$	$4.06 \times 10^{+0}$	$4.48 \times 10^{+2}$
Cadmium	3.95×10^{-2}	7.14×10^{-2}	$1.91 \times 10^{+0}$
Chromium vi	8.31×10^{-2}	2.42×10^{-2}	1.23×10^{-1}
Cobalt	3.41×10^{-1}	3.30×10^{-2}	2.42×10^{-1}
Copper	$7.98 \times 10^{+0}$	$1.21 \times 10^{+0}$	$8.08 \times 10^{+0}$
Cyanide	3.95×10^{-5}	1.25×10^{-5}	$6.07 \times 10^{+0}$
Lead	2.62×10^{-1}	2.63×10^{-1}	$1.06 \times 10^{+0}$
Manganese	$6.80 \times 10^{+0}$	$6.01 \times 10^{+0}$	$2.44 \times 10^{+2}$
Mercury	$3.96 \times 10^{+0}$	7.17×10^{-3}	1.93×10^{-1}
Molybdenum	1.27×10^{-1}	3.15×10^{-2}	3.89×10^{-1}
Nickel	4.62×10^{-1}	7.67×10^{-2}	$1.36 \times 10^{+0}$
Selenium	1.77×10^{-2}	4.86×10^{-3}	1.58×10^{-2}
Silver	3.19×10^{-1}	$2.12 \times 10^{+0}$	$2.41 \times 10^{+0}$
Thallium	1.53×01^{-2}	7.18×10^{-4}	2.23×10^{-3}
Thorium-total	1.37×10^{-5}	1.45×10^{-4}	2.73×10^{-4}
Uranium-total	9.28×10^{-2}	6.01×10^{-1}	8.94×10^{-1}
Vanadium	5.03×10^{-2}	4.01×10^{-4}	1.43×10^{-1}
Zinc	$4.78 \times 10^{+2}$	$4.78 \times 10^{+1}$	$9.62 \times 10^{+1}$
2-Methylnaphthalene	2.32×10^{-4}	7.65×10^{-5}	2.84×10^{-6}
4,4-dde	3.77×10^{-5}	1.86×10^{-5}	5.18×10^{-9}
Arcoclor-1221	3.53×10^{-26}	1.34×10^{-26}	1.15×10^{-23}
Aroclor-1248	NA	NA	NA
Aroclor-1254	4.69×10^{-3}	3.57×10^{-3}	5.53×10^{-6}
Aroclor-1260	2.46×10^{-2}	1.48×10^{-3}	2.04×10^{-6}
Carbazole	3.89×10^{-5}	1.26×10^{-5}	1.06×10^{-7}
Endrin	NA	NA	NA
2,3,7,8-tcdd	3.50×10^{-9}	3.96×10^{-9}	5.25×10^{-13}

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TABLE I.6-18
(Continued)

Radionuclides	Meat Concentration (mg/kg)	Dairy Product Concentration (mg/l)	Vegetable Concentration (mg/kg)
Cs_{137+1d}	$7.13 \times 10^{+1}$	$2.50 \times 10^{+1}$	$6.34 \times 10^{+1}$
Pb_{210+2d}	8.29×10^{-1}	8.46×10^{-1}	2.12×10^{-2}
Np_{237+1d}	9.13×10^{-3}	1.55×10^{-3}	$2.78 \times 10^{+0}$
Pu_{238}	2.66×10^{-5}	1.21×10^{-4}	1.45×10^{-2}
Pu_{239}	6.44×10^{-6}	2.97×10^{-5}	1.21×10^{-3}
Pu_{240}	2.33×10^{-5}	1.08×10^{-4}	4.39×10^{-3}
Pa_{231}	2.02×10^{-5}	3.95×10^{-2}	1.21×10^{-3}
Ra_{226+8d}	2.41×10^{-1}	7.21×10^{-1}	$1.23 \times 10^{+0}$
Ra_{228+1d}	3.39×10^{-1}	$1.02 \times 10^{+0}$	1.28×10^{-3}
Ru_{106}	3.60×10^{-1}	1.68×10^{-4}	5.31×10^{-4}
Rn_{222+4d}	NA	NA	NA
Sr_{90+1d}	$6.33 \times 10^{+1}$	$3.18 \times 10^{+2}$	1.19×10^{-2}
Tc_{99}	$3.21 \times 10^{+4}$	$3.83 \times 10^{+4}$	$3.33 \times 10^{+4}$
Th_{228+7d}	3.78×10^{-4}	4.09×10^{-3}	9.98×10^{-4}
Th_{230}	1.03×10^{-3}	1.09×10^{-2}	4.65×10^{-3}
$Th_{232+10d}$	6.06×10^{-4}	6.43×10^{-3}	3.61×10^{-3}
U_{234}	$4.72 \times 10^{+0}$	$2.78 \times 10^{+1}$	$4.99 \times 10^{+2}$
U_{235+1d}	1.26×10^{-1}	7.41×10^{-1}	$1.32 \times 10^{+1}$
U_{236}	5.18×10^{-2}	3.05×10^{-1}	$5.48 \times 10^{+0}$
U_{238+2d}	$2.82 \times 10^{+0}$	$1.66 \times 10^{+1}$	$3.00 \times 10^{+2}$

I.7.0

I.7.0 TOXICITY ASSESSMENT

This toxicity assessment examines information concerning the potential effects of exposure to COCs. The COCs described in this section apply to the FEMP as a whole; they are the result of the Section I.4.0 screening process and are used in the Section I.6.0 fate and transport models. Those COCs that were screened out have been omitted from this discussion (see Section I.4.0 for a complete list).

For this CRARE, the goal was to quantitatively estimate the relationship between COC exposure and the severity or probability of human biological effect. Throughout this assessment, potential health effects caused by concurrent exposure to multiple COCs were assumed to be additive. This assumption ignores possible synergisms or antagonisms among chemicals. However, quantitative data to assess such interactions are generally lacking. In the absence of adequate information, EPA guidelines indicate that carcinogenic risks should be treated as additive and noncancer hazard indices should also be treated as additive. These assumptions are made to help prevent an underestimation of cancer risk or potential noncancer health effects at a site (EPA 1989c).

This section contains a compilation of chronic noncarcinogenic and carcinogenic risk parameters followed by detailed toxicity profiles of the major COCs. The toxicity profiles emphasize chronic noncarcinogenic and carcinogenic health effects. Subchronic health effects are also addressed as necessary for the major COCs. The toxicity assessment for ecological effects will be provided in future operable unit CRAREs when such effects are evaluated.

I.7.1 NONCARCINOGENS

Reference doses (RfDs) and dose-response data for noncarcinogenic effects associated with exposure to the COCs are presented in Table I.7-1. Since the RfD is usually based on data from exposure studies using animal models, an uncertainty factor has been incorporated to provide a safety factor for the extrapolation from animals to humans. When available, RfDs for both the ingestion and inhalation pathways are presented. The sources for reference dose values and dose-response data were the IRIS database (EPA 1994a) and the HEAST which are compiled and maintained by EPA (1994b). IRIS was used as the primary source for toxicity information. HEAST was used only if IRIS values were unavailable (EPA 1989d).

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TABLE I.7-1
REFERENCE DOSES[a]

Chemical	Chronic Oral Reference Dose (mg/kg/day)	Chronic Inhalation Reference Dose (mg/kg/day)	Reference Concentration (mg/m^3)	Target Organ (Critical Effect)		Uncertainty Factor	
				Oral	Inhalation	Oral	Inhalation
Inorganics							
Antimony	4×10^{-4}	ND	ND	Whole body (Increased Mortality); Blood (Altered Chemistries)	ND	1000	ND
Arsenic	3×10^{-4}	ND	ND	Skin (Keratosis; Hyperpigmentation)	ND	3	ND
Barium	7×10^{-2}	1.4×10^{-4}	5×10^{-4}	CVS (Increased Blood Pressure)	Fetus (Fetotoxicity)	3	1000
Beryllium (Soluble Salts)	5×10^{-3}	ND	ND	None (None Observed)	ND	100	ND
Boron	9×10^{-2}	5.7×10^{-3}	2×10^{-2}	Testis (Lesions)	Respiratory Tract (Irritation)	100	100
Cadmium (Food)	1×10^{-3}	ND	ND	Kidney (Proteinuria)	ND	10	ND
Cadmium (Water)	5×10^{-4}	ND	ND	Kidney (Proteinuria)	ND	10	ND
Chromium (VI)	5×10^{-3}	ND	ND	None (None Observed)	ND	500	ND
Cobalt	6×10^{-2}	3×10^{-7}	1×10^{-6}	Heart (Cardiomyopathy)	Lung (Lesions)	ND	ND
Copper	ND	ND	ND	ND	ND	ND	ND
Cyanide	2×10^{-2}	ND	ND	Whole Body (Decreased Weight); Thyroid (Effects); Nerve (Myelin Degeneration)	ND	100	ND
Lead and Compounds (Inorganic)	ND	ND	ND	ND	ND	ND	ND
Manganese (Food)	1.4×10^{-1}	1.4×10^{-5}	5×10^{-5}	CNS (Effects)	CNS (Psychomotor Disturbances)	1	1000
Manganese (Water)	5×10^{-3}	ND	ND	CNS (Effects)	ND	1	ND
Mercury, Inorganic	3×10^{-4}	8.6×10^{-5}	3×10^{-4}	Kidney (Effects)	CNS (Neurotoxicity)	1000	30
Molybdenum	5×10^{-3}	ND	ND	Urine (Increased Uric Acid)	ND	30	ND

See footnotes at end of table.

TABLE I.7-1
(Continued)

Chemical	Chronic Oral Reference Dose (mg/kg/day)	Chronic Inhalation Reference Dose (mg/kg/day)	Reference Concentration (mg/m^3)	Target Organ (Critical Effect)		Uncertainty Factor	
				Oral	Inhalation	Oral	Inhalation
Inorganics (cont.)							
Nickel	2×10^{-2}	ND	ND	Whole Body (Decreased Weight); Major Organs (Decreased Weight)	ND	300	ND
Selenium	5×10^{-3}	ND	ND	Whole Body (Selenosis)	ND	3	ND
Silver	5×10^{-3}	ND	ND	Skin (Argyria)	ND	3	ND
Thallium (Sulfate)	8×10^{-5}	ND	ND	None (None observed)	ND	3000	ND
Thorium	ND	ND	ND	ND	ND	ND	ND
Uranium (Soluble Salts)	3×10^{-3}	ND	ND	Kidney (Nephritis)	ND	1000	ND
Vanadium	7×10^{-3}	ND	ND	ND	ND	100	ND
Zinc	3×10^{-1}	ND	ND	Blood (Decrease in Erythrocyte Superoxide Dismutase)	ND	3	ND
Semivolatiles							
Carbazole	ND	ND	ND	ND	ND	ND	ND
2-Methylnapthalene	ND	ND	ND	ND	ND	ND	ND
TCDD,2,3,7,8	ND	ND	ND	ND	ND	ND	ND
Pesticides/PCBs							
Aroclors	ND	ND	ND	ND	ND	ND	ND
DDE	ND	ND	ND	ND	ND	ND	ND
Endrin	3×10^{-4}	ND	ND	CNS (Convulsions), Liver (Lesions)	ND	100	ND

[a]The values in this table, except where noted in other footnotes, are from IRIS (EPA 1994a), or HEAST (EPA 1994b).

CNS = Central nervous system
CVS = Cardiovascular system
ND = No data available

See footnotes at end of table.

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I.7.2 CHEMICAL CARCINOGENS

The incremental lifetime cancer risk (ILCR) due to exposure to a chemical was calculated as the product of the lifetime chronic daily intake (mg/kg/day) and the cancer slope factor of that chemical. The values used for carcinogenic slope factors (Table I.7-2) came entirely from EPA sources (IRIS and HEAST) and were defined by EPA's Carcinogen Assessment Group (CAG).

In developing the cancer slope factors, the EPA gave preference to human epidemiology studies; however, the slope factors for most chemicals were in fact derived from animal exposure studies. An inherent assumption in the EPA's approach is that there is no threshold for a carcinogenic effect. That is, smaller doses result in smaller risks, but any dose, no matter how small, carries some risk. The dose-related number of tumors and the time of incidence of tumors were fitted using a linear multi-stage model. A slope factor describing the linear relationship of lifetime risk to dose was computed using the 95 percent UCL of this slope. This approach is inherently conservative because of the no-threshold assumption and the use of the 95 percent UCL.

Dermal Reference Doses and Cancer Slope Factors

For this CRARE, dermal RfD values and cancer slope factors were calculated from the corresponding oral values. To calculate a dermal RfD, the oral RfD was multiplied by the gastrointestinal absorption efficiency factor, expressed as a fraction. The resulting dermal RfD is based on absorbed dose. This is the appropriate value with which to compare dermal doses, because they are expressed as absorbed rather than exposed doses. In a similar manner, and for the same reasons, to calculate a dermal cancer slope factor, the oral slope factor was divided by the gastrointestinal adsorption efficiency. This is because cancer slope factors are expressed as reciprocal doses. Dermal RfD values and cancer slope factors for the COCs in Operable Units 1 and 2 are presented in Table I.7-3.

The most important aspect in calculating a dermal RfD or cancer slope factor is the accuracy of the gastrointestinal absorption efficiency factor. For this reason, the toxicity profiles contain pharmacokinetics discussions in which the oral absorption data were evaluated. Where appropriate, the low (i.e., most conservative) end of the range of available gastrointestinal absorption data for humans was used to derive the dermal RfD or cancer slope factor. When the human data were insufficient, animal data were used. Data from high-dose experiments were not

TABLE I.7-2

CANCER SLOPE FACTORS FOR CHEMICALS[a]

Chemical	Oral Cancer Slope Factor [(mg/kg/day)$^{-1}$]	Inhalation Cancer Slope Factor [(mg/kg/day)$^{-1}$]	Unit Risk ($\mu g/m^3$)$^{-1}$	Tumor Site		Cancer Classification
				Oral	Inhalation	
Inorganics						
Antimony	ND	ND	ND	ND	ND	ND
Arsenic	1.8×10^0	1.5×10^1	4.3×10^{-3}	Skin, Lung	Respiratory System	A
Barium	ND	ND	ND	ND	ND	ND
Beryllium	4.3×10^0	8.4×10^0	2.4×10^{-3}	Total Tumors	Lung	B2
Boron	ND	ND	ND	ND	ND	ND
Cadmium	ND	6.3×10^0	1.8×10^{-3}	ND	Respiratory System	B1
Chromium (VI)	ND	4.1×10^1	1.2×10^{-2}	ND	Lung	A
Cobalt	ND	ND	ND	ND	ND	ND
Copper	ND	ND	ND	ND	ND	D
Cyanide	ND	ND	ND	ND	ND	D
Lead (Inorganic)	ND	ND	ND	ND	ND	B2
Manganese	ND	ND	ND	ND	ND	D
Mercury (Inorganic)	ND	ND	ND	ND	ND	D
Molybdenum	ND	ND	ND	ND	ND	ND
Nickel (Refinery Dust)	ND	8.4×10^{-1}	2.4×10^{-4}	ND	Respiratory System	A
Selenium (Selenium Sulfide)	ND	ND	ND	Liver, Lung	ND	B2
Silver	ND	ND	ND	ND	ND	D
Thallium	ND	ND	ND	ND	ND	D
Thorium	ND	ND	ND	ND	ND	ND
Uranium	ND	ND	ND	ND	ND	ND
Vanadium	ND	ND	ND	ND	ND	ND
Zinc	ND	ND	ND	ND	ND	D

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See footnotes at end of table

TABLE I.7-2
(Continued)

Chemical	Oral Cancer Slope Factor [(mg/kg/day)$^{-1}$]	Inhalation Cancer Slope Factor [(mg/kg/day)$^{-1}$]	Unit Risk ($\mu g/m^3$)$^{-1}$	Tumor Site		Cancer Classification
				Oral	Inhalation	
Semivolatiles						
2-Methylnapthalene	ND	ND	ND	ND	ND	ND
Carbazole	2.0×10^{-2}	ND	ND	Liver	ND	B2
TCDD, 2, 3, 7, 8	1.5×10^{5}	1.5×10^{5}	3.3×10^{-5} (pg/m^3)$^{-1}$	Respiratory System, Liver	ND	B2
Pesticides / PCBs						
Aroclors	7.7×10^{0}	ND	ND	Liver	ND	B2
4,4-DDE	3.4×10^{-1}	ND	ND	Liver	ND	B2
Endrin	ND	ND	ND	ND	ND	D

[a]Except where qualified by other footnotes, IRIS (EPA 1994a) or HEAST (EPA 1994b).

ND = No data available

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TABLE I.7-3

DERMAL REFERENCE DOSES AND CANCER SLOPE FACTORS FOR COCs

Chemical	Gastrointestinal Absorption Fraction	Dermal Reference Dose (mg/kg/day)	Dermal Slope Factor $(mg/kg/day)^{-1}$
Inorganics			
Antimony	0.15[a]	6.00×10^{-5}	ND
Arsenic	0.95[b]	2.85×10^{-4}	1.90×10^{0}
Barium	0.91[b]	6.37×10^{-2}	ND
Beryllium	1.00[g]	5.00×10^{-3}	4.3×10^{0}
Boron	0.05[c]	4.50×10^{-3}	ND
Cadmium (Food)	0.05	5.00×10^{-5}	ND
Chromium (VI)	0.05[a]	2.50×10^{-4}	ND
Cobalt	0.45[a]	2.70×10^{-2}	ND
Copper	0.60[b]	ND	ND
Cyanide	0.72[d]	ND	ND
Lead	NA	ND	ND
Manganese (Food)	0.03[a]	4.20×10^{-3}	ND
Mercury	0.15[b]	4.50×10^{-5}	ND
Molybdenum	0.38[a]	1.90×10^{-3}	ND
Nickel	0.10[b]	2.00×10^{-3}	ND
Selenium	0.80[a]	4.00×10^{-3}	ND
Silver	0.05[c]	ND	ND
Thallium	1.00[a]	6.00×10^{-5}	ND
Thorium	NA	ND	ND
Uranium	0.05[c]	1.50×10^{-4}	ND
Vanadium	0.05[c]	3.50×10^{-4}	ND
Zinc	0.25[b]	7.50×10^{-2}	ND
Semivolatiles			
Carbazole	0.90	ND	2.22×10^{-2}
2-Methylnaphthalene	1.00[e]	ND	ND
Pesticides/PCBs			
Aroclors	0.75[a]	NA	1.03×10^{1}
Endrin	0.90	2.70×10^{-4}	ND
4,4-DDE	0.90[e]	ND	3.78×10^{-1}
Dioxins/furans	0.50[f]	ND	3.00×10^{5}

NA = Not appropriate.
ND = Not derived.
[a]See the Toxicity Profile for this chemical in this Section.
[b]EPA 1993b.
[c]EPA 1989c.
[d]ATSDR 1988a.
[e]Jones, T.D. and B.A. Owen, 1989.
[f]ATSDR 1989a
[g]EPA Region V Guidance, July 1994 (Saunders, M. 1994)

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used if more suitable data were available and it appeared the gastrointestinal absorption process could have been saturated. When adequate quantitative data were not located, a default gastrointestinal absorption factor was used.

As noted by (EPA 1989c), the absorption of many metals from the gastrointestinal tract is limited, and 0.05 is a reasonable default for metals and inorganic substances. The EPA 1989c) did not recommend a separate default value for organic chemicals. A compilation of data for 19 organic chemicals presented gastrointestinal absorption efficiencies of at least 0.9, indicating that organic chemicals generally are readily absorbed. The arithmetic average of the efficiencies for the 19 organic chemicals, 0.91368 (equivalent to 0.9 when rounded to one significant figure), appears to be a reasonable default gastrointestinal absorption efficiency factor for organic chemicals. The default of 0.9 was used for organic chemicals for which quantitative data were not adequate.

I.7.3 RADIONUCLIDES

The principal adverse biological effects associated with ionizing radiation from radioactive substances in the environment are mutagenicity, teratogenicity, and carcinogenicity:

- Mutagenicity is the ability to induce genetic mutations in the nuclei of either somatic or reproductive cells.
- Teratogenicity is the ability to induce or increase the incidence of congenital malformations, which are permanent structural or functional deviations produced during embryonic growth and development.
- Carcinogenicity is the ability to produce neoplastic changes which result in tumors.

The guidance for the EPA Superfund risk assessment clearly states that carcinogenicity is considered to be the limiting deleterious effect at the radiation dose levels expected at the remediated FEMP. The carcinogenic effects may then be used as the sole basis for assessing the radiation-related human health risks of a site contaminated with radionuclides (EPA 1989c).

Each radionuclide produces a unique radiation spectrum and can affect different organs in the human body. The EPA has calculated the annual radiation dose equivalent from each radionuclide to each organ in each year of life, per unit intake or external exposure, over a lifetime. The average excess number of all types of radiation-induced fatal cancers that occur in a

year can then be estimated for the corresponding dose equivalents received during that year and relevant preceding years. The excess number of radiation-induced fatal cancers is derived from epidemiological data, extrapolation from high radiation doses to low doses, and mathematical models for projecting risk over a lifetime. Because the EPA is concerned with assessing cancer incidence, each radionuclide slope factor has been calculated by dividing the excess fatal cancer risk for that radionuclide by the mortality-to-incidence risk ratio (EPA 1989c) for the types of cancer induced by that radionuclide. This mortality-to-incidence risk ratio is not incorporated into the cancer potency factors derived by EPA for chemical carcinogens; therefore, the basis for cancer risk estimates for radionuclides and chemical carcinogens is not the same.

The relationship between cancer incidence and exposure to radioactive materials is quantified by using mathematical extrapolation models, which estimate the largest possible linear slope (within the 95 percent UCL) at low extrapolated doses consistent with the data. This "radiocarcinogenicity slope factor" is characterized as the "maximum likelihood estimate of the age-averaged lifetime total excess cancer risk per unit intake or exposure" (EPA 1991a). For this reason, the true risk to humans, although not identifiable, is not likely to be the upperbound estimate. It may in fact be lower.

The EPA Office of Radiation Programs (ORP) has calculated cancer slope factors for radionuclides of potential concern at Superfund sites. These values are listed in the HEAST (not IRIS) and are subject to revision. The slope factors are presented in Table I.7-4.

I.7.4 RADIATION EXPOSURE PATHWAYS

EPA and DOE use different methodologies to evaluate human health risk from radiation. The purpose of this section is to distinguish these two methods and define radiation considerations for the analysis used in this FS. The pathways of exposure and the mathematical models used to evaluate the potential health risks associated with radionuclides in the environment are similar to those used for evaluating COCs.

TABLE I.7-4

CANCER SLOPE FACTORS FOR RADIONUCLIDES

Radionuclide	ICRP Lung Class[a]	Inhalation Risk/(pCi)	Ingestion Risk/(pCi)	External Exposure (Risk/year per pCi/g soil)
Cs-137 + Progeny	D	1.9×10^{-11}	2.8×10^{-11}	2.0×10^{-6}
Np-237 + Progeny	W	2.9×10^{-8}	2.2×10^{-10}	4.3×10^{-7}
Pa-231	Y	3.6×10^{-8}	9.2×10^{-11}	2.6×10^{-8}
Pb-210 + Progeny	D	4.0×10^{-9}	6.6×10^{-10}	1.6×10^{-10}
Pu-238	Y	3.9×10^{-8}	2.2×10^{-10}	2.8×10^{-11}
Pu-239	Y	3.8×10^{-8}	2.3×10^{-10}	1.7×10^{-11}
Pu-240	Y	3.8×10^{-8}	2.3×10^{-10}	2.7×10^{-11}
Ra-226 + Progeny	W	3.0×10^{-9}	1.2×10^{-10}	6.0×10^{-6}
Ra-228 + Progeny	W	6.9×10^{-10}	1.0×10^{-10}	2.9×10^{-6}
Rn-222 + Progeny	Gas	7.7×10^{-12}	1.7×10^{-12}	5.9×10^{-6}
Ru-106	Y	4.4×10^{-10}	9.5×10^{-12}	0.0×10^{0}
Sr-90 + Progeny	D	6.2×10^{-11}	3.6×10^{-11}	0.0×10^{0}
Tc-99	W	8.3×10^{-12}	1.3×10^{-12}	6.0×10^{-13}
Th-228 + Progeny	Y	7.8×10^{-8}	5.5×10^{-11}	5.6×10^{-6}
Th-230	Y	2.9×10^{-8}	1.3×10^{-11}	5.4×10^{-11}
Th-232	Y	2.8×10^{-8}	1.2×10^{-11}	2.6×10^{-11}
U-234	Y	2.6×10^{-8}	1.6×10^{-11}	3.0×10^{-11}
U-235 + Progeny	Y	2.5×10^{-8}	1.6×10^{-11}	2.4×10^{-7}
U-236	Y	2.5×10^{-8}	1.5×10^{-11}	2.4×10^{-11}
U-238 + Progeny	Y	2.4×10^{-8}	2.0×10^{-11}	5.1×10^{-8}

[a] Classification recommended by the ICRP for half-time of clearance from the lung: Y = years, W = weeks, D = days.

SOURCE: HEAST (EPA 1994b)

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Radionuclides found at contaminated sites behave in the environment like their nonradioactive isotopes. Consequently, the types of data needed for a radiation risk assessment are similar to those required for a chemical risk assessment. The primary differences lie in the procedures used to characterize the radionuclide contaminants. Exposure pathways for radionuclides include both internal and external pathways. Intakes by inhalation, ingestion, and dermal absorption are the important internal pathways.

The quantification of the amount of energy deposited in living tissue due to internal and external exposure to ionizing radiation is termed "radiation dosimetry." The amount of energy deposited in living tissue is of concern because the potential adverse effects of radiation are proportional to energy deposition. Therefore, the term "dose," used regarding radiation exposure, is defined as the energy imparted to a unit mass of tissue, whereas chemical dose means the mass of chemical absorbed into an organism.

Despite the fundamental difference between the way exposures are expressed for radionuclides and chemicals, the approach to exposure assessment is the same. An exposure assessment for radionuclides involves three steps: 1) characterization of the exposure setting, 2) identification of the exposure pathways, and 3) quantification of exposure. The primary differences in conducting exposure assessments for radionuclides as compared to chemicals are: 1) consideration of external exposures, 2) conversion of radiation exposures to dose equivalents, and 3) modification of fate and transport models for radiation exposure.

Toxicity assessment for radionuclides generally follows a two-step process. The first step, hazard identification, is used to determine whether exposure can increase the incidence of an adverse health effect. The second step, dose response assessment, is used to quantify the toxicity information and characterize the relationship between the dose of the contaminant administered or received and the incidence of adverse health effects in the exposed population.

Exposure to a radioactive substance is assumed to be hazardous. An extensive body of literature exists on radiation carcinogenesis in man and animals. Ionizing radiation can be considered pancarcinogenic (i.e., it acts as a complete carcinogen in that it serves as both initiator and promotor and can induce cancers in almost any tissue or organ).

With regard to the mutagenic effects of radiation, very little quantitative data are available, particularly for low-dose exposures. The bulk of evidence supporting the mutagenic character of ionizing radiation comes from extensive studies using animal models, which have demonstrated all forms of radiation mutagenesis. Mutation rates calculated from these studies have been extrapolated to humans and form the basis for estimating the genetic impact of ionizing radiation on humans.

Radiation is a well-known teratogenic agent. The developing fetus is much more sensitive to radiation than is the mother. The age of the fetus at the time of exposure is the most important factor in determining the extent and type of damage from radiation. The malformations produced in the embryo depend on which cells, tissues, or organs in the fetus are most actively differentiating at the time of radiation exposure. Embryos are relatively resistant to radiation-induced teratogenic effects during the later stages of their development and are most sensitive from just after implantation until approximately 8 weeks into term. The greatest risk of brain damage for the human fetus occurs from 8 to 15 weeks into term.

The dose-response assessment of radionuclides is straight-forward compared to that of chemicals. The type of effects and the likelihood of possible adverse health effects occurring from radiation exposure depends on the radiation dose. The probability of adverse health effects increases with the dose of radiation, but the severity of the effects is independent of dose.

Estimates of human health effects are based primarily on single, acute, high doses of radiation. The current model used to describe these effects as a function of dose is called the linear quadratic model. This model assumes that there is no threshold for the induction of cancer or genetic effects. It is assumed that any radiation dose could give rise to a cancer or genetic effect. This is a conservative assumption and a conservative model. There is very little data on the effects of radiation at low doses or on the effects of chronic, long-term exposure in humans.

Human Health Effects

Two major international groups have been responsible for collecting and evaluating data on the human health effects of ionizing radiation, the Committee on the Biological Effects of Ionizing Radiations (BEIR) of the National Research Council, and the United Nations Scientific

Committee on the Effects of Atomic Radiation (UNSCEAR). These groups have issued a series of reports presenting the data and recommendations on risk values. The EPA is responsible for developing guidelines for radiation risk assessment in the United States and has relied on the published evaluations of these groups, along with those of the International Commission on Radiological Protection (ICRP) and the National Council on Radiation Protection and Measurements (NCRP). The following discussion contains a brief overview of effects of ionizing radiation on human health, and the relative risks associated with these effects.

Carcinogenic Effects. Radiation effects are usually separated into low and high linear energy transfer (LET) effects for risk evaluation. LET refers to the rate at which energy is lost as the particle or gamma ray travels through matter. Low LET radiation include x-rays and gamma rays. High LET radiation includes alpha particles and some beta particles. High LET radiation is more cytotoxic and oncogenic than low LET radiation. The EPA (1989) has estimated cancer risks factors for estimating risks associated with radiation exposure (Table I.7-5).

TABLE I.7-5
LET CANCER RISK FACTORS

Risk	Exposure Period	Radiation	Risk Factor $(rem)^{-1}$
Fatal Cancers	Lifetime	Low LET	3.9×10^{-4}
		High LET	3.1×10^{-3}
All Cancers	Lifetime	Low LET	6.2×10^{-4}
		High LET	5.0×10^{-3}
Fatal Cancers	In utero	Low LET	6.0×10^{-4}

Cancer slope factors for individual radionuclides are presented as Table I.7-4.

Genetic Effects. Genetic effects have been studied extensively using animal models and in the Japanese atomic-bomb survivors. A comparison of the survivor data has consistently led to estimates of genetic effects that imply lower risks in humans than in animals (NAS 1990). Taking into account the confidence intervals associated with the various data, the difference between humans and animals remains, indicating that humans are less sensitive to radiation induction of mutations in germ cells, and that risks derived from animal data will be conservative if applied to

humans. Because of this, BEIR V and UNSCEAR have based their evaluation of genetic risk on the lower 95 percent confidence limit for Japanese atomic-bomb survivor data, which is also consistent with the range of doubling doses observed in mice. A doubling dose is the dose required to double the incidence of genetic defects in a population.

The doubling dose for humans is currently estimated to be 100 rem (NAS 1990). Genetic effects expected per rem per 30-year generation, based on this doubling dose, fall into the range of less than 1 to about 100 per million liveborn offspring for multi-generations. The natural incidence for genetic anomalies ranges from 400 to 30,000 per million liveborn offspring (NAS 1990).

The EPA has recommended (1989n) a genetic risk of 2600 effects per rad per 30-year generation for low LET radiation where 1 rad equals approximately 1 rem, and 6900 per rad per 30-year generation for high LET radiation (alpha and beta radiation) where 1 rad equals approximately 0.05 to 1 rem (depending on energy, LET, etc). These risks are based on the older BEIR III report. This is slightly more restrictive than the current BEIR V estimates.

Teratogenic Effects. Teratogenic effects are somatic effects resulting from exposure in utero to ionizing radiation. These effects, which are not passed on to other generations, can include severe mental retardation, microcephaly, and structural or limb abnormalities. Extrapolating the results of animal studies to humans has proved difficult because of the significant differences in fetal development rates. The EPA (1989n) uses an estimate of 4000 effects per rad of exposure during weeks 8 to 15 of gestation for low LET radiation (primarily gamma radiation).

I.7.5 TOXICITY PROFILES: RADIONUCLIDES

This section presents toxicity information for radionuclide compounds. It was assumed that all radionuclides are present in the soils as oxides or carbonates. This represents a conservative assumption because radionuclides clear slowly from environmental media.

I.7.5.1 Cesium-137

Biological Distribution and Retention; Pharmacokinetics

The gastrointestinal uptake of cesium is rapid, and its absorption coefficient is around 85 percent in mammals. The cesium body burden decreases with a half-life of approximately 80 days. The EPA (1993c) has derived a gastrointestinal absorption factor for cesium of 1.0, equivalent to 100 percent.

The physiological properties of cesium resemble those of potassium, although quantitative differences arise in transport by cell membranes; cesium can displace potassium from muscle and red blood cells. Potassium enters the cells via sodium-potassium dependent ATPase. Cesium ions are effective in activating this enzyme and compete with potassium for carrier sites (Davie and Coleman 1988).

Noncarcinogenic Toxicity

Cesium salts can be regarded as being virtually nontoxic. Acute toxicity, which was observed only at very high cesium concentrations (10 to 20 mmol Cs/kg) in mice, is characterized by dysautonomic upset with parasympathetic predominance and a multiphasic excitation/depression action on the central nervous system. The organs most affected appear to be the liver, intestine, heart, and kidneys.

In beagles injected with massive doses of Cs-137, early deaths occurred as a result of bone marrow destruction (Davie and Coleman 1988).

Carcinogenicity

In beagles injected with massive doses of Cs-137, neurofibrosarcomas occurred in the survivors (Davie and Coleman 1988).

The EPA has derived cancer slope factors for cesium and its progeny, and they are presented in Table I.7-4.

I.7.5.2 Lead-210

Biological Distribution and Retention; Pharmacokinetics

The pharmacokinetics of lead are discussed in Section I.7.6.17.

Noncarcinogenic Toxicity

The noncarcinogenic toxicity of lead is discussed in Section I.7.6.17.

Carcinogenicity

The EPA has derived cancer slope factors for Pb-210, and they are presented in Table I.7-4.

I.7.5.3 Neptunium-237

Biological Distribution and Retention; Pharmacokinetics

The fraction of ingested neptunium absorbed from the gastrointestinal tract into blood (f_1) is assumed to be approximately 1 percent. This value was based on experimental data involving a large group of rats fed with doses of neptunium exceeding 1 mg/kg. When the dietary dose was lower than 1 mg/kg, the fraction F_1 was 0.1 percent or less. Data on distribution and retention of neptunium in rats indicate that its metabolic behavior is similar to that of plutonium. However, there are some indications that neptunium may distribute more like calcium than like plutonium in the skeleton. Forty-five percent of the neptunium leaving the transfer compartment will be translocated to mineral bone. Another 45 percent will be transported to the liver, and 0.035 percent to the testes or 0.011 percent to the ovaries. The remaining neptunium leaving the transfer compartment is assumed to go directly to excreta. The biological half-life of neptunium is about 100 years in mineral bone, about 40 years in the liver, and it is assumed that neptunium is permanently retained in the gonads. These retention and translocation data were based on the ICRP common model for systemic distribution and retention of all transuranic elements. The model itself was largely based on plutonium data.

Noncarcinogenic Toxicity

The presence of neptunium in high-level nuclear waste and its presumed environmental mobility have made it an isotope of special environmental concern.

All animal toxicity studies with neptunium have employed Np-237. Because of its low specific activity (0.76 mCi/g), the chemical toxicity effects of Np-237 are often observed to the exclusion of radiation effects. Soviet data in this area were studied by Moskalev et al. (NCRP 1988). Although the chemical toxicity effects might be a controlling factor in an acute exposure to Np-237, they would not be an important factor at the usual levels concerning radiation protection, and certainly not at the very low levels of potential environmental exposure. In this presentation, therefore, the health effects of Np-237 are assessed only with respect to carcinogenicity, as described below.

Carcinogenicity

The effects of neptunium exposure have not been studied in man. For radiation protection purposes, it has been assumed that radiation doses resulting from neptunium deposition in organs and tissues will result in biomedical effects similar to those observed following the exposure of humans to other sources of ionizing radiation. The very limited data on neptunium effects in animals provide no direct useful estimates of risk to humans. Although these data play no direct role in establishing neptunium standards, they can nevertheless help to validate these standards through comparisons with other animal studies employing other radionuclides.

The long-term radiation effects of Np-237 have been studied only in rats. Genetic effects have not been studied. Bone cancer has been the predominant long-term effect of low-level injections of Np-237. Both lung and bone cancer incidences are elevated following inhalation exposure. There is no indication that neptunium at low exposure levels constitutes a unique health risk unpredictable from its general radiological characteristics.

The 1987 NCRP recommendations for annual limits on Np-237 intake are as follows:

• Oral ingestion	0.6 μCi	Based on nonstochastic limits
	2.0 μCi	Based on stochastic limits

• Inhalation	0.005 μCi	Based on nonstochastic limits
	0.010 μCi	Based on stochastic limits

The nonstochastic limit or dose equivalent applies to bone surface.

The EPA has derived cancer slope factors for neptunium, and they are presented in Table I.7-4.

I.7.5.4 Plutonium

Biological Distribution and Retention; Pharmacokinetics

Regarding distribution and retention, inhaled plutonium is retained in the lungs with an effective half-life that varies from hundreds of days for plutonium oxides to tens of days for more soluble forms. A significant portion of the plutonium oxide that leaves the lungs is translocated to the tracheobronchial lymph nodes. Plutonium solubilized within the lungs is translocated to the liver and skeleton where it is tenaciously retained (Klaassen 1986).

Noncarcinogenic Toxicity

Among the plutonium isotopes, Pu-241 is especially toxic because of its short half-life. The toxicity of plutonium compounds is based primarily on the very high radiotoxicity of the plutonium atom and secondarily upon whatever atoms or combinations of atoms they might contain (Sax 1989). There are no reports on the chemical toxicity of plutonium; however, the fibrosis observed in the lungs of exposed animals and humans could be due to chemical interactions. The radiologic toxicity of plutonium involves bone necrosis, bone and lung cancer, and detrimental effects on the reproductive system. Also, toxic effects are observed in offspring of pregnant animals exposed to plutonium. No ingestion data specific to plutonium are available.

In a classic long-term toxicity study performed by Bair et al., the effects of inhaled plutonium oxide were studied in beagle dogs for up to 10 years following inhalation exposure. At the highest levels of deposited activity, the dogs died within several hundred days with radiation pneumonitis and pulmonary fibrosis; at later times death was related to severe pulmonary fibrosis, and beyond 1000 days, although pulmonary fibrosis was still prominent, death was due to primary pulmonary neoplasia. The most common neoplasm was bronchioloalveolar carcinoma (Klaassen 1986). Hahn et al. (1983), using data reported by Bair and Thomas (1976), calculated the risk

factor for Pu-239 alpha irradiation of the lungs to be 600 lung tumors per million rad to lung, or, assuming an RBE of 20, 30 lung tumors per millirem to lung.

Human data for plutonium exposure are available. Among workers contaminated, the case histories have been documented of 26 men who worked with plutonium during World War II. The initial body burden of these workers was between 540 and 229,500 pCi (reported as between 20 and 8500 Becquerel), and 11 of them received doses exceeding the maximum allowed by the International Commission for Radiological Protection. After a medical follow up of 37 years, 2 members of this group died of myocardial infarction and accidental trauma, respectively, compared to the 6.6 deaths expected on the basis of the adjusted rates for white males. Their 1982 exam provided no evidence that 37 years of exposure to internally deposited plutonium had adverse effects on their health (Seiler 1988).

Less toxicity data are available on trans-plutonium radionuclides such as americium and curium; however, the data that are available indicate a qualitative similarity to the toxicity of plutonium. McClellan, et al. (1972) noted that inhaled americium and curium, even as oxides, appeared more soluble than inhaled plutonium and rapidly translocated to the liver and skeleton. (Klaassen 1986)

Carcinogenicity

The EPA classifies all radionuclides as weight-of-evidence Group A substances (human carcinogens), based on their characteristic of emitting ionizing radiation and on the extensive epidemiologic data associating exposure with radiogenic cancers in humans (EPA 1992d). The carcinogenicity of Pu-238 (the predominant plutonium isotope at the FEMP) from internal exposure is due to alpha particles. The EPA (1992b) has reported cancer potency slope factors for the plutonium isotopes, and these are presented in Table I.7-4.

I.7.5.5 Protactinium-231

Biological Distribution and Retention; Pharmacokinetics

Experiments with laboratory animals treated orally with different forms of protactinium yielded absorption efficiencies ranging from 0.01 to 1 percent (Burkart and Kopp 1988). The EPA (1992b) reported a gastrointestinal absorption factor of 0.001 equivalent to 0.1 percent. Quantitative inhalation data for protactinium have not been located, but one case of human

inhalation yielded a lung clearance half-life 1000 days (Burkart and Kopp 1988). An ICRP lung class designation of "Y" indicates that clearing inhaled protactinium would be expected to take years.

Absorbed protactinium is distributed principally to the skeleton, and to a lesser extent to the liver and kidneys. Protactinium in the blood is excreted directly (Burkart and Kopp 1988), but the route and rate of excretion are not specified.

Noncarcinogenic Toxicity

Data regarding the noncarcinogenic effects of protactinium have not been located.

Carcinogenicity

The EPA classifies all radionuclides as weight-of-evidence Group A substances (human carcinogens), based on their characteristic of emitting ionizing radiation and on the extensive epidemiologic data associating exposure with radiogenic cancers in humans (EPA 1992d). The carcinogenicity of protactinium-231 is due to its emission of alpha particles (Burkart and Kopp 1988). The EPA (1992b) presents cancer potency slope factors for Po-231 of 9.2×10^{-11} per pCi for ingestion, 3.6×10^{-8} per pCi for inhalation, and 2.6×10^{-8} per pCi yr/g for external exposure.

I.7.5.6 Radium

Biological Distribution and Retention; Pharmacokinetics

Four isotopes of radium occur naturally, Ra-223 (actinium series), Ra-224 and Ra-228 (thorium series), and Ra-226 (uranium series); radium is ubiquitous in the earth's crust and common in groundwater, mineral deposits, soil, food products, and common building materials. Ra-226 has the longest half-life (1600 years) of the radium isotopes and decays by alpha particle emission. Ra-223 and Ra-224 are also alpha-particle emitters, and Ra-228 is a beta-particle emitter. The primary uses of radium are for manufacturing luminous dials and instrument faces and for internal radiation therapy; thus, the bulk of human data on the effects of radium intake are available from studies of radium-dial painters and medical patients who have been administered therapeutic doses of radium.

Radium introduced into the body generates decay products, including gaseous isotopes of radon. Rn-222 generated in the body persists long enough that it easily diffuses into the bloodstream and accumulates in the sinuses, significantly reducing the alpha dose to the radium accumulating tissues but increasing the dose in the sinuses. Ultimately the bone tissues are the principal site of radium accumulation because of the similar chemistry of radium and calcium (NAS 1988). In the bone tissues, radium is initially deposited in endosteal bone surface tissue. There is then a redistribution to the bone volume, where the radium resides with a long retention time.

Noncarcinogenic Toxicity

No chemical toxic effects of exposure to radium have been documented, and the EPA has not developed an RfD for radium; therefore, the health hazard for radium is associated with potential radiocarcinogenic effects.

Although epidemiological investigations have documented the association between radium exposure and carcinogenic effects, there has been considerable debate over the dose-response relationship involved. Bone cancer incidence has been evaluated as a function of a variety of parameters that represent a measure of radium exposure, such as absorbed dose to the skeleton, pure radium equivalents, and cumulative rad-years (Evans 1966).

Cancers of the paranasal sinuses and the mastoid air cells have been associated with exposure to Ra-226 and Ra-228 since the 1930s (Martland 1939). These effects were initially seen in radium-dial painters, who received high absorbed doses from the quantities of radium they ingested. Excess incidence is evident when compared to the natural incidence, which is very low. After exposure to radium, these types of cancers were expressed later than bone cancers (Evans et al. 1969; Finkel et al. 1969; Rowland et al. 1971; Rundo et al. 1986).

As discussed above, Rn-222 generated in the body persists long enough that it easily diffuses into the bloodstream and accumulates in the sinuses, significantly increasing the dose in the sinuses. Studies of cancers of the sinuses and mastoid cells conducted in beagle dogs injected with a variety of alpha-emitting radionuclides revealed excess incidence of these cancers (Schlenker 1980). Not all of the tumors were induced by alpha emitters that produce a gaseous decay product; therefore, a gaseous decay product was not essential to induction. Nevertheless, the risk

of these cancers from Ra-226 and its decay products (including Rn-222) is considered significantly greater than from other alpha-emitting radionuclides.

The accumulation of very high levels of radium is associated with severe anemias and leukemia (NAS 1988). However, at lower levels of accumulation, such as those experienced by the majority of U.S. radium-dial painters, especially in later years, the accumulated radium does not appear to significantly increase the risk of leukemia (NAS 1988). The BEIR IV Committee presented a cancer risk factor of 200 x 10^{-6} per rad for bone sarcomas from protracted exposure to radium in its report on radon and other alpha emitters (NAS 1988).

I.7.5.7 Radon and Progeny

Biological Distribution and Retention; Pharmacokinetics

The health risk accompanying radon exposure can be attributed to inhalation of the short-lived progeny of radon. The daughter atoms of concern are attached to particulates which then lodge in the lung passages and produce a radiation dose which may causes lung cancer. Radon progeny that do not lodge in the lung passages are exhaled, and do not deliver a radiation dose. Lung cancer results when the bronchial epithelium of the lung passages is exposed to alpha particles emitted from decaying radon progeny (i.e., Po-214 and Po-218) lodged in the lung passages.

Short-lived radon progeny will decay to lead. Because lead is a chemical toxicant, significant accumulations of radon pose a potential source of lead for exposure. Lead and its potential toxicity is discussed in more detail within Section I.7.6.17.

Noncarcinogenic Toxicity

There are no known toxic effects of direct exposure to radon gas or its short-lived progeny.

Carcinogenicity

Radon gas and associated progeny have been linked to an increase in incidence of lung cancer in individuals exposed via inhalation.

The following discussion regarding the health effects of exposure to radon and radon progeny is summarized from the report of the BEIR IV Committee on radon and other alpha emitters (NAS 1988). The radiological effect of concern from exposure is lung cancer.

The lung cancer mortality risk estimates for radon progeny exposure published by the BEIR IV Committee (NAS 1988) were based on an epidemiological study of underground miner populations. The assessment of the risk from exposure to radon progeny by the BEIR IV Committee represents the most recent comprehensive examination of estimated health risks associated with exposure.

In its study of the human epidemiological data, the BEIR IV Committee reevaluated the primary data (i.e., exposure histories and mortality) for the four principal epidemiological study groups of underground miners exposed to radon progeny. From this reevaluation, the committee estimated the risk of developing fatal lung cancer. The risk from lifetime exposure to radon progeny was estimated at 350×10^{-6} excess fatal lung cancers per cumulative working level month (WLM) as exposure. The WLM is defined as the cumulative exposure to an airborne concentration of short-lived radon progeny (equal to one working level) for a period of one working month. It must be noted that this estimate, quantified as fatal lung cancer risk, was based primarily on epidemiological studies of human and is expressed per unit cumulative exposure to progeny (WLM^{-1}). The EPA slope factors addressing cancer incidence were based on calculated radiation doses to organs and tissues and are expressed per unit radioactivity intake (pCi^{-1}). Thus, the EPA and BEIR IV risk estimates are not directly comparable. The EPA cancer slope factors were used to assess risk attributable to radon and radon progeny exposure. It is also noted that EPA has adopted a nominal risk estimate of 360×10^{-6} per WLM for use in NESHAPS (EPA 1989c). This estimate was based primarily on EPA's consideration of the BEIR IV assessment; however, EPA did average radon risk estimates derived from BEIR IV and ICRP models to calculate the estimate of 360×10^{-6} per WLM.

Although the carcinogenicity of radon progeny is established and the hazards of exposure during mining are well recognized, the hazards of exposure in other environments have not yet been adequately quantified (NAS 1988).

Using the BEIR IV risk factor (NAS 1988) of 350 x 10^{-6} WLM^{-1} for lung cancer mortality from inhalation of Rn-222 and progeny, and by assuming 51.5 working months per year (8760 hours per year divided by 170 hours worked per month), 100 pCi Rn/liter air, short-lived Rn-222 progeny present in 50 percent equilibrium, and an inhalation rate of 20 m^3/day for 365 days/year, one can derive a lung cancer mortality risk factor of 1.2 x 10^{-11} per pCi. The EPA cancer slope factor from HEAST for inhalation of Rn-222 plus progeny is 7.7 x 10^{-12} per pCi (EPA 1992d). It must be noted that the BEIR IV risk estimate pertains to lung cancer mortality, while the EPA cancer slope factors all pertain to cancer induction rather than cancer fatality.

I.7.5.8 Ruthenium-106

Biological Distribution and Retention; Pharmacokinetics

The biochemistry and metabolism of ruthenium and its salts have not been investigated in detail. Ruthenium chelates are readily absorbed and rapidly excreted. A transient retention of ruthenium occurs in the kidneys, muscle, liver, bone, and probably also in the lungs during experiments using radioruthenium chloride. Once absorbed into the bone, ruthenium is retained for a long time (Léonard 1988).

The EPA (1993c) has derived a gastrointestinal absorption factor for ruthenium of 0.05, equivalent to 5 percent.

Noncarcinogenic Toxicity

Most ruthenium salts are considered to be slightly toxic, but fumes of ruthenium tetroxide and of ruthenium heated in air are highly injurious to the eyes and the lung and can produce nasal ulcerations.

Ruthenium red is a known antagonist of Ca^{+2} and inhibits Ca^{+2} transport and binding in mitochondria membranes and muscle tissues. This salt also inhibits Ca^{+2}-ATPase activity.

Ruthenium red is also an antagonist of the depressive action of noradrenaline and 5-hydroxytryptamine on cortical neurons, and by action on neurotransmitters it can produce paralysis and convulsions in laboratory animals (Léonard 1988).

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Carcinogenicity

The EPA has derived cancer slope factors for Ru-106, which are presented in Table I.7-4.

I.7.5.9 Strontium

Biological Distribution and Retention; Pharmacokinetics

Wenning and Kirsch (1988) reported that the gastrointestinal absorption of soluble strontium compounds ranges from 5 to 25 percent of the ingested dose and the EPA (1992b) has derived a gastrointestinal absorption efficiency factor of 0.3. Insoluble strontium compounds are absorbed to about 5 percent. Data regarding inhalation or dermal absorption have not been located.

Strontium is an alkaline earth metal similar in chemical behavior to calcium (Wenning and Kirsch 1988). About 99 percent of the body burden is in the skeleton. Excretion is principally in the urine.

Noncarcinogenic Toxicity

Stable strontium has induced rachitic changes in the bones, particularly of the young (EPA 1992d). Presumably, Sr-90 would also induce rachitic changes in bone. The concern at the FEMP, however, is with the radiological effects (carcinogenicity) of Sr-90, rather than the noncarcinogenic toxicity.

Carcinogenicity

The EPA (1992b) has assigned stable strontium to cancer weight-of-evidence Group D, indicating it is not classifiable as to human carcinogenicity. Quantitative cancer risk estimates were not derived for Group D substances. The EPA classifies all radionuclides as Group A substances (human carcinogens), based on their characteristic of emitting ionizing radiation and on the extensive epidemiologic data associating exposure with radiogenic cancers in humans (EPA 1992d). The EPA (1992b) has derived cancer potency slope factors for Sr-90, and its radioactive decay product of 3.6×10^{-11} per pCi for ingestion and 6.2×10^{-11} per pCi for inhalation exposure. There is no slope factor for external exposure to Sr-90, which does not emit penetrating radiation (gamma- or x-rays).

I.7.5.10 Technetium

Biological Distribution and Retention; Pharmacokinetics

No isotopes of technetium are stable (Clarke and Podbielski 1988). Lethality due to radiation toxicity usually occurs before the nonradiologic effects of technetium become manifest; hence, little is known of the absorption, distribution or pharmacokinetics of the element.

Noncarcinogenic Toxicity

No isotopes of technetium are stable (Clarke and Podbielski 1988). Lethality due to radiation toxicity usually occurs before the nonradiologic effects of technetium become manifest; hence, little is known of the metabolic effects of the element.

Carcinogenicity

The EPA classifies all radionuclides as weight-of-evidence Group A substances (human carcinogens), based on their characteristic of emitting ionizing radiation and on the extensive epidemiologic data associating exposure with radiogenic cancers in humans (EPA 1992d). The internal carcinogenicity of Tc-99 is due to its emission of beta particles (Clarke and Podbielski, 1988). The EPA (1992b) has derived cancer potency slope factors for Tc-99 of 1.3×10^{-12} per pCi for ingestion, 8.3×10^{-12} per pCi for inhalation, and 6.0×10^{-13} per pCi yr/g for external exposure.

I.7.5.11 Thorium

Biological Distribution and Retention; Pharmacokinetics

Thorium is a naturally occurring radionuclide. Oxides and hydroxides of thorium are assigned to inhalation Class Y, while all other chemical forms are assigned Class W. It is deposited primarily in bone with a very long half-life (8000 days), and to a lesser extent in the liver and other soft tissues (ICRP 1978).

Noncarcinogenic Toxicity

No toxic effects of exposure to thorium have been documented, and the EPA has not developed an RfD for thorium; therefore, the health hazard for thorium is associated with its potential radiocarcinogenic effects.

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Carcinogenicity

The half-life of Th-232 is approximately 10 billion years; thus the specific activity is relatively low and the rate of decay is slow. Th-232 decays by alpha particle emission, as do most of the progeny in the thorium natural decay series.

Thorium has historically been used as a medical imaging agent, because it is a heavy atom that provides contrast in radiographic imaging. In this role thorium has been used commercially as Thorotrast, a 25-percent colloidal solution of thorium dioxide. The following discussion of the health effects from thorium exposure is summarized from the report of the BEIR IV Committee on radon and other alpha emitters (NAS 1988).

Thorotrast has been used extensively in the United States, Europe, and Japan as an intravascular contrast agent for cerebral and limb angiography. The human epidemiological evidence from the studies of Thorotrast patients represents the primary source of data from which estimates of risk have been derived (NAS 1988). These data can be used to derive estimates of risk for liver cancer and leukemia; however, such estimates strictly apply only to conditions of intravascular Thorotrast injection. The BEIR IV committee derived a risk estimate of up to 300 x 10^{-6} per rad of alpha particle radiation to the liver, and emphasized that these estimates are for Thorotrast, not thorium. The emphasis is because the dosimetry of other isotopes of thorium differs from that of Th-232 in the Thorotrast colloid form. BEIR IV also derived a risk estimate of up to 60 x 10^{-6} per rad of alpha radiation to bone marrow for leukemia, and a value of up to 120 x 10^{-6} per rad of alpha radiation to the skeleton without marrow for bone cancer (NAS 1988).

In summary, the animal experimental evidence indicates that Thorotrast induces cancers as a result of the radiation dose delivered by the solution. The physical presence of particles in the colloid solution and the chemical effect of the thorium are not likely to influence the induction of cancer (NAS 1988). The EPA derived slope factors are presented in Table I.7-4.

I.7.5.12 Uranium

Biological Distribution and Retention; Pharmacokinetics

In general, uranium compounds are not easily absorbed across the human gastrointestinal tract. Soluble uranium compounds demonstrate the best absorption. In a study in which patients drank

a solution of uranyl nitrate hexahydrate, a water soluble compound, only 0.5 to 5 percent of the dose was absorbed (Hursh et al. 1969). Recent uranium metabolic models estimated absorption from the gastrointestinal tract to the blood to be 0.6 percent (Wrenn et al. 1987). Although human data concerning absorption by dermal exposure are sparse, water-insoluble uranium compounds were not absorbed in significant quantities across the skin (Yuile 1973) and are not believed to pose a significant risk to humans by this exposure route.

Once absorbed into the bloodstream, uranium compounds are metabolically converted to uranyl ions. The uranyl ion acts as a ligand in the systemic circulation, binding to the plasma proteins and bicarbonate. Although this uranyl-bicarbonate complex is stable at the pH of the plasma, the pH of urine favors dissociation of the complex. This leaves the uranyl ion free to bind to the tissues in the proximal tubule wall of the nephrons of the kidneys, resulting in cellular necrosis (Leggett 1989).

As well as being the only soft tissue that stores uranium in any appreciable quantity, the kidneys are the main organs of excretion (Hursh and Spoor 1973). Approximately 70 percent of an intake of uranium has been estimated to be excreted by the kidneys within 24 hours of intake (Berlin and Rudell 1979). Uranium that is not excreted is stored in the kidneys and bones. Binding to the bone is thought to be caused by the affinity of uranium for the phosphate groups in the bone structure; indeed, the bone surface is the most probable target tissue for exposure to uranium, and bone sarcoma as the carcinogenic effect of concern. Radiocarcinogenic effects, including bone sarcoma and head carcinoma, have also been observed in animals and humans from exposure to isotopes of radium, and studies involving exposure of mice to high specific activity U-232 and U-233 have also revealed an increase in bone sarcomas.

Noncarcinogenic Toxicity

In humans, exposure to uranium leads to nephritis in the kidneys. Data on human exposure to uranium compounds were collected from 1940 to 1960 in acute studies on terminal and volunteer patients. Single injections of 70 to 100 μg/kg of uranium nitrate to terminally ill patients resulted in proteinuria and increased levels of catalase in the urine (Berlin and Rudell 1979; Luessenhop et al. 1958). In another study, patients were given uranyl nitrate injections ranging from 6.3 to 71

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μg/kg. One of the early signs of renal damage, the appearance of the enzyme catalase in the urine, occurred in patients receiving 55 to 71 μg/kg (Hursh and Spoor 1973; Leggett 1989).

The EPA (1991a) has established an RfD for uranium of 3×10^{-3} mg/kg/day. In lieu of a NOAEL, the RfD was based on the LOAEL of 2.8 mg/kg/day (Maynard and Hodge 1949) and an uncertainty factor of 1000. The uncertainty factor accounts for intraspecies and interspecies variability in toxicological response and for the use of the LOAEL rather than an NOAEL. No factor was included for the short duration of the exposure (30 days), because it has been shown that chronic nephrotoxic effects can be adequately characterized with experiments of acute/subacute duration (EPA 1991a). The RfD for uranium is presented in Table I.7-1.

Carcinogenicity

Uranium can induce cancer as a result of intake into the body through inhalation or ingestion pathways. The induction of cancer results when organs and tissues of the body are exposed to alpha particles emitted from decaying uranium atoms. Alpha particles are energetic emissions that cause molecular ionizations in a very dense pattern along a short path through matter. The effect of an alpha particle is highly localized due to the short path length traveled (low penetrability) and the ability of the particle to produce many ionizations. The ionization events cause biological damage believed to be responsible for inducing cells to become cancerous. Although other energetic emissions from radioactive decay of atoms (such as beta particles and gamma rays) also cause molecular ionizations, these radiations do not produce the density of ionizations that alpha particles produce. The dense pattern of ionizations caused by alpha particles and the low penetrability of alpha particles are the factors that determine uranium is an internal exposure hazard. Alpha particles are not an external exposure hazard because they do not penetrate sensitive tissues from outside the body. The outer layers of the skin stop the alpha particles before they can penetrate and damage sensitive tissues of inner layers.

The type of uranium (i.e., natural, enriched, or depleted) under consideration is important because different types of uranium have different specific activities (the amount of radioactivity per unit mass). The value of the specific activity of the uranium reflects the number of alpha particles emitted per unit mass. This has a direct impact on the magnitude of the radiological dose delivered internally after the uranium enters the body. Naturally occurring uranium and uranium processed from natural uranium is a mixture of U-234, U-235, and U-238. The

difference between natural, enriched, and depleted uranium is defined by the percent U-235 mass enrichment. The higher the U-235 enrichment, the higher the specific activity of the mixture.

Convincing epidemiological evidence of uranium-induced radiocarcinogenic effects in humans is difficult to obtain. Available epidemiological evidence has come from studies of workers involved in uranium mining and milling operations. It has been noted for some time that uranium workers are at risk of increased cancer mortality; however, inhalation of airborne radon progeny rather than uranium particulates is considered the predominant source of radiation damage to the respiratory tract in uranium miners. Simultaneous exposures to radon progeny and other elements present in uranium ore are considered confounding factors in those studies of uranium miners intended specifically to examine the radiological effects of exposure to uranium.

Risk estimation for exposure to uranium is based heavily on the carcinogenic effects of other alpha-emitting radionuclides and on animal experiments involving exposure to uranium. Chronic exposure to uranium should be controlled on the basis of nephrotoxicity more than by radiocarcinogenicity from alpha particle emissions (NAS 1988). Quantification of the risk from chronic exposure to uranium alpha particles cannot be determined from published epidemiological studies because of confounding factors and the limited power of the studies to detect increased rates of cancer incidence or mortality (NAS 1988). Therefore, the BEIR IV Committee's risk estimate for uranium was based on the carcinogenic effects of other alpha emitting radionuclides and animal experiments involving exposure to uranium. The most probable radiogenic effect is an increase in bone sarcomas. The likelihood of sarcomas from exposure to naturally occurring uranium is considered low and demonstrable only if a linear dose-response relationship is assumed (Mays et al. 1985). If the dose-response relationship is quadratic, then virtually no effect would be expected from naturally occurring uranium. Assuming a linear dose-response relationship and a constant nonoccupational uranium intake of 1 pCi/day, then the risk of bone sarcoma induction over a lifetime is estimated to be 1.5×10^{-6} or 1.5 bone sarcomas per million persons (Mays et al. 1985). This is compared to a natural incidence of 750 bone sarcomas in the absence of excess exposure.

Assuming a constant nonoccupational uranium intake rate of 1 pCi/day, an exposure frequency of 365 days/year, and a lifetime of 70 years, then a lifetime uranium intake of nearly 26,000 pCi is

calculated. Using the risk factor from Mays (Mays et al. 1985) and dividing by the calculated lifetime intake, one can derive a risk factor of 5.9×10^{-11} per pCi. A comparison of this risk factor with the cancer slope factors from HEAST for ingestion of U-234, U-235, and U-238 indicates that the ratios of the HEAST values to the former value are 2.4, 2.2, and 2.2, respectively. The EPA derived cancer slope factors for uranium isotopes are presented in Table I.7-4.

I.7.6 TOXICITY PROFILES: CHEMICALS

I.7.6.1 Antimony

Pharmacokinetics

Antimony exists in the tri- and pentavalent states (Budavari 1989). The pharmacokinetics of antimony appear to be strongly valence- and species-dependent. Elinger and Friberg (1986a) estimated GI absorption to be at least 15 percent in mice given a single oral dose of labeled trivalent antimony potassium tartrate. This estimate was based on the recovery of labeled antimony in urine and tissues. Actual absorption may have been considerably higher, because GI excretion starts immediately after absorption following an oral dose. The 15 percent absorption efficiency is considered sufficiently conservative and well documented for use in estimating a dermal RfD from the oral RfD.

Although quantitative data were not provided, Elinger and Friberg (1986a) stated that the pulmonary absorption of inhaled trivalent antimony is substantial.

Patterns of tissue distribution of absorbed antimony appear to be largely species-dependent. In humans injected with labeled sodium antimony dimercaptosuccinate, highest amounts of antimony are located in the liver, thyroid, and heart (Elinger and Friberg 1986a). Smelter workers exposed to inhaled antimony compounds retain antimony in their lungs for several years. Single or repeated injections of trivalent or pentavalent antimony in monkeys, dogs, and mice result in highest levels in the kidney, liver, and thyroid. Rats appear to retain higher levels in the blood than do other laboratory animals. In rats, trivalent antimony is retained principally in the erythrocytes (at least 95 percent), but pentavalent antimony is retained principally in the plasma (about 90 percent).

In humans, pentavalent antimony appears to be cleared from the body more efficiently than trivalent antimony (Elinger and Friberg 1986a). Urinary excretion predominates over fecal excretion for both penta- and trivalent antimony, but particularly for pentavalent antimony. In rats and hamsters, urinary excretion predominates for pentavalent antimony and fecal excretion predominates for trivalent antimony.

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Noncarcinogenic Toxicity

Chronic oral exposure studies in animal models include two briefly reported lifetime drinking water studies with potassium antimony tartrate in rats and mice that reported reduced longevity in both species and reduced mean heart weight and altered blood chemistry in the rats (EPA 1992d). A verified chronic oral RfD of 0.0004 mg/kg/day was based on the rat study and an uncertainty factor of 1000 (Table I.7-1).

Chronic effects from occupational exposure include irritation of the respiratory tract, pneumoconiosis, pustular eruptions of the skin called "antimony spots," allergic contact dermatitis, and cardiac effects, including abnormalities of the ECG and myocardial changes (Elinger and Friberg 1986c). Cardiac effects were also observed in rats and rabbits exposed by inhalation for six weeks, and in animals (dogs and possibly other species) treated by intravenous injection. Inhalation RfC values are not available from the EPA. The heart, respiratory tract, and skin are the principal target organs for antimony.

Carcinogenicity

Data were not located regarding the human carcinogenicity of antimony. Antimony fed to rats did not produce excess tumors (Goyer 1991), but a high frequency of lung tumors was observed in rats exposed by inhalation to antimony trioxide for one year (Elinger and Friberg 1986c). The EPA (1994b) has not evaluated the carcinogenicity of antimony.

I.7.6.2 Aroclors

Pharmacokinetics

Aroclors-1016, -1221, -1242, -1248, -1254, and -1260 are marketed commercially as mixtures of polychlorinated biphenyls (PCBs). PCBs were detected in the serum and breast milk of women who consumed PCB-contaminated fish from Lake Michigan, and in the blood of volunteers who ingested PCB mixtures. These detections provide qualitative evidence of GI absorption in humans (ATSDR 1991). In volunteers who ingested PCBs in fish, blood levels peaked in approximately 5 hours after the meal and returned to baseline levels 17 hours later, suggesting that absorption is rapid. Quantitative GI absorption studies with rats, monkeys, and ferrets dosed with individual PCB congeners revealed retention of 75 to 95 percent of the administered dose, with some evidence that absorption efficiency may be inversely related to the extent of

chlorination. The 75 percent GI absorption efficiency is considered sufficiently conservative and well documented for use in estimating a dermal RfD and cancer slope factor from the respective oral values.

Quantitative inhalation absorption data were not located for humans or animals. ATSDR (1991) reviewed the occupational exposure data presented by Wolff (1985) and concluded that inhalation uptake contributed up to 80 percent of the concentration measured in the adipose tissue of exposed workers. Dermal uptake accounted for the remainder. Dermal application studies with PCBs containing 42 and 54 percent chlorine in animals revealed uptakes of 15 to 34 percent of the applied dose in monkeys and 56 percent in guinea pigs (ATSDR 1991). The dosing vehicle appeared to influence absorption; uptake in monkeys was 29 percent from mineral oil and 15 percent from trichlorobenzene.

In humans, PCBs distribute preferentially to adipose tissue (ATSDR 1991). In occupationally exposed workers, the adipose/plasma partition ratio ranged from 185/1 to 210/1. Inhalation and oral exposure data in animals revealed that distribution is biphasic, first to liver and muscle followed by redistribution to adipose tissue. PCB residues were detected in human breast milk and in umbilical cord blood, indicating transfer to the fetus and offspring. Studies in several species suggested that transfer to the offspring is greater through nursing than through placental transfer (ATSDR 1991).

PCB residues in human fat consisted largely of the more highly chlorinated congeners that were substituted in the meta-para vicinal positions, probably because these congeners are relatively more resistant to metabolism (ATSDR 1991). In vitro studies with human microsomes and animal studies indicated that metabolism involves hydroxylation, preferentially at the para position in the least chlorinated phenyl ring. Some PCB congeners were transformed to dihydrodiols, probably through a pathway involving formation of an arene oxide intermediate. The hydroxy derivatives may be conjugated with glucuronide or sulfate for excretion. Considerable interspecies variation was noted in the rate of metabolism of specific PCB congeners.

Animal studies indicate that both fecal and urinary excretion are important in the elimination of PCBs and their metabolites (ATSDR 1991). Lactation represented a major excretory pathway in

nursing women, resulting in higher concentrations of PCB residues in infant's blood than in maternal blood. In humans who had consumed PCB-contaminated rice, elimination half-lives from blood for individual PCB congeners ranged from 4 to 24 months, with longer half-lives estimated for those congeners that were more resistant to metabolism.

Noncarcinogenic Toxicity

Target organs for PCBs include the skin, liver, fetus, and neonate. Epidemiologic studies of women in the United States have associated oral PCB exposure with low birth weight or retarded musculoskeletal or neurobehavioral development of their infants (ATSDR 1991). Occupational exposure to PCBs have been associated with upper respiratory tract and ocular irritation, loss of appetite, liver enlargement, increased serum concentrations of liver enzymes, skin irritation, rashes and chloracne, and in heavily exposed female workers, decreased birth weight of their infants (ATSDR 1991). However, concurrent exposure to contaminants have confounded the interpretation of the occupational exposure studies. Animal models exposed by inhalation to Aroclor-1254 vapors exhibited moderate liver degeneration, decreased body weight gain, and slight renal tubular degeneration. Neither verified nor provisional chronic inhalation RfC values are available.

Oral studies in animals have established the liver as the target organ in all species, and the thyroid as an additional target organ in the rat. Effects observed in monkeys included gastritis, anemia, chloracne-like dermatitis, and immunosuppression. Oral exposure in animal models induced developmental effects, including retarded neurobehavioral and learning development in monkeys. Neither verified nor provisional chronic oral RfD values were located for any of the Aroclors.

Carcinogenicity

The EPA (1991b) has classified the PCBs as cancer weight-of-evidence Group B2 substances (probable human carcinogens), based on inadequate data for humans but sufficient data for animals. The human data consists of several epidemiologic occupational and accidental oral exposure studies with serious limitations, including poorly quantified concentrations of PCBs and durations of exposure, and probable exposures to other potential carcinogens (EPA 1992d).

It is known that PCB congeners vary greatly as to their potency in producing biological effects. There is some evidence that mixtures containing more highly chlorinated biphenyls are more potent inducers of hepatocellular carcinoma in rats than mixtures containing less chlorine by weight (EPA 1993e).

The animal data consists of several oral studies in rats and mice with various Aroclors, Kanechlors or Clophens (commercial PCB mixtures manufactured in the United States, Japan, and Germany, respectively) that reported increased incidence of liver tumors in both species (EPA 1992d). The EPA (1991b) has presented a verified oral slope factor of 7.7 per mg/kg/day for all PCBs, based on liver tumors in rats treated with Aroclor-1260 (Table I.7-2).

I.7.6.3 Arsenic

Pharmacokinetics

Arsenic occurs in compounds in the trivalent and pentavalent forms (Budavari 1989). The extent of the GI absorption of arsenic depends on the particular arsenic compound ingested. Several studies with humans and laboratory animals indicate that the GI absorption of dissolved trivalent or pentavalent arsenic exceeds 90 percent (Ishinishi et al. 1986). Hamsters appear to have somewhat lower (50 to 75 percent) GI absorption of soluble arsenic compounds (ATSDR 1989c). Organic arsenic compounds, which may occur in seafoods, are also readily absorbed (70 to 99.7 percent). The GI absorption of less soluble compounds (e.g., arsanilic acid, arsenic trioxide) is determined by particle size, and pH of the gastric juice. An estimate of 95 percent GI absorption efficiency is considered to be sufficiently conservative and well documented for use in estimating a dermal RfD and cancer slope factor from the respective oral values (EPA 1993e).

The extent of absorption of arsenic from the lungs depends on the solubility of the inhaled compound and particle size (ATSDR 1989c; Ishinishi et al. 1986). In a study with arsenite in cigarettes and with arsenic aerosols in lung cancer patients, deposition was estimated at approximately 40 percent, and 75 to 85 percent of the deposited arsenic was absorbed from the lungs within 4 days.

The occurrence of systemic toxic effects following dermal exposure to arsenic acid or arsenic trichloride (Ishinishi et al. 1986) indicates qualitatively that dermal absorption of some arsenic compounds occurs.

In most animals, all but a small fraction of systemic arsenic is rapidly cleared from the blood and other tissues (ATSDR 1989c). Residual arsenic is located in tissues (liver, kidney, spleen, heart, skin, hair, epithelium of the upper GI tract) containing a high concentration of sulfhydryl groups, to which arsenic preferentially binds (Arnold 1988; Ishinishi et al. 1986). In rats, more than in the other laboratory animals and in humans, arsenic binds to the erythrocytes with high affinity and clearance from the blood is slow (ATSDR 1989c).

Arsenic is extensively metabolized, principally in the liver, in humans and animals (ATSDR 1989c). Metabolism involves methylation of trivalent arsenic (arsenite) to dimethylarsinic acid, or, to a lesser extent, to monomethylarsonic acid. Both methylation products, as well as inorganic arsenic, are excreted principally and rapidly through the urine.

Noncarcinogenic Toxicity

The only noncarcinogenic effects in humans clearly attributable to chronic oral exposure to arsenic are dermal hyperpigmentation and keratosis, as revealed by studies of several hundred Chinese exposed to naturally occurring arsenic in well water (EPA 1992d). Similar effects were observed in persons exposed to high levels of arsenic in water in the western hemisphere. Occupational (predominantly inhalation) exposure was also associated with neurological deficits, anemia, and cardiovascular effects (Ishinishi et al. 1986). The EPA (1991b) has presented an RfD of 0.0003 mg/kg/day for chronic oral exposure, based on a NOAEL from the Chinese data and an uncertainty factor of 1 (Table I.7-1). The principal target organs for arsenic are the skin, nervous system, blood and cardiovascular system.

Carcinogenicity

Inorganic arsenic is clearly a carcinogen in humans (EPA 1992d). Inhalation exposure was associated with increased risk of lung cancer in persons employed as smelter workers, in arsenical pesticide applicators, and in a population residing near a pesticide manufacturing plant. Oral exposure to high levels in well water was associated with increased risk of skin cancer. The EPA

(1991b) has classified inorganic arsenic in cancer weight-of-evidence Group A (human carcinogen). An inhalation slope factor of 50 per mg/kg/day, based on absorbed arsenic, was derived from occupational data. Applying an absorption factor of 0.3 yielded an inhalation slope factor of 15 per mg/kg/day, based on an ambient or inhaled dose. The slope factor based on the inhaled, rather than absorbed, dose is the correct parameter to use in risk assessments. Assuming a human inhales 20 m^3 of air per day and weighs 70 kilograms, the EPA (1991b) estimated an inhalation unit risk of 0.0043 $\mu g/m^3$. EPA (1993c) proposed an inorganic arsenic ingestion unit risk of 5.0×10^{-5} per mg/l. The equivalent oral slope factor is 1.8 per mg/kg/day assuming a 70 kg adult ingests 2 liters per day (Table I.7-2). "The uncertainties associated with ingested inorganic arsenic are such that estimates could be revised downward as much as an order of magnitude, relative to the risk estimates associated with most other carcinogens.

I.7.6.4 Barium

Pharmacokinetics

Barium is an alkaline earth metal that occurs in compounds as a divalent cation (Reeves 1986a). Soluble barium salts are absorbed by the GI tract. In experiments with barium chloride, absorption from the GI tract of hamsters was 11 to 32 percent of the dose. Barium sulfate, which is practically insoluble in water, is virtually unabsorbed, which contributes to its usefulness as a contrast agent in radiography of the GI tract. An estimate of 5 percent appears to be sufficiently conservative and well documented (Tipton et al. 1966). EPA (1993e) recommends a gastrointestinal absorption factor of 0.91. Soluble forms of barium are readily (60 to 80 percent) absorbed from the respiratory tract. Clearance of barium compounds from the lungs was proportional to their solubilities. Data were not located regarding the dermal absorption of barium.

Following absorption, barium, like other alkaline earth metals, is deposited in the skeleton (Reeves 1986a). The affinity of the skeleton for barium is 1.5 to 5 times the affinity for calcium or strontium. Highest concentrations in soft tissues occur in the submaxillary gland, the pigmented structures of the eye, and in melanoma cells. In humans, the principal route of excretion is through the feces.

Noncarcinogenic Toxicity

The acute oral toxicity of barium is manifested by gastrointestinal upset, altered cardiac performance and transient hypertension, and convulsions and muscular paralysis (Reeves 1986a). Repeated oral exposures have been associated with hypertension. Occupational exposure to insoluble barium sulfate induced benign pneumoconiosis (ACGIH 1991). The EPA (1993c) has derived a verified chronic oral RfD of 0.07 mg/kg/day, based on increased blood pressure in subchronic to chronic human drinking water studies and on an uncertainty factor of 3. A *provisional chronic inhalation RfC of 0.0005 mg/m^3 was based on a NOEL for fetotoxicity of 0.8 mg/m^3 in a four-month, intermittent-exposure inhalation study with barium carbonate in the rat, and on an uncertainty factor of 1000 (EPA 1992d). The equivalent chronic inhalation RfD value is 0.00014 mg/kg/day, assuming humans inhale 20 m^3 of air per day and weigh 70 kilograms (Table I.7-1). Barium is principally a muscle toxin. Its targets are the gastrointestinal system, skeletal muscle, and the cardiovascular system. The fetus also appears to be a target.

Carcinogenicity

The EPA (1994b) reports no data for a carcinogenicity assessment for barium.

I.7.6.5 Beryllium

Pharmacokinetics

Absorption of beryllium from the GI tract is low, probably not exceeding 20 percent of an ingested dose, because the metal forms insoluble precipitates with phosphate and is eliminated in the feces (Reeves 1986b). Region V EPA (Saunders, M. 1994) recommends a gastrointestinal absorption factor of 1.00.

Clearance of inhaled beryllium is multiphasic; small quantities of beryllium compounds may remain encapsulated in the lung parenchyma for several years (Reeves 1986b). Water-soluble forms of beryllium at pH 3 are absorbed through the skin of animals (Zorn et al. 1988), but the extent of absorption is probably minimal, because most beryllium salts are insoluble at physiologic pH, and ionized beryllium is readily bound to epidermal contaminants (Reeves 1986b).

Most beryllium in the circulation probably exists as a colloidal phosphate adsorbed to serum protein; minor amounts exist as the citrate or hydroxide (Reeves 1986b). Distribution of small

doses is primarily to the skeleton; for larger doses, distribution is primarily to the liver. Secondary distribution results in movement of beryllium from the liver to the skeleton. The primary route of excretion is through the urine.

Noncarcinogenic Toxicity

Beryllium has a low order of toxicity when ingested because it is poorly absorbed from the gastrointestinal tract (Reeves 1986b). Occupational exposure has induced dermatitis, acute pneumonitis, and chronic pulmonary granulomatosis (berylliosis). Berylliosis was also observed in humans living in the vicinity of a beryllium plant. Pulmonary effects also occurred in laboratory animals subjected to inhalation exposure. A verified chronic oral RfD value of 0.005 mg/kg/day was based on a NOAEL of 0.54 mg/kg/day in a lifetime drinking water study with beryllium sulfate in the rat, and on an uncertainty factor of 100 (EPA 1991b) Table I.7-1). The target organs for inhalation exposure appear to be the lungs; target organs for oral exposure are not identified.

Carcinogenicity

The EPA (1991b) has classified beryllium in cancer weight-of-evidence Group B2 (probable human carcinogen), based on inadequate human data but sufficient animal data. The human data consist of occupational studies that weakly associate exposure with increased risk of lung cancer, but confounding variables were not controlled and the studies lacked sensitivity. A significant increase in lung tumors occurred in three strains of rats and in rhesus monkeys subjected to inhalation exposure or intratracheal instillation of a variety of beryllium compounds. Osteogenic sarcomas were induced in rabbits and mice, but not in rats or guinea pigs injected intravenously with various beryllium compounds. Oral studies in animal models yielded inconclusive results. The EPA (1991b) derived an oral slope factor of 4.3 per mg/kg/day from a slight but statistically nonsignificant increase in total tumors in a lifetime drinking water study with beryllium sulfate in the rat. An inhalation unit risk of 0.0024 per $\mu g/m^3$, equivalent to 8.4 per mg/kg/day (assuming humans inhale 20 m^3 of air per day and weigh 70 kilograms), was derived from a human occupational study. (Table I.7-2)

I.7.6.6 Boron

Noncarcinogenic Toxicity

Acute exposure to boron compounds has been associated with gastrointestinal irritation and central nervous system depression (ACGIH 1991). Occupational exposure induced respiratory tract irritation. Several dietary and drinking water studies with boron (chemical form not specified) in dogs, rats, and mice identified testicular atrophy and impaired spermatogenesis as the critical effect of oral exposure (EPA 1993e). Other effects included reduced body and organ weights, reduced ovulation in female rats, and possibly increased extramedullary hematopoiesis in the spleen. The EPA (1993d) has presented a verified RfD of 0.09 mg/kg/day for chronic oral exposure to boron, based on an NOAEL in a two-year dietary study in dogs (form of boron not specified). An uncertainty factor of 100 was used. The chronic oral RfD was adopted as the provisional subchronic oral RfD (EPA 1992d). The principal target organs of boron are the testis, respiratory mucosa, and central nervous system. The EPA (1992b) has also presented a chronic inhalation RfC of 2×10^{-2} mg/m^3, based on a LOAEL for respiratory tract irritation in a human study, and on an uncertainty factor of 100. The inhalation RfC is equivalent to 0.0057 mg/kg/day, assuming humans inhale 20 m^3 of air per day and weigh 70 kilograms (Table I.7-1).

Carcinogenicity

Data were not located regarding the carcinogenicity of boron.

I.7.6.7 Cadmium

Pharmacokinetics

GI absorption of ingested cadmium is ordinarily 5 to 8 percent, but may reach 20 percent in cases of serious dietary iron deficiency (Friberg et al. 1986a; Goyer 1991). EPA (1993e) recommends use of a gastrointestinal absorption factor of 0.025. Data regarding dermal absorption of cadmium were not located.

Estimates of cadmium uptake by the respiratory tract range from 10 to 50 percent; uptake is greatest for fumes and small particles and least for large dust particles (Friberg et al. 1986a; Goyer 1991). Highest tissue levels are normally found in the kidneys followed by the liver, although levels in the liver may exceed those in the kidneys of persons suffering from cadmium-induced renal dysfunction. The half-life of cadmium in the kidneys and liver may be as

long as 10 to 30 years. Fecal and urinary excretion of cadmium are approximately equivalent in normal humans exposed to small amounts. Urinary excretion increases markedly in humans with cadmium-induced renal disease.

Noncarcinogenic Toxicity

The EPA (1991b) has presented verified chronic oral RfD values of 0.0005 mg/kg/day for cadmium ingested in water and 0.001 mg/kg/day for cadmium ingested in food. Medium-specific oral RfD values reflected the assumption that cadmium is more efficiently absorbed from water than from food. The RfD values were based on a NOAEL for proteinuria (a sensitive indicator of renal toxicity), determined from several human exposure studies, and on an uncertainty factor of 10 (Table I.7-1). Occupational exposure to fumes of cadmium induced metal fume fever (ACGIH 1991). The principal target organs for oral exposure to cadmium are the kidneys.

Carcinogenicity

Cadmium is classified as an EPA cancer weight-of-evidence Group B1 substance (probable human carcinogen), based on limited evidence from occupational studies and sufficient evidence of carcinogenicity in rats and mice following inhalation exposure or parenteral injection (EPA 1991b). There is insufficient information to classify cadmium as carcinogenic to humans by the oral route. A provisional inhalation slope factor of 6.3 per mg/kg/day and a unit risk of 0.0018 per $\mu g/m^3$ (assuming inhale 20 m^3 of air per day and humans weigh 70) was based on the incidence of lung cancer in cadmium smelter workers (Table I.7-2).

I.7.6.8 Carbazole

Noncarcinogenic Toxicity

Only the oral LD_{50} in rats for carbazole has been located. The oral LD_{50} in rats is reported to be greater than 5000 mg/kg (EPA 1993e).

The EPA has not derived chronic oral and chronic inhalation reference doses for carbazole.

Carcinogenicity

The EPA has classified carbazole as a cancer weight-of-evidence Group B2 substance (probable human carcinogen) based on liver tumors in mice administered carbazole in the diet. The EPA (1993c) has derived an oral cancer slope factor of 2 x 10^{-2} $(mg/kg/day)^{-1}$ (Table I.7-2)

I.7.6.9 Chromium (VI)

Pharmacokinetics

Chromium is poorly absorbed from the GI tract. Absorption efficiencies of 3 to 6 percent in rats and approximately 2 percent m humans were reported for chromates (hexavalent chromium). These absorption efficiencies may be underestimations, because they were based on urinary excretion, which disregards excretion by other routes (e.g., intestinal and biliary secretion), and retention in the body tissues. In the absence of more precisely quantified estimates of GI absorption efficiency, the default value of 5 percent (EPA 1989c) will be used to estimate a dermal RfD from an oral RfD.

The observation of high levels of chromium in the lungs of exposed humans indicates that at least part of the inhaled chromium is deposited as insoluble compounds that are cleared slowly from the lungs (Langård and Norseth 1986). Water soluble hexavalent chromium compounds are cleared more rapidly. In animals treated by intratracheal instillation, 53 to 85 percent of hexavalent compounds were cleared from the lungs (duration of evaluation not specified) (ATSDR 1989e).

Direct evidence from human volunteers and indirect evidence from occupational exposure indicate that dermal uptake of chromium occurs (ATSDR 1989e). The extent of dermal uptake appears to depend more on the specific compound rather than the valence of chromium. Quantitative absorption data were not located.

Noncarcinogenic Toxicity

Little chromium (VI) exists in biological materials, except shortly after exposure, because reduction to chromium (III) occurs rapidly (Langård and Norseth 1986). Chromium (III) is considered a nutritionally essential trace element and is considerably less toxic than chromium (VI). Acute oral exposure of humans to high doses of chromium (VI) induces neurological

effects, gastrointestinal hemorrhage and fluid loss, and kidney and liver effects. Parenteral dosing of animals with chromium (VI) was selectively toxic to the kidney tubules. A NOAEL of 2.4 mg Cr(VI)/kg/day in a one-year drinking water study in rats with potassium permanganate, along with an uncertainty factor of 500, formed the basis of a verified RfD (EPA 1991b) for chronic oral exposure of 0.005 mg/kg/day (Table I.7-1).

Occupational (inhalation and dermal) exposure to chromium (VI) induced ulcerative and allergic contact dermatitis, irritation of the upper respiratory tract including ulceration of the mucosa and perforation of the nasal septum, and possibly kidney effects (ACGIH 1991). Currently an inhalation RFC and RFD are not available for chromium (VI) from EPA.

Target organs for dermal and inhalation exposure include the skin and respiratory mucosa.

Carcinogenicity

The EPA (1991b) has classified chromium (VI) in cancer weight-of-evidence Group A (human carcinogen), based on the consistent observation of increased risk of lung cancer in occupational studies of workers in chromate production and the chrome pigment industry. Parenteral dosing of animals with chromium (VI) compounds consistently induced injection-site tumors. There is no evidence that oral exposure to chromium (VI) induces cancer. A verified inhalation unit risk of 0.012 per $\mu g/m^3$, equivalent to 41 per mg/kg/day (assuming humans inhale 20 m^3 of air per day and weigh 70 kilograms), was based on increased risk of lung cancer deaths in chromate production workers (Table I.7-2).

I.7.6.10 Cobalt

Pharmacokinetics

There is considerable individual variation in the extent of GI absorption of cobalt in humans. Estimates of GI absorption range from 5 to 45 percent, based on recovery of cobalt in the feces in volunteers given radiolabeled cobalt chloride (Elinger and Friberg 1986b). The 45 percent estimate is considered sufficiently conservative and well documented for use in estimating a dermal RfD from an oral RfD.

Quantitative data regarding respiratory tract absorption of cobalt were not located. Occupational exposure data, however, indicate that substantial respiratory tract uptake occurs (Elinger and Friberg 1986b). Blood and urinary levels of cobalt were markedly increased, compared to pre-exposure levels or to unexposed controls, in workers exposed for a short time to 0.09 mg cobalt per m^3 in workroom air. Data regarding dermal absorption were not located.

In both humans and animals, cobalt distributes preferentially to the liver and kidneys (Elinger and Friberg 1986b). In pregnant mice treated with radioactive cobalt, substantial levels of radioactivity located in the liver, kidney, fetuses, and placenta. After parenteral administration or occupational exposure to cobalt, excretion is principally through the urine, although fecal (possibly biliary) excretion is also significant.

Noncarcinogenic Toxicity

Occupational (inhalation and dermal) exposure has been associated with allergic dermatitis, chronic interstitial pneumonitis, reversibly impaired lung function, occupational asthma, and myocardial effects (ACGIH 1991). Important target organs in orally exposed humans are the heart, erythrocyte, and thyroid. Target organs for occupational exposure are the skin, lungs, and heart. Cobalt has been determined to be the etiologic factor in hard metal disease, the syndrome of respiratory symptoms and pneumoconiosis associated with inhalation exposure to dusts containing tungsten carbide with cobalt powder as a binder (Elinger and Friberg 1986b). The lowest occupational air concentration of cobalt associated with hard metal disease was 0.003 mg Co/m^3 (Sprince et al. 1988). It should be noted that the workers were also exposed to tungsten and sometimes to titanium, tantalum, and niobium (Elinger and Friberg 1986b). Similar lung effects have been seen in animals exposed to cobalt by inhalation.

Acute, high oral or parenteral doses of cobalt in humans and animals induced myocardial degeneration, often leading to mortality, erythropoiesis, enlarged thyroid, and in animals, renal tubular degeneration (Elinger and Friberg 1986b). Chronic ingestion from the consumption of beer containing high concentrations of cobalt has been associated with a condition called "beer-drinkers cardiomyopathy," which includes polycythemia, goiter, and marked myocardial degeneration and mortality. The therapeutic use of 0.16 to 0.32 mg Co/kg/day in anemic,

anephric dialysis patients for 12 to 32 weeks induced a significant but reversible rise in blood hemoglobin concentration (EPA 1992d).

The EPA (1992e) concluded that the oral toxicity data were insufficient to derive an oral RfD for cobalt. The relatively well-characterized dietary intake data, however, can provide useful guidance. The EPA noted that the upper range of dietary intake for children, 0.06 mg/kg/day, was below the level associated with enhanced erythropoiesis in anephric patients. Therefore, the upper range of dietary intake, 0.06 mg Co/kg/day, can be considered a guidance level for the oral intake of cobalt and can be used in place of an oral RfD in CERCLA and RCRA risk assessments.

The EPA (1990a) has derived an interim inhalation RfC from the LOAEL of 0.003 mg Co/m^3 associated with hard metal disease in occupationally exposed humans. Correcting for intermittent occupational exposure (10 m^3 of air inhaled per work day/20 m^3 of air inhaled per day x 5 work days per week/7 days per week) yielded an adjusted LOAEL of 0.001 mg/m^3. Applying an uncertainty factor of 1000 (10 for use of a LOAEL, 10 to protect sensitive individuals, and 10 to account for the disparity between the latency period and exposure duration — not further explained) resulted in an interim chronic RfC of 1×10^{-6} mg/m^3. Assuming humans inhale 20 m^3 of air per day and weigh 70 kilograms, the RfC is equivalent to 2.9×10^{-7} mg/kg/day, rounded to 3×10^{-7} mg/kg/day (Table I.7-1).

Carcinogenicity

The carcinogenicity of cobalt has not yet been evaluated by the EPA (1992d, 1992b).

I.7.6.11 Copper

Pharmacokinetics

Estimates of the absorption of copper from the GI tract range from 15 to 97 percent, with an average of approximately 60 percent (ATSDR 1989c; EPA 1993e). Several factors, including the dose of copper, the presence of other metals in the diet, the form of copper administered, and the presence of substances that inhibit uptake (vitamin C, phytate, fiber), influence the extent of GI absorption.

Quantitative data were not located regarding the uptake of copper from the respiratory tract. The observation of elevated plasma copper levels in some workers in a heavily polluted industrial atmosphere indicates that respiratory tract uptake occurs (Aaseth and Norseth 1986). Data were not located regarding the dermal uptake of copper.

Circulating copper is taken up by the liver, transferred to the high molecular weight protein, ceruloplasmin, reenters the circulation, and accumulates in liver, heart, brain, kidney, and muscles (Aaseth and Norseth 1986). Excretion is principally through bile.

Noncarcinogenic Toxicity

Copper is a nutritionally essential element that functions as a cofactor in several enzyme systems (Aaseth and Norseth, 1986). Acute exposure to large oral doses of copper salts has been associated with gastrointestinal disturbances, hemolysis, and liver and kidney lesions. Chronic oral toxicity in humans has not been reported. Chronic oral exposure of animals has been associated with an iron-deficiency type of anemia, hemolysis, and lesions in the liver and kidneys. Occupational exposure has induced metal fume fever, and in cases of chronic exposure to high levels, hemolysis and anemia (ACGIH 1991). Neither oral nor inhalation RfD or RfC values are available for copper from the US EPA. The target organs for copper are the erythrocyte, liver, and kidneys, and for inhalation exposure, the lung.

The EPA (1992b) has concluded that the health effects data were inadequate for deriving a chronic oral RfD for copper. The current drinking water maximum contaminant level goal (MCLG) for copper is 1.3 mg/l, which was based on an LOAEL for gastrointestinal effects in acutely exposed humans, and an uncertainty factor of 2. The MCLG is equivalent to a daily intake from water of 2.6 mg/day, assuming a drinking water ingestion rate of 2 l/day. The MCLG of 1.3 mg/l is an inappropriate basis for deriving a toxicity value for use in a CERCLA risk assessment, for three main reasons:

1. The MCLG is based on the effects resulting from acute exposure, and it is not reasonable to assume that a toxicity value designed to protect against effects from short-term exposure would sufficiently protect against effects from chronic exposure.

2. The estimated safe and adequate daily dietary intake of copper for adults is 1.5 to 3.0 mg/day, which exceeds the equivalent daily intake from drinking water estimated from the MCLG.

3. The estimated adult daily intake of copper from food is 2.0 to 4.0 mg/day, which also exceeds the equivalent daily intake from drinking water estimated from the MCLG.

Carcinogenicity

Copper is in cancer weight-of-evidence Group D, meaning it is not classifiable as to human carcinogenicity (EPA 1992a). Quantitative risk estimates are not derived from Group D chemicals.

I.7.6.12 Cyanide

Noncarcinogenic Toxicity

Acute exposure to cyanide induces histotoxic hypoxia (inability of the tissues to use oxygen); death is due to central respiratory arrest (Smith 1991). Chronic dietary exposure to cyanide has induced reduced body weight gain, decreased thyroid activity, myelin degeneration, and reduced fertility in rats (EPA 1992d). The EPA (1993c) has presented a verified RfD of 0.02 mg/kg/day for oral exposure to cyanide, based on a NOAEL in a two-year study of rats that consumed food fumigated with hydrogen cyanide, and on an uncertainty factor of 100 (Table I.7-1). The target organs for chronic oral exposure to cyanide appear to be the thyroid and nervous system.

Carcinogenicity

The EPA (1991b) classified cyanide as a cancer weight-of-evidence Group D substance (not classifiable as to humans carcinogenicity).

I.7.6.13 4,4'-DDE

Noncarcinogenic Toxicity

In humans, 4,4'-dichlorodiphenyldichloroethane (DDE) is a major metabolic product of the metabolism of the organochlorine insecticide dichlorodiphenyltrichloroethane (DDT). Four percent of technical DDT is composed of DDE (EPA 1993e). As a class, these insecticides are neuropoisons. Since DDT and DDE have practically equal biological effects, DDT is generally used as a surrogate for the much less studied 4,4'-DDE.

DDT was used extensively during World War II to control lice and other insects by direct application to humans. There is no evidence that harm to these people resulted from this direct application. There seems to be no documented, unequivocal report of fatal human poisoning from DDT in spite of its past widespread use and availability. DDT is poorly absorbed after dermal exposure, especially when applied in the powder form. This poor absorption from the skin probably accounts for the rather good safety record of DDT in spite of its wide and sometimes careless use by applicators and formulators.

The signs and symptoms of poisoning in humans and animals resulting from high doses of DDT include paresthesia of the tongue, lips, and face; apprehension; hypersusceptibility to stimuli; irritability; dizziness; disturbed equilibrium; tremor; and tonic and clonic convulsions. Motor unrest and fine tremors associated with voluntary movements progress to coarse tremors without interruption in moderate to severe poisoning. It has been estimated that a dose of 10 mg/kg will cause signs of poisoning in humans.

Although the functional injury produced by high doses of DDT is referable to effects in the central nervous system, little pathologic change occurs there. Primary pathologic changes that result from exposure to high but nonfatal doses, or from subacute or chronic feeding, are observed in the liver. With large doses, centrolobular necrosis of the liver has been reported. Smaller doses result in liver enlargement, which in rodents is somewhat characteristic in that the cells and mitochondria themselves are enlarged. Histologic changes in the livers of male rats fed diets containing 5 to 15 ppm or more for 6 months include hypertrophy, inclusion bodies, and cytoplasmic granulation of a type in which the granules orient themselves around the periphery of the cell. DDT and related compounds induce mixed-function oxidase enzymes of the liver in several species, including humans, and increases the incidence of liver tumors when fed in the diet of rodents.

DDT and one of its major metabolic products, DDE, have high fat-to-water partition coefficients and therefore tend to accumulate in adipose tissue. The adipose tissue concentrations of DDT in heavily exposed workmen have achieved amazingly high concentrations (in the hundreds of parts per million) without clinical evidence of injury. Following cessation of exposure, DDT is slowly

eliminated from the body. Elimination has been estimated at a rate of approximately 1 percent of stored DDT excreted per day.

During the years of its most extensive use in the late 1950s and early 1960s, the average storage of DDT in human fat was about 5 ppm. Total storage of DDT derived from material was about 15 ppm; this consisted primarily of DDT and its lipophilic metabolite, DDE. With the declining use of DDT, there appears to have been a reduction in these levels so that the average adipose tissue level for humans in the late 1960s was 1 to 2 ppm of DDT and about 9 ppm of total DDT-derived materials. Corresponding in time with these observations, analyses of whole meals indicated that the average amount of DDT that an adult in the United States obtained from food decreased from approximately 0.2 mg in 1958 to only about 0.04 mg per day in 1970 (Murphy 1986).

The EPA has not derived chronic oral and inhalation reference doses for DDE.

Carcinogenicity

Human epidemiological data are not available for DDE.

The EPA has classified DDE as a cancer weight-of-evidence Group B2 substance (probable human carcinogen) based on liver tumors in mice and hamsters and thyroid tumors in female rats administered DDE in feed. The EPA has derived an oral cancer slope factor of 3.4×10^{-1} mg/kg/day (EPA 1993e).

I.7.6.14 Dioxin/Furan

Pharmacokinetics

No data were located regarding the pharmacokinetics of the chlorinated dibenzo-p-dioxins (PCDDs) or (PCDFs) of concern; however, 2,3,7.8-tetrachlorodibenzo-p-dioxin (TCDD) has been used as a surrogate for other structurally similar members of these chemical classes. Estimates of the gastrointestinal absorption of TCDD ranged from 50 to 86 percent of the administered dose in rats; comparable data were obtained for rates and hamsters (Fries and Morrow 1975; Nolan et al. 1979; Olson et al. 1986). The EPA (1992c) has recommended that the measured value of 3 percent from dermal absorption studies with TCDD be applied to all PCDDs or PCDFs.

In rodents given single oral or intraperitoneal doses, or treated for two years with TCDD in the diet, the highest concentrations and greatest tissue depots occurred in the liver, followed closely by adipose tissue (Piper et al. 1973; Poiger and Schlatter 1979; Rose et al. 1975; Kociba et al. 1976). Concentrations in other tissues were considerably lower than those in fat. Mouse liver continued to sequester TCDD more efficiently with prolonged exposure (Teitelbaum and Poland 1978). In nonhuman primates and guinea pigs, however, greater TCDD concentrations and tissue depots occurred in the adipose tissue than in the liver (Nolan et al. 1979; Van Miller et al. 1976). Data obtained at necropsy from one woman potentially exposed to TCDD showed concentrations in adipose tissue about an order of magnitude higher than levels in the liver (Facchetti et al. 1980). Radioactivity from intravenous dosing with [^{14}C]2,3,7,8-TCDD has been shown to cross the placenta of rats and mice; concentrations of fetal tissues were lower than in maternal tissues (Moore et al. 1976; Nau and Bass 1981).

In rodents and guinea pigs, TCDD was metabolized by microsomal mixed-function oxidase enzymes to hydroxylated derivatives that were conjugated with glucuronide or sulfate for excretion via the bile or urine, respectively (Olson and Bitner 1983). The hydroxylation of several different PCDDs in the rat was postulated to involve formation of arene oxide intermediates (EPA 1985c). In rats, the metabolism of TCDD was inducible but relatively slow, about four orders of magnitude slower than the metabolism of benzo(a)pyrene. There was considerable species variation in the rate of metabolism of TCDD.

Studies with [^{14}C],-2,3,7,8-TCDD showed that fecal excretion accounted for 39 to 99 percent of the total (fecal and urinary) excretion of radioactivity (EPA 1985c). Elimination half-lives (assuming first order kinetics) ranged from 11 to 30 days, inversely correlated with species sensitivity to TCDD. There was considerable interspecies variation in the relative importance of fecal versus urinary excretion and in the elimination half-lives.

Noncarcinogenic Toxicity

The only effect in humans clearly attributable to TCDD was chloracne (ATSDR 1989a). The available data, however, also associated exposure to TCDD with hepatotoxicity and neurotoxicity in humans. In animals, TCDD toxicity is most commonly manifested as a wasting syndrome with thymic atrophy terminating in death, with a large number of organ systems showing nonspecific

effects. Chronic treatment of animals with TCDD or a mixture of two isomers of hexachlorodibenzo-p-dioxin resulted in liver damage. Immunologic effects may be among the more sensitive endpoints of exposure to the PCDDs in animals. TCDD is a developmental and reproductive toxicant in animal models. Data were not located regarding the noncarcinogenic toxicity of unsubstituted dibenzofuran or the other PCDFs. No verified or provisional noncarcinogenic toxicity values were located for any of the chemicals of concern in these classes (EPA 1992d, 1992b).

Carcinogenicity

Data regarding the human carcinogenicity of TCDD obtained from epidemiologic studies of workers exposed to pesticides or to other chlorinated chemicals known to be contaminated with TCDD are conflicting (ATSDR 1989a). The interpretation of these studies is clouded, because exposure to TCDD was not quantified, multiple routes of exposure (dermal, inhalation, oral) were involved, and the workers were exposed to other potentially carcinogenic compounds. TCDD, however, is clearly carcinogenic in animal models, inducing thyroid, lung, and liver tumors in orally treated rats and mice (EPA 1985c). Similarly, oral treatment with a mixture of two hexachlorodibenzo-p-dioxin isomers induced liver tumors in rats and mice. On the basis of the animal data, TCDD and the hexachlorodibenzo-p-dioxins were assigned to EPA cancer weight-of-evidence Group B2 (probable human carcinogen). Although the PCDDs and PCDFs of concern were not classified, they are treated as probable human carcinogens, for which slope factors are derived.

The EPA (1992d) has presented provisional oral and inhalation slope factors for TCDD of 150,000 per mg/kg/day (Table I.7-2), based on the incidence of liver and lung tumors in an oral study in rats (Kociba et al. 1978). In the absence of satisfactory congener-specific cancer data, the EPA (1989f) derived toxicity equivalency factors (TEFs) for the other PCDDs and PCDFs, by assuming that all manifestations of toxicity for all members of these classes are mediated by a common mechanism (i.e., binding to the intracellular AH receptor of target cells). For polychlorinated dibenzo-p-dioxin and polychlorinated dibenzofurans; 2,3,7,8-TCDD toxicity equivalents will be calculated using the appropriate 1-TEFs/89 Toxicity Equivalent Factors (EPA 1989f). Table I.7-6 presents the TEFs developed by EPA.

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TABLE I.7-6

DIOXIN AND FURAN TOXICITY EQUIVALENCY FACTORS

Compound	TEF
Dioxins	
Mono-, Di-, and Trichlorodibenzo-p-dioxins	0
2,3,7,8-Tetrachlorodibenzo-p-dioxin (TCDD)	1
Other TCDDs	0
2,3,7,8-Pentachlorodibenzo-p-dioxin (PeCDDs)	0.5
Other PeCDDs	0
2,3,7,8-Hexachlorodibenzo-p-dioxins (HxCDDs)	0.1
Other HxCDDs	0
2,3,7,8-Heptachlorodibenzo-p-dioxin (HpCDD)	0.01
Other HpCDDs	0
Octachlorodibenzo-p-dioxin (OCDD)	0.001
Furans	
Mono-, Di-, and Trichlorodibenzofurans	0
2,3,7,8-Tetrachlorodibenzofuran (TCDF)	0.1
Other TCDFs	0
1,2,3,7,8-Pentachlorodibenzofuran (PeCDF)	0.05
2,3,4,7,8-Pentachlorodibenzofuran (PeCDF)	0.5
Other PeCDFs	0
2,3,7,8-Hexachlorodibenzofurans (HxCDFs)	0.1
Other HxCDFs	0
2,3,7,8-Heptachlorodibenzofurans (HpCDFs)	0.01
Other HpCDFs	0
Octachlorodibenzofuran (OCDF)	0.001

SOURCE: EPA 1989f

Considerable uncertainty surrounds the carcinogenic potential of the PCDDs and PCDFs of concern. Although TCDD is classified as a weight-of-evidence Group B2 substance, the homologues of concern are not classified. The appropriateness of estimating cancer potency of (i.e., regulating as carcinogens) compounds not assigned to a cancer weight-of-evidence group is questionable (EPA 1986b).

There is uncertainty about the slope factor for TCDD. Additional uncertainty is introduced by the use of the TEFs themselves, most of which were derived not from cancer data, but from in vitro data such as enzyme induction, which is only hypothetically related to a carcinogenic role. For example, the TEF of 0.001 for octachlorodibenzo-p-dioxins (OCDDs) and octachlorodibenzofurans (OCDFs) is based on the appearance of "dioxin-like" effects and detectable levels of OCDD late in a 13-week study of male rats treated with OCDD (Couture et al. 1988) and on in vitro evidence of enzyme induction (EPA 1989f). Before the Couture et al. (1988), paper was available, the TEF for these homologues, based on limited in vivo and in vitro data, was 0.0.

I.7.6.15 Endrin

Noncarcinogenic Toxicity

The EPA (1994a) has derived a chronic oral RfD of 3 x 10^{-4} mg/kg/day based on animal studies in which endrin was administered in the diet, and an uncertainty factor of 100 (Table I.7-1).

Carcinogenicity

The EPA has classified endrin as a cancer weigh-of-evidence Group D substance, i.e., not classifiable as to human carcinogenicity (EPA 1994b). Oral administration of endrin did not produce carcinogenic effects in either sex of two strains of rats and three strains of mice.

In an epidemiological study, vital status and cause of death were assessed for 232 of 233 workers engaged in the manufacturing and/or formulation of aldrin, dieldrin, and endrin. This group was selected due to the high exposures in the initial years of manufacturing and formulation, and the long exposure (mean 11 years) and observation (mean 24 years) periods. Total observed mortality was 25 versus 38 expected on the basis of the death statistics of the male Dutch population. Of the 9 cancer deaths, 3 were caused by lung cancer, while the remaining 6 were each different. Although in this group exposures have been high, and exposure and observation period long enough for meaningful evaluation, this study revealed no indication of a specific carcinogenic activity of aldrin, dieldrin, or endrin in manufacturing plant workers exposed to these products (EPA 1993e).

I.7.6.16 Lead

Pharmacokinetics

Studies in humans indicate that an average of 10 percent of ingested lead is absorbed, but estimates as high as 40 percent were obtained in some individuals (Tsuchiya 1986). Nutritional factors have a profound effect on GI absorption efficiency. Children absorb ingested lead more efficiently than adults; absorption efficiencies up to 53 percent were recorded for children 3 months to 8 years of age. Similar results were obtained for laboratory animals; absorption efficiencies of 5 to 10 percent were obtained for adults and $\geq$50 percent were obtained for young animals. The deposition rate of inhaled lead averages approximately 30 to 50 percent, depending on particle size, with as much as 60 percent deposition of very small particles (0.03 μm) near highways. All lead deposited in the lungs is eventually absorbed.

Approximately 95 percent of the lead in the blood is located in the erythrocytes (EPA 1990b). Lead in the plasma exchanges with several body compartments, including the internal organs, bone, and several excretory pathways. In humans, lead concentrations in bone increase with age (Tsuchiya 1986). About 90 percent of the body burden of lead is located in the skeleton. Neonatal blood concentrations are about 85 percent of maternal concentrations (EPA 1990b). Excretion of absorbed lead is principally through the urine, although GI secretion, binary excretion, and loss through hair, nails, and sweat are also significant.

Noncarcinogenic Toxicity

The noncarcinogenic toxicity of lead has been well characterized through decades of medical observation and scientific research (EPA 1993e). The primary effects of long-term exposure to levels expected to be encountered in the environment are neurological and hematological. Some of the effects on the blood, particularly changes in levels of certain blood enzymes, and subtle neurobehavioral changes in children appear to occur at levels so low as to be considered nonthreshold effects. In part for this reason the RfD/RfC Work Group considered inappropriate the derivation of an RfC or RfD for inhalation exposure, or an RfD for oral exposure (EPA 1993e). The principal target organs of lead are the central nervous system and the hematopoietic system.

The EPA has developed an uptake/biokinetic model to predict blood lead levels in populations exposed to lead in air, diet, drinking water, indoor dust, soil and paint. This makes it possible to evaluate the effects of regulatory decisions concerning each medium on blood lead levels and potential health effects. The model is used to estimate lead uptake and subsequent blood lead levels in young children, who are the most sensitive subpopulation for exposure to lead. It accepts user input of variables pertaining to site-specific exposure to lead through air, diet, water, soil, dust, and paint (EPA 1990c).

OSWER Directive No. 9355.4-02 (EPA 1989g) established a soil cleanup level for lead of 500 to 1000 ppm, based on recommendations by the Centers for Disease Control designed to protect children from blood lead concentrations above background, which are associated with lead-induced neurological effects. In compliance with EPA guidance (Saunders, M. 1994), the OSWER directive has been applied in this risk assessment.

Carcinogenicity

Lead is assigned to cancer weight-of-evidence Group B2 (probable human carcinogen), based on inadequate human evidence but sufficient animal evidence (EPA 1993e). Rat and mouse bioassays have shown statistically significant increases in renal tumors following dietary and subcutaneous exposure to several soluble lead salts. The EPA has declined to quantitatively estimate risk for oral exposure to lead because many factors (i.e., age, general health, nutritional status, existing body burden, and duration of exposure) influence the bioavailability of ingested lead, introducing a great deal of uncertainty into any estimate of risk.

I.7.6.17 Manganese

Pharmacokinetics

Manganese is a nutritionally essential element (Saric 1986). Its absorption from the GI tract is homeostatically controlled. Absorption of manganese from the GI tract of healthy humans was measured at 3 percent of a single 200 μg oral dose. Human epidemiologic data suggest that manganese in drinking water is somewhat more bioavailable than manganese in the diet (EPA 1992a). In humans suffering from manganese toxicity or anemia, GI absorption was measured at 4 and 7.5 percent, respectively. The 3 percent GI absorption estimate is considered sufficiently

conservative and well documented to use in estimating a dermal RfD from an oral RfD. Sufficient data were not located for estimating respiratory tract or dermal uptake of manganese.

Distribution of absorbed manganese is first to the liver, and then to other tissues (Saric 1986). Although no tissue accumulates large amounts, highest concentrations of manganese in humans are located in the liver, kidney, endocrine glands, and the intestines. The principal route of excretion is through the feces, in part due to biliary and pancreatic secretion. Urinary excretion and loss through sweat, hair, and lactation also occur.

Noncarcinogenic Toxicity

The EPA (1993c) has presented a verified chronic (food) oral RfD of 0.14 mg/kg/day of manganese, based on a NOEL for humans in chronic dietary intake studies and an uncertainty factor of 1, plus a chronic oral (water) RfD of 0.005 mg/kg/day based on a NOEL for humans in a chronic water ingestion study and an uncertainty factor of 1. The EPA (1993c) has also presented a chronic inhalation RfC of 0.0004 mg/m^3, based on a LOAEL for psychomotor disturbances and respiratory symptoms in occupationally exposed humans, and on an uncertainty factor of 300. The inhalation RfC is equivalent to 0.00011 mg/kg/day (assuming humans inhale 20 m^3 of air per day and weigh 70 kilograms (Table I.7-1). The central nervous system and respiratory tract are the target organs of inhalation exposure to manganese.

Carcinogenicity

The EPA (1993c) has classified manganese in cancer weight-of-evidence Group D (not classifiable as to human carcinogenicity).

I.7.6.18 Mercury

Pharmacokinetics

Metallic mercury liquid is poorly absorbed from the GI tract, but metallic mercury vapor is readily absorbed by the lung because of the rapid diffusion of the vapor across the alveolar membrane (Berlin 1986). Although it was suggested that mercury vapor and inorganic mercury can be absorbed by the skin, empirical data were not located. GI absorption of inorganic mercury salts is about 2 to 10 percent in humans, and slightly higher in experimental animals (Berlin 1986; Goyer 1991). EPA (1993e) recommends use of a gastrointestinal absorption factor of 0.15.

Absorbed elemental mercury is oxidized to the inorganic divalent cation (Magos 1988). Inorganic mercury in the blood is roughly equally divided between the plasma and erythrocytes. Distribution is preferentially to the kidney, with somewhat lower concentrations found in the liver, and even lower levels found in the skin, spleen, testes, and brain (Berlin 1986). Inorganic mercury is excreted principally through the feces and urine, with minor pathways including the secretions of exocrine glands and exhalation of elemental mercury vapor.

Methyl mercury is nearly completely (90 to 95 percent) absorbed from the GI tract (Berlin 1986), and probably at least 80 percent absorbed from the respiratory tract (Magos 1988). Methyl mercury is probably absorbed through the skin but quantitative data were not located (Magos 1988). The concentration of methyl mercury in the erythrocytes is about 10 times that in the plasma. Methyl mercury leaves the blood slowly, showing particular affinity for the brain, particularly in primates. In rats, 1 percent of the body burden of methyl mercury is found in the brain, but in humans, 10 percent of the body burden is found in the brain. Lower levels are found in the liver and kidney. During pregnancy, methyl mercury accumulates in the fetal brain, often at levels higher than in the maternal brain. Most tissues except the brain transform methyl mercury to inorganic mercury. Excretion of methyl mercury is principally through the bile, with a half-life of 70 days in healthy humans. Following exposure to methyl mercury, some of the mercury in the bile exists as methyl mercury and some as the inorganic form. The inorganic form is largely passed in the feces, but the methyl mercury is subject to enterohepatic recirculation. Another important excretory pathway for methyl mercury is lactation.

Noncarcinogenic Toxicity

Acute oral exposure to high doses of inorganic mercury causes severe damage to the gastrointestinal mucosa, which may lead to bloody diarrhea, shock, circulatory collapse, and death (Berlin 1986). Acute sublethal poisoning induces severe kidney damage, while chronic exposure induces an autoimmune glomerular disease and renal tubular injury. The EPA (1991b) has presented a verified RfD of 0.0003 mg/mg/day for chronic oral exposure to inorganic mercury, based on kidney effects in rats and an uncertainty factor of 1000. The form of mercury used in these studies was not described. Occupational exposure has induced neurotoxicity (Berlin 1986). The EPA (1991b) has also presented a verified chronic inhalation RfC of 0.0003 mg/m^3, based on occupational data and an uncertainty factor of 30. The RfC is equivalent to 8.6 x 10^{-5} mg/kg/day,

assuming humans inhale 20 m^3 of air per day and weigh 70 kilograms (Table I.7-1). Target organs for inorganic mercury include the gastrointestinal tract, the central nervous system and kidneys.

Carcinogenicity

The EPA (1991b) has classified mercury in cancer weight-of-evidence Group D (not classifiable as to humans carcinogenicity).

I.7.6.19 2-Methylnaphthalene

Noncarcinogenic Toxicity

Data located regarding the noncancer toxicity of 2-methylnaphthalene are limited to an oral lowest dose associated with lethality (LD_{Lo}) in rats of 5000 mg/kg (Sax 1984). Neither oral nor inhalation RfD or RfC values were located.

Carcinogenicity

Data regarding the carcinogenicity of 2-methylnaphthalene were not located.

I.7.6.20 Molybdenum

Pharmacokinetics

Molybdenum from soluble compounds is readily absorbed from the gastrointestinal or respiratory tracts (Friberg and Lener 1986b). Estimates of gastrointestinal absorption in humans average around 50 percent, with a range of 38 to 72 percent observed in young women, and 77 percent reported for school children. The form of oxidation state of molybdenum used in these studies was not specified. Estimates of gastrointestinal absorption in laboratory animals have ranged from 40 to 85 percent for hexavalent molybdenum. The 38 percent estimate of gastrointestinal absorption is considered sufficiently conservative and well-documented for use in estimating a dermal RfD from an oral RfD.

Inhalation uptake studies with guinea pigs showed that molybdenum disulfide was essentially unabsorbed, but that hexavalent molybdenum was absorbed to an appreciable (unquantified) extent (Friberg and Lener 1986b).

Absorbed molybdenum was distributed primarily to the kidneys, liver, and bone in several animal models (Friberg and Lener 1986b). Molybdenum appears to accumulate in the liver, cartilage of the long bones, and skin. In humans and most animal models, the kidneys are the principal copper and sulfate organs of excretion. The excretion of molybdenum is affected by the level of in the diet.

Noncarcinogenic Toxicity

Molybdenum is a nutritionally essential trace element (Friberg and Lener 1986b). Its most important oxidation states are +2, +3, +4, and +6. Chronic molybdenum poisoning in livestock (teart) has resulted from a molybdenum-copper imbalance and is characterized by anemia, gastrointestinal disturbances, bone disorders, and growth depression (Friberg and Lener 1986b). In laboratory animals, excess molybdenum has induced effects in the liver, kidneys, and spleen. Gout-like symptoms were observed in humans living in a high-molybdenum, low-copper area. A few cases of pneumoconiosis were reported in occupationally exposed workers. The EPA (1992d) has derived a provisional chronic oral RfD of 0.005 mg/kg/day, based on an LOAEL in humans exposed to high levels in water and diet, and on an uncertainty factor of 30 (Table I.7-1). The effects of concern were increased urinary excretion of uric acid, decreased copper levels in the blood, and pain and swelling in the joints. Target organs for molybdenum toxicity include the erythrocyte, joints, liver, and kidneys.

Carcinogenicity

No information was located regarding the carcinogenicity of molybdenum.

I.7.6.21 Nickel

Pharmacokinetics

Estimates of GI absorption of nickel in humans range from 1 to 10 percent (ATSDR 1988b). Nickel in water appears to more bioavailable than nickel in food, but absorption was inhibited when the nickel was given in coffee, tea, whole milk, or orange juice. The GI absorption efficiency of 10 percent is used to derive a dermal RfD from an oral RfD (EPA 1993e).

Quantitative data were not located for the uptake of inhaled nickel in humans, but the data suggest that the more soluble compounds are more readily absorbed (ATSDR 1988b). Animal

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data indicate that soluble nickel compounds are cleared from the lungs more rapidly than insoluble compounds. Dermal uptake of nickel in humans ranged from 55 to 77 percent for nickel sulfate when the application site was occluded. In vitro studies indicate that occlusion increases the rate of dermal uptake, and that the nickel cation is absorbed more rapidly from nickel chloride than from nickel sulfate.

Animal studies indicate that systemic nickel is distributed in highest concentrations to the kidney (ATSDR 1988b). Autopsy data from occupationally exposed humans show that nickel accumulates only in the lungs. Excretion is principally through the urine, although excretion through the sweat and through incorporation into hair may be significant.

Noncarcinogenic Toxicity

The EPA (1991e) has presented a verified RfD of 0.02 for chronic oral exposure to nickel, based on a NOAEL for decreased organ and body weights in a two-year dietary study with nickel sulfate in rats. An uncertainty factor of 300 was used (Table I.7-1). In a subchronic study with nickel chloride in water, clinical signs of toxicity included lethargy, ataxia, irregular breathing, reduced body temperature, salivation, and discolored extremities (EPA 1992d). These clinical signs suggest the central nervous system may be a target for the toxicity of nickel.

Carcinogenicity

Occupational exposure to nickel has been associated with increased risk of nasal, laryngeal, and lung cancer (ATSDR 1988b). Rats inhaling nickel subsulfide increased their incidence of lung tumors. The EPA (1991b) has assigned nickel to cancer weight-of-evidence Group A (human carcinogen) and for nickel refinery dust has presented an inhalation slope factor of 0.84 per mg/kg/day and an inhalation unit risk of 0.00024 per $\mu g/m^3$ (Table I.7-2). The quantitative estimates were derived from the human occupational studies.

I.7.6.22 Selenium

Pharmacokinetics

Several studies indicate that different forms of selenium (sodium selenite, selenomethionine) are efficiently absorbed from the human GI tract (ATSDR 1989f). Absorption efficiencies ranged from 80 to 97 percent, and appeared to be independent of dose, suggesting the absence of a

homeostatic mechanism that limited absorption. Other studies inexplicably reported lower absorption efficiencies (e.g., less than 30 percent for sodium selenite). The observation of high GI absorption efficiencies in animals (80 to 100 percent for sodium selenite, sodiron selenate, selenomethionine, selenocystine) supports the high absorption efficiencies observed in humans. The 80 percent GI absorption efficiency is considered adequately conservative and well documented for use in deriving a dermal RfD from an oral RfD.

Inhalation absorption data in humans are limited to occupational studies (ATSDR 1989f). The observation of selenium in the urine of workers exposed to unspecified selenium compounds is qualitative evidence that absorption occurs from the respiratory tract. The urinary excretion of selenium was greater in workers exposed to higher concentrations of selenium in workroom air. In animals, absorption from the respiratory tract is extensive, but the rate of absorption depends on the chemical form. Data regarding the dermal uptake of selenium were not located.

The tissue distribution pattern of selenium in the body is dependent upon the form of selenium administered. Selenium from selenomethionine tends to concentrate in the pancreas of humans, rats and chicks, following oral or intravenous dosing (ATSDR 1989f). Highest tissue concentrations of selenium from sodium selenite or sodium selenate were located in the liver and kidney of humans and laboratory animals following oral or parenteral dosing.

Metabolism of selenium involves incorporation into body proteins, formation of volatile alkyl compounds (dimethyl selenide, dimethyl diselenide) that are excreted in expired air, and formation of soluble compounds (trimethylselonium ion) that are excreted in the urine (ATSDR 1989f). Usually, excretion by the feces and urine each account for about 50 percent of total selenium output; excretion by the respiratory tract assumes greater importance at higher doses.

Noncarcinogenic Toxicity

Selenium is a nutritionally essential trace element that is an integral part of the enzyme glutathione peroxidase and other proteins (Högberg and Alexander 1986). NRC (1989) recommended dietary allowances (RDAs) for humans range from 10-75 μg/day. Chronic ingestion of 5 mg/day (0.071 mg/kg/day, assuming humans weigh 70 kilograms) induced selenosis in humans, characterized by abnormal hair and nail formation (Högberg and Alexander 1986). Effects in

domestic grazing animals exposed to high levels of selenium included emaciation, lameness, and loss of hair and hooves. The EPA (1991b) has derived a verified RfD of 0.005 mg/kg/day for chronic oral exposure to selenium, based on effects in humans exposed to selenium in high selenium areas. An uncertainty factor of 15 was used (Table I.7-1). The principal target organs for selenium are the skin, including the nails and hair, and in animals, the hooves and joints.

Carcinogenicity

An impressive body of data indicates that selenium exerts an anticarcinogenic effect (Högberg and Alexander 1986). In laboratory animals, selenium supplementation decreased the incidence of chemical-induced cancers. In humans, the incidence of lymphomas and cancers of the breast, digestive tract, and lungs were lower in geographic areas with high soil selenium levels. Occupational data suggest that selenium may protect against lung cancer. Several animal tests with various deficiencies in design and conduct equivocally associated exposure to selenium with cancer induction. In a well-controlled oral experiment, selenium sulfide was associated with an increase in the incidence of liver tumors in rats, and with liver and lung tumors in mice. On the basis of this study, the EPA (1991b) has assigned selenium sulfide to cancer weight-of-evidence Group B2 (probable human carcinogen). Quantitative risk estimates were not derived.

I.7.6.23 Silver

Pharmacokinetics

The GI absorption of ingested silver in animals was estimated at ≤ 10 percent; however, absorption of 18 percent was estimated for one human subject given silver acetate (Fowler and Nordberg 1986). EPA (1993e) determined that derivation of a dermal RfD from an oral RfD is inappropriate for silver.

Occupational studies indicate that absorption from the respiratory tract occurs, but absorption could not be quantified (ATSDR 1989g). In a study in dogs exposed to silver metal particles in air, 90 percent of the deposited silver was absorbed. Dermal absorption of silver compounds in humans was estimated at less than 1 percent of the applied dose.

Highest tissue levels are located in the liver; lower levels are located in the lungs, brain, spleen, bone marrow, muscle, and skin (Fowler and Nordberg 1986; Goyer 1991). Excretion is virtually

entirely through the bile. The excretion kinetics appear to be species- and organ-dependent. In humans, the apparent half-life for silver in the liver is approximately 50 days. Silver in skin also has a long half-life (not quantified).

Noncarcinogenic Toxicity

Silver compounds have been used in dentistry, medicinally in the treatment of burns, as a local disinfectant, and as a drinking-water disinfectant (Fowler and Nordberg 1986). The classical syndrome of toxicity, called argyria, is a blue-gray to nearly black discoloration of areas of the skin or the viscera resulting from deposition of microscopic granules of silver compounds in the affected tissues. Argyria results from occupational (inhalation), parenteral, or oral exposure. The EPA (1993d) has derived an RfD of 0.005 mg/kg/day for chronic oral exposure, based on an LOAEL for argyria in a two- to nine-year intravenous administration study in humans, and an uncertainty factor of 3 (Table I.7-1).

Carcinogenicity

The EPA (1993d) has assigned silver to cancer weight-of-evidence Group D (not classifiable as to human carcinogenicity). The human data show no evidence in the literature of cancer despite frequent medical use of silver compounds. The animal data are limited to studies of implanted silver foil or injected metallic silver that provide unconvincing indications of a carcinogenic response relevant to humans.

I.7.6.24 Thallium, Soluble Salts

Pharmacokinetics

Thallium is readily absorbed from the GI and respiratory tracts, and is readily absorbed through the skin (Kazantzis 1986). Absorption from the GI and respiratory tracts may be virtually complete. The GI absorption efficiency of 100 percent is considered sufficiently well documented for use in deriving a dermal RfD from an oral RfD.

Thallium is widely distributed to the tissues of the body, rapidly leaving the blood and entering the tissues against a concentration gradient (Manzo and Sabbioni 1988). Highest tissue concentrations after a single exposure are located in the kidney (Kazantzis 1986). In cases of human intoxication, about 45 percent of the dose was present in the body 24 days after ingestion

(Manzo and Sabbioni 1988). Excretion is mainly through the kidney, gut, and salivary glands, with enteric recirculation accounting for the long biological half-life. Loss in the hair and nails are important excretory mechanisms for the long-term reduction of body burden (Kazantzis 1986).

Noncarcinogenic Toxicity

Thallium is highly toxic; acute ingestion in humans or laboratory animals induces gastroenteritis, neurological dysfunction, and renal and liver damage (Kazantzis 1986). Chronic ingestion of more moderate doses characteristically causes alopecia. Thallium was once used medicinally to induce alopecia in cases of ringworm of the scalp, sometimes with disastrous results. In industrial exposure (inhalation, oral, dermal), neurologic signs precede alopecia, suggesting that the nervous system is more sensitive than the hair follicle. The EPA (1991b) has derived a chronic oral RfD of 8×10^{-5} mg/kg/day based on increased incidence of alopecia and increased serum levels of liver enzymes indicative of hepatocellular damage in rats treated with thallium sulfate for 90 days. An uncertainty factor of 3000 was used. Chronic oral RfDs have also been developed for thallium acetate, thallium carbonate, thallium selenite, thallium chloride and thallium mononitrate based on the study performed with thallium sulfate. These oral RfDs are calculated by analogy to thallium sulfate by correcting for molecular weight differences. These RfDs range from 8×10^{-5} to 9×10^{-5} mg/kg/day. The RfD for thallium sulfate is presented in Table I.7-1. Target organs for thallium include the gastrointestinal tract (acute exposure), central nervous system, skin, kidneys and liver.

Carcinogenicity

The EPA (1991b) has assigned several thallium compounds (thallium acetate, thallium carbonate, thallium chloride, thallium nitrate, and thallium sulfate) to cancer weight-of-evidence Group D (not classifiable as to carcinogenicity to humans).

I.7.6.25 Vanadium

Pharmacokinetics

The GI absorption of ingested vanadium is very low. A study in humans reported absorption of a very soluble compound, oxytartarovanadate, to be 0.1 to 1 percent (Lagerkvist et al. 1986). Uptake from the diet was estimated to be not greater than 1 percent. Uptake of vanadium from vanadium pentoxide was 2.6 percent of the administered dose in rats. In the absence of better

quantified absorption data, the EPA (1989a) default of 5 percent is used to derive a dermal RfD from an oral RfD.

The extent of absorption of vanadium from the respiratory tract depends on particle size and solubility of the vanadium compound (Lagerkvist et al. 1986). Although not precisely quantified, the respiratory tract absorption of soluble vanadium compounds was estimated at 25 percent (species not reported). Occupationally exposed workers excrete more vanadium in their urine than do controls. In rats, rapid uptake followed the intratracheal instillation of several vanadium compounds. For example, more than one-half of an intratracheal dose of vanadyl trichloride was absorbed from the lungs within 1 day; 3 percent of the dose remained in the lungs 63 days after treatment. Quantitative dermal absorption data were not located.

In laboratory animals, absorbed vanadium is distributed principally to bone, kidney, liver, and spleen (Lagerkvist et al. 1986). In humans and laboratory animals, systemic vanadium is excreted principally in the urine.

Noncarcinogenic Toxicity

The oral toxicity of vanadium and its compounds to humans is very low (Lagerkvist et al. 1986), probably because little vanadium is absorbed from the gastrointestinal tract. Effects in humans exposed by inhalation include upper and lower respiratory tract irritation. A provisional chronic oral RfD (EPA 1991b) of 0.007 mg/kg/day was derived from a NOEL in the rat in a lifetime drinking water study with vanadyl sulfate, and from an uncertainty factor of 100 (Table I.7-1). A target organ could not be identified for oral exposure, but the respiratory tract is the target organ for inhalation exposure.

Carcinogenicity

No information was located regarding the carcinogenicity of vanadium.

I.7.6.26 Zinc

Pharmacokinetics

Zinc is a nutritionally required trace element. Estimates of the efficiency of GI absorption of zinc in animals range from less than 10 to 90 percent (Elinger 1986c). Estimates in normal humans

range from approximately 20 to 77 percent (Elinger 1986c; Goyer 1991). EPA (1993e) recommends use of a gastrointestinal absorption factor of 0.25. The net absorption of zinc appears to be homeostatically controlled, but it is unclear whether GI absorption, intestinal secretion, or both are regulated.

Data regarding respiratory tract or dermal absorption of zinc were not located.

Distribution of absorbed zinc is primarily to the liver (Goyer 1991), with subsequent redistribution to bone, muscle, and kidney (Elinger 1986c). Highest tissue concentrations are found in the prostate. Excretion appears to be principally through the feces, in part from biliary secretion, but the relative importance of fecal and urinary excretion is species-dependent. The half-life of zinc absorbed from the GI tracts of humans in normal zinc homeostasis is approximately 162 to 500 days.

Noncarcinogenic Toxicity

Zinc is a nutritionally essential trace element required for the proper function of many metalloenzymes and DNA polymerase, which is required for cell division (Elinger 1986c). Acute oral exposure to high doses induces gastrointestinal irritation, while chronic oral toxicity may be manifested as anemia, resulting from impaired gastrointestinal absorption of copper. The inhalation of dust or vapor by occupationally exposed humans has induced pneumonitis and metal fume fever. A chronic oral RfD for zinc of 0.3 mg/kg/day (EPA 1991b) was based on a LOAEL for a decrease in erythrocyte superoxide dismutase in adult female humans after a 10 week zinc diet supplement study and on an uncertainty factor of 3 (Table I.7-1). The primary target organs for zinc include the gastrointestinal tract for oral exposure and the lungs for inhalation exposure.

Carcinogenicity

The EPA (1991b) has assigned zinc to cancer weight-of-evidence Group D (not classifiable as to human carcinogenicity).

I.8.0

I.8.0 QUANTIFICATION OF CONTAMINANT EXPOSURE AND INTAKE

This section defines the quantification methods used for evaluating cancer risks and the potential for adverse noncancer health effects. Minimum and maximum results calculated for intake of COCs contributing to the calculated risks are presented at the end of this section.

I.8.1 DEFINITIONS

Exposure is defined as the contact of an organism with a chemical or physical agent. When exposure occurs through inhalation or dermal ingestion, some of the contaminant is taken into the body. The amount of contaminant ingested or inhaled is referred to as the contaminant intake. The fraction of the contaminant absorbed into the body (across the membranes of the gastrointestinal or respiratory system, or through the skin after dermal contact) is referred to as the dose or the absorbed dose of contaminant. In the animal studies often used to develop toxicity values for risk assessment, the intake of contaminants is considered to be equivalent to the administered dose. Toxicity values (RfDs and cancer slope factors) are generally developed in terms of contaminant intake, rather than absorbed doses, particularly for ingestion and inhalation.

I.8.2 QUANTIFICATION METHODS

In evaluating cancer risks and the potential for adverse noncancer health effects, it was necessary to estimate contaminant intake for the exposed receptor. For both cancer and noncancer risk assessment, average long-term daily intakes were used to estimate risk. The chronic daily intake (CDI) for hazardous chemical contaminants were estimated as follows:

$$CDI = \frac{C \times CR \times EFD}{BW} \times \frac{1}{AT} \qquad \text{(I.8-1)}$$

where

CDI	=	chronic daily intake (mg/kg body weight/day),
C	=	chemical concentration in exposure medium (mg/l),
CR	=	contact rate with exposure medium (l/day),
EFD	=	exposure frequency and duration (days/year, years),
BW	=	body weight (kg), and
AT	=	average time, e.g., the period over which exposure is averaged (days).

In the case of cancer risk assessment, the average lifetime daily intake was used to estimate the incremental lifetime cancer risk (ILCR), and AT equalled a full 70-year lifespan. For noncancer risk assessment, intake was evaluated over the period during which exposures occur, and AT equalled the duration of exposure. In the case of dermal exposures, time-weighted absorbed doses, rather than intakes, were calculated as described in Section I.7.2. Otherwise, time-weighted average doses were calculated in the same manner as the contaminant intakes described above.

The equations used to calculate the intake of radioactive material by ingestion or inhalation were adapted from EPA (1989a) and the RAWPA. The intake equations follow.

Inhalation:

$$CDI\ (pCi) = C \times IR \times ED \times EF \times ET \qquad (I.8\text{-}2)$$

Ingestion of soils, liquids and products:

$$CDI\ (pCi) = C \times IR \times ED \times EF \times FI \qquad (I.8\text{-}3)$$

where

C	=	concentration of contaminant in exposure media (pCi/m^3, pCi/mg, pCi/kg, or pCi/l),
IR	=	inhalation or ingestion rate of media (m^3/d, mg/d, kg/d, or l/d),
ET	=	exposure time (hours/day),
EF	=	exposure frequency (days/year), and
ED	=	exposure duration (years).
FI	=	fractional intake

The exposure pathways used to assess receptor contaminant intakes and doses are discussed in Section I.5.2. The exposure parameters and factors used are summarized in Tables I.8-1 and 8-3. The exposure parameters were based on those used in the Operable Unit 2 RI report. Specifically, the receptor intakes of COCs were quantified using the methods, models, and parameters specified in the RAWPA (DOE 1992) and in the SWCR (DOE 1993a) with one exception. The soil ingestion rate used for the groundskeeper was 100 mg/day, consistent with the value used in the Operable Unit 4 RI report. This deviation is the direct result of FERMCO's response to EPA Region V review comments on the SWCR.

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The soil ingestion rate for the RME adult farmer is a site-specific time-weighted average value based on specific activities performed during the course of the receptor's lifetime and the relative length of time spent in each activity. The first six years of this receptor's life are spent as a young child ingesting 0.2g/day for 350 days/year (a total of 420 grams). Between 18 and 70 years of age, the RME farmer is assumed to spend 50 years working a farm. Assuming the farmer follows the usual and recommended agricultural practices in Hamilton County, he will spend 100 days/year outdoors working the land, during which he is assumed to consume 0.48g/day of soil (a total of 2400 grams). During the remaining 250 days a year spent on the property, the resident ingests soil at a rate of 0.1g/day - adding another 1,250 grams of soil to the farmer's intake during this 50 years. During the remaining 14 years (12 years as an older child and 2 years as an adult), it is assumed that the soil ingestion rate is 0.1g/day for each of the 350 days/year spent on site (a total of 490 grams). The total soil ingestion, 4560 grams, divided by 25,550 days (365 days x 70 years) yields a time-weighted average intake of 0.18g/day (180 mg/day).

I.8.3 RESULTS OF INTAKE QUANTIFICATION

The tables in Attachment I.IV present all CDIs whether or not toxicity factors (RfDs, RfCs, and cancer slope factors) were available. The summary tables do not carry forward the CDIs for COCs without toxicity factors. However, the uncertainty analysis in Section I.10.0 covers the impact of these chemicals. Attachment I.IV presents the intake and calculation worksheets. These intake estimates are used in Section I.9.0, in conjunction with contaminant toxicity data (from Section I.7.0), to quantify the risks resulting from exposures.

TABLE I.8-1
CRANE EXPOSURE PARAMETERS FOR RESIDENT RECEPTORS

	On-Property Resident Farm			Off-Property Resident Farm		GMR User		
Exposure Pathway	**Adult(GMA)**	**Adult(P)**	**Child**	**Adult**	**Child**	**Agricultural**	**Residential**	**Recreational**
Inhalation of Dusts and Radon								
IR (m^3/hr)	0.83	0.83	0.5	0.83	0.5	NA	NA	NA
ET (hr/d)	24	24	24	24	24	NA	NA	NA
EF (d/yr)	350	350	350	350	350	NA	NA	NA
ED (yr)	70	70	6	70	6	NA	NA	NA
BW (kg)	70	70	15	70	15	NA	NA	NA
AT Noncancer (d)	25550	25550	2190	25550	2190	NA	NA	NA
AT Cancer (d)	25550	25550	25550	25550	25550	NA	NA	NA
Drinking Water								
IR (l/d)	2	2	1	2	1	NA	2	NA
FI (unitless)	1	1	1	1	1	NA	1	NA
EF (d/yr)	350	350	350	350	350	NA	350	NA
Ed (yr)	70	70	6	70	6	NA	70	NA
BW (kg)	70	70	15	70	15	NA	70	NA
AT Noncancer (d)	25550	25550	2190	25550	2190	NA	25550	NA
AT Cancer (d)	25550	25550	25550	25550	25550	NA	25550	NA
Incidental Ingestion while Wading								
IR (l/hr)	NA	NA	NA	NA	NA	NA	NA	0.035
FI (unitless)	NA	NA	NA	NA	NA	NA	NA	1
ET (hr/d)	NA	NA	NA	NA	NA	NA	NA	1
Ef (d/yr)	NA	NA	NA	NA	NA	NA	NA	7

See footnotes at end of table.

TABLE I.8-1
(Continued)

Exposure Pathway	On-Property Resident Farm			Off-Property Resident Farm		GMR User		
	Adult(GMA)	Adult(P)	Child	Adult	Child	Agricultural	Residential	Recreational
Incidental Ingestion while Wading (Continued)								
ED (yr)	NA	NA	NA	NA	NA	NA	NA	30
BW (kg)	NA	NA	NA	NA	NA	NA	NA	70
AT Noncancer (d)	NA	NA	NA	NA	NA	NA	NA	10950
AT Cancer (d)	NA	NA	NA	NA	NA	NA	NA	25550
Dermal Contact while Wading								
DA (mg/cm^2-d)	NA	NA	NA	NA	NA	NA	NA	CSV
EF (d/yr)	NA	NA	NA	NA	NA	NA	NA	7
ED (yr)	NA	NA	NA	NA	NA	NA	NA	30
BW (kg)	NA	NA	NA	NA	NA	NA	NA	70
AT Noncancer (d)	NA	NA	NA	NA	NA	NA	NA	10950
AT Cancer (d)	NA	NA	NA	NA	NA	NA	NA	25550
SA (cm^2)	NA	NA	NA	NA	NA	NA	NA	23000
Incidental Ingestion of Soil/Sediment								
IR (mg/d)	180	180	200	NA	NA	NA	NA	NA
FI	1	1	1	NA	NA	NA	NA	NA
EF (d/yr)	350	350	350	NA	NA	NA	NA	NA
Ed (yr)	70	70	6	NA	NA	NA	NA	NA
BW (kg)	70	70	15	NA	NA	NA	NA	NA
AT Noncancer (d)	25550	25550	2190	NA	NA	NA	NA	NA
AT Cancer (d)	25550	25550	25550	NA	NA	NA	NA	NA

See footnotes at end of table.

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TABLE I.8-1
(Continued)

Exposure Pathway	On-Property Resident Farm			Off-Property Resident Farm		GMR User		
	Adult(GMA)	Adult(P)	Child	Adult	Child	Agricultural	Residential	Recreational
Incidental Ingestion of Soil/Sediment (Continued)								
CF-Chem (kg/mg)	1×10^{-6}	1×10^{-6}	1×10^{-6}	NA	NA	NA	NA	NA
CF-Rad (g/mg)	1×10^{-3}	1×10^{-3}	1×10^{-3}	NA	NA	NA	NA	NA
Dermal Contact with Soil/Sediment								
SA (cm^2)	5750	5750	2000	NA	NA	NA	NA	NA
AF (mg/cm^2)	1.0	1.0	1.0	NA	NA	NA	NA	NA
ABS (unitless)	CSV	CSV	CSV	NA	NA	NA	NA	NA
EF (dy/yr)	350	350	350	NA	NA	NA	NA	NA
ED (yr)	70	70	6	NA	NA	NA	NA	NA
BW (kg)	70	70	15	NA	NA	NA	NA	NA
AT Noncancer (d)	25550	25550	2190	NA	NA	NA	NA	NA
AT Cancer (d)	25550	25550	25550	NA	NA	NA	NA	NA
CF-Chem (kg/mg)	1×10^{-6}	1×10^{-6}	1×10^{-6}	NA	NA	NA	NA	NA
Soils/Vaults External Radiation Exposure								
ET Indoors (hr/d)	18.3	18.3	22	NA	NA	NA	NA	NA
ET Outdoors (hr/d)	5.7	5.7	2	NA	NA	NA	NA	NA
EF (d/yr)	350	350	350	NA	NA	NA	NA	NA
ED (yr)	70	70	6	NA	NA	NA	NA	NA
SH Indoors (unitless)	0.5	0.5	0.5	NA	NA	NA	NA	NA
SH Outdoors (unitless)	0	0	0	NA	NA	NA	NA	NA
CF (yr/hr)	1.1×10^{-4}	1.1×10^{-4}	1.1×10^{-4}	NA	NA	NA	NA	NA

See footnotes at end of table.

TABLE I.8-1
(Continued)

Exposure Pathway	On-Property Resident Farm			Off-Property Resident Farm		GMR User		
	Adult(GMA)	Adult(P)	Child	Adult	Child	Agricultural	Residential	Recreational
Ingestion of Vegetables and Fruit								
IR (kg/d)	0.122	0.122	0.106	0.122	0.106	0.122	NA	NA
FI (unitless)	0.5	0.5	0.5	0.5	0.5	0.5	NA	NA
EF (d/yr)	350	350	350	350	350	350	NA	NA
ED (yr)	70	70	6	70	6	70	NA	NA
BW (kg)	70	70	15	70	15	70	NA	NA
AT Noncancer (d)	25550	25550	2190	25550	2190	25550	NA	NA
AT Cancer (d)	25550	25550	25550	25550	25550	25550	NA	NA
Ingestion of Meat								
IR (kg/d)	0.10	0.10	0.039	0.10	0.039	0.10	NA	NA
FI (unitless)	0.75	0.75	0.75	0.75	0.75	0.75	NA	NA
EF (d/yr)	350	350	350	350	350	350	NA	NA
ED (yr)	70	70	6	70	6	70	NA	NA
BW (kg)	70	70	15	70	15	70	NA	NA
At Noncancer (d)	25550	25550	2190	25550	2190	25550	NA	NA
At Cancer (d)	25550	25550	2550	25550	2550	25550	NA	NA
Ingestion of Milk								
IR (l/d)	0.4	0.4	0.9	0.4	0.9	0.4	NA	NA
FI (unitless)	0.75	0.75	0.75	0.75	0.75	0.75	NA	NA
EF (d/yr)	350	350	350	350	350	350	NA	NA
ED (yr)	70	70	6	70	6	70	NA	NA

See footnotes at end of table.

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TABLE I.8-1
(Continued)

Exposure Pathway	On-Property Resident Farm			Off-Property Resident Farm		GMR User		
	Adult(GMA)	Adult(P)	Child	Adult	Child	Agricultural	Residential	Recreational
Ingestion of Milk (Continued)								
BW (kg)	70	70	15	70	15	70	NA	NA
AT Noncancer (d)	25550	25550	2190	25550	2190	25550	NA	NA
AT Cancer (d)	25550	25550	25550	25550	25550	25550	NA	NA
Ingestion of Fish								
IR (kg/d)	NA	NA	NA	NA	NA	NA	NA	0.054
EF (d/yr)	NA	NA	NA	NA	NA	NA	NA	122
ED (yr)	NA	NA	NA	NA	NA	NA	NA	30
BW (kg)	NA	NA	NA	NA	NA	NA	NA	70
AT Noncancer (d)	NA	NA	NA	NA	NA	NA	NA	10950
AT Cancer (D)	NA	NA	NA	NA	NA	NA	NA	25550

Acronyms used in this table:

ABS = Absorption factor
AF = Soil-to-skin adherence factor
AT = Averaging time
BW = Body weight
CF = Conversion factor
CSV = Chemical specific value
DR = Dose equivalent rate
ED = Exposure duration
EF = Exposure frequency
ET = Exposure time
FD = Fraction of day
FI = Fraction of year
GMA = Great Miami Aquifer (ingestion of water)
IR = Average inhalation rate or average ingestion rate based on pathway
Na = Not applicable
P = Perched groundwater (ingestion of)
SA = Skin surface area available for contact
SH = Building shielding factor

[a]Except where qualified by other footnotes, the values in this table are from the OU2 RI Report (DOE 1994a).
[b]Justification and clarification for these scenarios is provided in the OU4 FS Report (DOE 1993h).
[c]This value is different from the OU2 RI baseline risk assessment due to the site-wide nature of the CRANE compared to the more limited area of OU2.
[d]The CSV values are presented in Table I.8-2.

TABLE I.8-2
CRARE EXPOSURE PARAMETER FOR GROUNDSKEEPER AND TRESPASSERS

	RME Receptor			
			Expanded Trespasser[b]	
Exposure Pathway	**Groundskeeper**	**Trespassing Child[b]**	**Childhood Years**	**Adulthood Years**
Inhalation of Dusts and Radon				
IR (m^3/hr)	2.5	0.83	0.83	0.83
ET (hr/d)	8	4	2	1
EF (d/yr)	250[c]	52	110	40
ED (yr)	25	12	12	32
BW (kg)	70	43	43	70
AT Noncancer (d)	9125	4380	4380	11680
AT Cancer (d)	25550	25550	25550	25550
Drinking Water				
IR (l/d)	NA	NA	NA	NA
FI (unitless)	NA	NA	NA	NA
EF (d/yr)	NA	NA	NA	NA
Ed (yr)	NA	NA	NA	NA
BW (kg)	NA	NA	NA	NA
AT Noncancer (d)	NA	NA	NA	NA
AT Cancer (d)	NA	NA	NA	NA
Incidental Igestion while Wading				
IR (l/hr)	NA	0.035	0.035	NA
FI (unitless)	NA	1	1	NA
ET (hr/d)	NA	1	1	NA

See footnotes at end of table.

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TABLE I.8-2
(Continued)

	RME Receptor			
			Expanded Trespasser[b]	
Exposure Pathway	**Groundskeeper**	**Trespassing Child[b]**	**Childhood Years**	**Adulthood Years**
Incidental Igestion while Wading (Continued)				
EF (d/yr)	NA	7[c]	52	NA
ED (yr)	NA	12	12	NA
BW (kg)	NA	43	43	NA
AT Noncancer (d)	NA	4380	4380	NA
AT Cancer (d)	NA	25550	25550	NA
Dermal Contact while Wading				
DA (mg/cm^2-d)	NA	CSV	CSV	NA
EF (d/yr)	NA	7	52	NA
ED (yr)	NA	12	12	NA
BW (kg)	NA	43	43	NA
AT Noncancer (d)	NA	4380	4380	NA
AT Cancer (d)	NA	25550	25550	NA
Incidental Ingestion of Soil/Sediment				
IR (mg/d)	100	100	100	100
FI	1.0	0.25	0.125	0.125
EF (d/yr)	250[c]	52	110	40
ED (yr)	25	12	12	32
BW (kg)	70	43	43	70
AT Noncancer (d)	9125	4380	4380	11680

See footnotes at end of table.

TABLE I.8-2
(Continued)

	RME Receptor			
			Expanded Trespasser[b]	
Exposure Pathway	**Groundskeeper**	**Trespassing Child[b]**	**Childhood Years**	**Adulthood Years**
Incidental Ingestion of Soil/Sediment (Continued)				
AT Cancer (d)	25550	25550	25550	25550
CF-Chem (kg/mg)	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}
CF-Rad (g/mg)	1×10^{-3}	1×10^{-3}	1×10^{-3}	1×10^{-3}
Dermal Contact with Soil/Sediment				
SA (cm^2)	5750	4200	4200	5750
AF (mg/cm^2)	1.0	1.0	1.0	1.0
ABS (unitless)	CSV[d]	CSV	CSV	CSV
EF (dy/yr)	250[c]	52	110	40
ED (yr)	25	12	12	32
BW (kg)	70	43	43	70
AT Noncancer (d)	9125	4380	4380	11680
AT Cancer (d)	25550	25550	25550	25550
CF-Chem (kg/mg)	1×10^{-6}	$1x 10^{-6}$	1×10^{-6}	1×10^{-6}
Soils/Vaults External Radiation Exposure				
ET Indoors (hr/d)	NA	NA	NA	NA
ET Outdoors (hr/d)	8	4	2	1
EF (d/yr)	250[c]	52	110	40
ED (yr)	25	12	12	32
SH Indoors (unitless)	NA	NA	NA	NA
SH Outdoors (unitless)	0	0	0	0

See footnotes at end of table.

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TABLE I.8-2
(Continued)

	RME Receptor			
			Expanded Trespasser[b]	
Exposure Pathway	**Groundskeeper**	**Trespassing Child[b]**	**Childhood Years**	**Adulthood Years**
Soils/Vaults External Radiation Exposure (Continued)				
CF (yr/hr)	1.1×10^{-4}	1.1×10^{-4}	1.1×10^{-4}	1.1×10^{-4}
Ingestion of Vegetables and Fruit				
IR (kg/d)	NA	NA	NA	NA
FI (unitless)	NA	NA	NA	NA
EF (d/yr)	NA	NA	NA	NA
ED (yr)	NA	NA	NA	NA
BW (kg)	NA	NA	NA	NA
AT Noncancer (d)	NA	NA	NA	NA
AT Cancer (d)	NA	NA	NA	NA
Ingestion of Meat				
IR (kg/d)	NA	NA	NA	NA
FI (unitless)	NA	NA	NA	NA
EF (d/yr)	NA	NA	NA	NA
ED (yr)	NA	NA	NA	NA
BW (kg)	NA	NA	NA	NA
At Noncancer (d)	NA	NA	NA	NA
At Cancer (d)	NA	NA	NA	NA

See footnotes at end of table.

TABLE I.8-2
(Continued)

	RME Receptor			
			Expanded Trespasser[b]	
Exposure Pathway	Groundskeeper	Trespassing Child[b]	Childhood Years	Adulthood Years
Ingestion of Milk				
IR (l/d)	NA	NA	NA	NA
FI (unitless)	NA	NA	NA	NA
EF (d/yr)	NA	NA	NA	NA
ED (yr)	NA	NA	NA	NA
BW (kg)	NA	NA	NA	NA
AT Noncancer (d)	NA	NA	NA	NA
AT Cancer (D)	NA	NA	NA	NA
Ingestion of Fish				
IR (kg/d)	NA	NA	NA	NA
FI (unitless)	NA	NA	NA	NA
EF (d/yr)	NA	NA	NA	NA
ED (yr)	NA	NA	NA	NA
BW (kg)	NA	NA	NA	NA
AT Noncancer (d)	NA	NA	NA	NA
AT Cancer (d)	NA	NA	NA	NA

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See footnotes at end of table.

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TABLE I.8-2
(Continued)

Acronyms used in this table:

ABS	=	Absorption factor	ED	=	Exposure duration	IR	=	Average inhalation rate or average ingestion rate based on pathway
AF	=	Soil-to-skin adherence factor	EF	=	Exposure frequency	Na	=	Not applicable
AT	=	Averaging time	ET	=	Exposure time	P	=	Perched groundwater (ingestion of)
BW	=	Body weight	FD	=	Fraction of day	SA	=	Skin surface area available for contact
CF	=	Conversion factor	FI	=	Fraction of year	SH	=	Building shielding factor
CSV	=	Chemical specific value	GMA	=	Great Miami Aquifer (ingestion of water)			
DR	=	Dose equivalent rate						

[a]Except where qualified by other footnotes, the values in this table are from the OU2 RI Report (DOE 1994a).
[b]Justification and clarification for these scenarios is provided in the OU4 FS Report (DOE 1993h).
[c]This value is different from the OU2 RI baseline risk assessment due to the site-wide nature of the CRANE compared to the more limited area of OU2.
[d]The CSV values are presented in Table I.8-2.

TABLE I.8-3
DERMAL SOIL ABSORPTION COEFFICIENTS
USED IN EXPOSURE MODEL[a]

COC	Soil Absorption Coefficient (unitless)	COC	Soil Absorption Coefficient (unitless)
Inorganics			
Antimony	1.00×10^{-2}	Thorium	1.00×10^{-2}
Arsenic	1.00×10^{-2}	Uranium	1.00×10^{-2}
Barium	1.00×10^{-2}	Vanadium	1.00×10^{-3}
Beryllium	1.00×10^{-2}	Zinc	1.00×10^{-2}
Boron	1.00×10^{-2}		
Cadmium	1.00×10^{-2}	**Semivolatile Organics**	
Chromium	1.00×10^{-2}	Carbazole	3.00×10^{-1}
Cobalt	1.00×10^{-2}	Dioxins/Furans[b]	3.00×10^{-2}
Copper	1.00×10^{-2}	2-Methylnaphthalene	3.00×10^{-1}
Cyanide	1.00×10^{-2}	**Pesticide/PCBs**	
Lead	1.00×10^{-2}	Aroclor-1221[b]	6.00×10^{-2}
Manganese	1.00×10^{-2}	Aroclor-1248[b]	6.00×10^{-2}
Mercury	5.00×10^{-2}	Aroclor-1254[b]	6.00×10^{-2}
Molybdenum	1.00×10^{-2}	Aroclor-1260[b]	6.00×10^{-2}
Nickel	5.00×10^{-2}	4,4-DDE	3.00×10^{-1}
Selenium	1.00×10^{-2}	Endrin	3.00×10^{-1}
Silver	1.00×10^{-2}		
Thallium	1.00×10^{-2}		

[a]Except where qualified by other footnotes, the values in this table are from the OU2 RI Report (DOE 1994a).
[b]EPA 1992c. The measured uptake for 3,3',4,4'-tetrachlorobiphenyl (TCB) has been applied to all polychlorinated byphcnyls (PCB s). The measure uptake for 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD) has been applied to all polychlorinated dibenzo-p-dioxins (PCDDs) and polychlorinated dibenzofurans (PCDFs).

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I.9.0 RISK CHARACTERIZATION

Risk characterization is the final step in the CRARE process, combining the information developed in the toxicity assessment (Section I.7.0) and the exposure assessment (Section I.8.0). The potential of a COC to cause carcinogenic effects is presented as the incremental lifetime cancer risk (ILCR). Potential noncarcinogenic effects are presented as hazard quotients (HQs) or hazard indices (HIs), as defined in Section I.9.1.2.

Upper-bound risk estimates for receptors are presented either qualitatively or quantitatively, depending on the quality of the input parameters. Section I.9.1 describes the methodology employed to characterize health risks. Short-term risks associated with remediation are summarized in Section I.9.2. The residual human health risks, by exposure pathway, appear in Section I.9.3. Uncertainties associated with the risk characterization are examined in Section I.10.0.

I.9.1 RISK CHARACTERIZATION METHODOLOGY

In this CRARE, the potential risks to humans following exposure to postremediation residual COCs (radionuclides and nonradioactive chemicals) have been estimated using methods established by the EPA. The EPA has provided guidance documents and databases for characterizing human health risk, and these have been used as major sources in preparing CRARE risk assessments:

- *Risk Assessment Guidance for Superfund* (EPA 1991a)
- *Health Effects Assessment Summary Tables* (EPA 1994b)
- *Exposure Factors Handbook* (EPA 1989d)
- *Integrated Risk Information System* (EPA 1994a)

I.9.1.1 Hazardous Chemical Exposures

Risks from nonradionuclide COCs have been estimated for carcinogenic and/or noncarcinogenic effects. Some carcinogens may also pose a noncarcinogenic toxic hazard. For those COCs that have an RfD available, the noncarcinogenic HQ was calculated. Effects due to exposures from these chemicals have been characterized for both types of health effects.

I.9.1.1.1 Risk Characterization Methodology for Carcinogens

The risk attributed to a carcinogen was estimated as the ILCR of an individual as a result of exposure to the substance. At low doses, the risk of developing cancer was estimated as follows (EPA 1989c):

$$\text{Risk} = (\text{CDI})(\text{SF}) \qquad (1.9\text{-}1)$$

where

Risk	=	risk of cancer incidence, expressed as a unitless probability,
CDI	=	chronic daily intake averaged over 70 years (mg/kg/day), and
SF	=	slope factor $(\text{mg/kg/day})^{-1}$.

For dermal exposure, cancer risks were calculated using adjusted toxicity factors based on absorbed doses of contaminants rather than contaminant intakes. For a given pathway with simultaneous exposure of a receptor to several carcinogens, the following equation was used to sum cancer risks:

$$\text{Risk}_p = \text{Risk}\ (\text{chem}_1) + \text{Risk}\ (\text{chem}_2) + \ldots\ \text{Risk}\ (\text{chem}_i) \qquad (1.9\text{-}2)$$

where

Risk_p	=	total pathway risk of cancer incidence, and
$\text{Risk}\ (\text{chem}_i)$	=	risk associated with an individual carcinogenic chemical.

In compliance with EPA guidance (EPA 1989a), the ILCR values estimated in this CRARE for the potentially exposed receptor were compared to an incremental upper-bound lifetime cancer risk to an individual of 10^{-4} to 10^{-6}. A cancer risk of 10^{-6} served as the point of departure for CERCLA remediation goals (Federal Register 1990).

I.9.1.1.2 Risk Characterization Methodology for Noncarcinogens

The risk associated with exposure to noncarcinogenic hazardous COCs was evaluated by comparing an exposure level or intake to a reference dose (RfD). It is recognized that this methodology for assessing the human health effect for noncarcinogens does not give a measure of risk as is calculated for the carcinogens. Even so, for convenience the term "risk" will continue to be used when discussing these evaluations. The ratio of intake/RfD for a single contaminant is the HQ and is defined as (EPA 1989a):

$$HQ = I/RfD \quad (1.9\text{-}3)$$

where

HQ	=	hazard quotient (unitless),
I	=	intake of a chemical (mg/kg/day), and
RfD	=	reference dose (mg/kg/day).

When using this equation to estimate potential noncarcinogenic risk, the intake and RfD must be for exposures of equivalent duration (e.g., subchronic, chronic, or fewer than two weeks). For this CRARE, COC exposures have been evaluated in all cases on a chronic basis, using chronic RfD values. Analogous to cancer risks, dermal noncancer risks were assessed using absorbed dose rather than intake.

In the case of simultaneous exposure of a receptor to several chemicals, an HI was calculated as the sum of the HQs by:

$$HI = I_i/RfD_1 + I_2/RfD_2 + ...I_i/RfD_i \quad (1.9\text{-}4)$$

where

HI	=	hazard index (unitless),
I_i	=	intake for the ith toxicant, and
RfD_i	=	reference dose for the ith toxicant.

An HI is an indicator of the potential for adverse effects associated with chronic exposures to multiple chemicals. In effect, HIs assume dose additivity for all COCs (EPA 1989a).

In compliance with EPA guidance (EPA 1989a), the noncarcinogenic HIs summed across pathways were compared to "unity." An HI of unity indicates that the exposure intake is equal to the RfD. If the HI is greater than 1 or "above unity," there is concern for potential health effects. Major categories of noncarcinogenic health effects include neurotoxicity, developmental toxicity, reproductive toxicity, immunotoxicity, and adverse effects on target organs, such as hepatic, renal, respiratory, cardiovascular, and dermal/ocular problems (EPA 1989a).

As requested by EPA, and in compliance with EPA guidance in RAGS, an analysis of target organ/mechanism of action was performed for any receptor whose HI is greater than 1.

I.9.1.2 Radiological Exposures

The procedures for estimating the total lifetime excess cancer risks due to continuous, lifetime exposure (i.e., a 70-year average life span) to radionuclides are described in this section.

I.9.1.2.1 Risk Characterization Methodology for Internal Exposures

Risk characterization for internal exposures to radionuclides (intake via inhalation or ingestion) was calculated as follows:

$$\text{Risk} = (I)(SF) \qquad (1.9\text{-}5)$$

where

Risk	=	risk of cancer incidence, expressed as a unitless probability,
I	=	lifetime radionuclide intake (pCi), and
SF	=	slope factor $(pCi)^{-1}$.

The slope factor is either a HEAST value for a particular radionuclide or the sum of the HEAST slope factors for that radionuclide and its short-lived progeny to account for ingrowth during storage and/or environmental transport.

I.9.1.2.2 Risk Characterization Methodology for External Gamma Exposures

For this CRARE, risk characterization for external exposure to gamma-emitting radionuclides in contaminated surface soil was calculated as follows:

$$\text{Risk} = (SF)[(C_s)(EF)(ED)(ET)(1 - SH)] \qquad (1.9\text{-}6)$$

where

Risk	=	risk of cancer incidence, expressed as a unitless probability,
C_s	=	radionuclide soil concentration (pCi/g),
SF	=	radionuclide slope factor (risk/yr/pCi/g) from EPA (1994a),
ET	=	fraction of day exposed (unitless),
ED	=	exposure duration (years),
EF	=	modifying factor, fraction of year exposed (unitless), and
SH	=	shielding factor (unitless).

External slope factors do not include contributions from decay products (radioactive progeny). In some cases, these contributions were substantial and required the inclusion of progeny products in

the overall risk calculation. Progeny product concentrations were determined using Rad Decay, a radionuclide library and decay software program. Parent isotopes were decayed over a period of interest to predict future levels.

I.9.2 SHORT-TERM RISK EVALUATION FOR OPERABLE UNITS 1, 2, AND 4

The Operable Unit 1, 2, and 4 FS risk evaluations considered short-term health risks during remedial activities from construction, transportation, chemical exposure, and radionuclide exposure. The results are summarized below. The Operable Unit 3 and 5 short-term risks are not available as their FSs are not complete, but the information will be included in future CRAREs when it becomes available. Note that this CRARE is based on updated PRAs for Operable Units 1, 2, and 4 and on the LRAs from the SWCR for Operable Units 3 and 5.

I.9.2.1 Operable Unit 1 Short-Term Risks

The short-term risks associated with Operable Unit 1 off-site disposal remedial activities are from exposures incurred over the duration of the remediation. The risks evaluated are the ILCR associated with exposure to chemical carcinogens and ionizing radiation, toxic effects associated with noncarcinogenic chemicals, and direct physical injuries associated with operating machinery. The risk assessment estimated the exposure risks for three groups of individuals: remediation workers, nonremediation workers, and the general public. Remediation workers are at risk through their direct involvement in a specific component of a remedial alternative. Nonremediation workers (all other workers within the FEMP) are at risk from the airborne transport of contaminants from Operable Unit 1 to their workplace. The general public living adjacent to the FEMP is at risk from the off-site atmospheric transport of airborne contaminants from the operable unit. The general public living adjacent to the transport route for Operable Unit 1 waste materials is at risk from external radiation associated with transport containers and the accidental release of waste material during transportation.

Operable Unit 1 remedial activities will deliver an estimated dose to remediation workers of 61 millirem over the course of the remediation. The radiological and chemical ILCR to nonremediation workers is 5.2×10^{-5}, and their HI is 6.3×10^{-8}. The radiological and chemical ILCR to off-site individuals is 2.9×10^{-6}, and their HI is 3.5×10^{-9}. The collective radioactive dose equivalent estimates for truck drivers and train crew are 4×10^{-4} and 4.5×10^{-1} person-rem,

respectively, for the total shipment of material. For the total shipment, the off-site individual's maximum ILCR from radiation exposure is 4.6×10^{-6}. The ILCR from an accident during transport would be 4.6×10^{-5} for a train accident and 1.2×10^{-8} for a truck accident (DOE 1994b).

I.9.2.2 Operable Unit 2 Short-Term Risks

The short-term risks associated with Operable Unit 2 remediation were estimated for a trespassing youth, a nonremediation worker, and an off-property farmer exposed to surface soil during remedial activities at the South Field, Active Flyash Pile, Inactive Flyash Pile, Solid Waste Landfill, and Lime Sludge Ponds.

Both noncarcinogenic and carcinogenic risks were summed across all applicable soil pathways for these receptors. Carcinogenic risk did not deviate from the point of departure, and a hazard index of 1.0 was not exceeded for any proposed remedial alternative. ILCR did not exceed 2.6×10^{-6} and HI did not exceed 1.0 for the nonremediation worker. For the general public the ILCR did not exceed 2.0×10^{-6}, and the HI was less than 1.0 (DOE 1994a).

I.9.2.3 Operable Unit 4 Short-Term Risks

The receptors, exposure media, and exposure pathways considered in the Operable Unit 4 FS risk evaluation consist of a nonremediation worker exposed to radon and contaminated soil particulates in the air (comparable to the CRARE groundskeeper), a trespassing child exposed to contaminated soil particulates in the air and direct contact with surface soils, and an off-property resident farm adult exposed to radon and contaminated soil particulates in the air. Groundwater was not considered a complete pathway for short-term risks. Risks due to accidents were considered for remediation workers, workers involved in the transport of wastes or soils by truck and train, and the general public. The Operable Unit 4 FS report contains a complete description of these risks for each considered alternative of Operable Unit 4.

The greatest health risk for the nonremediation worker is exposure to total suspended particulate from the berm and surface soils. The radiological ILCR is 3.3×10^{-7} and the chemical ILCR is 2.5×10^{-10}. The total ILCR is lower than the departure point of 1×10^{-6}. Since the risk to the non-remediation worker is less than the departure point, the risk to the off-property public would also

be insignificant because of the additional dilution of dust in the air for the off-property receptor. The HI is less than 10^{-4}, which is below the benchmark of 1.0 and would not present a concern to the public. The radon risk to the nonremediation worker while the treatment facility is operating is 5.8×10^{-7} (DOE 1993b).

If a trespassing child comes into contact with operable unit soils, the ILCR would be 3.8×10^{-7} for radiological ILCR and 2.5×10^{-6} for chemical risk. While the cancer risk is within the target risk range, it is unlikely that a child would be present during remedial activities on a controlled-access site and consequently would not be exposed to the operable unit materials. Similarly, the HI for noncarcinogenic risks is 0.14, below the target of 1.0 (DOE 1993b).

Engineering controls will be used during remedial activities to limit radon release to as low as reasonably achievable (ALARA) levels. The target level at the fenceline is 4 pCi/l (indoor air quality). Engineering evaluations have estimated that the on-property radon concentration would be 0.12 pCi/l during treatment plant operation, and 0.002 pCi/l at the fence line. For three years of operation, this represents risk estimates of 5.8×10^{-7} and 3.3×10^{-7}, respectively (DOE 1993b).

In summary, it appears that Operable Unit 4 remedial activities would cause no short-term adverse risks to off-property receptors (DOE 1993b).

I.9.3 RESIDUAL HUMAN HEALTH RISKS

This section presents the ILCR and HI estimates for all receptors, by pathway, under each of the three land use scenarios. Table I.9-1 summarizes this information. Complete calculation sheets of the risk values and subsequent target organ analysis can be found in Attachment I.IV. The tables in Sections I.9.3.1 through I.9.3.3 present the risk values in a uniform format: the top portion presents the HI values derived from each exposure pathway applicable to the receptor; the bottom portion presents the ILCR values for the receptor by applicable pathways. The ILCR values resulting from exposures to pathways that include both radionuclides and carcinogenic COCs are presented separately to present the magnitude of risk contributed by each. While reviewing these risk values, please note that a receptor can be exposed to different COCs via different exposure pathways for each scenario. Major contributors to this phenomenon include

TABLE I.9-1

SUMMARY OF ILCR AND HI FOR ALL SCENARIOS, ALL PATHWAYS

Current Land Use

RME Receptor	ILCR	HI
Groundskeeper	3.2×10^{-5}	3.3×10^{-1}
Trespassing Child	2.0×10^{-6}	2.3×10^{-1}
Off-Property Farmer		
Adult	1.0×10^{-4}	7.7×10^{-2}
Child	6.0×10^{-6}	2.1×10^{-1}

Future Land Use With Federal Ownership

RME Receptor	ILCR	HI
Expanded Trespasser	1.7×10^{-6}	2.3×10^{-1}
Trespassing Child	2.0×10^{-6}	2.3×10^{-1}
Off-Property Farmer		
Adult	2.0×10^{-4}	7.8×10^{-1}
Child	1.1×10^{-5}	1.8×10^{0}

Future Land Use Without Federal Ownership

RME Receptor	ILCR	HI
On-Property Farmer		
Adult (ingests perched groundwater)	4.9×10^{-2}	1.0×10^{2}
Adult (ingests GMA water)	2.8×10^{-3}	3.3×10^{1}
Child	8.9×10^{-4}	1.0×10^{2}
Off-Property Farmer		
Adult	2.0×10^{-4}	7.8×10^{-1}
Child	1.1×10^{-5}	1.8×10^{0}
GMR User		
Agricultural	4.5×10^{-6}	1.2×10^{-2}
Residential	1.5×10^{-5}	4.2×10^{-2}
Recreational	8.9×10^{-6}	1.6×10^{-2}

GMA = Great Miami Aquifer
GMR = Great Miami River

changes in site accessibility and physical conditions, and COC migration in the environment (see Section I.5.0 for a detailed discussion).

I.9.3.1 Risks Under Current Land Use Scenario

Groundskeeper

Table I.9-2 presents the exposure pathway contribution to the total HI and ILCR for the groundskeeper receptor in the Current Land Use scenario. The total HI is 3.3×10^{-1} with the major pathway being the dermal contact with residual soils (2.6×10^{-1}). The principal contributors are manganese (1.31×10^{-1}) and antimony (5.02×10^{-2}), and the target organs receiving the principal impact are the kidney (5.66×10^{-2}), whole body (6.49×10^{-2}), skin (1.88×10^{-2}), and testis (1.52×10^{-2}).

The ILCR for this receptor is an estimated 3.2×10^{-5}, with the major contributors being inhalation of radionuclide particulate (1.8×10^{-5}) and ingestion of residual soils (chemical) (1.2×10^{-5}). The principal contributors to inhalation of radionuclide is radon (1.8×10^{-5}), while the main contributors to ingestion of residual soil is arsenic (8.7×10^{-6}) and beryllium (3.2×10^{-6}).

TABLE I.9-2

SUMMARY OF POTENTIAL HEALTH EFFECTS: GROUNDSKEEPER (CURRENT LAND USE)

Exposure Pathway	RME Receptor HI
Inhalation of Particulates (Chemicals)	2.7×10^{-3}
Incidental Ingestion of Residual Soils (Chemicals)	6.1×10^{-2}
Dermal Contact with Residual Soils (Chemicals)	2.6×10^{-1}
Ingestion of Meat (Chemicals)	NA
Ingestion of Dairy Products (Chemicals)	NA
Ingestion of Vegetables and Fruit (Chemicals)	NA
Ingestion of Drinking Water (Chemicals)	NA
Dermal Contact While Bathing (Chemicals)	NA
Incidental Ingestion While Wading (Chemicals)	NA
Dermal Contact While Wading (Chemicals)	NA
RME Individual HI =	3.3×10^{-1}
Exposure Pathway	**RME Receptor ILCR**
Inhalation of Particulates (Chemicals)	7.2×10^{-8}
Inhalation of Particulates (Radionuclides)	1.8×10^{-5}
Incidental Ingestion of Residual Soils (Chemicals)	1.2×10^{-5}
Incidental Ingestion of Residual Soils (Radionuclides)	3.5×10^{-12}
Dermal Contact with Residual Soils (Chemicals)	2.4×10^{-6}
Ingestion of Drinking Water (Chemicals)	NA
Ingestion of Drinking Water (Radionuclides)	NA
Dermal Contact While Bathing (Chemicals)	NA
Incidental Ingestion While Wading (Chemicals)	NA
Dermal Contact While Wading (Chemicals)	NA
Incidental Ingestion While Wading (Radionuclides)	NA
Dermal Contact While Wading (Chemicals)*	NA
Ingestion of Meat (Radionuclides)	NA
Ingestion of Dairy Products (Chemicals)	NA
Ingestion of Dairy Products (Radionuclides)	NA
Ingestion of Vegetables and Fruit (Chemicals)	NA
Ingestion of Vegetables and Fruit (Radionuclides)	NA
Direct Radiation	4.4×10^{-11}
RME Individual ILCR =	3.2×10^{-5}

HI = Hazard Index
ILCR = Incremental Lifetime Cancer Risk
NA = Not applicable. Exposure route is incomplete.

090317

Trespassing Child

HI and ILCR values associated with the trespassing child are presented in Table I.9-3. The predicted total HI (2.3×10^{-1}) is below the level of concern, and the ILCR (2.0×10^{-6}) is within the target risk range. The major contributors are external radiation, and incidental ingestion of soils.

TABLE I.9-3

SUMMARY OF POTENTIAL HEALTH EFFECTS: TRESPASSING CHILD (CURRENT LAND USE)

Exposure Pathway	RME Receptor HI
Inhalation of Particulates (Chemicals)	1.5×10^{-4}
Incidental Ingestion of Residual Soils (Chemicals)	4.1×10^{-2}
Dermal Contact with Residual Soils (Chemicals)	6.5×10^{-2}
Ingestion of Meat (Chemicals)	NA
Ingestion of Dairy Products (Chemicals)	NA
Ingestion of Vegetables and Fruit (Chemicals)	NA
Ingestion of Drinking Water (Chemicals)	NA
Dermal Contact While Bathing (Chemicals)	NA
Incidental Ingestion While Wading (Chemicals)	1.9×10^{-3}
Dermal Contact While Wading (Chemicals)	1.2×10^{-1}
RME Individual HI =	2.3×10^{-1}

Exposure Pathway	RME Receptor ILCR
Inhalation of Particulates (Chemicals)	6.9×10^{-10}
Inhalation of Particulates (Radionuclides)	1.1×10^{-7}
Incidental Ingestion of Residual Soils (Chemicals)	1.4×10^{-6}
Incidental Ingestion of Residual Soils (Radionuclides)	2.8×10^{-9}
Dermal Contact with Residual Soils (Chemicals)	1.0×10^{-7}
Ingestion of Drinking Water (Chemicals)	NA
Ingestion of Drinking Water (Radionuclides)	NA
Incidental Ingestion While Wading (Chemicals)	NA
Dermal Contact While Wading (Chemicals)	4.4×10^{-8}
Incidental Ingestion While Wading (Radionuclides)	5.7×10^{-8}
Ingestion of Meat (Chemicals)	4.0×10^{-8}
Ingestion of Meat (Radionuclides)	NA
Ingestion of Dairy Products (Chemicals)	NA
Ingestion of Dairy Products (Radionuclides)	NA
Ingestion of Vegetables and Fruit (Chemicals)	NA
Ingestion of Vegetables and Fruit (Radionuclides)	NA
Direct Radiation	2.3×10^{-7}
RME Individual ILCR =	2.0×10^{-6}

HI = Hazard Index
ILCR = Incremental Lifetime Cancer Risk
NA = Not applicable. Exposure route is incomplete.

090319

Off-Property Resident Farm Adult

The risk results for this receptor are presented in Table I.9-4. The total HI for this receptor is 7.7×10^{-2} below the 1.0 benchmark.

The estimated total ILCR (1.0×10^{-4}) is at the upper end of the target risk range (10^{-4} to 10^{-6}). The principal contributors are the risks due to inhalation of radionuclide particulates (4.9×10^{-5}) and the ingestion of drinking water (3.9×10^{-5}).

TABLE I.9-4

SUMMARY OF POTENTIAL HEALTH EFFECTS: OFF-PROPERTY RESIDENT FARM ADULT (CURRENT LAND USE)

Exposure Pathway	RME Receptor HI
Inhalation of Particulates (Chemicals)	6.0×10^{-3}
Incidental Ingestion of Residual Soils (Chemicals)	NA
Dermal Contact with Residual Soils (Chemicals)	NA
Ingestion of Meat (Chemicals)	3.5×10^{-4}
Ingestion of Dairy Products (Chemicals)	4.9×10^{-4}
Ingestion of Vegetables and Fruit (Chemicals)	1.6×10^{-2}
Ingestion of Drinking Water (Chemicals)	5.1×10^{-2}
Dermal Contact While Bathing (Chemicals)	2.9×10^{-3}
Incidental Ingestion While Wading (Chemicals)	NA
Dermal Contact While Wading (Chemicals)	NA
RME Individual HI =	7.7×10^{-2}

Exposure Pathway	RME Receptor ILCR
Inhalation of Particulates (Chemicals)	1.7×10^{-7}
Inhalation of Particulates (Radionuclides)	4.9×10^{-5}
Incidental Ingestion of Residual Soils (Chemicals)	NA
Incidental Ingestion of Residual Soils (Radionuclides)	NA
Dermal Contact with Residual Soils (Chemicals)	NA
Ingestion of Drinking Water (Chemicals)	4.7×10^{-35}
Ingestion of Drinking Water (Radionuclides)	3.9×10^{-5}
Dermal Contact While Bathing (Chemicals)	5.8×10^{-34}
Incidental Ingestion While Wading (Chemicals)	NA
Dermal Contact While Wading (Chemicals)	NA
Incidental Ingestion While Wading (Radionuclides)	NA
Ingestion of Meat (Chemicals)	6.9×10^{-8}
Ingestion of Meat (Radionuclides)	4.2×10^{-7}
Ingestion of Dairy Products (Chemicals)	1.6×10^{-8}
Ingestion of Dairy Products (Radionuclides)	2.3×10^{-6}
Ingestion of Vegetables and Fruit (Chemicals)	7.1×10^{-8}
Ingestion of Vegetables and Fruit (Radionuclides)	8.8×10^{-6}
Direct Radiation	NA
RME Individual ILCR =	1.0×10^{-4}

HI = Hazard Index
ILCR = Incremental Lifetime Cancer Risk
NA = Not applicable. Exposure route is incomplete.

090321

Off-Property Resident Farm Child

The total HI for this receptor (2.1×10^{-1}) is due primarily to ingestion of drinking water (1.2×10^{-1}) and is below the benchmark (Table I.9-5). Principal contributor is uranium (1.10×10^{-1}). The target organ impacted by these contributors are the kidney (1.19×10^{-1}).

A total ILCR of 6.0×10^{-6} is predicted for this receptor, with inhalation of radionuclide particulates (3.2×10^{-6}) and ingestion of drinking water radionuclides (1.7×10^{-6}) contributing more than 80 percent (Table I.9-5). The total ILCR is within the target risk range, with the principal contributors being the same as those for the off-property resident farm adult (inhalation of radionuclide particulates, and ingestion of radionuclides in drinking water).

TABLE I.9-5

SUMMARY OF POTENTIAL HEALTH EFFECTS: OFF-PROPERTY RESIDENT FARM CHILD (CURRENT LAND USE)

Exposure Pathway	RME Receptor HI
Inhalation of Particulates (Chemicals)	2.1×10^{-2}
Incidental Ingestion of Residual Soils (Chemicals)	NA
Dermal Contact with Residual Soils (Chemicals)	NA
Ingestion of Meat (Chemicals)	6.3×10^{-4}
Ingestion of Dairy Products (Chemicals)	5.1×10^{-3}
Ingestion of Vegetables and Fruit (Chemicals)	6.1×10^{-2}
Ingestion of Drinking Water (Chemicals)	1.2×10^{-1}
Dermal Contact While Bathing (Chemicals)	4.8×10^{-3}
Incidental Ingestion While Wading (Chemicals)	NA
Dermal Contact While Wading (Chemicals)	NA
RME Individual HI =	2.1×10^{-1}

Exposure Pathway	RME Receptor ILCR
Inhalation of Particulates (Chemicals)	5.1×10^{-8}
Inhalation of Particulates (Radionuclides)	3.2×10^{-6}
Incidental Ingestion of Residual Soils (Chemicals)	NA
Incidental Ingestion of Residual Soils (Radionuclides)	NA
Dermal Contact with Residual Soils (Chemicals)	NA
Ingestion of Drinking Water (Chemicals)	9.3×10^{-36}
Ingestion of Drinking Water (Radionuclides)	1.7×10^{-6}
Dermal Contact While Bathing (Chemicals)	8.1×10^{-35}
Incidental Ingestion While Wading (Chemicals)	NA
Dermal Contact While Wading (Chemicals)	NA
Incidental Ingestion While Wading (Radionuclides)	NA
Ingestion of Meat (Chemicals)	1.1×10^{-8}
Ingestion of Meat (Radionuclides)	1.4×10^{-8}
Ingestion of Dairy Products (Chemicals)	1.4×10^{-8}
Ingestion of Dairy Products (Radionuclides)	1.4×10^{-8}
Ingestion of Vegetables and Fruit (Chemicals)	2.3×10^{-8}
Ingestion of Vegetables and Fruit (Radionuclides)	6.2×10^{-7}
Direct Radiation	NA
RME Individual ILCR =	6.0×10^{-6}

HI = Hazard Index
ILCR = Incremental Lifetime Cancer Risk
NA = Not applicable. Exposure route is incomplete.

I.9.3.2 Risks Under Future Land Use With Federal Ownership Scenario

Expanded Trespasser

The total HI for this receptor is 2.3×10^{-1}, below the 1.0 benchmark. A total ILCR of 1.7×10^{-6} is estimated, with external radiation exposure (6.8×10^{-7}), inhalation of particulates, dermal contact, and incidental ingestion of soil and sediment while on-site contributing 80 percent of the ILCR. This ILCR is within the 10^{-4} to 10^{-6} target range (Table I.9-6).

TABLE I.9-6

SUMMARY OF POTENTIAL HEALTH EFFECTS: EXPANDED TRESPASSER (FUTURE LAND USE WITH FEDERAL OWNERSHIP)

Exposure Pathway	RME Receptor HI
Inhalation of Particulates (Chemicals)	1.8×10^{-4}
Incidental Ingestion of Residual Soils (Chemicals)	6.7×10^{-3}
Dermal Contact with Residual Soils (Chemicals)	1.8×10^{-1}
Ingestion of Meat (Chemicals)	NA
Ingestion of Dairy Products (Chemicals)	NA
Ingestion of Vegetables and Fruit (Chemicals)	NA
Ingestion of Drinking Water (Chemicals)	NA
Dermal Contact While Bathing (Chemicals)	
Incidental Ingestion While Wading (Chemicals)	1.9×10^{-3}
Dermal Contact While Wading (Chemicals)	4.2×10^{-2}
RME Individual HI =	2.3×10^{-1}

Exposure Pathway	RME Receptor ILCR
Inhalation of Particulates (Chemicals)	9.6×10^{-10}
Inhalation of Particulates (Radionuclides)	1.7×10^{-7}
Incidental Ingestion of Residual Soils (Chemicals)	2.9×10^{-7}
Incidental Ingestion of Residual Soils (Radionuclides)	7.2×10^{-10}
Dermal Contact with Residual Soils (Chemicals)	3.9×10^{-7}
Ingestion of Drinking Water (Chemicals)	NA
Ingestion of Drinking Water (Radionuclides)	NA
Dermal Contact While Bathing (Chemicals)	NA
Incidental Ingestion While Wading (Chemicals)	4.4×10^{-8}
Dermal Contact While Wading (Chemicals)	7.0×10^{-8}
Incidental Ingestion While Wading (Radionuclides)	3.3×10^{-8}
Ingestion of Meat (Chemicals)	NA
Ingestion of Meat (Radionuclides)	NA
Ingestion of Dairy Products (Chemicals)	NA
Ingestion of Dairy Products (Radionuclides)	NA
Ingestion of Vegetables and Fruit (Chemicals)	NA
Ingestion of Vegetables and Fruit (Radionuclides)	NA
Direct Radiation	6.8×10^{-7}
RME Individual ILCR =	1.7×10^{-6}

HI = Hazard Index
ILCR = Incremental Lifetime Cancer Risk
NA = Not applicable. Exposure route is incomplete.

090325

Trespassing Child

HI and ILCR values associated with the trespassing child are presented in Table I.9-7. The predicted HI (2.3×10^{-1}) is below the level of concern, and the total ILCR (2.0×10^{-6}) is within the target risk range. The major contributors are incidental ingestion, external radiation, inhalation of particulates, and dermal contact with soils.

TABLE I.9-7

SUMMARY OF POTENTIAL HEALTH EFFECTS: TRESPASSING CHILD (FUTURE LAND USE WITH FEDERAL OWNERSHIP)

Exposure Pathway	RME Receptor HI
Inhalation of Particulates (Chemicals)	1.5×10^{-4}
Incidental Ingestion of Residual Soils (Chemicals)	4.1×10^{-2}
Dermal Contact with Residual Soils (Chemicals)	6.5×10^{-2}
Ingestion of Meat (Chemicals)	NA
Ingestion of Dairy Products (Chemicals)	NA
Ingestion of Vegetables and Fruit (Chemicals)	NA
Ingestion of Drinking Water (Chemicals)	NA
Dermal Contact While Bathing (Chemicals)	NA
Incidental Ingestion While Wading (Chemicals)	1.9×10^{-3}
Dermal Contact While Wading (Chemicals)	1.2×10^{-3}
RME Individual HI =	2.3×10^{-1}

Exposure Pathway	RME Receptor ILCR
Inhalation of Particulates (Chemicals)	6.9×10^{-10}
Inhalation of Particulates (Radionuclides)	1.1×10^{-7}
Incidental Ingestion of Residual Soils (Chemicals)	1.4×10^{-6}
Incidental Ingestion of Residual Soils (Radionuclides)	2.8×10^{-9}
Dermal Contact with Residual Soils (Chemicals)	1.0×10^{-7}
Ingestion of Drinking Water (Chemicals)	NA
Ingestion of Drinking Water (Radionuclides)	NA
Dermal Contact While Bathing (Chemicals)	NA
Incidental Ingestion While Wading (Chemicals)	4.4×10^{-8}
Dermal Contact While Wading (Chemicals)	5.7×10^{-8}
Incidental Ingestion While Wading (Radionuclides)	4.0×10^{-8}
Ingestion of Meat (Chemicals)	NA
Ingestion of Meat (Radionuclides)	NA
Ingestion of Dairy Products (Chemicals)	NA
Ingestion of Dairy Products (Radionuclides)	NA
Ingestion of Vegetables and Fruit (Chemicals)	NA
Ingestion of Vegetables and Fruit (Radionuclides)	NA
Direct Radiation	2.3×10^{-7}
RME Individual ILCR =	2.0×10^{-6}

HI = Hazard Index
ILCR = Incremental Lifetime Cancer Risk
NA = Not applicable. Exposure route is incomplete.

090327

Off-Property Resident Farm Adult

The total HI for this receptor is 7.8×10^{-1} (Table I.9-8) and is driven by the ingestion of drinking water (4.1×10^{-1}) vegetables and fruits (1.2×10^{-1}) and dermal contact while bathing (2.4×10^{-1}), all primarily driven by uranium. The principal target organs impacted by these contributors are the kidney (5.37×10^{-1}).

The ILCRs for chemical and radioactive COCs are presented in Table I.9-8, with the total for all pathways being greater than 10^{-4}. A total ILCR of 2.0×10^{-4} is predicted for this receptor, with the principal contributors being ingestion of radionuclides in drinking water.

TABLE I.9-8

SUMMARY OF POTENTIAL HEALTH EFFECTS: OFF-PROPERTY RESIDENT FARM ADULT (FUTURE LAND USE WITH FEDERAL OWNERSHIP)

Exposure Pathway	RME Receptor HI
Inhalation of Particulates (Chemicals)	6.0×10^{-3}
Incidental Ingestion of Residual Soils (Chemicals)	NA
Dermal Contact with Residual Soils (Chemicals)	NA
Ingestion of Meat (Chemicals)	4.9×10^{-4}
Ingestion of Dairy Products (Chemicals)	2.4×10^{-3}
Ingestion of Vegetables and Fruit (Chemicals)	1.2×10^{-1}
Ingestion of Drinking Water (Chemicals)	4.1×10^{-1}
Dermal Contact While Bathing (Chemicals)	2.4×10^{-1}
Incidental Ingestion While Wading (Chemicals)	NA
Dermal Contact While Wading (Chemicals)	NA
RME Individual HI =	7.8×10^{-1}

Exposure Pathway	RME Receptor ILCR
Inhalation of Particulates (Chemicals)	1.7×10^{-7}
Inhalation of Particulates (Radionuclides)	4.9×10^{-5}
Incidental Ingestion of Residual Soils (Chemicals)	NA
Incidental Ingestion of Residual Soils (Radionuclides)	NA
Dermal Contact with Residual Soils (Chemicals)	NA
Ingestion of Drinking Water (Chemicals)	8.7×10^{-8}
Ingestion of Drinking Water (Radionuclides)	1.1×10^{-4}
Dermal Contact While Bathing (Chemicals)	2.7×10^{-9}
Incidental Ingestion While Wading (Chemicals)	NA
Dermal Contact While Wading (Chemicals)	NA
Incidental Ingestion While Wading (Radionuclides)	NA
Ingestion of Meat (Chemicals)	7.0×10^{-8}
Ingestion of Meat (Radionuclides)	1.2×10^{-6}
Ingestion of Dairy Products (Chemicals)	1.6×10^{-8}
Ingestion of Dairy Products (Radionuclides)	7.0×10^{-6}
Ingestion of Vegetables and Fruit (Chemicals)	9.7×10^{-8}
Ingestion of Vegetables and Fruit (Radionuclides)	2.7×10^{-5}
Direct Radiation	NA
RME Individual ILCR =	2.0×10^{-4}

HI = Hazard Index
ILCR = Incremental Lifetime Cancer Risk
NA = Not applicable. Exposure route is incomplete.

090329

Off-Property Resident Farm Child

For this receptor, the total HI of 1.8 (Table I.9-9) is due to ingestion of vegetable and fruit (4.7×10^{-1}), of drinking water (9.6×10^{-1}) and dermal contact while bathing (3.8×10^{-1}), all due to uranium. The effect of this contaminants is localized in the kidney (5.0×10^{-1} and 1.0×10^{0} for food and water respectively). A total ILCR of 1.1×10^{-5} is predicted, with inhalation of particulates (2.5×10^{-6}), ingestion of radionuclides in drinking water (4.9×10^{-6}), ingestion of radionuclides in dairy products (1.3×10^{-6}) and ingestion of radionuclides in fruits and vegetables (1.9×10^{-6}) being the major contributors (Table I.9-9). The total ILCR is within the acceptable range.

TABLE I.9-9

SUMMARY OF POTENTIAL HEALTH EFFECTS: OFF-PROPERTY RESIDENT FARM CHILD (FUTURE LAND USE WITH FEDERAL OWNERSHIP)

Exposure Pathway	RME Receptor HI
Inhalation of Particulates (Chemicals)	1.7×10^{-2}
Incidental Ingestion of Residual Soils (Chemicals)	NA
Dermal Contact with Residual Soils (Chemicals)	NA
Ingestion of Meat (Chemicals)	8.7×10^{-4}
Ingestion of Dairy Products (Chemicals)	2.6×10^{-2}
Ingestion of Vegetables and Fruit (Chemicals)	4.7×10^{-1}
Ingestion of Drinking Water (Chemicals)	9.6×10^{-1}
Dermal Contact While Bathing (Chemicals)	3.8×10^{-1}
Incidental Ingestion While Wading (Chemicals)	NA
Dermal Contact While Wading (Chemicals)	NA
RME Individual HI =	1.8×10^{0}

Exposure Pathway	RME Receptor ILCR
Inhalation of Particulates (Chemicals)	
Inhalation of Particulates (Radionuclides)	2.5×10^{-6}
Incidental Ingestion of Residual Soils (Chemicals)	NA
Incidental Ingestion of Residual Soils (Radionuclides)	NA
Dermal Contact with Residual Soils (Chemicals)	NA
Ingestion of Drinking Water (Chemicals)	1.7×10^{-8}
Ingestion of Drinking Water (Radionuclides)	4.9×10^{-6}
Dermal Contact While Bathing (Chemicals)	3.8×10^{-10}
Incidental Ingestion While Wading (Chemicals)	NA
Dermal Contact While Wading (Chemicals)	NA
Incidental Ingestion While Wading (Radionuclides)	NA
Ingestion of Meat (Chemicals)	1.1×10^{-8}
Ingestion of Meat (Radionuclides)	4.0×10^{-8}
Ingestion of Dairy Products (Chemicals)	1.4×10^{-8}
Ingestion of Dairy Products (Radionuclides)	1.3×10^{-6}
Ingestion of Vegetables and Fruit (Chemicals)	3.2×10^{-8}
Ingestion of Vegetables and Fruit (Radionuclides)	1.9×10^{-6}
Direct Radiation	NA
RME Individual ILCR =	**1.1×10^{-5}**

HI = Hazard Index
ILCR = Incremental Lifetime Cancer Risk
NA = Not applicable. Exposure route is incomplete.

000331

I.9.3.3 Risks Under Future Land Use Without Federal Ownership

On-Property Resident Farm Adult (Perched Groundwater)

HI and ILCR values for this receptor are presented in Table I.9-10. The total HI (1.0×10^2) exceeds the benchmark of 1. The ingestion of drinking water has the highest HI value of 6.7×10^1, with the principal contribution being uranium (6.12×10^1). The ingestion of meat has an HI value of 1.6×10^1, with the principal contributors being mercury (1.4×10^1) and zinc (1.6×10^0). The ingestion of dairy products has an HI of 4.1, with the principal contributors being silver (1.7×10^0). Ingestion of vegetables and fruits has an HI of 9.9×10^0, with the principal contributors being boron (4.2×10^0), cadmium (1.6×10^0) and manganese (1.5×10^0).

The total ILCR (4.9×10^{-2}) for this receptor exceeds 10^{-4}, with dermal contact while bathing (3.9×10^{-2}), being the primary contributor (Table I.9-10). The driving contaminant to the dermal exposure is aroclor 1221 (3.2×10^{-2}).

On-Property Resident Farm Adult (GMA Water)

A total HI of 3.3×10^1 is predicted for this receptor (Table I.9-11), with the ingestion of meat (1.6×10^1), vegetables and fruits (9.9×10^0), dairy products (4.1×10^0) and drinking water (2.1×10^0), all exceeding the target level of 1.0. The principal target organs impacted for this receptor are kidney (1.9×10^1 (mercury 1.4×10^1).

The ILCRs for chemical and radioactive COCs are presented in Table I.9-11. The total ILCR (2.8×10^{-3}) exceeds the target range of 10^{-4} to 10^{-6}. Ingestion of drinking water (chemical and radionuclide 2.2×10^{-4} and 4.9×10^{-4}, respectively), ingestion of meat (chemical 3.2×10^{-4}), ingestion of dairy products (6.0×10^{-4} and 4.7×10^{-4} chemical and radionuclides, respectively) and ingestion of vegetables and fruits (3.6×10^{-4} chemical) contribute the majority of the total ILCR. The principal contributors for chemical ingestion are arsenic and aroclor 1260, while the principal contributor for radionuclides is TC-99.

TABLE I.9-10

SUMMARY OF POTENTIAL HEALTH EFFECTS: ON-PROPERTY RESIDENT FARM ADULT WHO INGESTS PERCHED WATER (FUTURE LAND USE WITHOUT FEDERAL OWNERSHIP)

Exposure Pathway	RME Receptor HI
Inhalation of Particulates (Chemicals)	7.3×10^{-3}
Incidental Ingestion of Residual Soils (Chemicals)	8.6×10^{-2}
Dermal Contact with Residual Soils (Chemicals)	3.7×10^{-1}
Ingestion of Meat (Chemicals)	1.6×10^{1}
Ingestion of Dairy Products (Chemicals)	4.1×10^{0}
Ingestion of Vegetables and Fruit (Chemicals)	9.9×10^{0}
Ingestion of Drinking Water (Chemicals)	6.7×10^{1}
Dermal Contact While Bathing (Chemicals)	4.0×10^{0}
Incidental Ingestion While Wading (Chemicals)	NA
Dermal Contact While Wading (Chemicals)	NA
RME Individual HI =	1.0×10^{2}

Exposure Pathway	RME Receptor ILCR
Inhalation of Particulates (Chemicals)	2.6×10^{-7}
Inhalation of Particulates (Radionuclides)	5.0×10^{-5}
Incidental Ingestion of Residual Soils (Chemicals)	1.7×10^{-5}
Incidental Ingestion of Residual Soils (Radionuclides)	5.0×10^{-12}
Dermal Contact with Residual Soils (Chemicals)	3.3×10^{-6}
Ingestion of Drinking Water (Chemicals)	4.5×10^{-3}
Ingestion of Drinking Water (Radionuclides)	9.9×10^{-3}
Dermal Contact While Bathing (Chemicals)	3.2×10^{-2}
Incidental Ingestion While Wading (Chemicals)	NA
Dermal Contact While Wading (Chemicals)	NA
Incidental Ingestion While Wading (Radionuclides)	NA
Ingestion of Meat (Chemicals)	3.2×10^{-4}
Ingestion of Meat (Radionuclides)	8.6×10^{-5}
Ingestion of Dairy Products (Chemicals)	6.0×10^{-4}
Ingestion of Dairy Products (Radionuclides)	4.7×10^{-4}
Ingestion of Vegetables and Fruit (Chemicals)	3.6×10^{-4}
Ingestion of Vegetables and Fruit (Radionuclides)	9.1×10^{-5}
Direct Radiation	8.2×10^{-10}
RME Individual ILCR =	4.9×10^{-2}

HI = Hazard Index
ILCR = Incremental Lifetime Cancer Risk
NA = Not applicable. Exposure route is incomplete.

000333

TABLE I.9-11
SUMMARY OF POTENTIAL HEALTH EFFECTS: ON-PROPERTY RESIDENT FARM ADULT WHO INGESTS GMA WATER (FUTURE LAND USE WITHOUT FEDERAL OWNERSHIP)

Exposure Pathway	RME Receptor HI
Inhalation of Particulates (Chemicals)	7.3×10^{-3}
Incidental Ingestion of Residual Soils (Chemicals)	8.6×10^{-2}
Dermal Contact with Residual Soils (Chemicals)	3.7×10^{-1}
Ingestion of Meat (Chemicals)	1.6×10^{1}
Ingestion of Dairy Products (Chemicals)	4.1×10^{0}
Ingestion of Vegetables and Fruit (Chemicals)	9.9×10^{0}
Ingestion of Drinking Water (Chemicals)	2.1×10^{0}
Dermal Contact While Bathing (Chemicals)	1.2×10^{-1}
Incidental Ingestion While Wading (Chemicals)	NA
Dermal Contact While Wading (Chemicals)	NA
RME Individual HI =	3.3×10^{1}

Exposure Pathway	RME Receptor ILCR
Inhalation of Particulates (Chemicals)	2.6×10^{-7}
Inhalation of Particulates (Radionuclides)	5.0×10^{-5}
Incidental Ingestion of Residual Soils (Chemicals)	1.7×10^{-5}
Incidental Ingestion of Residual Soils (Radionuclides)	5.4×10^{-8}
Dermal Contact with Residual Soils (Chemicals)	3.3×10^{-6}
Ingestion of Drinking Water (Chemicals)	2.2×10^{-4}
Ingestion of Drinking Water (Radionuclides)	4.9×10^{-4}
Dermal Contact While Bathing (Chemicals)	6.8×10^{-6}
Incidental Ingestion While Wading (Chemicals)	NA
Dermal Contact While Wading (Chemicals)	NA
Incidental Ingestion While Wading (Radionuclides)	NA
Ingestion of Meat (Chemicals)	3.2×10^{-4}
Ingestion of Meat (Radionuclides)	8.6×10^{-5}
Ingestion of Dairy Products (Chemicals)	6.0×10^{-4}
Ingestion of Dairy Products (Radionuclides)	4.7×10^{-4}
Ingestion of Vegetables and Fruit (Chemicals)	3.6×10^{-4}
Ingestion of Vegetables and Fruit (Radionuclides)	9.1×10^{-5}
Direct Radiation	8.2×10^{-10}
RME Individual ILCR =	2.8×10^{-3}

HI = Hazard Index
ILCR = Incremental Lifetime Cancer Risk
NA = Not applicable. Exposure route is incomplete.

On-Property Resident Farm Child

A total HI of 1.2×10^2 is predicted for this receptor (Table I.9-12), with four of the exposure pathways exceeding the benchmark of 1.0: ingestion of meat (2.9×10^1), ingestion of dairy products (4.3×10^1), ingestion of vegetables and fruit (3.8×10^1) and ingestion of drinking water (5.0). The principal target organs impacted for this receptor are the testis (1.8×10^1, boron), skin (2.4×10^1, arsenic and silver), kidney (3.7×10^1, mercury and cadmium), central nervous system (7.9×10^0, manganese), and blood (1.1×10^1, zinc).

A total ILCR of 8.9×10^{-4} is estimated for this receptor. The highest COC-induced ILCR to this receptor is 5.4×10^{-4} from ingestion of dairy products (chemicals). The following pathways have ILCR values above 1×10^{-6}: inhalation of particulates (radionuclides), ingestion of chemicals and radionuclides in drinking water, incidental ingestion of soil and sediment (chemicals) external radiation, ingestion of meat (chemicals and radionuclides), ingestion of dairy products (chemicals and radionuclides), and ingestion of vegetables and fruits (chemicals and radionuclides).

Off-Property Resident Farm Adult and Child

The results for these two receptors are given in Tables I.9-13 and I.9-14. They are identical to those for the Future Land Use With Federal Ownership scenario.

GMR Users - Agricultural, Residential, and Recreational

The results for these three receptors are given in Tables I.9-15, I.9-16, and I.9-17. The agricultural GMR user has an HI of 1.2×10^{-2}. This risk is mostly due to the ingestion of vegetables and fruit.

A total ILCR of 4.5×10^{-6} is estimated for this receptor. The highest COC-induced ILCR to this receptor is 2.2×10^{-6} from ingestion of vegetables and fruit (radionuclides). The ingestion of vegetables and fruit (chemicals) contributes a ILCR of 1.6×10^{-6}.

For the GMR user - Residential, a total HI of 4.2×10^{-2} was calculated. The contributor pathways are ingestion of drinking water (4.0×10^{-2}) and dermal contact while bathing.

000335

A total ILCR of 1.5×10^{-5} is estimated for this receptor. The highest COC-induced ILCR to this receptor is ingestion of drinking water (radionuclides) at 9.1×10^{-6}. The other pathway above 10^{-6} is the ingestion of drinking water (chemicals) at 5.5×10^{-6}.

For the GMR user - Recreational, a total HI of 1.6×10^{-2} was estimated. The contributing pathway was the ingestion of fish (chemicals) at 1.6×10^{-2}.

A total ILCR of 8.9×10^{-6} is estimated for this receptor. The highest COC-induced ILCR to this receptor is the ingestion of fish (chemicals) at 8.8×10^{-6}.

TABLE I.9-12

SUMMARY OF POTENTIAL HEALTH EFFECTS: ON-PROPERTY RESIDENT FARM CHILD (FUTURE LAND USE WITHOUT FEDERAL OWNERSHIP)

Exposure Pathway	RME Receptor HI
Inhalation of Particulates (Chemicals)	2.0×10^{-2}
Incidental Ingestion of Residual Soils (Chemicals)	8.0×10^{-1}
Dermal Contact with Residual Soils (Chemicals)	6.0×10^{-1}
Ingestion of Meat (Chemicals)	2.9×10^{1}
Ingestion of Dairy Products (Chemicals)	4.3×10^{1}
Ingestion of Vegetables and Fruit (Chemicals)	3.8×10^{1}
Ingestion of Drinking Water (Chemicals)	5.0×10^{0}
Dermal Contact While Bathing (Chemicals)	2.0×10^{-1}
Incidental Ingestion While Wading (Chemicals)	NA
Dermal Contact While Wading (Chemicals)	NA
RME Individual HI =	1.2×10^{2}

Exposure Pathway	RME Receptor ILCR
Inhalation of Particulates (Chemicals)	6.2×10^{-8}
Inhalation of Particulates (Radionuclides)	2.6×10^{-6}
Incidental Ingestion of Residual Soils (Chemicals)	1.3×10^{-5}
Incidental Ingestion of Residual Soils (Radionuclides)	9.3×10^{-9}
Dermal Contact with Residual Soils (Chemicals)	4.6×10^{-7}
Ingestion of Drinking Water (Chemicals)	4.4×10^{-5}
Ingestion of Drinking Water (Radionuclides)	2.1×10^{-5}
Dermal Contact While Bathing (Chemicals)	9.4×10^{-7}
Incidental Ingestion While Wading (Chemicals)	NA
Dermal Contact While Wading (Chemicals)	NA
Incidental Ingestion While Wading (Radionuclides)	NA
Ingestion of Meat (Chemicals)	5.1×10^{-5}
Ingestion of Meat (Radionuclides)	2.9×10^{-6}
Ingestion of Dairy Products (Chemicals)	5.4×10^{-4}
Ingestion of Dairy Products (Radionuclides)	9.1×10^{-5}
Ingestion of Vegetables and Fruit (Chemicals)	1.2×10^{-4}
Ingestion of Vegetables and Fruit (Radionuclides)	6.4×10^{-6}
Direct Radiation	4.9×10^{-6}
RME Individual ILCR =	8.9×10^{-4}

HI = Hazard Index
ILCR = Incremental Lifetime Cancer Risk
NA = Not applicable. Exposure route is incomplete.

000337

TABLE I.9-13

SUMMARY OF POTENTIAL HEALTH EFFECTS: OFF-PROPERTY RESIDENT FARM ADULT (FUTURE LAND USE WITHOUT FEDERAL OWNERSHIP)

Exposure Pathway	RME Receptor HI
Inhalation of Particulates (Chemicals)	6.0×10^{-3}
Incidental Ingestion of Residual Soils (Chemicals)	NA
Dermal Contact with Residual Soils (Chemicals)	NA
Ingestion of Meat (Chemicals)	4.9×10^{-4}
Ingestion of Dairy Products (Chemicals)	2.4×10^{-3}
Ingestion of Vegetables and Fruit (Chemicals)	1.2×10^{-1}
Ingestion of Drinking Water (Chemicals)	4.1×10^{-1}
Dermal Contact While Bathing (Chemicals)	2.4×10^{-1}
Incidental Ingestion While Wading (Chemicals)	NA
Dermal Contact While Wading (Chemicals)	NA
RME Individual HI =	7.8×10^{-1}

Exposure Pathway	RME Receptor ILCR
Inhalation of Particulates (Chemicals)	1.7×10^{-7}
Inhalation of Particulates (Radionuclides)	4.9×10^{-5}
Incidental Ingestion of Residual Soils (Chemicals)	NA
Incidental Ingestion of Residual Soils (Radionuclides)	NA
Dermal Contact with Residual Soils (Chemicals)	NA
Ingestion of Drinking Water (Chemicals)	8.7×10^{-8}
Ingestion of Drinking Water (Radionuclides)	1.1×10^{-4}
Dermal Contact While Bathing (Chemicals)	2.7×10^{-9}
Incidental Ingestion While Wading (Chemicals)	NA
Dermal Contact While Wading (Chemicals)	NA
Incidental Ingestion While Wading (Radionuclides)	NA
Ingestion of Meat (Chemicals)	7.0×10^{-8}
Ingestion of Meat (Radionuclides)	1.2×10^{-6}
Ingestion of Dairy Products (Chemicals)	1.6×10^{-8}
Ingestion of Dairy Products (Radionuclides)	7.0×10^{-8}
Ingestion of Vegetables and Fruit (Chemicals)	9.7×10^{-8}
Ingestion of Vegetables and Fruit (Radionuclides)	2.7×10^{-5}
Direct Radiation	NA
RME Individual ILCR =	2.0×10^{-4}

HI = Hazard Index
ILCR = Incremental Lifetime Cancer Risk
NA = Not applicable. Exposure route is incomplete.

TABLE I.9-14

SUMMARY OF POTENTIAL HEALTH EFFECTS: OFF-PROPERTY RESIDENT FARM CHILD (FUTURE LAND USE WITHOUT FEDERAL OWNERSHIP)

Exposure Pathway	RME Receptor HI
Inhalation of Particulates (Chemicals)	1.7×10^{-2}
Incidental Ingestion of Residual Soils (Chemicals)	NA
Dermal Contact with Residual Soils (Chemicals)	NA
Ingestion of Meat (Chemicals)	8.7×10^{-4}
Ingestion of Dairy Products (Chemicals)	2.6×10^{-2}
Ingestion of Vegetables and Fruit (Chemicals)	4.7×10^{-1}
Ingestion of Drinking Water (Chemicals)	9.6×10^{-1}
Dermal Contact While Bathing (Chemicals)	3.8×10^{-1}
Incidental Ingestion While Wading (Chemicals)	NA
Dermal Contact While Wading (Chemicals)	NA
RME Individual HI =	1.8×10^{0}

Exposure Pathway	RME Receptor ILCR
Inhalation of Particulates (Chemicals)	4.0×10^{-8}
Inhalation of Particulates (Radionuclides)	2.5×10^{-6}
Incidental Ingestion of Residual Soils (Chemicals)	NA
Incidental Ingestion of Residual Soils (Radionuclides)	NA
Dermal Contact with Residual Soils (Chemicals)	NA
Ingestion of Drinking Water (Chemicals)	1.7×10^{-8}
Ingestion of Drinking Water (Radionuclides)	4.9×10^{-6}
Dermal Contact While Bathing (Chemicals)	3.8×10^{-10}
Incidental Ingestion While Wading (Chemicals)	NA
Dermal Contact While Wading (Chemicals)	NA
Incidental Ingestion While Wading (Radionuclides)	NA
Ingestion of Meat (Chemicals)	1.1×10^{-8}
Ingestion of Meat (Radionuclides)	4.0×10^{-8}
Ingestion of Dairy Products (Chemicals)	1.4×10^{-8}
Ingestion of Dairy Products (Radionuclides)	1.3×10^{-6}
Ingestion of Vegetables and Fruit (Chemicals)	3.2×10^{-8}
Ingestion of Vegetables and Fruit (Radionuclides)	1.9×10^{-6}
Direct Radiation	NA
RME Individual ILCR =	1.1×10^{-5}

HI = Hazard Index
ILCR = Incremental Lifetime Cancer Risk
NA = Not applicable. Exposure route is incomplete.

TABLE I.9-15

SUMMARY OF POTENTIAL HEALTH EFFECTS: GMR USER - AGRICULTURAL (FUTURE LAND USE WITHOUT FEDERAL OWNERSHIP)

Exposure Pathway	RME Receptor
Inhalation of Particulates (Chemicals)	NA
Incidental Ingestion of Residual Soils (Chemicals)	NA
Dermal Contact with Residual Soils (Chemicals)	NA
Ingestion of Meat (Chemicals)	4.9 E-5
Ingestion of Dairy Products (Chemicals)	1.7 E-4
Ingestion of Vegetables and Fruit (Chemicals)	1.2 E-2
Ingestion of Drinking Water (Chemicals)	NA
Dermal Contact While Bathing (Chemicals)	NA
Incidental Ingestion While Wading (Chemicals)	NA
Dermal Contact While Wading (Chemicals)	NA
RME Individual HI =	1.2 E-02

Exposure Pathway	RME Receptor
Inhalation of Particulates (Chemicals)	NA
Inhalation of Particulates (Radionuclides)	NA
Incidental Ingestion of Residual Soils (Chemicals)	NA
Incidental Ingestion of Residual Soils (Radionuclides)	NA
Dermal Contact with Residual Soils (Chemicals)	NA
Ingestion of Drinking Water (Chemicals)	NA
Ingestion of Drinking Water (Radionuclides)	NA
Dermal Contact While Bathing (Chemicals)	NA
Incidental Ingestion While Wading (Chemicals)	NA
Dermal Contact While Wading (Chemicals)	NA
Incidental Ingestion While Wading (Radionuclides)	NA
Ingestion of Meat (Chemicals)	8.0 E-8
Ingestion of Meat (Radionuclides)	9.8 E-8
Ingestion of Dairy Products (Chemicals)	2.8 E-9
Ingestion of Dairy Products (Radionuclides)	5.5 E-7
Ingestion of Vegetables and Fruit (Chemicals)	1.6 E-6
Ingestion of Vegetables and Fruit (Radionuclides)	2.2 E-6
Direct Radiation	NA
RMe Individual ILCR =	**4.5 E-6**

HI = Hazard Index
ILCR = Incremental Lifetime Cancer Risk
NA = Not applicable. Exposure route is incomplete.

TABLE I.9-16

SUMMARY OF POTENTIAL HEALTH EFFECTS: GMR USER - RESIDENTIAL (FUTURE LAND USE WITHOUT FEDERAL OWNERSHIP)

Exposure Pathway	RME Receptor
Inhalation of Particulates (Chemicals)	NA
Incidental Ingestion of Residual Soils (Chemicals)	NA
Dermal Contact with Residual Soils (Chemicals)	NA
Ingestion of Meat (Chemicals)	NA
Ingestion of Dairy Products (Chemicals)	NA
Ingestion of Vegetables and Fruit (Chemicals)	NA
Ingestion of Drinking Water (Chemicals)	4.0 E-2
Dermal Contact While Bathing (Chemicals)	2.1 E-3
Incidental Ingestion While Wading (Chemicals)	NA
Dermal Contact While Wading (Chemicals)	NA
RME Individual HI =	4.2 E-2

Exposure Pathway	RME Receptor
Inhalation of Particulates (Chemicals)	NA
Inhalation of Particulates (Radionuclides)	NA
Incidental Ingestion of Residual Soils (Chemicals)	NA
Incidental Ingestion of Residual Soils (Radionuclides)	NA
Dermal Contact with Residual Soils (Chemicals)	NA
Ingestion of Drinking Water (Chemicals)	5.5 E-6
Ingestion of Drinking Water (Radionuclides)	9.1 E-6
Dermal Contact While Bathing (Chemicals)	1.7 E-7
Incidental Ingestion While Wading (Chemicals)	NA
Dermal Contact While Wading (Chemicals)	NA
Incidental Ingestion While Wading (Radionuclides)	NA
Ingestion of Meat (Chemicals)	NA
Ingestion of Meat (Radionuclides)	NA
Ingestion of Dairy Products (Chemicals)	NA
Ingestion of Dairy Products (Radionuclides)	NA
Ingestion of Vegetables and Fruit (Chemicals)	NA
Ingestion of Vegetables and Fruit (Radionuclides)	NA
Direct Radiation	NA
RME Individual ILCR =	**1.5 E-5**

HI = Hazard Index
ILCR = Incremental Lifetime Cancer Risk
NA = Not applicable. Exposure route is incomplete.

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TABLE I.9-17

SUMMARY OF POTENTIAL HEALTH EFFECTS: GMR USER - RECREATIONAL (FUTURE LAND USE WITHOUT FEDERAL OWNERSHIP)

Exposure Pathway	RME Receptor
Inhalation of Particulates (Chemicals)	NA
Incidental Ingestion of Residual Soils (Chemicals)	NA
Dermal Contact with Residual Soils (Chemicals)	NA
Ingestion of Meat (Chemicals)	NA
Ingestion of Dairy Products (Chemicals)	NA
Ingestion of Vegetables and Fruit (Chemicals)	NA
Ingestion of Drinking Water (Chemicals)	NA
Dermal Contact While Bathing (Chemicals)	NA
Incidental Ingestion While Wading (Chemicals)	1.9 E-9
Dermal Contact While Wading (Chemicals)	1.4 E-9
Ingestion of Fish (chemicals)	1.6 E-2
RME Individual HI =	1.6 E-2

Exposure Pathway	RME Receptor
Inhalation of Particulates (Chemicals)	NA
Inhalation of Particulates (Radionuclides)	NA
Incidental Ingestion of Residual Soils (Chemicals)	NA
Incidental Ingestion of Residual Soils (Radionuclides)	NA
Dermal Contact with Residual Soils (Chemicals)	NA
Ingestion of Drinking Water (Chemicals)	NA
Ingestion of Drinking Water (Radionuclides)	NA
Dermal Contact While Bathing (Chemicals)	NA
Incidental Ingestion While Wading (Chemicals)	1.9 E-9
Dermal Contact While Wading (Chemicals)	1.4 E-9
Incidental Ingestion While Wading (Radionuclides)	1.4 E-9
Ingestion of Meat (Chemicals)	NA
Ingestion of Meat (Radionuclides)	NA
Ingestion of Dairy Products (Chemicals)	NA
Ingestion of Dairy Products (Radionuclides)	NA
Ingestion of Vegetables and Fruit (Chemicals)	NA
Ingestion of Vegetables and Fruit (Radionuclides)	NA
Direct Radiation	NA
Ingestion of Fish (Chemicals)	8.8 E-6
Ingestion of Fish (Radionuclides)	9.8 E-8
RME Individual ILCR =	**8.9 E-6**

HI = Hazard Index
ILCR = Incremental Lifetime Cancer Risk
NA = Not applicable. Exposure route is incomplete.

I.10.0 UNCERTAINTIES

In relying on multiple assumptions and models, all risk assessments contain elements of uncertainty. The purpose of examining the uncertainty is to provide information relative to the accuracy of the risk estimates and thus aid in the formation of risk management decisions. For the major categories of uncertainty relevant to the CRARE, questions were posed to examine the sources, characteristics, and degree of uncertainty in the risk evaluation:

- COC Selection:

  Are all COCs correctly identified?

- Toxicological Information and Models:

  How complete is the current information concerning the toxic properties and dose-response characteristics of the COCs?

- Exposure Pathways:

  Are all potential pathways for transporting COCs from the site environmental media to the receptors identified?

- Receptor Characterization and Exposure Assumptions:

  Are land use scenarios realistic, and are all potential receptors valid?

- Exposure Point Concentrations:

  Are the models for estimating COC transport from the site media to the receptor, and for estimating the COC exposures and intakes, realistic and reasonable?

- Risk Characterization:

  What uncertainties are associated with summing cancer risks or HIs for multiple COCs?

Baseline risk assessments use existing site conditions to estimate current potential exposures and risks. CRAREs estimate all exposure point concentrations using models and assumptions to estimate postremediation site conditions. Compared to baseline risk assessment results, CRARE results have much more inherent uncertainty with regard to exposure patterns, exposed populations, and exposure concentrations. Even more important for this Operable Unit 1&2

CRARE, however, is that the remedial alternatives for Operable Units 3 and 5 have not yet undergone a thorough analysis. One purpose of this uncertainty analysis is therefore to identify data quality objectives that have not been met or need to be strengthened. As previously mentioned, this CRARE is the second of four planned reports. Some uncertainties identified in this report will be reduced when subsequent editions of the CRARE are prepared as part of the other operable unit FSs.

I.10.1 COC SELECTION

A major concern in this CRARE is the reliability of COC identification, both in terms of ensuring that all COCs have been identified and that chemical or radionuclides have not been incorrectly identified as COCs. The accuracy of COC identification is directly related to the quality of COC characterization data, including contaminant identification, location, and concentrations. The characterization was defined by the design of the sampling and analysis plan, which described the sampling locations and analytical protocols.

The sources of chemical analytic data for the CRARE were the SWCR (for Operable Units 3 and 5) and the Operable Unit 1, 2, and 4 RI/FS reports. The data in the SWCR were not all obtained through sampling plans designed as part of the CERCLA process. There were three stages of sampling, and the analytical protocols and data validation techniques differed between stages. Consequently, data deficiencies have been identified that must be corrected in the individual operable unit RI, and will be included in their CRAREs when the information becomes available.

A source of potential uncertainty is the screening of postremediation COCs. COCs were screened out if they would be lost by the end of the 70-year remediation period, based on calculated losses due to volatilization, soil half-life, and/or groundwater pump and treat operations. The remaining COCs were modeled over time using reasonable and referenced assumptions following current scientific and engineering literature and the RAWPA.

It is unlikely that major COC contributors to overall site risk have been overlooked. Despite the described shortcomings of some of the chemical concentration data gathered at the FEMP, there is still a very large and comprehensive database of site contaminant data. The evaluation of these

data have identified a large number of contaminants present on the site, and confirm the general pattern of contamination as indicated by past site operations. It is clear that the major contaminants (uranium and other radionuclides, nonradionuclide inorganics, and organics) that could credibly contribute to site risks have been identified. If additional COCs are identified in future RI/FS efforts, they will be included in future CRAREs.

Chemicals not included as COCs in the quantitative CRARE risk assessment, as a consequence of missing information on health effects or a lack of quantitation in the chemical analysis, may provide a significant source of uncertainty which may underestimate final risk estimates (EPA 1989c). The risk associated with some COCs included in the CRARE may also be underestimated if the magnitude and extent of contamination have not been sufficiently characterized in RI studies.

I.10.2 TOXICOLOGICAL INFORMATION AND MODELS

Toxicological information is not operable-unit-specific and therefore is not discussed separately for each operable unit. EPA-supplied RfD values and cancer slope factors were used throughout the risk assessment. Toxicological constants were not derived for any of the COCs evaluated in this CRARE risk assessment. Because of this, the toxicological evaluations (upon which the CRARE risk assessment is based) contribute no more uncertainty than that present in comparable CERCLA documents. However, because this uncertainty arises out of the application of guidelines recommended by the agencies involved, these sources of uncertainty are beyond the control of the FEMP investigation personnel.

There are many sources of uncertainty in the cancer slope factors or unit risks and noncarcinogenic RfD or RfC values provided by the EPA. The three major sources are:

1. Interspecies extrapolations:

   Animal-to-human extrapolation, used in the absence of quantitative pharmacokinetic, dosimetric, or mechanistic data, is usually based on a consideration of interspecies differences in body weight, surface area, or basal metabolic rate.

2. Intraspecies or individual variation:

   Most toxicity experiments are performed with animals that are very similar in age and genotype, so that intragroup biological variation is minimal. The human population of concern may reflect a great deal of heterogeneity, however, including unusual sensitivity to the COCs.

   Even toxicity data from human occupational exposures reflect a bias because only those individuals sufficiently healthy to attend work regularly, and those not unusually sensitive to the COCs, are likely to be occupationally exposed.

3. Key study and database quality:

   The quality of key studies (from which the quantitative estimate is derived) and the quality of the literature databases add to the uncertainty. For carcinogenic effects, the uncertainty associated with some quality factors (e.g., group size) is expressed within the 95 percent upper bound of the slope factor. For noncarcinogenic effects, additional uncertainty factors may be applied in the derivation of the RfD or RfC to reflect the poor quality of the key studies or gaps in the database.

Dermal RfD values and cancer slope factors used in this CRARE were calculated from their corresponding oral values (Section I.7.2). To calculate a dermal RfD, the oral RfD was multiplied by the gastrointestinal absorption efficiency factor, expressed as a fraction. The resulting dermal RfD is based on an absorbed dose, because dermal doses are expressed as absorbed rather than exposure doses. In a similar manner, and for the same reasons, to calculate a dermal cancer slope factor, the oral slope factor was divided by the gastrointestinal adsorption efficiency.

The most important consideration associated with the uncertainty of the calculated dermal RfD values or cancer slope factors is the accuracy of the gastrointestinal absorption efficiency factor. For this reason, the toxicity profiles (Section I.7.6) contain pharmacokinetics discussions in which the oral absorption data were evaluated. Where appropriate, the low (i.e., most conservative) end of the range of available gastrointestinal absorption data for humans was used to derive the dermal RfD or cancer slope factor. When the human data were insufficient, animal data were used. Data from high-dose experiments were not used if more suitable data were available and it appeared the gastrointestinal absorption process could have been saturated. When adequate quantitative data were not located, a default absorption factor was used.

As noted by the EPA (1989c), the absorption of many metals from the gastrointestinal tract is limited, and 0.05 is a reasonable default for metals and inorganic substances. The EPA (1989c) did not recommend a separate default value for organic chemicals. A compilation of data for 19 organic chemicals presented gastrointestinal absorption efficiencies of at least 0.9, indicating that organic chemicals generally are readily absorbed. The arithmetic average of the efficiencies for the 19 organic chemicals, 0.91368 (equivalent to 0.9 when rounded to one significant figure), appears to be a reasonable default gastrointestinal absorption efficiency factor for organic chemicals. The default of 0.9 was used for organic chemicals for which quantitative data were inadequate.

Considerable uncertainty is associated with the qualitative (hazard assessment) and quantitative (dose-response) evaluations of Superfund risk assessments. The hazard assessment characterizes the nature and strength of the evidence of causation, or the likelihood that a chemical that induces adverse effects in animals would also induce adverse effects in humans. The hazard assessment of carcinogenicity is evaluated as a weight-of-evidence determination, using either the IARC (1987) or EPA (1986b) approaches. Positive results in animal cancer tests suggest that humans may also exhibit a carcinogenic response, but the animal data cannot necessarily be used to predict the target tissue in humans. In the hazard assessment of noncarcinogenic effects, positive animal test results may suggest the nature of the human effects, including the target tissues and type of effects (EPA 1989c).

Another source of uncertainty regarding the quantitative risk estimation for carcinogenicity is the method by which data from high doses in animal studies are extrapolated to the dose-range expected for environmentally exposed humans. The linear multi-stage model, which is used in almost all quantitative estimations of human risk from animal data, is based on the nonthreshold assumption of carcinogenesis. An impressive body of evidence, however, suggests that epigenetic carcinogens, as well as many genotoxic carcinogens, have a threshold below which they are noncarcinogenic (Williams and Weisberger 1991). The linear multi-stage model is therefore generally regarded as being extremely conservative for many chemicals.

Adding to the conservativeness of this approach is the fact that the EPA-derived cancer slope factors found in IRIS have been set at the 95 percent UCL of the linear slope of the multi-stage

model. Thus, risks estimated using the slope factors may be greatly overestimated. This consideration applies to both radiological and chemical estimates of carcinogenic risk. Of particular concern in this regard are the slope factors derived by EPA for the evaluation of risks due to external exposure to radiation. As discussed in Section I.7.3, these values were derived using very conservative assumptions about exposure conditions, and are likely to provide very conservative risk estimates.

The methods used to define RfD values for chemical contaminants also incorporate a large degree of conservatism. Sets of multiplicative uncertainty factors were used in deriving RfDs to adjust the results of animal and human toxicologic studies to take into account the nature of the endpoint (NOAEL to LOAEL) seen in the studies, differences in response to different dose schedules, the presence of sensitive populations, and the possible differences between human and animal sensitivity to contaminant exposures. Each uncertainty factor may take a value as high as 10, and thus RfD values for COCs typically have been set between 100 and 1000 times lower than the lowest dose seen in animal studies. If the human and animal responses to contaminant exposures are not as dissimilar as reflected in the uncertainty factors (or if humans are less sensitive, rather than more sensitive to contaminants), it is the possible that the use of RfDs greatly overstates the potential for adverse health effects in humans.

The level of uncertainty in the toxicologic data for different chemicals varies because information concerning some constituents and their associated health effects is comparatively scarce, while for others much more information is available from health effects studies. Also, different amounts of data may be available concerning the different types of effects for a given COC. For example, uranium has been established as a chemical toxicant (kidneys are the major target organ) based on human and animal studies. The RfD for uranium was based on the results of animal studies and was calculated by applying an uncertainty factor of 1000 to a LOAEL for nephrotoxicity in rabbits to provide a margin of safety for extrapolation to humans. The uncertainty factor consists of three factors of 10 each, for: 1) estimation of a NOAEL from a LOAEL, 2) extrapolation from animals to humans, and 3) the possible range of sensitivities among exposed humans.

There is even greater uncertainty regarding uranium carcinogenicity. As an alpha-particle emitter, uranium is considered to be a carcinogen; however, as discussed in Section I.7.5, epidemiological

evidence of uranium-induced excess cancers is very difficult to obtain. This is largely because the human data available on the radiocarcinogenic effects of uranium exposure are for miners who were also simultaneously exposed to radon and its progeny, which are confounding factors. The studies of humans sometimes lack quantitative information concerning uranium exposure, including potential exposure through previous employment, concurrent smoking patterns, or concurrent radon exposure levels, all of which are needed to definitively determine the risk attributable to uranium exposure. These facts weaken the power of the human studies to detect any excess cancer risk. The human studies of cancer from exposure to uranium frequently reveal a slight excess risk, if any, above the natural risk. These uncertainties are not well known or easily quantified.

Uncertainties in the interpretation of toxicologic data especially affect the results of the risk assessment for inhalation exposure to metals. HI values associated with particulate inhalation exceed 1.0 for several receptors. Almost all of the HI values result from estimated exposures to cobalt and manganese via the inhalation pathway. Similarly, boron, cadmium, manganese, mercury, silver, and zinc are the major contributors to the HI values from exposures via the food pathways.

In the case of cobalt, exposure concentrations result in contaminant intakes that barely exceed the inhalation RfD values. The inhalation RfD for cobalt (3.0×10^{-7} mg/kg/day) was derived using maximum values for all possible uncertainty factors, based on a single epidemiologic study of a disease from exposures to the hard metal and not from cobalt compounds. It is extremely unlikely that humans are actually as sensitive to cobalt exposures as reflected in this RfD. The RfD value is almost certainly well below normal background inhalation exposures received by members of the general population, and the RfD value for cobalt makes it more than one thousand times more toxic than mercury by the inhalation pathway. Thus, a cobalt HQ greater than 1.0 for some populations must be interpreted very cautiously, and probably does not reflect significant concerns over adverse effects.

Chemical speciation is an issue in evaluating the inhalation pathway risk estimates for chromium exposures. From the SWCR, chromium present in soils was assumed to be reported as total chromium. An assumption that this on-site chromium was entirely hexavalent would be

inconsistent with the prevailing redox and chemical conditions in environmental media at the FEMP. It is likely that only a small portion of the chromium present (1 percent or less) is actually hexavalent. In this CRARE, it was assumed that 10 percent of the chromium was presented as hexavalent chromium. This failure to adequately characterize on-site chromium species contributes uncertainty to the inhalation pathway risks associated with chromium exposures, since hexavalent chromium species are much more toxic than the trivalent species. Trivalent chromium is not thought to have any carcinogenic activity in humans, whereas the hexavalent chromium compounds are regarded as potent human carcinogens.

I.10.3 EXPOSURE PATHWAYS

The exposure pathways evaluated within the CRARE risk assessment were initially proposed in the SWCR and further reviewed during the Operable Unit 1, 2, and 4 RIs. The major source of uncertainty in predicting future exposures at the FEMP is the future disposition of the property itself. Because it is not possible to accurately predict future land use or condition of the site, conservative (rather than the most likely) future conditions were evaluated, as stipulated by the NCP. It has been assumed that the FEMP would not become a residential area. This is a conservative assumption, as the farm scenarios used in this CRARE have a greater chance of excess exposure due to the inclusion of the indirect pathways of vegetable, beef, and milk consumption.

In future CRAREs, additional data will be gathered to support a more detailed evaluation of the indirect human exposure pathways. Depending on the findings of the RI/FS for the other operable units, the evaluation of the indirect pathways may be expanded to include contributions to exposure concentrations through other transport mechanisms (particulate deposition, surface water runoff), as well as the possible inclusion of additional groundwater COCs that may be subject to bioconcentration.

I.10.4 RECEPTOR CHARACTERIZATION AND EXPOSURE ASSUMPTIONS

Receptor characterization is not operable-unit-specific and therefore is not discussed separately for each operable unit. The default values for characterizing FEMP receptors are presented in the RAWPA (DOE 1992b). For this CRARE, receptor scenarios (one Current and two Future Land Use scenarios) were selected to represent the reasonable maximum potential exposure.

Exposure factors were based on surveys of physiological and lifestyle profiles across the United States and the attributes and activities studied generally have a broad distribution. To account for most of this distribution, this risk assessment follows the EPA's recommendation to use the 95th percentile for most exposure factors. In addition, the exposure factors are consistent with EPA Region V guidance. This introduces a conservative bias into the results.

As previously stated, the following RME receptors were chosen for this CRARE:

- Groundskeeper
- Trespassing child
- Expanded trespasser
- Off-property resident farm adult and child
- On-property resident farm adults (two) and child
- Great Miami River user

Other receptors may be exposed to FEMP COCs; however, the conservative exposure scenarios addressed in this report make it likely that no actual exposed population will receive greater exposures than those estimated in the CRARE. A brief discussion of the uncertainty in selected exposure factors follows.

I.10.4.1 Exposure Duration

For FEMP risk assessments, it was assumed that the farm residents would occupy the land for a full lifetime exposure period (70 years). This is a conservative approach, but at most it overestimates the risk by a factor of three relative to representative residential tenure in the area. It was also assumed that all workers would occupy their jobs for 25 years, a realistic estimate of exposure duration given the stability of the surrounding communities.

I.10.4.2 Exposure Frequency

It was assumed the farm residents would occupy the property for 350 days per year, a realistic assumption, especially for a farming family. Likewise, workers were assumed to work for 250 days a year, the normal number of annual workdays. What is uncertain, however, is the number of days a trespassing child or expanded trespasser would be on FEMP property. The assumptions were 52 days for the trespassing child, 110 days for the expanded trespasser as a youth and 40 days as an adult. These are conservative but reasonable assumptions and only moderately affect the results of the risk assessment.

I.10.4.3 Exposure Time

The farm residents were assumed to spend 24 hours per day on the property. This is a slightly conservative assumption as it does not take into account school time, shopping time, work, and other activities. What is uncertain is the time a worker, trespassing child, or expanded trespasser would spend in contact with the property media. The exposure times chosen are realistic but could underestimate the exposure. The most-effected pathways are direct contact and inhalation.

I.10.4.4 Body Weight

The body weights used in this CRARE were derived from standard tables for U.S. body-weight distributions. The values were selected from the distribution midpoints because of the uncertainty regarding those distributions. Individual variances for adults are likely to be less than a factor of 2. And although children have a wide range of body weights, the uncertainty is at most a factor of 2 or 3 (plus or minus).

I.10.4.5 Ingestion of Soil, Food, and Water

There has been considerable discussion in the scientific literature concerning the appropriate oral ingestion rate of soil and dust for adults and children. Current EPA guidance recommends 100 mg/day for adults, 200 mg/day for children under the age of 6, and 50 mg/day for an industrial worker not engaged in construction work. Since the FEMP risk assessments also considered a farmer who would be exposed to great quantities of dust through farming activities, a value of 180 mg/day was used. These values are realistic as a multi-year average, but the soil ingestion rates could potentially be much higher for shorter-term exposures. If anything, these ingestion rates may be underestimated, but by less than a factor of 2 for multi-year exposures.

The consumption of drinking water was set to the EPA Region V default values, which are conservative estimates. Over multi-year exposures, these values are not likely to vary widely and may be overestimated by a factor of less than 2. Most likely, the consumption of drinking water will be less than the default values.

The rate and type of food consumption vary greatly from locality to locality and from individual to individual. The estimates of food consumption used in the FEMP risk assessments are national averages and may not be appropriate for some of the individuals exposed to FEMP COCs. The

values presented represent conservative estimates and are not likely to vary by more than a factor of 2 for the average individual. It was assumed that 50 percent of the fruit and vegetables, and 75 percent of the meat and milk in the farm residents' diet would consist of products from their farm. This may overestimate the risk from fruit and vegetable consumption. The risk from meat and milk consumption may be overestimated by a factor of 2. The greatest uncertainty is in the assumption of food consumption for children. The direction and magnitude of uncertainty are unknown.

I.10.4.6 Dermal Exposure Factors

Four critical assumptions have been made relating to the assessment of dermal exposure to soils: 1) the amount of exposed skin surface area, 2) the quantity of soil adhering to the skin, 3) the length of time the soil adheres to the skin, and 4) the partitioning rate of the COC from the soil across the skin barrier. The four factors vary widely from individual exposure to exposure and may contribute substantially to the uncertainty in risk assessment of these pathways. In general, the assumptions used to estimate dermal absorption are consistent with the conservative default values defined in recent EPA guidance. In addition, the adjustment of toxicity values for use in the dermal pathway risk assessment, particularly in the case of inorganic contaminants, was performed using conservative assumptions about contaminant intake, and likely contributes a further degree of conservatism to the characterization of dermal pathway risks.

I.10.4.7 Inhalation Exposure

Multiple breathing rates were used in estimating doses via inhalation. The receptors are typical for different exposed groups, including small children, adults at home, and adults at work. Each of these receptors has a wide range of breathing rates, which vary on a daily basis. The extent of the range is a factor of 3 for any defined level of activity. The breathing rates chosen for this evaluation are at the upper end of the distribution but do not represent the maximum.

I.10.5 EXPOSURE POINT CONCENTRATIONS

The values used to represent exposure point concentrations were designed to provide conservative estimates of exposure, thus ensuring a conservative evaluation of the risk. All CRARE exposure point concentrations are projected to be cleanup levels, existing soil concentrations, or modeled values, except for Operable Unit 1 which is proposed to be capped (clean soil was assumed with

no contaminants present). The uncertainty of exposure point concentrations estimated by models depends on input parameters (diffusion coefficients, groundwater flow, air flow, etc.), model characteristics, release mechanisms, and source terms. CRARE input parameters were based on site information together with professional judgment and were designed to be conservative. The input parameters and models were based on the RAWPA and SWCR. The exposure parameters were taken from the Operable Unit 2 RI.

I.10.5.1 Air Concentrations

The major contributors to uncertainty in CRARE air modeling are the release estimates for particulate and gaseous (radon) emissions and the concentrations and extent of COCs in the surface soil. The components of uncertainty include:

- Wind speed and direction
- Climate conditions (temperature, moisture, etc.)
- Surface soil COC concentrations
- Release of particulate to the air from soils, including frictional velocity concerns
- Volatilization
- Radon release

The uncertainties associated with the COC dispersion through the atmosphere are related to the EPA mathematical model used and variations in meteorological and climatological conditions. Five years of actual climatological data from the site provide a large database upon which long-term air quality modeling can be based. The overall level of uncertainty associated with the meteorological models is probably relatively low compared to the contribution of other factors.

The ISCLT2 model calculates dispersion for six wind speed categories (EPA 1992b). The use of a single emission rate for dispersion under all six wind speed categories will overestimate the concentrations at low wind speeds and underestimate the concentrations at high wind speeds. The frequency of wind speeds in the lower-speed categories is much greater than the frequency of wind speeds in the upper-speed categories. Therefore, using a single emission rate for all wind speed categories in ISCLT2 tends to overestimate the ground-level PM_{10} concentrations.

Evidence (EPA 1985b) indicates that no substantial fugitive particulate emissions occur for wind speeds less than 5 m/s (16.4 ft/s or 12 mph). These wind speeds include the lower three wind speed categories analyzed by ISCLT2.

The COC surface soil concentration in each area was multiplied by the annual average PM_{10} emission flux to determine the contaminant-specific emission rate used in the model for calculating airborne concentrations. The COC surface soil concentration was multiplied by the annual average TSP emission flux to determine the contaminant-specific emission rate used for calculating total deposition rates. The soil concentrations used are either maximum sample values, upper 95 percent UCL of the mean, or the appropriate PRL value; therefore, these are conservative values.

The potential for particles greater than 10μ becoming suspended in the air is a possible source of uncertainty. While PM_{10} represents the particles that can be inhaled, there are also larger particles that may be deposited on skin or crops.

The particulate COC concentrations depend on the estimated surface soil contamination, soil characteristics, and the percentage of vegetative cover. The estimated surface soil concentrations in Operable Units 1, 2, 4, and 5 were fixed at the cleanup levels for COCs that initially exceeded those levels. The COCs affected by this step were Cs-137 and Np-237, as well as isotopes of radium, thorium, and uranium. For COCs not affected by this step, the RI/FS database was preferentially used to characterize exposed soil concentrations in Operable Units 1, 2 and 5. The Operable Unit 2 RI, Operable Unit 4 RI, and Operable Unit 4 FS were also used as sources of exposed soil concentrations since these reports conveniently summarized RI/FS data for the given operable unit. The exposed soil COC concentrations were based on UCL values for the areas in which the COC concentration had not been reset to the cleanup level. Not all COC soil concentrations were characterized for all areas. When concentration data were not available for a given source, the contribution to the COC air concentration from that source was not calculated. The overall approach is considered realistic, with some potential for underestimation due to the lack of COC data for several source areas.

The vegetative cover for the surface areas was assumed to be at 85 percent, which is realistic for this area of southern Ohio. However, using 85 percent may underestimate the dust production if the FEMP becomes a farm.

The controlling factors in radon air concentrations are the extent of Ra-226 in the surface soils and the layers of cover for the covered area. As previously stated, the extent of Ra-226 contamination in the surface soils is incompletely characterized. It was assumed that all covered areas would remain intact for 1000 years and no significant radon release would occur from the capped areas or disposal facilities. Overall, the predicted air concentrations are realistic but not conservative.

The methods used to combine the particulate generation and air quality models may also contribute significantly to the uncertainty in the inhalation pathway risk assessment. As discussed in Section I.6.0, the particulate emission rate was determined using the unlimited erosion potential equation from EPA's *Rapid Assessment of Exposure to Particulate Emissions from Surface Contamination Sites (EPA 1985b)* developed for estimated annual PM_{10} emission rates from the annual mean wind speed. The equation used includes a distribution function which accounts for actual winds ranging above and below the annual mean wind speed. The use of this equation with the ISCLT2 model may overestimate emissions for the lower wind speeds. Since the frequency of wind speed in the lower-speed categories is much greater than in the upper-speed categories, using a single emission rate for all categories tends to overestimate ground-level PM_{10} concentrations.

The use of the unlimited erosion potential equation was based on the particle size distribution of surface soil. The equation does not account for moisture content, crustiness of the surface, and nonerodible elements present on the surface. The FEMP surface is probably more characteristic of an area with "limited" erosion potential: an inhomogeneous field covered with gravel, rocks, or clumps of vegetation that has a moderate moisture content and tends to form a hard crust when dried and/or frozen. The bias of using the unlimited erosion potential equation is clearly in the conservative direction based on calculations performed in this CRARE.

I.10.5.2 Surface Water and Groundwater Concentrations

The need to predict surface water and groundwater concentrations for 1000 years into the future represents a major source of uncertainty in the CRARE. In evaluating future water concentrations, the same models were used as in the baseline risk assessment (MUSLE, ODAST, and SWIFT III). The use of MUSLE was modified to incorporate data from two additional models, HEC-1 and VS2DT. The level of uncertainty associated with the modeling is large but cannot be easily quantified. Table I.10-1 identifies the major parameters used in the CRARE modeling and provides estimates of their relative effect on the loading of COCs to the aquifer.

For the specific locations of groundwater receptors, the U-238 and Tc-99 contour plots were reviewed, and a limited number of potential locations were selected for both on- and off-property receptors. These potential receptor locations were selected in areas where both U-238 and Tc-99 reached maximum values. COC concentrations with time were listed at each of these points. Then, to be conservative, a method was developed to determine both the location and the 10-year interval over which the greatest ILCR was estimated for an adult RME receptor. This receptor was assumed to ingest 2 liters of groundwater per day over a 70-year lifetime. For each 10-year interval of the groundwater modeling output, and for each potential receptor location, the ILCR was estimated for each modeled COC (which had an appropriate cancer slope factor). The resulting individual cancer risks were summed for each location over the 10-year interval. The single location where the RME receptor would experience the greatest total ILCR (over each 70 or 1000 years of groundwater modeling output) was selected as the representative receptor location for each scenario.

The process for locating a perched-water receptor was similar to that of the groundwater receptor. The initial leachate concentrations in Table I.6-2 (Section I.6.1.3.1) were assumed to represent potential perched-zone concentrations for the COCs after remediation. Several potential receptor locations were selected in the central portion of the FEMP, where the perched zone is known to exist. Locations were selected where the listed COC concentrations are at the highest values. The total ILCR was then calculated for each location, and the location with the highest total ILCR for perched-water concentrations was selected.

TABLE I.10-1

MAJOR PARAMETERS IN CRARE MODELING AND THEIR EFFECT ON AQUIFER LOADING

Parameter	Concentration[a]	Time[b]	Duration[c]	Confidence[d]
Source Term				
Quantities in Wastes			Medium+	Medium
Concentration in Wastes	Major+			Medium
Quantities in Soils			Medium+	Medium
Concentration in Soils	Major+			Medium
Surface Runoff Models				
K_d of Soils	Major–			Low
R_t - Total Storm Rainfall	Major–			Low
T_f - Storm Duration	Small–			Low
D_d - Overland Distance		Small+		High
K - Soil Erodibility Factor	Small+			Low
λ - Source Decay Factor	Small–		Small–	Hi/Low[e]
Vadose Zone Models (HELP, ODAST)				
D - Dispersion Coefficient	Small–		Small+	Low
V - Seepage Velocity		Medium–	Major–	Low
R - Retardation Factor	Small–	Major+		Low
α - Depletion Factor			Medium–	Low
T_o - Depletion Time			Major+	Low
λ - Source Decay Factor	Small–		Small–	Hi/Low[e]
Aquifer Model (SWIFT)				
H_H - Horizontal Conductivity	Medium–	Medium–		Medium
K_v - Vertical Conductivity	Medium–	Medium–		Low
α_H - Horizontal Dispersivity	Medium–	Medium–		Low
α_T - Transverse Dispersivity	Small–	Small–		Low
R - Retardation Factor	Medium+	Major+		Low

[a]Maximum level of concentration in the aquifer.
[b]Time of occurrence of peak concentration in the aquifer.
[c]Time duration of release.
[d]Level of confidence in parameter values.
[e]High level of confidence in decay factors for radionuclides and low level of confidence in decay factors for organic contaminants.

+ = Small, medium, or major positive effect, i.e., increase in parameter value will increase the value of the dependent variable.
– = Small, medium, or major negative effect, i.e., increase in parameter value will decrease the value of the dependent variable.

Other components of uncertainty in the water modeling are the partitioning coefficient (K_d) values of COCs in the vadose zone and the aquifer, and the source terms for release. The K_d uncertainty is of most importance when modeling over hundreds of years. The vadose layers provide a significant time delay to contamination reaching the aquifer (except that the contamination in surface runoff is assumed to reach the aquifer without delay) due to adsorption onto the soil. This delay in the vadose zone transport is evidenced by time shifting of the peak concentration in the aquifer. The two vadose layers are essentially in series (e.g., contamination must pass through vadose layers 1 and then 2 before reaching the aquifer). The average travel time, T_n, through each layer is:

$$T_n = \frac{R_n L_n}{V_n} \qquad \text{(C.10-1)}$$

where

n = layer,
R_n = retardation factor = $1 + \frac{K_d \rho_b}{\theta}$ for layer n,

L_n = thickness of layer,
V_n = seepage velocity in layer n,
ρ_b = bulk density, and
θ = moisture content.

Thus, the travel time in each layer is directly proportionate to the K_d of that layer. For many contaminants, the K_d of vadose layer 1 is much larger than that of layer 2. The K_d can vary according to the COC chemistry, the pH of water, concentrations of other components (chloride, sulfate, etc.), and soil characteristics (sand, clay, porosity, etc.). The K_d values for this CRARE were generally based on site-specific data or values from the literature, as summarized in the RAWPA. The uncertainty would be reduced by determining additional operable-unit-specific K_d values.

Additional uncertainty derives from the release mechanisms of the sources into the vadose zone. An important component in the release mechanism is the exfiltration rate (the rate at which the water moves through the source area). Engineering calculations and/or HELP modeling were used to estimate this rate for the engineered areas. The ambiguities associated with the long-term

groundwater monitoring and maintenance activities described in Section 4.0 of the FS also contribute to uncertainty.

The major operable-unit-specific sources of groundwater uncertainty with respect to source terms are summarized as follows:

- Operable Unit 1:

  Magnitude and location of COCs, cap design, and exfiltration rate.

- Operable Unit 2:

  Magnitude of COCs, disposal cell design, and exfiltration rate.

- Operable Unit 3:

  Little information is available on the nature, magnitude, and location of COCs beneath and within the buildings; in general, the concentrations of COCs and their leachate characteristics are uncertain. The vault design and exfiltration rate are also uncertain.

- Operable Unit 4:

  Uncertainty in the concentrations and distributions of subsurface COCs.

- Operable Unit 5:

  Site-wide surface soil contamination and perched water plume are not well-characterized. Characteristics of flow and transport in the vadose zone are probably more complex than modeled by ODAST. The extent of floral and faunal contamination and the geochemistry of water percolating through the remediated soils have not been well established.

I.10.6 RISK CHARACTERIZATION

Throughout this risk assessment, potential health effects caused by the simultaneous exposure to multiple on-site COCs were assumed to be additive in nature. Uncertainties associated with summing cancer risks or HIs for multiple substances are of particular concern in the risk characterization step. The assumption of dose additivity ignores possible synergisms or antagonisms among chemicals and assumes similarity in mechanisms of action and metabolism. However, data to quantitatively assess chemical interactions are generally lacking. In the absence

of adequate information on chemical interactions, EPA guidelines indicate that carcinogenic risks should be treated as additive and noncancer HIs should also be treated as additive. These assumptions help prevent an underestimation of cancer risk or potential noncancer health effects at a site (EPA 1989c).

I.10.7 SUMMARY

As subsequent CRAREs are completed, major sources of uncertainty will be further characterized and possible courses of action will be developed to reduce overall uncertainty.

I.11.0

I.11.0 SUMMARY OF METHODOLOGY AND RESULTS

This Operable Unit 1&2 CRARE presents a risk evaluation for all FEMP COCs transported via the direct pathways of air, soil, groundwater, surface water, and radiation, as well as the indirect pathway of farm product consumption. The results have been summarized in this section by the following categories:

- Site-wide sources of contamination
- Identification of COCs
- Receptor characterization
- Pathways of exposure
- Postremediation residual risk characterization
- Operable unit contribution to risk
- Impact of uncertainty on the risk estimates

I.11.1 METHODOLOGY

I.11.1.1 Site-Wide Sources of Contamination

The primary sources of contamination remaining after site remediation include the vaults, operable unit residual footprints, site soil, and the capped/covered areas of Operable Units 1 and 2. The site soil is the major source for all risk estimates. Section I.11.7 discusses the uncertainties associated with these sources of residual risk.

I.11.1.2 Identification of COCs

Potential COCs detected on-property were identified using Appendix R of the SWCR, and the Operable Unit 1, 2, and 4 RI/FS reports. A multi-step screening process identified those COCs that would be present on FEMP property during the 70- and 1000-year postremediation time frames. Volatile organic chemicals were eliminated from consideration as COCs because evaporation would rapidly remove these compounds from the FEMP during the time periods under evaluation. Similarly, other organic compounds were removed from consideration after evaluating their soil half-life. Finally, further organic COCs were removed as a result of groundwater pump treat operations.

The remaining COCs (presented in Section I.4.0) were then used in fate and transport modeling of air, surface water, groundwater, and farm products. During the groundwater fate and transport analysis (Section I.6.0), the COCs were further screened using preliminary techniques to

determine if significant quantities of COCs would reach groundwater within the 1000-year time frame. It is unlikely that any major COCs were overlooked.

The detailed risk analysis indicates that the major radionuclides of concern are U-238, U-234, Tc-99, Th-228, and Rn-222. The principal contributors to the carcinogenic risk are arsenic, beryllium, chromium, and the PCBs. The principal contributors to the noncarcinogenic HI are antimony, arsenic, boron, cadmium, cobalt, manganese, mercury, molybdenum, silver, and zinc.

COCs not included in the quantitative risk assessment, as a consequence of missing information on health effects or a lack of quantitation in chemical analyses, may provide a significant source of uncertainty which may underestimate final risk estimates.

I.11.1.3 Receptors

The following on-property and off-property RME receptors have been evaluated this CRARE.

On-Property

- Resident farm adult (who ingests GMA water)
- Resident farm adult (who ingests perched water)
- Resident farm child
- Expanded trespasser
- Trespassing child
- Groundskeeper

Off-Property

- Resident farm adult
- Resident farm child
- GMR user
  - Agricultural
  - Residential
  - Recreational

These receptors represent a wide array of potential land uses. Even though the FEMP was not evaluated for residential-only land use, it must be pointed out that the use of resident farm receptors (who consume the farm produce) is more conservative than the use of a residential-only receptor. For the evaluation of carcinogenic risk, all adult farmers were assumed to be exposed for their entire 70-year life spans.

The carcinogenic risk estimate for the on-property resident farmer is the most elevated and exceeds the target risk range of 10^{-4} to 10^{-6}. The ingestion of perched groundwater would increase the ILCR by more than tenfold for this receptor. Risks for the trespassing child and expanded trespasser are within the target range for both carcinogenic and noncarcinogenic effects. Risks for the groundskeeper are above the target range for both carcinogenic and

noncarcinogenic health effects. Carcinogenic risks for the off-property farm adult and child exposure scenarios are within the target risk range. The off-property farm adult and child are above the noncarcinogenic HI benchmark of 1.

I.11.1.4 Pathways

The pathways considered in this CRARE are:

- Inhalation of radon gas and particulates
- Incidental ingestion of soil and sediment
- Dermal contact with soil and sediment
- External radiation exposure
- Ingestion of groundwater (perched or GMA)
- Ingestion of farm products (milk, meat, and vegetables)
- Ingestion of surface water

For this CRARE, the major pathways of concern were found to be the inhalation of fugitive particulates, the consumption of drinking water, and dermal contact with soils. External radiation was a significant pathway of concern for all on-property receptors. The major uncertainty relating to the inhalation pathway is the resuspension rate of fugitive particulates. The specific concern for this factor is discussed in Section I.11.7.

I.11.2 POSTREMEDIATION RESIDUAL RISK RESULTS

The estimated risks from the FEMP are summarized in Table I.11-1 and presented in graphical format in Figure I.11-1. Tables I.11-2 through I.11-4 have been developed to further illustrate the risks associated with the selected on- and off-property activities by pathways and subsequent major contributing COCs. Table I.11-5 presents an analysis of major target organs impacted when HIs were greater than the benchmark of 1. The adult farm resident has been selected to represent the on- and off-property resident under all three scenarios. The adult off-property resident has not been included under the Future Land Use Without Federal Ownership scenario as the risk is the same as under the Future Land Use With Federal Ownership scenario. The residential risks from the remediated FEMP are summarized as follows.

TABLE I.11-1

SUMMARY OF ILCR AND HI FOR ALL SCENARIOS, ALL PATHWAYS

Current Land Use

RME Receptor	ILCR	HI
Groundskeeper	3.2×10^{-5}	3.3×10^{-1}
Trespassing Child	2.0×10^{-6}	2.3×10^{-1}
Off-Property Farm Residents		
Adult	1.0×10^{-4}	7.7×10^{-2}
Child	6.0×10^{-6}	2.1×10^{-1}

Future Land Use With Federal Ownership

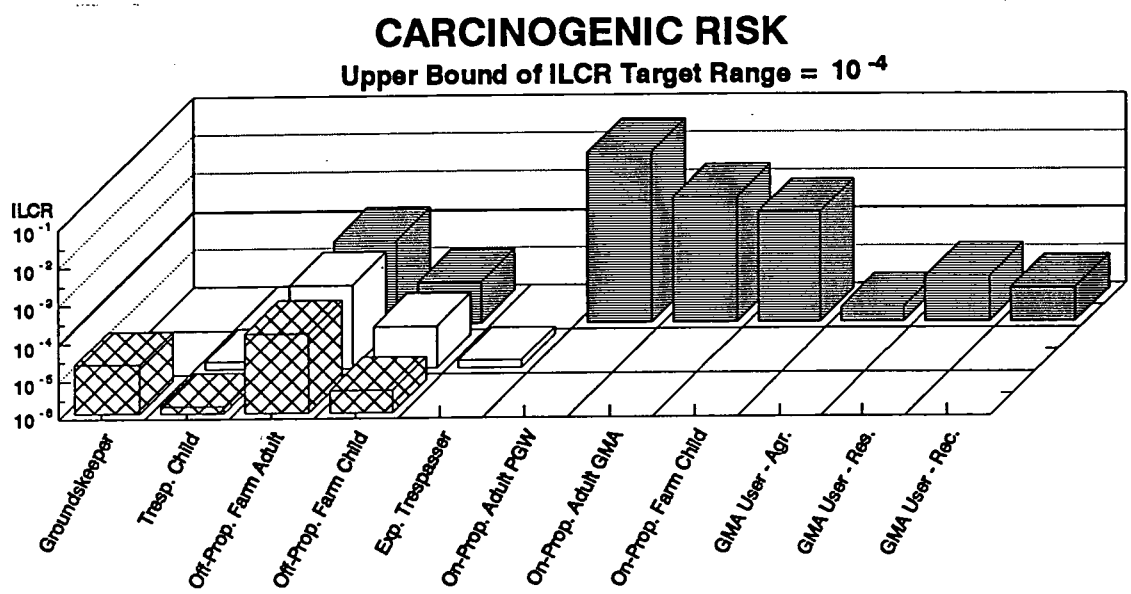
RME Receptor	ILCR	HI
Expanded Trespasser	1.7×10^{-6}	2.3×10^{-1}
Trespassing Child	2.0×10^{-6}	2.3×10^{-1}
Off-Property Farm Residents		
Adult	2.0×10^{-4}	7.8×10^{-1}
Child	1.1×10^{-5}	1.8×10^{0}

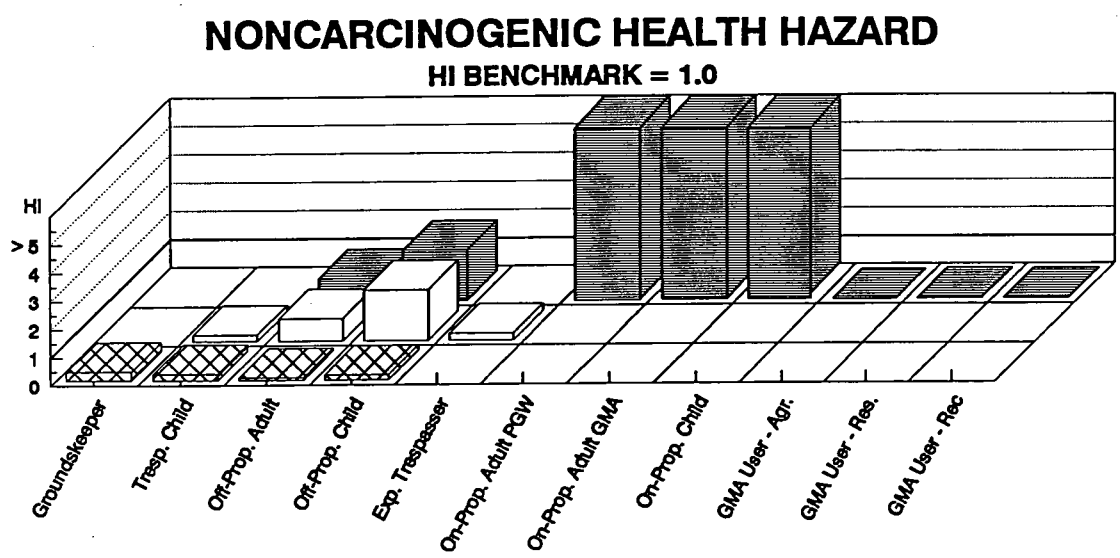
Future Land Use Without Federal Ownership

RME Receptor	ILCR	HI
On-Property Farm Residents		
Adult (ingests perched groundwater)	4.9×10^{-2}	1.0×10^{2}
Adult (ingests GMA water)	2.8×10^{-3}	3.3×10^{1}
Child	8.9×10^{-4}	1.0×10^{2}
Off-Property Farm Residents		
Adult	2.0×10^{-4}	7.8×10^{-1}
Child	1.1×10^{-5}	1.8×10^{0}
GMR User		
Agricultural	4.5×10^{-6}	1.2×10^{-2}
Residential	1.5×10^{-5}	4.2×10^{-2}
Recreational	8.9×10^{-6}	1.6×10^{-2}

GMA = Great Miami Aquifer
GMR = Great Miami River

000365





CURRENT FUTURE W/FEDERAL FUTURE W/O FEDERAL

OU2 CRARE CADFILE: 424331\AU12I11 AUG 1994

FIGURE 1.11-1
SUMMARY OF RECEPTOR HAZARDS AND RISKS

TABLE I.11-2

PATHWAY RISKS: CURRENT LAND USE SCENARIO

	Groundskeeper		Trespassing Child		Off-Property Farm Adult	
Pathway	**HI**	**ILCR**	**HI**	**ILCR**	**HI**	**ILCR**
Inhalation	Co 2.7×10^{-3}	Rn-222 1.8×10^{-5}	Co 1.5×10^{-4}	Cr 5.4×10^{-10} Rn-222 1.0×10^{-7}	Co 5.8×10^{-3} Ba 1.6×10^{-4}	Rn-222 4.8×10^{-5}
Subtotal:	2.7×10^{-3}	1.8×10^{-5}	1.5×10^{-4}	1.1×10^{-7}	6.0×10^{-3}	4.9×10^{-5}
Ingestion (Soil)	Sb 1.3×10^{-2} As 1.7×10^{-2} Mn 6.8×10^{-3} Tl 6.8×10^{-3}	As 8.7×10^{-6} Be 3.2×10^{-6}	As 1.1×10^{-2} Mn 4.6×10^{-3} Tl 4.6×10^{-3} Sb 8.9×10^{-3}	As 1.0×10^{-6} Be 3.7×10^{-7}	NA	NA
Subtotal:	6.1×10^{-2}	1.2×10^{-5}	4.1×10^{-2}	1.4×10^{-6}		
Dermal (Soil)	Sb 5.0×10^{-2} Mn 1.3×10^{-1} Cd 3.9×10^{-2}	Be 1.8×10^{-6} As 5.4×10^{-7}	Sb 1.2×10^{-2} Cd 9.7×10^{-3} Mn 3.2×10^{-2}	Be 7.7×10^{-8} As 2.3×10^{-8}	NA	NA
Subtotal:	2.6×10^{-1}	2.4×10^{-6}	6.5×10^{-2}	1.0×10^{-7}		
Dermal (Water) Bathing	NA	NA	NA	NA	NA	NA
Subtotal:						
Drinking Water	NA	NA	NA	NA	U 5.1×10^{-2}	U-234 7.3×10^{-6} U-238 5.4×10^{-6} Tc-99 2.6×10^{-5}
Subtotal:					5.1×10^{-2}	3.9×10^{-5}
Ingestion (Meat)	NA	NA	NA	NA	Hg 8.8×10^{-5} Z 1.9×10^{-4}	Tc-99 4.2×10^{-7}
Subtotal:					3.5×10^{-4}	4.9×10^{-7}
Ingestion (Dairy)	NA	NA	NA	NA	Ag 6.3×10^{-5} U 3.4×10^{-4} Z 7.4×10^{-5}	Tc-99 2.3×10^{-6}
Subtotal:					4.9×10^{-4}	2.3×10^{-6}
Ingestion (Vegetables and Fruit)	NA	NA	NA	NA	U 1.6×10^{-2}	Tc-99 8.7×10^{-6}
Subtotal:					1.6×10^{-2}	8.8×10^{-6}
External Radiation	NA	Ra-226 1.3×10^{-11} Ra-228 1.1×10^{-11} Th-228 1.3×10^{-11}	NA	Cs-137 2.3×10^{-7}	NA	NA
Subtotal:		4.4×10^{-11}		2.3×10^{-7}		
Ingestion (Wading)	NA	NA	U 1.4×10^{-3} As 4.6×10^{-4}	Tc-99 2.5×10^{-8} As 4.1×10^{-8}	NA	NA
Subtotal:			1.9×10^{-3}	8.4×10^{-8}		
Dermal (Water) Wading	NA	NA	U 1.2×10^{-1}	As 5.4×10^{-8} Be 3.9×10^{-9}	U 2.9×10^{-3}	Aroclor - 1221 5.8×10^{-34}
Subtotal:			1.2×10^{-1}	5.7×10^{-8}	2.9×10^{-3}	5.8×10^{-34}
Receptor Total:	3.3×10^{-1}	3.2×10^{-5}	2.3×10^{-1}	2.0×10^{-6}	7.7×10^{-2}	1.0×10^{-4}

TABLE I.11-3

PATHWAY RISKS: FUTURE LAND USE WITH FEDERAL OWNERSHIP

	Expanded Trespasser		Off-Property Farm Adult	
Pathway	**HI**	**ILCR**	**HI**	**ILCR**
Inhalation	Co 1.8×10^{-4}	Rn-222 1.7×10^{-7}	Co 5.8×10^{-3} Ba 1.6×10^{-4}	Rn-222 4.8×10^{-5}
Subtotal:	1.8×10^{-4}	1.7×10^{-7}	6.0×10^{3}	4.9×10^{-5}
Ingestion (Soil)	As 1.8×10^{-3} Mn 7.5×10^{-4} Sb 1.4×10^{-3} Tl 7.5×10^{-4}	As 2.1×10^{-7} Be 7.8×10^{-8}	NA	NA
Subtotal:	6.7×10^{-3}	2.9×10^{-7}		
Dermal (Soil)	Cd 2.7×10^{-2} Mn 8.9×10^{-2} Sb 3.4×10^{-2}	Be 3.0×10^{-7} As 8.9×10^{-8}	NA	NA
Subtotal:	1.8×10^{-1}	3.9×10^{-7}		
Dermal (Water) Bathing			U 2.4×10^{-1}	As 2.7×10^{-9}
Subtotal:	NA	NA	2.4×10^{-1}	2.7×10^{-9}
Drinking Water	NA	NA	U 4.1×10^{-1}	U-234 2.0×10^{-5} U-238 1.5×10^{-5} Tc-99 7.8×10^{-5}
Subtotal:			4.1×10^{-1}	1.1×10^{-4}
Ingestion (Meat)	NA	NA	U 1.6×10^{-4} Zn 1.9×10^{-4}	Sr-90 1.2×10^{-6}
Subtotal:			4.9×10^{-4}	1.2×10^{-6}
Ingestion (Dairy)	NA	NA	U 2.3×10^{-3}	Tc-99 7.0×10^{-6}
Subtotal:			2.4×10^{-3}	7.0×10^{-6}
Ingestion (Vegetables and Fruit)	NA	NA	U 1.2×10^{-1}	Tc-99 2.6×10^{-5}
Subtotal:			1.2×10^{-1}	2.7×10^{-5}
External Radiation	NA	Cs-137 6.8×10^{-7}	NA	NA
Subtotal:		6.8×10^{-7}		
Ingestion (Wading)	U 1.4×10^{-3} As 4.6×10^{-4}	As 4.1×10^{-8} Tc-99 2.5×10^{-8} U-238 5.3×10^{-9} Ra-226 2.0×10^{-9}	NA	NA
Subtotal:	1.9×10^{-3}	7.7×10^{-8}		
Dermal (Water) Wading	U 1.4×10^{-2}	As 6.5×10^{-8}	U 2.4×10^{-1}	As 2.7×10^{-9}
Subtotal:	4.2×10^{-2}	7.0×10^{-8}	2.4×10^{-1}	2.7×10^{-9}
Receptor Total:	2.3×10^{-1}	1.7×10^{-6}	7.8×10^{-1}	2.0×10^{-4}

TABLE I.11-4

PATHWAY RISKS:
FUTURE LAND USE WITHOUT FEDERAL OWNERSHIP[a]

	On-Property Farm Adult (Ingests Perched Groundwater)				On-Property Farm Adult (Ingests GMA Water)			
Pathway	**HI**		**ILCR**		**HI**		**ILCR**	
Inhalation	Co	7.0×10^{-3}	Rn-222	4.8×10^{-5}	Co	7.0×10^{-3}	Cr	2.0×10^{-7}
	Ba	2.5×10^{-4}			Ba	2.5×10^{-4}	Rn-222	4.8×10^{-5}
							U-234	6.4×10^{-7}
							U-238	3.5×10^{-7}
Subtotal:		7.3×10^{-3}		5.0×10^{-5}		7.3×10^{-3}		5.0×10^{-5}
Ingestion (Soil)	As	2.3×10^{-2}	As	1.2×10^{-5}	As	2.3×10^{-2}	As	1.2×10^{-5}
	Sb	1.8×10^{-2}	Be	4.4×10^{-6}	Sb	1.8×10^{-2}	Be	4.4×10^{-6}
					Tl	9.6×10^{-3}		
					Mn	9.5×10^{-3}		
Subtotal:		8.6×10^{-2}		1.7×10^{-5}		8.6×10^{-2}		1.7×10^{-5}
Dermal (Soil)	Mn	1.8×10^{-1}	Be	2.6×10^{-6}	Mn	1.8×10^{-1}	Be	2.6×10^{-6}
	Sb	7.2×10^{-2}	As	7.6×10^{-7}	Sb	7.0×10^{-2}		
	Cd	5.5×10^{-2}			Cd	5.5×10^{-2}		
Subtotal:		3.7×10^{-1}		3.3×10^{-6}		3.7×10^{-1}		3.3×10^{-6}
Dermal (Water) Bathing	U	3.5×10^{0}	Arocl-1221	3.2×10^{-2}	U	9.6×10^{-2}	As	6.4×10^{-6}
					Sb	1.6×10^{-2}	Be	3.9×10^{-7}
Subtotal:		4.0×10^{0}		3.2×10^{-2}		1.2×10^{-1}		6.8×10^{-6}
Drinking Water	U	6.1×10^{-1}	Arocl-1221	2.6×10^{-3}	Sb	8.5×10^{-2}	Tc-99	3.3×10^{-4}
	Sb	1.7×10^{0}	Np-237	3.6×10^{-3}	As	3.9×10^{-1}	As	2.0×10^{-4}
	As	3.7×10^{0}	As	1.9×10^{-3}	U	1.7×10^{0}	U-234	8.0×10^{-5}
							U-238	6.0×10^{-5}
Subtotal:		6.7×10^{1}		1.4×10^{-2}		2.1×10^{0}		7.1×10^{-4}
Ingestion (Meat)	Hg	1.4×10^{1}	Arocl-1254	3.7×10^{-5}	Hg	1.4×10^{1}	Arocl-1254	3.7×10^{-5}
	Zn	1.6×10^{0}	Arocl-1260	1.9×10^{-4}	Zn	1.6×10^{0}	Arocl-1260	1.9×10^{-4}
			As	8.8×10^{-5}			As	8.8×10^{-5}
							Tc-99	7.7×10^{-5}
Subtotal:		1.6×10^{1}		3.2×10^{-4}		1.6×10^{1}		4.0×10^{-4}
Ingestion (Dairy)	Ag	1.7×10^{0}	Arocl-1254	4.7×10^{-4}	Ag	1.7×10^{0}	Arocl-1254	1.1×10^{-4}
	U	8.2×10^{-1}	Sr-90	8.4×10^{-5}	U	8.2×10^{-1}	Arocl-1260	4.7×10^{-4}
	Zn	6.5×10^{-1}	Tc-99	3.7×10^{-4}	Zn	6.6×10^{-1}	Tc-99	3.7×10^{-4}
Subtotal:		4.1×10^{0}		1.07×10^{-3}		4.1×10^{0}		1.1×10^{-3}
Ingestion (Vegetables and Fruit)	B	4.2×10^{0}	As	3.3×10^{-4}	B	4.2×10^{0}	Tc-99	6.5×10^{-5}
	Mn	1.5×10^{0}	Be	2.9×10^{-5}	Cd	1.6×10^{0}	As	3.3×10^{-4}
	Cd	1.6×10^{0}	Tc-99	6.5×10^{-5}	Mn	1.5×10^{0}	Be	2.9×10^{-5}
			U-234	1.2×10^{-5}			U-234	1.2×10^{-5}
							U-238	9.0×10^{-6}
Subtotal:		9.9×10^{0}		4.5×10^{-4}		9.9×10^{0}		4.5×10^{-4}
External Radiation		NA	Th-222	3.0×10^{-10}		NA	Th-222	3.0×10^{-10}
			Th-238	1.3×10^{-10}			Th-238	1.3×10^{-10}
			Ra-226	1.4×10^{-10}			Ra-226	1.4×10^{-10}
			Ra-228	1.2×10^{-10}			Ra-228	1.2×10^{-10}
Subtotal:				8.2×10^{-10}				8.2×10^{-10}
Ingestion (Wading)		NA		NA		NA		NA
Subtotal:								
Dermal (Water) Wading		NA						
Subtotal:								
Receptor Total:		1.0×10^{2}		4.9×10^{-2}		3.3×10^{1}		2.8×10^{-3}

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LEGEND:
For Tables I.11-2 through I.11-4.

	On-Property Farm Adult			
Pathway	**HI**		**ILCR**	
Inhalation	Ba	5.2×10^{-1}	As	6.9×10^{-6}
	Co	1.4×10^{0}	Cr	5.2×10^{-6}
			Rn-222	3.6×10^{-5}
			U-238	5.5×10^{-5}
Subtotal:		2.3×10^{0}		1.9×10^{-4}
• • •		• • •		• • •
Receptor Total:		7.1×10^{1}		8.4×10^{-3}

Hypothetical RME Receptor

Significant COCs and their contribution to HI/ILCR

Pathway Total (includes all COCs)

Pathway or Route of Exposure

Receptor HI/ILCR Totals

COC = Contaminant of Concern

HI = Hazard Index

ILCR = Incremental Lifetime Cancer Risk

NA = Not Applicable

[a]Not shown: Off-property farm adult, which is identical under Future Land Use With Federal Ownership scenario (see Table I.11-3).

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TABLE I.11-5

ANALYSIS OF MAJOR IMPACTS ON TARGET ORGANS

	Off-Property Farm Child				On-Property Farm Adult (Perched)				On-Property Farm Adult (GMA)				On-Property Farm Child			
Air	Liver	1.62×10^{-2}	Co	1.62×10^{-1}	Liver	7.00×10^{-3}	Co	7.00×10^{-3}	Liver	7.00×10^{-3}	Co	7.00×10^{-3}	Liver	1.97×10^{-2}	Co	1.97×10^{-2}
Subtotal:				1.67×10^{-2}				7.26×10^{-3}				7.26×10^{-3}				2.04×10^{-2}
Water	Kidney	1.34×10^{0}	U	1.34×10^{0}	Body	2.03×10^{0}	Sb	2.03×10^{0}	Kidney	1.66×10^{0}	U	1.66×10^{0}	Body	1.98×10^{-1}	Sb	1.98×10^{-1}
					Skin	3.80×10^{0}	As	3.80×10^{0}					Skin	9.08×10^{-1}	As	9.08×10^{-1}
					Kidney	6.47×10^{1}	U	6.47×10^{1}					Kidney	3.88×10^{0}	U	3.88×10^{0}
Subtotal:				1.34×10^{0}				7.08×10^{1}				2.14×10^{0}				4.99×10^{0}
Soil	Not Calculated (Pathway Incomplete)				CNS	1.93×10^{-1}	Mn	1.93×10^{-1}	CNS	1.93×10^{-1}	Mn	1.93×10^{-1}	CNS	3.86×10^{-1}	Mn	3.86×10^{-1}
													Skin	2.34×10^{-1}	As	2.19×10^{-1}
													Body	3.02×10^{-1}	Sb	2.85×10^{-1}
													Kidney	1.73×10^{-1}	Cd	1.33×10^{-1}
Subtotal:								4.56×10^{-1}				4.56×10^{-1}				1.40×10^{0}
Food	Kidney	4.96×10^{-1}	U	4.96×10^{-1}	Kidney	1.72×10^{1}	U	1.10×10^{0}	Testis	4.37×10^{0}	B	4.37×10^{0}	Testis	1.79×10^{1}	B	1.79×10^{1}
							Hg	1.42×10^{1}	Kidney	1.72×10^{1}	Hg	1.42×10^{1}	Kidney	4.67×10^{1}	Hg	2.78×10^{1}
							Cd	1.93×10^{0}			Cd	1.93×10^{0}			Cd	9.27×10^{0}
					Testis	4.37×10^{0}	B	4.37×10^{0}			U	1.1×10^{0}			U	9.65×10^{0}
					CNS	1.68×10^{0}	Mn	1.68×10^{0}	Skin	3.03×10^{0}	Ag	2.21×10^{0}	Skin	2.28×10^{1}	Ag	1.99×10^{1}
					Skin	3.03×10^{0}	As	8.15×10^{-1}			As	8.15×10^{-1}			As	2.93×10^{0}
							Ag	2.21×10^{0}	Blood	2.56×10^{0}	Zn	2.56×10^{0}	Blood	1.09×10^{1}	Zn	1.09×10^{1}
					Blood	2.56×10^{0}	Zn	2.56×10^{0}					CNS	7.51×10^{0}	Mn	7.51×10^{0}
Subtotal:				4.99×10^{-1}				2.00×10^{1}				2.99×10^{1}				1.10×10^{2}
Receptor Total:				1.86×10^{0}				1.0×10^{2}				3.3×10^{1}				1.16×10^{2}

Body = Whole body
CNS = Central nervous system
Kdny = Kidney
None = None observed

Perched = Ingests perched water
GMA = Ingests Great Miami Aquifer water

Current Land Use Scenario

Table I.11-2 summarizes the pathway-specific risks for the Current Land Use receptors. The off-property farm adult receptor has a life-time cancer risk at the upper end of the target range of 10^{-4} to 10^{-6}, primarily due to the inhalation of particulate and, to a lesser extent, the consumption of groundwater from the south plume. Carcinogenic risks for the trespassing child are within the 10^{-4} to 10^{-6} range. The major pathway is ingestion of arsenic and beryllium, plus external radiation exposure from Cs-137. The groundskeeper is also within the target cancer risk range, with most of the risk coming from Rn-222 in the inhalation pathway, plus some contribution from the soil ingestion pathway.

The noncarcinogenic HIs are all below the benchmark of 1.0 for the trespassing child, the groundskeeper and the off-property resident farm receptors. The groundskeeper has the highest HI (3.3×10^{-1}), primarily due to dermal contact with soil (HI = 2.6×10^{-1}).

Future Land Use With Federal Ownership Scenario

The risks for receptors under the Future Land Use With Federal Ownership scenario are summarized by pathway in Table I.11-3. The carcinogenic risk results for the off-property receptor are similar to those found in the Current Land Use scenario. Carcinogenic risks are slightly above the range of 10^{-4} to 10^{-6} for this receptor with the major pathways being inhalation of Rn-222 and the ingestion of drinking water, and vegetables and fruit. The expanded trespasser has a much lower carcinogenic risk, with most of the risk coming from Cs-137 in the external radiation pathway.

Noncarcinogenic HIs are below 1.0 for both receptors. Dermal contact with soil presents the greatest HI risk for the expanded trespasser; and dermal contact with uranium in water while bathing and wading presents the greatest HI risk for the off-property farm adult.

Future Land Use Without Federal Ownership Scenario

Table I.11-4 summarizes the risks under the Future Land Use Without Federal Ownership scenario. Carcinogenic risks exceed the target level of 10^{-4} to 10^{-6} for the on-property farm (adult) receptors due to ingestion of drinking water, farm food products (Aroclors, Tc-99 and arsenic), and inhalation of Rn-222. The presence of the Aroclors is due to the very conservative biotransfer factors in the food chain modeling. See Section I.11.7 for more information. The

ingestion of perched groundwater increases the ILCR for the on-property adult farmer (adult) by more than 100 percent.

The on-property adult farm receptors both exceed the HI benchmark of 1.0, primarily due to the ingestion of drinking water meat, vegetables, and dairy products grown on the FEMP. The principal COCs are boron, cadmium, mercury, manganese, silver, zinc and uranium.

The off-property resident farm receptors (adult and child) have the same risk as for the Future Land Use With Federal Ownership scenario for both the HI and the ILCR.

Target Organ Impacts

An analysis of the major impact on target organs for all receptors whose HIs exceed the benchmark of 1 is presented in Table I.11-5. This analysis was performed for these receptors in order to determine which organs are adversely impacted and to identify the major contributing contaminants. For the contaminant RfDs and RfCs used in the noncarcinogenic health hazard analysis, the EPA IRIS database and HEAST were used as the sources of target organs/critical effects. The target organ impacts and responsible contaminants are summarized below.

For the off-property farm child receptor, the major target organs are the liver (cobalt) and the kidney (uranium).

For the on-property farm adult and child, the major target organs include the liver (cobalt), testis (boron), kidney (mercury, cadmium and uranium), skin (arsenic and silver), whole body (antimony), central nervous system (manganese), and blood (zinc).

I.11.3 SUMMARY OF UNCERTAINTIES

The preparation of this Operable Unit 2 CRARE employed conservative assumptions and the best scientific and engineering judgement consistent with the EPA guidance expressed in RAGS (EPA 1989l). The risk principles and equations found in the RAWPA were used throughout this analysis. The exposure parameters found in the Operable Unit 2 RI were used in this CRARE. Deviations are summarized in Section I.2.5. Results of the CRARE have identified points of departure from target risk ranges, as discussed in the NCP.

Inhalation of particulates and radon is a principal component of the carcinogenic and noncarcinogenic risks that exceed the target ranges. Another significant contributor is the deposition of dust on crops and the subsequent uptake of COCs into the food chain by plants. The two major elements of uncertainty in these pathways include the dust emission rate and food consumption parameters. The development of emission factors for air modeling and the use of the modeling results for the subsequent inhalation intake are likely overestimated. This potential overestimate is inherent in the RAWPA emission rate model, which was developed for short-term emissions. After using these models, it appears that some results tend to misrepresent the actual scenario. For example, the assumptions used in the Rapid Assessment Model for particulate emission generation may be inappropriate and may not reflect the true nature of the long term scenarios evaluated in the CRARE. Revisions to the RAWPA have been proposed, and when adapted, will be incorporated into future CRAREs.

The critical assumptions in this model are the percentage of vegetative cover, the resuspension rate at different wind speeds, and the surface characteristics of exposed soils. In this CRARE, a vegetative cover of 85 percent was assumed, which is a realistic value. The model is not designed to accurately produce different emission rates with different wind speeds and classes because the algorithm is designed for annual averages. The algorithm's effect on the varying emissions is unknown. A potential source of over-conservatism is the assumption that the uncovered surfaces were relatively smooth and consisted of loose, fine, silty particles.

One hundred percent of the meat and milk and fifty percent of the fruit and vegetables consumed by the on- and off-property farmers were assumed to come from their farms. This assumption is both conservative and unlikely as may fruits and vegetables such as citrus are not grown in the area, and some locally grown supplies would cease during winter months. The nature of the uncertainties associated with the RAWPA and other assumptions for the CRARE are summarized below and in Table I.11-6.

<u>COC Selection</u>. There are potential uncertainties in the selection and screening of COCs introduced via the modeling of COCs in the ambient environment over time and ambiguities associated with long-term groundwater pump and treat operations.

Toxicological Information and Models. The inhalation pathway risks are likely to be overestimated due to the conservatism of the inhalation RfDs and cancer slope factors. It is unlikely that any major exposure pathways have not been evaluated. There is uncertainty introduced for COCs which have no toxicity factors and the omission of TICs.

Exposure Pathways. It is unlikely that any major exposure pathways have not been evaluated.

Receptor Characterization. Due to the range of receptors selected, it is unlikely that a significant receptor has been left out. It must be noted that the use of a resident farm receptor is more conservative than the use of a residential receptor.

Exposure Point Concentrations. Modeling has indicated that the fugitive particulate emissions model may be overestimating emissions primarily since the source is modeled as a constantly replenished or "eternal" source. The applicability of the model needs to be further investigated and will be addressed in future CRAREs. The surface characteristics of the remediated FEMP need to be more fully characterized. The major uncertainty relating to groundwater modeling is due to source term uncertainty and the quantity of material leaching out of the disposal areas over time. This is also an uncertainty relating to rate of leaching (i.e., partitioning factors) from surface soil materials.

TABLE I.11-6

SUMMARY OF UNCERTAINTIES, ACTIONS FOR REDUCTION

Uncertainty Problem	Specification of Problem	Direction and Extent of Uncertainty	Effects on the Reported Risks	Actions for Reduction of Uncertainty
COC Selection				
1. Species of Contaminants	Not all COCs have been identified.	Low order of uncertainty. Probably localized in small areas: OU 3 and 4 trench	Probably underestimates risks by a factor less than 10.	Specific review of existing histories to determine if investigation of these three areas is warranted.
2. Quality of COC Information	Not all quantities are known and validated in various media.	Moderate order of uncertainty involving material volumes. Specific areas to address would include pipe/trench between OU4 and OU3 and OU3 soils.	Varied. Can overestimate or underestimate risk by more than 1 order of magnitude.	Focus calculations on known waste volumes and predict by facility capacities.
Toxicological Information and Models	Extrapolation of data missing RfDs or slope factors.	Underestimates COCs not quantified.	Varied. Can range from less than a factor of 10 to 1 order of magnitude.	Contact EPA ECAO to derive constants.
	Conservative derivation of slope factors and RfDs.	Overestimates risks for all COCs.	May overestimate risk by 2 to 3 orders of magnitude.	Re-evaluate derivations and conservative assumptions
	Linear dose-response modeling.	Overestimates risks for some contaminants.	May overestimate risks by several orders of magnitude.	Carefully evaluate toxicity data and risk results.
Exposure Pathways	Improbable pathways to receptors; lack of institutional controls after 70 years.	Depending on the land use, the receptors may represent an overestimate.	Moderate. Possibly 1 order of magnitude.	Establish end land use and guiding receptor for FEMP with EPA.
Receptor Characterization				
1. Expanded Trespasser	Exposure of 110 days per year may be excessive.	Mild overestimate for drinking water exposures by using a maximum concentration and swimming in Paddys Run, etc.	Overestimates by less than a factor of 3.	Propose to eliminate unlikely pathways.
2. Resident Farm Receptors	Assumption that 50 percent of fruit and vegetables and 100 percent of meat and milk is derived from the farm.	Overestimate.	Possibly a factor of 3.	Consider a reduction of consumption.
	Estimation of exposure parameters.	In general, the exposure parameters are mild overestimates.	Mild. Less than 1 order of magnitude.	Better characterization of living habits of receptors.

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TABLE I.11-6
(Continued)

Uncertainty Problem	Specification of Problem	Direction and Extent of Uncertainty	Effects on the Reported Risks	Actions for Reduction of Uncertainty
Exposure Point Concentration				
1. Air Concentrations	Surface soil concentrations.	Unknown due to lack of data.	Unknown.	Collect more data concerning surface soils and remediated soils.
	Dust emission rate relating to vegetative cover and particle size.	Vegetative cover assumptions may cause underestimate, particularly relating to farming activities. May be offset if particle size distribution shows low potential for particulate generation.	Mild. Less than 1 order of magnitude.	Gather site-specific soil particle size distribution data.
	Temporal correlation between particulate generation and dispersion not accounted for.	Overestimate of air particulate expansion.	Probably moderate. 1 order of magnitude or less.	Perform refined air modeling for particulates using short-term generation rates.
2. Groundwater Concentration	Migration rate.	Overestimate due to selecting small K_d values. This affects both concentrations and time of peak.	Moderate. 1 to 2 orders of magnitude.	Perform studies of site-specific K_d relating to specific media.
	Leachate concentrations.	Overestimate due to conservative assumptions, also availability of contaminants.	Moderate. 1 to 2 orders of magnitude.	Perform studies of leaching of contaminants from remediated and unremediated materials.
	Source term.	Direction is unknown due to the overall uncertainty in the extent of contamination. Could be an underestimate.	Moderate. Could vary both plus and minus 1 order of magnitude.	Improve characterization.
3. Farm Product Concentrations	Toxicity of COC on Farm Product.	Could be an overestimate.	Unknown.	Specific review of data on COC toxicity on farm products. Risks are currently calculated assuming crops are irrigated with contaminated groundwater. In actuality, studies of the area indicate that rainwater is the primary source of crop water.

Groundwater Modeling. Current groundwater modeling predicts that the highest cancer risk in this pathway will be associated with COCs leaching from the site-wide soil, which will be addressed by Operable Unit 5. An important consideration is that the accuracy of the groundwater modeling depends on the representativeness of the geochemical, surface-water and vadose-zone transport modeling. These processes are affected by many parameters, some of which vary by orders of magnitude across the site. The use of a numerical, multi-dimensional vadose-zone model, rather than the analytical ODAST model, is also being evaluated. These developments should reduce the uncertainty associated with the geochemical and vadose-zone simulations, and may cause major changes in the groundwater modeling results.

I.12.0

I.12.0 CONCLUSIONS AND RECOMMENDATIONS

I.12.1 OPERABLE UNIT CONTRIBUTIONS TO RISK

Each operable unit's contribution to site-wide risk is specific to the RME receptor point selected. Since this CRARE reflects the predicted point of maximum impact, each RME receptor is proximate to the most influential source. The removal off-property of Operable Unit 1 and 4 wastes, the removal of Operable Unit 2 wastes to the disposal cell, and the sealing of Operable Unit 3 wastes in vaults will leave no significant source terms for RME receptors. The volume of uncapped remediated soils from Operable Unit 5 is therefore predicted to provide the bulk of residual risk under postremediation conditions.

Operable Unit 1 and 2 Contributions to FEMP Residual Risk

The Operable Unit 2 Disposal Cell design, as well as the removal of Operable Unit 1 material off-property, will preclude these sources from contributing significant risk to human health or the environment. These operable units are estimated to contribute less than two percent of the total site risk to any one receptor through the groundwater, surface water, soil ingestion, and dermal contact with soils pathways. Total risk contributions for Operable Units 1 and 2 via the air pathway are 0.71 and 1.31 percent, respectively.

Operable Unit 4 Contributions to FEMP Residual Risk

Operable Unit 4 contributes very little to the carcinogenic and noncarcinogenic risks. The majority of the COCs from Operable Unit 4 will be removed off-site or isolated in the vaults, away from human contact and the environment. Less than 1.72 percent of radionuclide emissions are from Operable Unit 4 under the Future Land Use scenario.

Operable Unit 3 and 5 Contributions to FEMP Residual Risk

Operable Unit 5 contamination is associated with almost all of the residual risk after FEMP remediation. Under the Current Land Use scenario, approximately 99 percent of radionuclide emissions are from Operable Unit 5 (the former production area soils and the remaining FEMP surface soil). The soil beneath the former production area accounts for approximately 99 percent

TABLE I.12-1

OPERABLE UNIT CONTRIBUTIONS TO RISK

Contributions to Radiological Risk: Air/Radiation Exposure Based on Emissions

	Contribution (%)[1]				
RME Receptor	**OU1**	**OU2**	**OU3**	**OU4**	**OU5**
Trespassers	0.71	1.31	<0.01	1.72	96.26
Groundskeeper	0.71	1.31	<0.01	1.72	96.26
Off-Property Resident (Adult)	0.71	1.31	<0.01	1.72	96.26
On-Property Resident (Adult)	0.71	1.31	<0.01	1.72	96.26

Source: Attachment I.II-3 of this CRARE and based on the following:

$$\text{Contribution\%} = \frac{\Sigma \text{ radionuclides emissions for one OU}}{\Sigma \text{ radionuclide emissions all OUs}} \times 100$$

Contributions to Radiological and Chemical Risk: COC Mass Loading in Ground/Surface Water

	Contribution (%)				
	OU1	**OU2**	**OU3**	**OU4**	**OU5**
COC Mass/Total Mass (mg/l)	<0.01	<0.01	<0.01	<0.01	99.7

Source: Tables I.6-4 and I.6-6 of this CRARE.

Contributions to Carcinogenic Risk: Ingestion of and Dermal Contact with Soil

	Contribution (%)				
RME Receptor	**OU1**	**OU2**	**OU3**	**OU4**	**OU5**
Trespassers	<0.01	<0.01	<0.01	<0.01	>99.00
Groundskeeper	<0.01	<0.01	<0.01	<0.01	>99.00
On-Property Resident (Adult)	<0.01	<0.01	<0.01	<0.01	>99.00

Source: Attachment I.II-1 of this CRARE.

of the off-property resident risk. It also accounts for approximately 99 percent of the on-property groundskeeper and trespasser risk associated with direct inhalation of radionuclides.

Under the two Future Land Use scenarios, atmospheric emissions from Operable Unit 5 result in the largest contributions to inhalation pathway cancer risks. The majority of the radionuclide emissions are from Operable Unit 5 areas, indicating that this operable unit is the major contributor to the inhalation pathway risks. The soil beneath the former production area accounts for approximately 99 percent of the cancer risk for the on-property resident, off-property resident, and expanded trespasser. Surface soil from the remainder of the FEMP accounts for the remaining risks.

I.12.2 CONCLUSIONS

Scenarios

For all three land use scenarious all receptors are above the ILCR of 10^{-6}. All receptors in the Current Land Use scenario are below the HI of 1.0. For the Future Land Use with Federal Ownership, all receptors are less than the HI of 1.0 except for the off-property farmer (child) which has an HI of 1.8. For the Future Land Use Without Federal Ownership only the off-property farmer (adult) has an HI less than 1.0. All GMR users have an HI of less than 1.0.

COCs

The detailed risk analysis indicates that the major radionuclides of concern are U-234, U-238, Tc−99, Th-228, Rn-222. The principal contributors to the chemical carcinogenic risk are arsenic, beryllium, chromium, and the PCBs. The principal contributors to the HI are antimony, arsenic, boron, cadmium, cobalt, manganese, mercury, molybdenum, silver, and zinc.

Remedial Action

For the RME receptors evaluated, most of the residual risk is contributed by the Operable Unit 5 soils. The conclusion reached by applying the CRARE process is that the FEMP would appear to be unsuitable as a family farm even after remediation is complete. Also, to meet the ILCR and HI criteria for off-property farm residents, additional information specific to the Operable 5 Feasibility Study will be needed.

I.12.3 RECOMMENDATIONS

Because the majority of the FEMP residual risk is associated with Operable Unit 5 soils, future CRAREs should focus on refining and completing information on this unit. For example, more accurate modeling of COC concentrations, less than the cleanup levels for the Operable Unit 5 soils, would decrease risk. Additional recommended measures to reduce uncertainty in the CRARE need to be evaluated in the Operable Unit 5 FS. Other specific recommendations would include:

- Conduct bench-scale testing to determine changes in remediated soil conditions, for modeling purposes.
- Conduct investigations into the physical characteristics of the remediated soils and develop an appropriate fugitive particulate emission model for long-term risk analysis.
- Conduct risk mapping to show isopleths describing the areas where the ILCR is less than 10^{-4} and the HI is less than 1. As shown in this CRARE, the risk of a modeled receptor is a function of several factors, including its location and the cumulative source terms of the area under study. Consequently, a bias is introduced by using only one receptor point to predict on-property farm resident risk. Risk mapping will facilitate the free-release of areas for development and avoid relying on a single point for health risk modeling.

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I.13.0 REFERENCES

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Attachments

ATTACHMENT I.I

U-238 MASS LOADINGS TO SWIFT III MODEL

ATTACHMENT I.I
U-238 MASS LOADINGS TO SWIFT III MODEL

OU-5 RESIDUAL SOILS

TIME (YR)	REMAINING SOURCE MASS (MG)	MASS EXITING BOTTOM	DECAYED + SORBED + DISSOLVED
10.	0.2943D+12	0.7861D+00	0.1133D+10
20.	0.2931D+12	0.9740D+02	0.2261D+10
30.	0.2920D+12	0.8874D+03	0.3382D+10
40.	0.2909D+12	0.3620D+04	0.4497D+10
50.	0.2898D+12	0.9360D+04	0.5605D+10
60.	0.2887D+12	0.1877D+05	0.6707D+10
70.	0.2876D+12	0.3229D+05	0.7805D+10
80.	0.2865D+12	0.5630D+05	0.8896D+10
90.	0.2854D+12	0.1128D+06	0.9980D+10
100.	0.2844D+12	0.2144D+06	0.1106D+11
110.	0.2832D+12	0.3480D+06	0.1213D+11
120.	0.2822D+12	0.4986D+06	0.1320D+11
130.	0.2811D+12	0.6587D+06	0.1426D+11
140.	0.2801D+12	0.8252D+06	0.1532D+11
150.	0.2790D+12	0.9962D+06	0.1637D+11
160.	0.2780D+12	0.1171D+07	0.1741D+11
170.	0.2769D+12	0.1347D+07	0.1845D+11
180.	0.2759D+12	0.1526D+07	0.1949D+11
190.	0.2749D+12	0.1707D+07	0.2052D+11
200.	0.2738D+12	0.1888D+07	0.2154D+11
210.	0.2728D+12	0.2070D+07	0.2256D+11
220.	0.2718D+12	0.2254D+07	0.2357D+11
230.	0.2708D+12	0.2438D+07	0.2458D+11
240.	0.2698D+12	0.2622D+07	0.2558D+11
250.	0.2688D+12	0.2807D+07	0.2658D+11
260.	0.2678D+12	0.2993D+07	0.2757D+11
270.	0.2668D+12	0.3178D+07	0.2856D+11
280.	0.2659D+12	0.3365D+07	0.2954D+11
290.	0.2648D+12	0.3554D+07	0.3052D+11
300.	0.2639D+12	0.3747D+07	0.3149D+11
310.	0.2629D+12	0.3945D+07	0.3246D+11
320.	0.2620D+12	0.4158D+07	0.3342D+11
330.	0.2610D+12	0.4388D+07	0.3438D+11
340.	0.2600D+12	0.4649D+07	0.3533D+11
350.	0.2591D+12	0.4957D+07	0.3628D+11
360.	0.2582D+12	0.5329D+07	0.3722D+11
370.	0.2572D+12	0.5790D+07	0.3816D+11
380.	0.2562D+12	0.6369D+07	0.3910D+11
390.	0.2553D+12	0.7102D+07	0.4003D+11
400.	0.2544D+12	0.8024D+07	0.4095D+11
410.	0.2535D+12	0.9180D+07	0.4187D+11
420.	0.2526D+12	0.1061D+08	0.4279D+11
430.	0.2517D+12	0.1237D+08	0.4370D+11
440.	0.2508D+12	0.1451D+08	0.4460D+11
450.	0.2499D+12	0.1706D+08	0.4550D+11
460.	0.2490D+12	0.2009D+08	0.4640D+11
470.	0.2481D+12	0.2365D+08	0.4729D+11

480.	0.2471D+12	0.2777D+08	0.4818D+11
490.	0.2463D+12	0.3251D+08	0.4906D+11
500.	0.2454D+12	0.3792D+08	0.4994D+11
510.	0.2445D+12	0.4404D+08	0.5081D+11
520.	0.2437D+12	0.5092D+08	0.5168D+11
530.	0.2428D+12	0.5861D+08	0.5254D+11
540.	0.2419D+12	0.6717D+08	0.5340D+11
550.	0.2411D+12	0.7665D+08	0.5425D+11
560.	0.2402D+12	0.8714D+08	0.5511D+11
570.	0.2393D+12	0.9869D+08	0.5595D+11
580.	0.2385D+12	0.1114D+09	0.5678D+11
590.	0.2376D+12	0.1254D+09	0.5762D+11
600.	0.2368D+12	0.1408D+09	0.5844D+11
610.	0.2360D+12	0.1576D+09	0.5927D+11
620.	0.2351D+12	0.1761D+09	0.6008D+11
630.	0.2343D+12	0.1964D+09	0.6090D+11
640.	0.2334D+12	0.2186D+09	0.6170D+11
650.	0.2326D+12	0.2429D+09	0.6250D+11
660.	0.2318D+12	0.2695D+09	0.6330D+11
670.	0.2310D+12	0.2985D+09	0.6408D+11
680.	0.2302D+12	0.3302D+09	0.6487D+11
690.	0.2294D+12	0.3647D+09	0.6564D+11
700.	0.2285D+12	0.4021D+09	0.6642D+11
710.	0.2277D+12	0.4427D+09	0.6718D+11
720.	0.2270D+12	0.4865D+09	0.6793D+11
730.	0.2262D+12	0.5338D+09	0.6868D+11
740.	0.2254D+12	0.5846D+09	0.6942D+11
750.	0.2246D+12	0.6390D+09	0.7016D+11
760.	0.2238D+12	0.6973D+09	0.7089D+11
770.	0.2230D+12	0.7594D+09	0.7162D+11
780.	0.2222D+12	0.8254D+09	0.7232D+11
790.	0.2215D+12	0.8954D+09	0.7299D+11
800.	0.2210D+12	0.9695D+09	0.7344D+11
810.	0.2205D+12	0.1048D+10	0.7389D+11
820.	0.2199D+12	0.1130D+10	0.7433D+11
830.	0.2194D+12	0.1216D+10	0.7477D+11
840.	0.2189D+12	0.1307D+10	0.7519D+11
850.	0.2184D+12	0.1401D+10	0.7561D+11
860.	0.2179D+12	0.1500D+10	0.7602D+11
870.	0.2174D+12	0.1602D+10	0.7643D+11
880.	0.2168D+12	0.1709D+10	0.7682D+11
890.	0.2163D+12	0.1820D+10	0.7721D+11
900.	0.2159D+12	0.1934D+10	0.7759D+11
910.	0.2154D+12	0.2053D+10	0.7797D+11
920.	0.2149D+12	0.2175D+10	0.7834D+11
930.	0.2144D+12	0.2301D+10	0.7870D+11
940.	0.2139D+12	0.2430D+10	0.7906D+11
950.	0.2134D+12	0.2564D+10	0.7941D+11
960.	0.2129D+12	0.2701D+10	0.7975D+11
970.	0.2124D+12	0.2841D+10	0.8009D+11
980.	0.2120D+12	0.2985D+10	0.8042D+11
990.	0.2115D+12	0.3133D+10	0.8075D+11
1000.	0.2111D+12	0.3283D+10	0.8106D+11

EAST VAULT :

TIME (YR)	REMAINING SOURCE MASS (MG)	MASS EXITING BOTTOM	DECAYED + SORBED + DISSOLVED
10.	0.2635D+13	0.0000D+00	0.1186D+06
20.	0.2635D+13	0.0000D+00	0.2371D+06
30.	0.2635D+13	0.0000D+00	0.3557D+06
40.	0.2635D+13	0.0000D+00	0.4742D+06
50.	0.2635D+13	0.0000D+00	0.5928D+06
60.	0.2635D+13	0.0000D+00	0.7113D+06
70.	0.2635D+13	0.0000D+00	0.8299D+06
80.	0.2635D+13	0.0000D+00	0.9485D+06
90.	0.2635D+13	0.0000D+00	0.1067D+07
100.	0.2635D+13	0.0000D+00	0.1186D+07
110.	0.2635D+13	0.0000D+00	0.1304D+07
120.	0.2635D+13	0.0000D+00	0.1423D+07
130.	0.2635D+13	0.0000D+00	0.1541D+07
140.	0.2635D+13	0.0000D+00	0.1660D+07
150.	0.2635D+13	0.0000D+00	0.1778D+07
160.	0.2635D+13	0.0000D+00	0.1897D+07
170.	0.2635D+13	0.0000D+00	0.2015D+07
180.	0.2635D+13	0.0000D+00	0.2134D+07
190.	0.2635D+13	0.0000D+00	0.2253D+07
200.	0.2635D+13	0.0000D+00	0.2371D+07
210.	0.2635D+13	0.0000D+00	0.2490D+07
220.	0.2635D+13	0.0000D+00	0.2608D+07
230.	0.2635D+13	0.0000D+00	0.2727D+07
240.	0.2635D+13	0.0000D+00	0.2845D+07
250.	0.2635D+13	0.0000D+00	0.2964D+07
260.	0.2635D+13	0.0000D+00	0.3082D+07
270.	0.2635D+13	0.0000D+00	0.3201D+07
280.	0.2635D+13	0.0000D+00	0.3320D+07
290.	0.2635D+13	0.0000D+00	0.3438D+07
300.	0.2635D+13	0.0000D+00	0.3557D+07
310.	0.2635D+13	0.0000D+00	0.3675D+07
320.	0.2635D+13	0.0000D+00	0.3794D+07
330.	0.2635D+13	0.0000D+00	0.3912D+07
340.	0.2635D+13	0.0000D+00	0.4031D+07
350.	0.2635D+13	0.0000D+00	0.4150D+07
360.	0.2635D+13	0.0000D+00	0.4268D+07
370.	0.2635D+13	0.0000D+00	0.4387D+07
380.	0.2635D+13	0.0000D+00	0.4505D+07
390.	0.2635D+13	0.0000D+00	0.4624D+07
400.	0.2635D+13	0.0000D+00	0.4742D+07
410.	0.2635D+13	0.0000D+00	0.4861D+07
420.	0.2635D+13	0.0000D+00	0.4979D+07
430.	0.2635D+13	0.0000D+00	0.5098D+07
440.	0.2635D+13	0.0000D+00	0.5217D+07
450.	0.2635D+13	0.0000D+00	0.5335D+07
460.	0.2635D+13	0.0000D+00	0.5454D+07
470.	0.2635D+13	0.0000D+00	0.5572D+07
480.	0.2635D+13	0.0000D+00	0.5691D+07
490.	0.2635D+13	0.0000D+00	0.5809D+07
500.	0.2635D+13	0.0000D+00	0.5928D+07
510.	0.2635D+13	0.0000D+00	0.6046D+07
520.	0.2635D+13	0.0000D+00	0.6165D+07
530.	0.2635D+13	0.0000D+00	0.6284D+07

540.	0.2635D+13	0.0000D+00	0.6402D+07
550.	0.2635D+13	0.0000D+00	0.6521D+07
560.	0.2635D+13	0.0000D+00	0.6639D+07
570.	0.2635D+13	0.0000D+00	0.6758D+07
580.	0.2635D+13	0.0000D+00	0.6876D+07
590.	0.2635D+13	0.0000D+00	0.6995D+07
600.	0.2635D+13	0.0000D+00	0.7113D+07
610.	0.2635D+13	0.0000D+00	0.7232D+07
620.	0.2635D+13	0.0000D+00	0.7351D+07
630.	0.2635D+13	0.0000D+00	0.7469D+07
640.	0.2635D+13	0.0000D+00	0.7588D+07
650.	0.2635D+13	0.0000D+00	0.7706D+07
660.	0.2635D+13	0.0000D+00	0.7825D+07
670.	0.2635D+13	0.0000D+00	0.7943D+07
680.	0.2635D+13	0.0000D+00	0.8062D+07
690.	0.2635D+13	0.0000D+00	0.8180D+07
700.	0.2635D+13	0.0000D+00	0.8299D+07
710.	0.2635D+13	0.0000D+00	0.8418D+07
720.	0.2635D+13	0.0000D+00	0.8536D+07
730.	0.2635D+13	0.0000D+00	0.8655D+07
740.	0.2635D+13	0.0000D+00	0.8773D+07
750.	0.2635D+13	0.0000D+00	0.8892D+07
760.	0.2635D+13	0.0000D+00	0.9010D+07
770.	0.2635D+13	0.0000D+00	0.9129D+07
780.	0.2635D+13	0.0000D+00	0.9247D+07
790.	0.2635D+13	0.0000D+00	0.9366D+07
800.	0.2635D+13	0.0000D+00	0.9485D+07
810.	0.2635D+13	0.0000D+00	0.9603D+07
820.	0.2635D+13	0.0000D+00	0.9722D+07
830.	0.2635D+13	0.0000D+00	0.9840D+07
840.	0.2635D+13	0.0000D+00	0.9959D+07
850.	0.2635D+13	0.0000D+00	0.1008D+08
860.	0.2635D+13	0.0000D+00	0.1020D+08
870.	0.2635D+13	0.0000D+00	0.1031D+08
880.	0.2635D+13	0.0000D+00	0.1043D+08
890.	0.2635D+13	0.0000D+00	0.1055D+08
900.	0.2635D+13	0.0000D+00	0.1067D+08
910.	0.2635D+13	0.0000D+00	0.1079D+08
920.	0.2635D+13	0.0000D+00	0.1091D+08
930.	0.2635D+13	0.0000D+00	0.1103D+08
940.	0.2635D+13	0.0000D+00	0.1114D+08
950.	0.2635D+13	0.0000D+00	0.1126D+08
960.	0.2635D+13	0.0000D+00	0.1138D+08
970.	0.2635D+13	0.0000D+00	0.1150D+08
980.	0.2635D+13	0.0000D+00	0.1162D+08
990.	0.2635D+13	0.0000D+00	0.1174D+08
1000.	0.2635D+13	0.0000D+00	0.1186D+08

OU-4 RESIDUAL SOILS :

TIME (YR)	REMAINING SOURCE MASS (MG)	MASS EXITING BOTTOM	DECAYED + SORBED + DISSOLVED
10.	0.9283D+07	0.0000D+00	0.1547D+07
20.	0.7736D+07	0.0000D+00	0.3094D+07
30.	0.6189D+07	0.0000D+00	0.4641D+07
40.	0.4641D+07	0.0000D+00	0.6189D+07
50.	0.3094D+07	0.0000D+00	0.7736D+07

60.	0.1547D+07	0.0000D+00	0.9283D+07
70.	0.0000D+00	0.0000D+00	0.1083D+08
80.	0.0000D+00	0.0000D+00	0.1083D+08
90.	0.0000D+00	0.1682D-43	0.1083D+08
100.	0.0000D+00	0.4867D-36	0.1083D+08
110.	0.0000D+00	0.4922D-30	0.1083D+08
120.	0.0000D+00	0.3941D-25	0.1083D+08
130.	0.0000D+00	0.4498D-21	0.1083D+08
140.	0.0000D+00	0.1117D-17	0.1083D+08
150.	0.0000D+00	0.8237D-15	0.1083D+08
160.	0.0000D+00	0.2284D-12	0.1083D+08
170.	0.0000D+00	0.2850D-10	0.1083D+08
180.	0.0000D+00	0.1842D-08	0.1083D+08
190.	0.0000D+00	0.6888D-07	0.1083D+08
200.	0.0000D+00	0.1629D-05	0.1083D+08
210.	0.0000D+00	0.2619D-04	0.1083D+08
220.	0.0000D+00	0.3031D-03	0.1083D+08
230.	0.0000D+00	0.2652D-02	0.1083D+08
240.	0.0000D+00	0.1825D-01	0.1083D+08
250.	0.0000D+00	0.1020D+00	0.1083D+08
260.	0.0000D+00	0.4806D+00	0.1083D+08
270.	0.0000D+00	0.1923D+01	0.1083D+08
280.	0.0000D+00	0.6706D+01	0.1083D+08
290.	0.0000D+00	0.2073D+02	0.1083D+08
300.	0.0000D+00	0.5767D+02	0.1083D+08
310.	0.0000D+00	0.1462D+03	0.1083D+08
320.	0.0000D+00	0.3410D+03	0.1083D+08
330.	0.0000D+00	0.7394D+03	0.1083D+08
340.	0.0000D+00	0.1501D+04	0.1083D+08
350.	0.0000D+00	0.2874D+04	0.1083D+08
360.	0.0000D+00	0.5217D+04	0.1082D+08
370.	0.0000D+00	0.9027D+04	0.1082D+08
380.	0.0000D+00	0.1495D+05	0.1082D+08
390.	0.0000D+00	0.2381D+05	0.1081D+08
400.	0.0000D+00	0.3655D+05	0.1079D+08
410.	0.0000D+00	0.5427D+05	0.1078D+08
420.	0.0000D+00	0.7817D+05	0.1075D+08
430.	0.0000D+00	0.1095D+06	0.1072D+08
440.	0.0000D+00	0.1494D+06	0.1068D+08
450.	0.0000D+00	0.1990D+06	0.1063D+08
460.	0.0000D+00	0.2594D+06	0.1057D+08
470.	0.0000D+00	0.3312D+06	0.1050D+08
480.	0.0000D+00	0.4151D+06	0.1041D+08
490.	0.0000D+00	0.5114D+06	0.1032D+08
500.	0.0000D+00	0.6201D+06	0.1021D+08
510.	0.0000D+00	0.7410D+06	0.1009D+08
520.	0.0000D+00	0.8737D+06	0.9956D+07
530.	0.0000D+00	0.1018D+07	0.9812D+07
540.	0.0000D+00	0.1172D+07	0.9658D+07
550.	0.0000D+00	0.1337D+07	0.9493D+07
560.	0.0000D+00	0.1511D+07	0.9319D+07
570.	0.0000D+00	0.1693D+07	0.9137D+07
580.	0.0000D+00	0.1883D+07	0.8947D+07
590.	0.0000D+00	0.2081D+07	0.8749D+07
600.	0.0000D+00	0.2286D+07	0.8544D+07
610.	0.0000D+00	0.2497D+07	0.8333D+07
620.	0.0000D+00	0.2715D+07	0.8115D+07
630.	0.0000D+00	0.2939D+07	0.7891D+07
640.	0.0000D+00	0.3170D+07	0.7660D+07

650.	0.0000D+00	0.3406D+07	0.7424D+07
660.	0.0000D+00	0.3647D+07	0.7183D+07
670.	0.0000D+00	0.3895D+07	0.6935D+07
680.	0.0000D+00	0.4147D+07	0.6683D+07
690.	0.0000D+00	0.4403D+07	0.6427D+07
700.	0.0000D+00	0.4664D+07	0.6166D+07
710.	0.0000D+00	0.4928D+07	0.5902D+07
720.	0.0000D+00	0.5195D+07	0.5635D+07
730.	0.0000D+00	0.5463D+07	0.5367D+07
740.	0.0000D+00	0.5732D+07	0.5098D+07
750.	0.0000D+00	0.6001D+07	0.4829D+07
760.	0.0000D+00	0.6268D+07	0.4562D+07
770.	0.0000D+00	0.6533D+07	0.4297D+07
780.	0.0000D+00	0.6794D+07	0.4036D+07
790.	0.0000D+00	0.7051D+07	0.3779D+07
800.	0.0000D+00	0.7302D+07	0.3528D+07
810.	0.0000D+00	0.7546D+07	0.3284D+07
820.	0.0000D+00	0.7783D+07	0.3047D+07
830.	0.0000D+00	0.8011D+07	0.2819D+07
840.	0.0000D+00	0.8231D+07	0.2599D+07
850.	0.0000D+00	0.8440D+07	0.2390D+07
860.	0.0000D+00	0.8640D+07	0.2190D+07
870.	0.0000D+00	0.8829D+07	0.2001D+07
880.	0.0000D+00	0.9008D+07	0.1822D+07
890.	0.0000D+00	0.9176D+07	0.1654D+07
900.	0.0000D+00	0.9333D+07	0.1497D+07
910.	0.0000D+00	0.9479D+07	0.1351D+07
920.	0.0000D+00	0.9615D+07	0.1215D+07
930.	0.0000D+00	0.9740D+07	0.1090D+07
940.	0.0000D+00	0.9855D+07	0.9746D+06
950.	0.0000D+00	0.9961D+07	0.8689D+06
960.	0.0000D+00	0.1006D+08	0.7723D+06
970.	0.0000D+00	0.1015D+08	0.6846D+06
980.	0.0000D+00	0.1022D+08	0.6050D+06
990.	0.0000D+00	0.1030D+08	0.5332D+06
1000.	0.0000D+00	0.1036D+08	0.4686D+06

OU-1 RESIDUAL SOILS :

TIME (YR)	REMAINING SOURCE MASS (MG)	MASS EXITING BOTTOM	DECAYED + SORBED + DISSOLVED
10.	0.2867D+11	0.0000D+00	0.8491D+08
20.	0.2859D+11	0.0000D+00	0.1695D+09
30.	0.2850D+11	0.0000D+00	0.2538D+09
40.	0.2842D+11	0.0000D+00	0.3378D+09
50.	0.2833D+11	0.0000D+00	0.4215D+09
60.	0.2825D+11	0.0000D+00	0.5050D+09
70.	0.2817D+11	0.0000D+00	0.5881D+09
80.	0.2809D+11	0.0000D+00	0.6709D+09
90.	0.2800D+11	0.0000D+00	0.7535D+09
100.	0.2792D+11	0.0000D+00	0.8357D+09
110.	0.2784D+11	0.0000D+00	0.9176D+09
120.	0.2775D+11	0.0000D+00	0.9993D+09
130.	0.2767D+11	0.0000D+00	0.1081D+10
140.	0.2760D+11	0.0000D+00	0.1161D+10
150.	0.2752D+11	0.0000D+00	0.1242D+10

160.	0.2743D+11	0.0000D+00	0.1323D+10
170.	0.2735D+11	0.0000D+00	0.1404D+10
180.	0.2728D+11	0.0000D+00	0.1483D+10
190.	0.2720D+11	0.0000D+00	0.1563D+10
200.	0.2711D+11	0.0000D+00	0.1643D+10
210.	0.2704D+11	0.0000D+00	0.1721D+10
220.	0.2696D+11	0.0000D+00	0.1800D+10
230.	0.2688D+11	0.0000D+00	0.1879D+10
240.	0.2680D+11	0.0000D+00	0.1957D+10
250.	0.2672D+11	0.0000D+00	0.2035D+10
260.	0.2665D+11	0.0000D+00	0.2113D+10
270.	0.2656D+11	0.0000D+00	0.2190D+10
280.	0.2649D+11	0.0000D+00	0.2267D+10
290.	0.2641D+11	0.0000D+00	0.2344D+10
300.	0.2634D+11	0.0000D+00	0.2421D+10
310.	0.2626D+11	0.0000D+00	0.2498D+10
320.	0.2618D+11	0.0000D+00	0.2573D+10
330.	0.2611D+11	0.0000D+00	0.2649D+10
340.	0.2603D+11	0.0000D+00	0.2725D+10
350.	0.2596D+11	0.0000D+00	0.2800D+10
360.	0.2588D+11	0.0000D+00	0.2875D+10
370.	0.2581D+11	0.0000D+00	0.2950D+10
380.	0.2574D+11	0.0000D+00	0.3024D+10
390.	0.2566D+11	0.0000D+00	0.3098D+10
400.	0.2559D+11	0.0000D+00	0.3173D+10
410.	0.2552D+11	0.0000D+00	0.3247D+10
420.	0.2543D+11	0.0000D+00	0.3319D+10
430.	0.2536D+11	0.0000D+00	0.3393D+10
440.	0.2529D+11	0.0000D+00	0.3466D+10
450.	0.2522D+11	0.0000D+00	0.3538D+10
460.	0.2514D+11	0.0000D+00	0.3611D+10
470.	0.2507D+11	0.0000D+00	0.3683D+10
480.	0.2501D+11	0.0000D+00	0.3754D+10
490.	0.2494D+11	0.0000D+00	0.3826D+10
500.	0.2486D+11	0.0000D+00	0.3898D+10
510.	0.2479D+11	0.0000D+00	0.3970D+10
520.	0.2472D+11	0.0000D+00	0.4040D+10
530.	0.2464D+11	0.0000D+00	0.4111D+10
540.	0.2458D+11	0.0000D+00	0.4180D+10
550.	0.2451D+11	0.0000D+00	0.4251D+10
560.	0.2444D+11	0.0000D+00	0.4321D+10
570.	0.2436D+11	0.0000D+00	0.4391D+10
580.	0.2430D+11	0.0000D+00	0.4460D+10
590.	0.2423D+11	0.0000D+00	0.4529D+10
600.	0.2416D+11	0.0000D+00	0.4599D+10
610.	0.2409D+11	0.0000D+00	0.4667D+10
620.	0.2402D+11	0.0000D+00	0.4735D+10
630.	0.2396D+11	0.0000D+00	0.4804D+10
640.	0.2389D+11	0.0000D+00	0.4871D+10
650.	0.2382D+11	0.0000D+00	0.4939D+10
660.	0.2375D+11	0.0000D+00	0.5007D+10
670.	0.2369D+11	0.0000D+00	0.5074D+10
680.	0.2361D+11	0.0000D+00	0.5141D+10
690.	0.2355D+11	0.0000D+00	0.5208D+10
700.	0.2348D+11	0.0000D+00	0.5274D+10
710.	0.2342D+11	0.0000D+00	0.5341D+10
720.	0.2335D+11	0.0000D+00	0.5407D+10
730.	0.2328D+11	0.0000D+00	0.5472D+10
740.	0.2322D+11	0.0000D+00	0.5538D+10

750.	0.2315D+11	0.0000D+00	0.5604D+10
760.	0.2309D+11	0.0000D+00	0.5668D+10
770.	0.2302D+11	0.0000D+00	0.5734D+10
780.	0.2296D+11	0.0000D+00	0.5799D+10
790.	0.2290D+11	0.0000D+00	0.5863D+10
800.	0.2283D+11	0.0000D+00	0.5927D+10
810.	0.2277D+11	0.0000D+00	0.5992D+10
820.	0.2271D+11	0.0000D+00	0.6055D+10
830.	0.2264D+11	0.0000D+00	0.6119D+10
840.	0.2257D+11	0.0000D+00	0.6181D+10
850.	0.2251D+11	0.0000D+00	0.6245D+10
860.	0.2245D+11	0.0000D+00	0.6308D+10
870.	0.2238D+11	0.0000D+00	0.6370D+10
880.	0.2232D+11	0.0000D+00	0.6433D+10
890.	0.2226D+11	0.0000D+00	0.6496D+10
900.	0.2221D+11	0.0000D+00	0.6557D+10
910.	0.2214D+11	0.0000D+00	0.6619D+10
920.	0.2208D+11	0.0000D+00	0.6681D+10
930.	0.2202D+11	0.0000D+00	0.6742D+10
940.	0.2196D+11	0.0000D+00	0.6803D+10
950.	0.2189D+11	0.0000D+00	0.6864D+10
960.	0.2183D+11	0.0000D+00	0.6925D+10
970.	0.2178D+11	0.0000D+00	0.6986D+10
980.	0.2172D+11	0.0000D+00	0.7045D+10
990.	0.2165D+11	0.0000D+00	0.7106D+10
1000.	0.2159D+11	0.0000D+00	0.7166D+10

OU-2 : SOLID WASTE LANDFILL SOILS

TIME (YR)	REMAINING SOURCE MASS (MG)	MASS EXITING BOTTOM	DECAYED + SORBED + DISSOLVED
10.	0.9408D+09	0.0000D+00	0.4916D+05
20.	0.9408D+09	0.0000D+00	0.9835D+05
30.	0.9408D+09	0.0000D+00	0.1475D+06
40.	0.9408D+09	0.0000D+00	0.1966D+06
50.	0.9408D+09	0.0000D+00	0.2458D+06
60.	0.9408D+09	0.0000D+00	0.2949D+06
70.	0.9408D+09	0.0000D+00	0.3441D+06
80.	0.9401D+09	0.0000D+00	0.3933D+06
90.	0.9401D+09	0.0000D+00	0.4424D+06
100.	0.9401D+09	0.0000D+00	0.4915D+06
110.	0.9401D+09	0.0000D+00	0.5407D+06
120.	0.9401D+09	0.0000D+00	0.5898D+06
130.	0.9401D+09	0.0000D+00	0.6390D+06
140.	0.9401D+09	0.0000D+00	0.6880D+06
150.	0.9401D+09	0.0000D+00	0.7371D+06
160.	0.9401D+09	0.0000D+00	0.7861D+06
170.	0.9401D+09	0.0000D+00	0.8351D+06
180.	0.9401D+09	0.0000D+00	0.8848D+06
190.	0.9401D+09	0.0000D+00	0.9338D+06
200.	0.9401D+09	0.0000D+00	0.9828D+06
210.	0.9401D+09	0.0000D+00	0.1032D+07
220.	0.9394D+09	0.0000D+00	0.1081D+07
230.	0.9394D+09	0.0000D+00	0.1130D+07
240.	0.9394D+09	0.0000D+00	0.1180D+07
250.	0.9394D+09	0.0000D+00	0.1229D+07

260.	0.9394D+09	0.0000D+00	0.1278D+07
270.	0.9394D+09	0.0000D+00	0.1327D+07
280.	0.9394D+09	0.0000D+00	0.1376D+07
290.	0.9394D+09	0.0000D+00	0.1425D+07
300.	0.9394D+09	0.1401D-44	0.1474D+07
310.	0.9394D+09	0.2881D-41	0.1523D+07
320.	0.9394D+09	0.2975D-38	0.1572D+07
330.	0.9394D+09	0.1870D-35	0.1621D+07
340.	0.9394D+09	0.7483D-33	0.1670D+07
350.	0.9394D+09	0.1984D-30	0.1719D+07
360.	0.9387D+09	0.3610D-28	0.1768D+07
370.	0.9387D+09	0.4650D-26	0.1817D+07
380.	0.9387D+09	0.4363D-24	0.1866D+07
390.	0.9387D+09	0.3057D-22	0.1915D+07
400.	0.9387D+09	0.1636D-20	0.1965D+07
410.	0.9387D+09	0.6827D-19	0.2014D+07
420.	0.9387D+09	0.2262D-17	0.2063D+07
430.	0.9387D+09	0.6054D-16	0.2112D+07
440.	0.9387D+09	0.1328D-14	0.2161D+07
450.	0.9387D+09	0.2421D-13	0.2210D+07
460.	0.9387D+09	0.3715D-12	0.2259D+07
470.	0.9387D+09	0.4854D-11	0.2308D+07
480.	0.9387D+09	0.5457D-10	0.2357D+07
490.	0.9387D+09	0.5330D-09	0.2406D+07
500.	0.9380D+09	0.4562D-08	0.2455D+07
510.	0.9380D+09	0.3451D-07	0.2504D+07
520.	0.9380D+09	0.2324D-06	0.2553D+07
530.	0.9380D+09	0.1404D-05	0.2602D+07
540.	0.9380D+09	0.7654D-05	0.2651D+07
550.	0.9380D+09	0.3787D-04	0.2700D+07
560.	0.9380D+09	0.1711D-03	0.2749D+07
570.	0.9380D+09	0.7095D-03	0.2798D+07
580.	0.9380D+09	0.2713D-02	0.2848D+07
590.	0.9380D+09	0.9610D-02	0.2897D+07
600.	0.9380D+09	0.3166D-01	0.2946D+07
610.	0.9380D+09	0.9742D-01	0.2995D+07
620.	0.9380D+09	0.2816D+00	0.3044D+07
630.	0.9380D+09	0.7652D+00	0.3093D+07
640.	0.9380D+09	0.1960D+01	0.3142D+07
650.	0.9373D+09	0.4749D+01	0.3191D+07
660.	0.9373D+09	0.1092D+02	0.3240D+07
670.	0.9373D+09	0.2392D+02	0.3289D+07
680.	0.9373D+09	0.4998D+02	0.3337D+07
690.	0.9373D+09	0.9991D+02	0.3386D+07
700.	0.9373D+09	0.1915D+03	0.3435D+07
710.	0.9373D+09	0.3528D+03	0.3484D+07
720.	0.9373D+09	0.6259D+03	0.3533D+07
730.	0.9373D+09	0.1071D+04	0.3581D+07
740.	0.9373D+09	0.1773D+04	0.3629D+07
750.	0.9373D+09	0.2840D+04	0.3677D+07
760.	0.9373D+09	0.4416D+04	0.3725D+07
770.	0.9373D+09	0.6672D+04	0.3772D+07
780.	0.9373D+09	0.9812D+04	0.3817D+07
790.	0.9366D+09	0.1406D+05	0.3862D+07
800.	0.9366D+09	0.1967D+05	0.3905D+07
810.	0.9366D+09	0.2690D+05	0.3947D+07
820.	0.9366D+09	0.3601D+05	0.3987D+07
830.	0.9366D+09	0.4724D+05	0.4025D+07
840.	0.9366D+09	0.6082D+05	0.4060D+07

850.	0.9366D+09	0.7690D+05	0.4093D+07
860.	0.9366D+09	0.9565D+05	0.4123D+07
870.	0.9366D+09	0.1171D+06	0.4151D+07
880.	0.9366D+09	0.1414D+06	0.4175D+07
890.	0.9366D+09	0.1684D+06	0.4197D+07
900.	0.9366D+09	0.1981D+06	0.4217D+07
910.	0.9366D+09	0.2302D+06	0.4233D+07
920.	0.9366D+09	0.2648D+06	0.4248D+07
930.	0.9359D+09	0.3016D+06	0.4260D+07
940.	0.9359D+09	0.3403D+06	0.4270D+07
950.	0.9359D+09	0.3807D+06	0.4278D+07
960.	0.9359D+09	0.4228D+06	0.4285D+07
970.	0.9359D+09	0.4661D+06	0.4291D+07
980.	0.9359D+09	0.5106D+06	0.4295D+07
990.	0.9359D+09	0.5560D+06	0.4299D+07
1000.	0.9359D+09	0.6022D+06	0.4302D+07

OU-2 : LSP RESIDUAL SOILS

TIME (YR)	REMAINING SOURCE MASS (MG)	MASS EXITING BOTTOM	DECAYED + SORBED + DISSOLVED
10.	0.4197D+08	0.0000D+00	0.6281D+06
20.	0.4135D+08	0.0000D+00	0.1247D+07
30.	0.4074D+08	0.0000D+00	0.1857D+07
40.	0.4014D+08	0.0000D+00	0.2457D+07
50.	0.3955D+08	0.0000D+00	0.3049D+07
60.	0.3896D+08	0.0000D+00	0.3632D+07
70.	0.3839D+08	0.5059D-40	0.4207D+07
80.	0.3783D+08	0.1640D-29	0.4773D+07
90.	0.3727D+08	0.1151D-21	0.5331D+07
100.	0.3672D+08	0.1093D-15	0.5880D+07
110.	0.3618D+08	0.4564D-11	0.6422D+07
120.	0.3564D+08	0.1859D-07	0.6955D+07
130.	0.3512D+08	0.1292D-04	0.7481D+07
140.	0.3460D+08	0.2296D-02	0.7998D+07
150.	0.3409D+08	0.1412D+00	0.8509D+07
160.	0.3359D+08	0.3946D+01	0.9009D+07
170.	0.3309D+08	0.5426D+02	0.9504D+07
180.	0.3261D+08	0.4490D+03	0.9990D+07
190.	0.3212D+08	0.2467D+04	0.1047D+08
200.	0.3165D+08	0.9796D+04	0.1094D+08
210.	0.3119D+08	0.3004D+05	0.1139D+08
220.	0.3073D+08	0.7495D+05	0.1180D+08
230.	0.3027D+08	0.1584D+06	0.1217D+08
240.	0.2983D+08	0.2928D+06	0.1248D+08
250.	0.2939D+08	0.4858D+06	0.1273D+08
260.	0.2895D+08	0.7383D+06	0.1291D+08
270.	0.2852D+08	0.1045D+07	0.1303D+08
280.	0.2810D+08	0.1396D+07	0.1310D+08
290.	0.2768D+08	0.1781D+07	0.1313D+08
300.	0.2728D+08	0.2190D+07	0.1313D+08
310.	0.2687D+08	0.2612D+07	0.1311D+08
320.	0.2648D+08	0.3041D+07	0.1307D+08
330.	0.2609D+08	0.3473D+07	0.1303D+08
340.	0.2570D+08	0.3903D+07	0.1299D+08
350.	0.2533D+08	0.4330D+07	0.1294D+08

360.	0.2496D+08	0.4753D+07	0.1289D+08
370.	0.2459D+08	0.5170D+07	0.1284D+08
380.	0.2422D+08	0.5582D+07	0.1279D+08
390.	0.2387D+08	0.5989D+07	0.1274D+08
400.	0.2352D+08	0.6390D+07	0.1269D+08
410.	0.2317D+08	0.6788D+07	0.1264D+08
420.	0.2282D+08	0.7181D+07	0.1259D+08
430.	0.2249D+08	0.7572D+07	0.1254D+08
440.	0.2216D+08	0.7959D+07	0.1248D+08
450.	0.2183D+08	0.8347D+07	0.1242D+08
460.	0.2151D+08	0.8735D+07	0.1235D+08
470.	0.2120D+08	0.9123D+07	0.1228D+08
480.	0.2088D+08	0.9512D+07	0.1220D+08
490.	0.2057D+08	0.9905D+07	0.1212D+08
500.	0.2027D+08	0.1030D+08	0.1203D+08
510.	0.1997D+08	0.1070D+08	0.1193D+08
520.	0.1967D+08	0.1110D+08	0.1182D+08
530.	0.1939D+08	0.1150D+08	0.1171D+08
540.	0.1910D+08	0.1191D+08	0.1159D+08
550.	0.1882D+08	0.1232D+08	0.1147D+08
560.	0.1854D+08	0.1273D+08	0.1133D+08
570.	0.1827D+08	0.1313D+08	0.1120D+08
580.	0.1800D+08	0.1354D+08	0.1106D+08
590.	0.1773D+08	0.1395D+08	0.1091D+08
600.	0.1747D+08	0.1436D+08	0.1077D+08
610.	0.1722D+08	0.1476D+08	0.1062D+08
620.	0.1696D+08	0.1517D+08	0.1047D+08
630.	0.1671D+08	0.1556D+08	0.1032D+08
640.	0.1646D+08	0.1596D+08	0.1018D+08
650.	0.1622D+08	0.1635D+08	0.1003D+08
660.	0.1598D+08	0.1673D+08	0.9886D+07
670.	0.1574D+08	0.1711D+08	0.9741D+07
680.	0.1552D+08	0.1748D+08	0.9599D+07
690.	0.1528D+08	0.1785D+08	0.9457D+07
700.	0.1506D+08	0.1822D+08	0.9319D+07
710.	0.1484D+08	0.1858D+08	0.9182D+07
720.	0.1462D+08	0.1893D+08	0.9047D+07
730.	0.1440D+08	0.1928D+08	0.8914D+07
740.	0.1419D+08	0.1963D+08	0.8782D+07
750.	0.1398D+08	0.1996D+08	0.8652D+07
760.	0.1378D+08	0.2030D+08	0.8525D+07
770.	0.1357D+08	0.2063D+08	0.8400D+07
780.	0.1337D+08	0.2095D+08	0.8276D+07
790.	0.1318D+08	0.2127D+08	0.8154D+07
800.	0.1298D+08	0.2158D+08	0.8034D+07
810.	0.1279D+08	0.2189D+08	0.7915D+07
820.	0.1260D+08	0.2220D+08	0.7798D+07
830.	0.1241D+08	0.2250D+08	0.7683D+07
840.	0.1223D+08	0.2280D+08	0.7570D+07
850.	0.1205D+08	0.2309D+08	0.7458D+07
860.	0.1187D+08	0.2338D+08	0.7348D+07
870.	0.1170D+08	0.2366D+08	0.7240D+07
880.	0.1153D+08	0.2394D+08	0.7133D+07
890.	0.1136D+08	0.2421D+08	0.7028D+07
900.	0.1119D+08	0.2448D+08	0.6924D+07
910.	0.1103D+08	0.2475D+08	0.6823D+07
920.	0.1086D+08	0.2501D+08	0.6722D+07
930.	0.1070D+08	0.2528D+08	0.6622D+07
940.	0.1054D+08	0.2553D+08	0.6525D+07

950.	0.1039D+08	0.2578D+08	0.6429D+07
960.	0.1023D+08	0.2603D+08	0.6334D+07
970.	0.1008D+08	0.2627D+08	0.6241D+07
980.	0.9936D+07	0.2651D+08	0.6149D+07
990.	0.9792D+07	0.2675D+08	0.6058D+07
1000.	0.9648D+07	0.2698D+08	0.5969D+07

OU-2 : AFP RESIDUAL SOILS

TIME (YR)	REMAINING SOURCE MASS (MG)	MASS EXITING BOTTOM	DECAYED + SORBED + DISSOLVED
10.	0.1362D+09	0.0000D+00	0.5166D+05
20.	0.1362D+09	0.0000D+00	0.1033D+06
30.	0.1361D+09	0.0000D+00	0.1549D+06
40.	0.1360D+09	0.0000D+00	0.2065D+06
50.	0.1359D+09	0.0000D+00	0.2581D+06
60.	0.1359D+09	0.0000D+00	0.3097D+06
70.	0.1359D+09	0.0000D+00	0.3612D+06
80.	0.1358D+09	0.0000D+00	0.4127D+06
90.	0.1357D+09	0.0000D+00	0.4642D+06
100.	0.1357D+09	0.0000D+00	0.5158D+06
110.	0.1357D+09	0.0000D+00	0.5672D+06
120.	0.1356D+09	0.0000D+00	0.6187D+06
130.	0.1355D+09	0.0000D+00	0.6700D+06
140.	0.1355D+09	0.0000D+00	0.7217D+06
150.	0.1355D+09	0.0000D+00	0.7728D+06
160.	0.1354D+09	0.0000D+00	0.8239D+06
170.	0.1353D+09	0.0000D+00	0.8757D+06
180.	0.1353D+09	0.0000D+00	0.9268D+06
190.	0.1352D+09	0.0000D+00	0.9779D+06
200.	0.1352D+09	0.0000D+00	0.1030D+07
210.	0.1352D+09	0.0000D+00	0.1081D+07
220.	0.1351D+09	0.0000D+00	0.1132D+07
230.	0.1350D+09	0.0000D+00	0.1183D+07
240.	0.1350D+09	0.8772D-42	0.1235D+07
250.	0.1350D+09	0.4086D-38	0.1286D+07
260.	0.1349D+09	0.8921D-35	0.1337D+07
270.	0.1348D+09	0.9959D-32	0.1388D+07
280.	0.1348D+09	0.6118D-29	0.1439D+07
290.	0.1348D+09	0.2203D-26	0.1490D+07
300.	0.1347D+09	0.4910D-24	0.1541D+07
310.	0.1346D+09	0.7109D-22	0.1593D+07
320.	0.1346D+09	0.6971D-20	0.1644D+07
330.	0.1345D+09	0.4803D-18	0.1695D+07
340.	0.1345D+09	0.2402D-16	0.1746D+07
350.	0.1344D+09	0.8969D-15	0.1796D+07
360.	0.1344D+09	0.2567D-13	0.1847D+07
370.	0.1343D+09	0.5757D-12	0.1898D+07
380.	0.1343D+09	0.1033D-10	0.1950D+07
390.	0.1342D+09	0.1510D-09	0.2001D+07
400.	0.1342D+09	0.1828D-08	0.2051D+07
410.	0.1341D+09	0.1859D-07	0.2102D+07
420.	0.1341D+09	0.1611D-06	0.2153D+07
430.	0.1341D+09	0.1204D-05	0.2204D+07
440.	0.1340D+09	0.7840D-05	0.2255D+07
450.	0.1339D+09	0.4497D-04	0.2305D+07

460.	0.1338D+09	0.2292D-03	0.2356D+07
470.	0.1338D+09	0.1047D-02	0.2407D+07
480.	0.1338D+09	0.4318D-02	0.2458D+07
490.	0.1337D+09	0.1619D-01	0.2509D+07
500.	0.1336D+09	0.5563D-01	0.2559D+07
510.	0.1336D+09	0.1765D+00	0.2610D+07
520.	0.1336D+09	0.5175D+00	0.2661D+07
530.	0.1335D+09	0.1411D+01	0.2711D+07
540.	0.1335D+09	0.3597D+01	0.2762D+07
550.	0.1334D+09	0.8610D+01	0.2813D+07
560.	0.1334D+09	0.1944D+02	0.2863D+07
570.	0.1333D+09	0.4153D+02	0.2913D+07
580.	0.1333D+09	0.8429D+02	0.2964D+07
590.	0.1332D+09	0.1631D+03	0.3015D+07
600.	0.1331D+09	0.3016D+03	0.3065D+07
610.	0.1331D+09	0.5348D+03	0.3115D+07
620.	0.1331D+09	0.9117D+03	0.3165D+07
630.	0.1330D+09	0.1498D+04	0.3215D+07
640.	0.1329D+09	0.2378D+04	0.3265D+07
650.	0.1329D+09	0.3655D+04	0.3314D+07
660.	0.1329D+09	0.5448D+04	0.3362D+07
670.	0.1328D+09	0.7900D+04	0.3410D+07
680.	0.1327D+09	0.1116D+05	0.3458D+07
690.	0.1327D+09	0.1538D+05	0.3504D+07
700.	0.1327D+09	0.2073D+05	0.3549D+07
710.	0.1326D+09	0.2737D+05	0.3592D+07
720.	0.1326D+09	0.3544D+05	0.3635D+07
730.	0.1325D+09	0.4507D+05	0.3675D+07
740.	0.1324D+09	0.5640D+05	0.3714D+07
750.	0.1324D+09	0.6955D+05	0.3751D+07
760.	0.1324D+09	0.8459D+05	0.3786D+07
770.	0.1323D+09	0.1016D+06	0.3819D+07
780.	0.1322D+09	0.1206D+06	0.3851D+07
790.	0.1322D+09	0.1418D+06	0.3880D+07
800.	0.1322D+09	0.1650D+06	0.3907D+07
810.	0.1321D+09	0.1903D+06	0.3931D+07
820.	0.1320D+09	0.2178D+06	0.3954D+07
830.	0.1320D+09	0.2474D+06	0.3975D+07
840.	0.1320D+09	0.2790D+06	0.3993D+07
850.	0.1319D+09	0.3127D+06	0.4009D+07
860.	0.1319D+09	0.3483D+06	0.4024D+07
870.	0.1318D+09	0.3857D+06	0.4036D+07
880.	0.1317D+09	0.4249D+06	0.4047D+07
890.	0.1317D+09	0.4656D+06	0.4056D+07
900.	0.1317D+09	0.5078D+06	0.4064D+07
910.	0.1316D+09	0.5515D+06	0.4070D+07
920.	0.1315D+09	0.5965D+06	0.4075D+07
930.	0.1315D+09	0.6424D+06	0.4079D+07
940.	0.1315D+09	0.6892D+06	0.4082D+07
950.	0.1314D+09	0.7369D+06	0.4084D+07
960.	0.1313D+09	0.7852D+06	0.4086D+07
970.	0.1313D+09	0.8341D+06	0.4087D+07
980.	0.1313D+09	0.8835D+06	0.4087D+07
990.	0.1312D+09	0.9334D+06	0.4087D+07
1000.	0.1312D+09	0.9836D+06	0.4087D+07

OU-2 : IFP/SF RESIDUAL SOILS

TIME (YR)	REMAINING SOURCE MASS (MG)	MASS EXITING BOTTOM	DECAYED + SORBED + DISSOLVED
10.	0.1095D+10	0.1103D-22	0.2808D+06
20.	0.1095D+10	0.2489D+01	0.5607D+06
30.	0.1095D+10	0.3117D+05	0.8086D+06
40.	0.1094D+10	0.1112D+06	0.1007D+07
50.	0.1094D+10	0.2589D+06	0.1136D+07
60.	0.1094D+10	0.4668D+06	0.1204D+07
70.	0.1093D+10	0.6842D+06	0.1262D+07
80.	0.1093D+10	0.9283D+06	0.1293D+07
90.	0.1093D+10	0.1195D+07	0.1299D+07
100.	0.1093D+10	0.1470D+07	0.1298D+07
110.	0.1092D+10	0.1745D+07	0.1294D+07
120.	0.1092D+10	0.2020D+07	0.1290D+07
130.	0.1092D+10	0.2294D+07	0.1286D+07
140.	0.1092D+10	0.2568D+07	0.1281D+07
150.	0.1091D+10	0.2840D+07	0.1277D+07
160.	0.1091D+10	0.3112D+07	0.1273D+07
170.	0.1091D+10	0.3382D+07	0.1269D+07
180.	0.1090D+10	0.3652D+07	0.1265D+07
190.	0.1090D+10	0.3921D+07	0.1261D+07
200.	0.1090D+10	0.4189D+07	0.1257D+07
210.	0.1090D+10	0.4456D+07	0.1253D+07
220.	0.1089D+10	0.4722D+07	0.1249D+07
230.	0.1089D+10	0.4988D+07	0.1244D+07
240.	0.1089D+10	0.5251D+07	0.1240D+07
250.	0.1089D+10	0.5516D+07	0.1236D+07
260.	0.1088D+10	0.5779D+07	0.1232D+07
270.	0.1088D+10	0.6041D+07	0.1229D+07
280.	0.1088D+10	0.6302D+07	0.1225D+07
290.	0.1088D+10	0.6563D+07	0.1221D+07
300.	0.1087D+10	0.6821D+07	0.1217D+07
310.	0.1087D+10	0.7079D+07	0.1213D+07
320.	0.1087D+10	0.7338D+07	0.1209D+07
330.	0.1087D+10	0.7594D+07	0.1205D+07
340.	0.1086D+10	0.7850D+07	0.1201D+07
350.	0.1086D+10	0.8105D+07	0.1197D+07
360.	0.1086D+10	0.8360D+07	0.1193D+07
370.	0.1086D+10	0.8613D+07	0.1189D+07
380.	0.1085D+10	0.8866D+07	0.1185D+07
390.	0.1085D+10	0.9119D+07	0.1182D+07
400.	0.1085D+10	0.9369D+07	0.1178D+07
410.	0.1085D+10	0.9619D+07	0.1174D+07
420.	0.1084D+10	0.9868D+07	0.1170D+07
430.	0.1084D+10	0.1012D+08	0.1166D+07
440.	0.1084D+10	0.1036D+08	0.1162D+07
450.	0.1084D+10	0.1061D+08	0.1159D+07
460.	0.1083D+10	0.1086D+08	0.1155D+07
470.	0.1083D+10	0.1110D+08	0.1151D+07
480.	0.1083D+10	0.1135D+08	0.1147D+07
490.	0.1083D+10	0.1159D+08	0.1144D+07
500.	0.1082D+10	0.1183D+08	0.1140D+07
510.	0.1082D+10	0.1208D+08	0.1136D+07
520.	0.1082D+10	0.1232D+08	0.1133D+07
530.	0.1082D+10	0.1256D+08	0.1129D+07

540.	0.1081D+10	0.1280D+08	0.1125D+07
550.	0.1081D+10	0.1304D+08	0.1122D+07
560.	0.1081D+10	0.1328D+08	0.1118D+07
570.	0.1081D+10	0.1351D+08	0.1115D+07
580.	0.1081D+10	0.1375D+08	0.1111D+07
590.	0.1080D+10	0.1399D+08	0.1107D+07
600.	0.1080D+10	0.1422D+08	0.1104D+07
610.	0.1080D+10	0.1446D+08	0.1100D+07
620.	0.1080D+10	0.1469D+08	0.1096D+07
630.	0.1079D+10	0.1492D+08	0.1093D+07
640.	0.1079D+10	0.1515D+08	0.1089D+07
650.	0.1079D+10	0.1539D+08	0.1086D+07
660.	0.1079D+10	0.1562D+08	0.1082D+07
670.	0.1078D+10	0.1585D+08	0.1079D+07
680.	0.1078D+10	0.1608D+08	0.1075D+07
690.	0.1078D+10	0.1630D+08	0.1072D+07
700.	0.1078D+10	0.1653D+08	0.1068D+07
710.	0.1078D+10	0.1676D+08	0.1065D+07
720.	0.1077D+10	0.1698D+08	0.1061D+07
730.	0.1077D+10	0.1721D+08	0.1058D+07
740.	0.1077D+10	0.1743D+08	0.1055D+07
750.	0.1077D+10	0.1766D+08	0.1051D+07
760.	0.1076D+10	0.1788D+08	0.1048D+07
770.	0.1076D+10	0.1810D+08	0.1044D+07
780.	0.1076D+10	0.1832D+08	0.1041D+07
790.	0.1076D+10	0.1855D+08	0.1038D+07
800.	0.1076D+10	0.1877D+08	0.1034D+07
810.	0.1075D+10	0.1899D+08	0.1031D+07
820.	0.1075D+10	0.1920D+08	0.1028D+07
830.	0.1075D+10	0.1942D+08	0.1024D+07
840.	0.1075D+10	0.1964D+08	0.1021D+07
850.	0.1075D+10	0.1986D+08	0.1018D+07
860.	0.1074D+10	0.2007D+08	0.1015D+07
870.	0.1074D+10	0.2029D+08	0.1011D+07
880.	0.1074D+10	0.2050D+08	0.1008D+07
890.	0.1074D+10	0.2072D+08	0.1005D+07
900.	0.1073D+10	0.2093D+08	0.1001D+07
910.	0.1073D+10	0.2114D+08	0.9980D+06
920.	0.1073D+10	0.2135D+08	0.9948D+06
930.	0.1073D+10	0.2156D+08	0.9916D+06
940.	0.1073D+10	0.2178D+08	0.9883D+06
950.	0.1072D+10	0.2198D+08	0.9853D+06
960.	0.1072D+10	0.2219D+08	0.9820D+06
970.	0.1072D+10	0.2240D+08	0.9789D+06
980.	0.1072D+10	0.2261D+08	0.9757D+06
990.	0.1072D+10	0.2282D+08	0.9725D+06
1000.	0.1071D+10	0.2302D+08	0.9695D+06

OU-2 : DISPOSAL CELL

TIME (YR)	REMAINING SOURCE MASS (MG)	MASS EXITING BOTTOM	DECAYED + SORBED + DISSOLVED
10.	0.3378D+12	0.0000D+00	0.1539D+10
20.	0.3364D+12	0.0000D+00	0.3071D+10
30.	0.3348D+12	0.0000D+00	0.4596D+10
40.	0.3333D+12	0.0000D+00	0.6113D+10

50.	0.3318D+12	0.0000D+00	0.7625D+10
60.	0.3303D+12	0.0000D+00	0.9129D+10
70.	0.3288D+12	0.0000D+00	0.1063D+11
80.	0.3273D+12	0.0000D+00	0.1212D+11
90.	0.3258D+12	0.0000D+00	0.1360D+11
100.	0.3243D+12	0.0000D+00	0.1508D+11
110.	0.3229D+12	0.0000D+00	0.1655D+11
120.	0.3214D+12	0.0000D+00	0.1801D+11
130.	0.3199D+12	0.0000D+00	0.1947D+11
140.	0.3185D+12	0.0000D+00	0.2092D+11
150.	0.3170D+12	0.0000D+00	0.2237D+11
160.	0.3156D+12	0.0000D+00	0.2380D+11
170.	0.3142D+12	0.0000D+00	0.2524D+11
180.	0.3128D+12	0.0000D+00	0.2666D+11
190.	0.3113D+12	0.0000D+00	0.2807D+11
200.	0.3099D+12	0.0000D+00	0.2949D+11
210.	0.3085D+12	0.0000D+00	0.3089D+11
220.	0.3071D+12	0.0000D+00	0.3229D+11
230.	0.3057D+12	0.0000D+00	0.3368D+11
240.	0.3043D+12	0.0000D+00	0.3507D+11
250.	0.3029D+12	0.0000D+00	0.3645D+11
260.	0.3016D+12	0.0000D+00	0.3782D+11
270.	0.3002D+12	0.0000D+00	0.3919D+11
280.	0.2988D+12	0.0000D+00	0.4055D+11
290.	0.2975D+12	0.0000D+00	0.4191D+11
300.	0.2961D+12	0.0000D+00	0.4325D+11
310.	0.2948D+12	0.0000D+00	0.4459D+11
320.	0.2935D+12	0.0000D+00	0.4593D+11
330.	0.2921D+12	0.0000D+00	0.4726D+11
340.	0.2908D+12	0.2803D-44	0.4859D+11
350.	0.2895D+12	0.5577D-42	0.4991D+11
360.	0.2882D+12	0.1033D-39	0.5122D+11
370.	0.2869D+12	0.1419D-37	0.5252D+11
380.	0.2856D+12	0.1481D-35	0.5382D+11
390.	0.2843D+12	0.1200D-33	0.5512D+11
400.	0.2829D+12	0.7686D-32	0.5640D+11
410.	0.2817D+12	0.3963D-30	0.5769D+11
420.	0.2804D+12	0.1670D-28	0.5896D+11
430.	0.2792D+12	0.5834D-27	0.6023D+11
440.	0.2779D+12	0.1711D-25	0.6150D+11
450.	0.2766D+12	0.4260D-24	0.6276D+11
460.	0.2754D+12	0.9106D-23	0.6402D+11
470.	0.2741D+12	0.1687D-21	0.6527D+11
480.	0.2729D+12	0.2734D-20	0.6650D+11
490.	0.2716D+12	0.3906D-19	0.6774D+11
500.	0.2704D+12	0.4959D-18	0.6897D+11
510.	0.2692D+12	0.5631D-17	0.7020D+11
520.	0.2680D+12	0.5758D-16	0.7141D+11
530.	0.2667D+12	0.5332D-15	0.7263D+11
540.	0.2655D+12	0.4498D-14	0.7384D+11
550.	0.2644D+12	0.3473D-13	0.7504D+11
560.	0.2632D+12	0.2466D-12	0.7625D+11
570.	0.2620D+12	0.1618D-11	0.7743D+11
580.	0.2607D+12	0.9848D-11	0.7862D+11
590.	0.2596D+12	0.5582D-10	0.7980D+11
600.	0.2584D+12	0.2956D-09	0.8098D+11
610.	0.2572D+12	0.1468D-08	0.8215D+11
620.	0.2561D+12	0.6858D-08	0.8331D+11
630.	0.2549D+12	0.3022D-07	0.8447D+11

640.	0.2537D+12	0.1260D-06	0.8563D+11
650.	0.2526D+12	0.4980D-06	0.8678D+11
660.	0.2514D+12	0.1872D-05	0.8793D+11
670.	0.2504D+12	0.6703D-05	0.8907D+11
680.	0.2492D+12	0.2292D-04	0.9019D+11
690.	0.2481D+12	0.7502D-04	0.9133D+11
700.	0.2470D+12	0.2354D-03	0.9245D+11
710.	0.2458D+12	0.7091D-03	0.9357D+11
720.	0.2447D+12	0.2055D-02	0.9468D+11
730.	0.2436D+12	0.5743D-02	0.9580D+11
740.	0.2425D+12	0.1548D-01	0.9690D+11
750.	0.2414D+12	0.4034D-01	0.9799D+11
760.	0.2404D+12	0.1017D+00	0.9909D+11
770.	0.2392D+12	0.2486D+00	0.1002D+12
780.	0.2381D+12	0.5894D+00	0.1013D+12
790.	0.2371D+12	0.1359D+01	0.1023D+12
800.	0.2360D+12	0.3046D+01	0.1034D+12
810.	0.2349D+12	0.6643D+01	0.1045D+12
820.	0.2339D+12	0.1412D+02	0.1056D+12
830.	0.2328D+12	0.2926D+02	0.1066D+12
840.	0.2318D+12	0.5923D+02	0.1077D+12
850.	0.2307D+12	0.1171D+03	0.1087D+12
860.	0.2297D+12	0.2266D+03	0.1097D+12
870.	0.2286D+12	0.4289D+03	0.1108D+12
880.	0.2276D+12	0.7953D+03	0.1118D+12
890.	0.2265D+12	0.1446D+04	0.1129D+12
900.	0.2255D+12	0.2578D+04	0.1139D+12
910.	0.2245D+12	0.4512D+04	0.1149D+12
920.	0.2234D+12	0.7757D+04	0.1159D+12
930.	0.2225D+12	0.1310D+05	0.1169D+12
940.	0.2215D+12	0.2178D+05	0.1179D+12
950.	0.2204D+12	0.3560D+05	0.1190D+12
960.	0.2194D+12	0.5730D+05	0.1200D+12
970.	0.2185D+12	0.9082D+05	0.1209D+12
980.	0.2175D+12	0.1420D+06	0.1219D+12
990.	0.2165D+12	0.2185D+06	0.1229D+12
1000.	0.2155D+12	0.3328D+06	0.1239D+12

III

ATTACHMENT I.II

AIR FATE AND TRANSPORT MODELING INPUT PARAMETERS AND OUTPUT

ATTACHMENT I.II-1

POST-REMEDIAL SURFACE SOIL CONTAMINANT CONCENTRATIONS

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TABLE I.II-1-1
RADIONUCLIDE CONCENTRATIONS IN EXPOSED SOIL

Source	Radionuclide Concentrations (pCi/g)					
Area	Cesium-137	Lead-210	Neptunium-237	Plutonium-238	Plutonium-239	Plutonium-240
560A	1.00E+00	1.00E+00	8.10E-01	0.00E+00	0.00E+00	0.00E+00
560B	6.95E-01	1.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
560C	1.40E+00	1.00E+00	0.00E+00	2.20E+00	2.90E+00	1.06E+01
560D	6.00E-01	1.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
570A	1.30E+00	1.00E+00	5.97E-01	0.00E+00	0.00E+00	0.00E+00
570B	1.44E+00	1.00E+00	0.00E+00	4.00E-01	6.10E-01	2.22E+00
570C	5.00E-01	1.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
570D	1.44E+00	1.00E+00	2.07E-01	3.30E+00	6.00E-01	2.18E+00
570E	1.00E+00	1.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
575A	6.00E-01	1.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
575B	1.10E+00	1.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
580A	5.00E-01	1.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
581A	8.00E-01	1.00E+00	0.00E+00	0.00E+00	9.00E-01	3.28E+00
581B	5.96E-01	1.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
581C	1.01E+00	1.00E+00	0.00E+00	1.50E+00	0.00E+00	0.00E+00
581D	7.11E-01	1.00E+00	0.00E+00	1.51E+02	1.50E+00	5.46E+00
582A	8.00E-01	1.00E+00	0.00E+00	0.00E+00	6.00E-01	2.18E+00
582B	9.19E-01	1.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
WPAA	8.00E-01	3.98E+00	8.34E-01	7.00E-01	2.13E-01	7.75E-01
5NEC	8.63E-01	7.10E+01	0.00E+00	0.00E+00	0.00E+00	0.00E+00
WastePit1	4.41E-01	1.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
WastePit2	4.41E-01	1.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
WastePit3	4.41E-01	1.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
WastePit4	4.41E-01	1.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
WastePit5	4.41E-01	1.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
WastePit6	4.41E-01	1.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Bumpit	4.41E-01	1.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Clearwell	4.41E-01	1.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
SF-GMA	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
SF-Till	0.00E+00	0.00E+00	2.91E-01	0.00E+00	0.00E+00	0.00E+00
SF-Fill	6.92E-01	0.00E+00	3.69E-01	0.00E+00	0.00E+00	0.00E+00
IFP-GMA	0.00E+00	0.00E+00	1.80E-01	0.00E+00	0.00E+00	0.00E+00
IFP-Till	0.00E+00	0.00E+00	1.60E-01	0.00E+00	0.00E+00	0.00E+00
AFP-GMA	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
AFP-Till	0.00E+00	0.00E+00	4.30E-02	0.00E+00	0.00E+00	0.00E+00
SWL-Till	0.00E+00	0.00E+00	4.00E-01	2.00E-01	0.00E+00	0.00E+00
LSP-Till	0.00E+00	0.00E+00	1.30E-01	0.00E+00	0.00E+00	0.00E+00
OU4 Soil	2.30E-01	1.96E+01	0.00E+00	0.00E+00	0.00E+00	0.00E+00
PAA	5.00E-01	1.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
PAB	7.00E-01	1.00E+00	0.00E+00	7.18E-01	6.50E+00	2.37E+01
PAC	2.50E-01	1.00E+00	2.63E+00	0.00E+00	7.13E-01	2.59E+00
PAD	6.00E-01	1.00E+00	0.00E+00	8.52E-01	0.00E+00	0.00E+00
PAE	5.00E-01	1.00E+00	7.10E-01	1.05E+00	1.51E+00	5.50E+00
PAF	6.08E-01	1.00E+00	0.00E+00	1.51E+02	0.00E+00	0.00E+00
PAG	1.44E+00	1.00E+00	0.00E+00	2.56E-01	1.29E+01	4.69E+01
PAH	8.90E-01	1.00E+00	6.76E-01	0.00E+00	0.00E+00	0.00E+00
PAI	4.41E-01	1.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

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TABLE I.II–1–1 (Continued)

Source	Radionuclide Concentrations (pCi/g)					
Area	Proactinium–231	Radium–226	Radium–228	Ruthenium–106	Strontium–90	Technetium–99
560A	0.00E+00	9.77E–01	1.84E+00	0.00E+00	1.40E+00	1.30E+00
560B	0.00E+00	1.58E+00	1.84E+00	0.00E+00	4.60E+00	1.60E+00
560C	0.00E+00	1.63E+00	1.84E+00	0.00E+00	4.24E–01	2.73E+01
560D	0.00E+00	1.63E+00	1.84E+00	0.00E+00	6.50E+00	0.00E+00
570A	0.00E+00	1.63E+00	1.84E+00	0.00E+00	9.00E–01	5.10E+00
570B	0.00E+00	1.33E+00	1.84E+00	3.00E+00	1.80E+00	4.80E+00
570C	0.00E+00	1.00E+00	1.84E+00	0.00E+00	7.00E–01	0.00E+00
570D	0.00E+00	1.63E+00	1.84E+00	0.00E+00	1.70E+00	3.30E+01
570E	0.00E+00	1.20E+00	1.84E+00	0.00E+00	1.10E+00	0.00E+00
575A	0.00E+00	7.00E–01	1.84E+00	0.00E+00	4.24E–01	0.00E+00
575B	0.00E+00	5.00E–01	1.84E+00	0.00E+00	4.24E–01	0.00E+00
580A	0.00E+00	3.00E–01	1.84E+00	5.20E–01	4.24E–01	0.00E+00
581A	0.00E+00	1.30E+00	1.84E+00	0.00E+00	1.53E+00	1.10E+00
581B	0.00E+00	1.63E+00	1.84E+00	0.00E+00	1.69E+00	1.13E+01
581C	0.00E+00	1.19E+00	1.84E+00	0.00E+00	4.30E+00	0.00E+00
581D	5.04E+00	1.63E+00	1.84E+00	0.00E+00	3.70E+00	2.28E+02
582A	0.00E+00	1.08E+00	1.84E+00	0.00E+00	1.20E+00	0.00E+00
582B	0.00E+00	1.63E+00	1.84E+00	0.00E+00	4.24E–01	0.00E+00
WPAA	0.00E+00	1.63E+00	1.84E+00	0.00E+00	1.00E+00	5.30E+00
5NEC	0.00E+00	0.00E+00	1.84E+00	0.00E+00	3.60E+00	0.00E+00
WastePit1	0.00E+00	1.22E+00	1.84E+00	0.00E+00	4.24E–01	0.00E+00
WastePit2	0.00E+00	1.22E+00	1.84E+00	0.00E+00	4.24E–01	0.00E+00
WastePit3	0.00E+00	1.22E+00	1.84E+00	0.00E+00	4.24E–01	0.00E+00
WastePit4	0.00E+00	1.22E+00	1.84E+00	0.00E+00	4.24E–01	0.00E+00
WastePit5	0.00E+00	1.22E+00	1.84E+00	0.00E+00	4.24E–01	0.00E+00
WastePit6	0.00E+00	1.22E+00	1.84E+00	0.00E+00	4.24E–01	0.00E+00
Burnpit	0.00E+00	1.22E+00	1.84E+00	0.00E+00	4.24E–01	0.00E+00
Clearwell	0.00E+00	1.22E+00	1.84E+00	0.00E+00	4.24E–01	0.00E+00
SF–GMA	0.00E+00	6.76E–01	4.61E–01	0.00E+00	7.00E–01	0.00E+00
SF–Till	0.00E+00	1.63E+00	1.44E+00	0.00E+00	1.10E+00	9.00E–01
SF–Fill	0.00E+00	1.63E+00	1.84E+00	0.00E+00	1.36E+00	9.00E–01
IFP–GMA	0.00E+00	8.70E–01	5.30E–01	0.00E+00	0.00E+00	0.00E+00
IFP–Till	0.00E+00	1.01E+00	7.30E–01	0.00E+00	0.00E+00	0.00E+00
AFP–GMA	0.00E+00	5.94E–01	5.37E–01	0.00E+00	5.00E–01	0.00E+00
AFP–Till	0.00E+00	1.43E+00	1.26E+00	0.00E+00	3.61E+00	0.00E+00
SWL–Till	0.00E+00	1.00E+00	9.00E–01	0.00E+00	7.30E–01	0.00E+00
LSP–Till	0.00E+00	1.19E+00	1.11E+00	0.00E+00	5.40E–01	0.00E+00
OU4 Soil	1.37E+01	1.63E+00	1.84E+00	0.00E+00	1.79E+00	3.60E+00
PAA	0.00E+00	1.63E+00	1.84E+00	0.00E+00	3.10E+00	0.00E+00
PAB	0.00E+00	1.63E+00	1.84E+00	0.00E+00	3.40E+00	8.10E+00
PAC	0.00E+00	1.63E+00	1.84E+00	0.00E+00	2.04E+00	5.03E+00
PAD	0.00E+00	1.20E+00	1.84E+00	0.00E+00	1.11E+00	2.20E+00
PAE	0.00E+00	8.36E–01	1.84E+00	0.00E+00	4.15E+00	2.10E+02
PAF	5.04E+00	1.26E+00	1.84E+00	0.00E+00	1.91E+00	2.40E+00
PAG	0.00E+00	1.63E+00	1.84E+00	0.00E+00	3.87E+00	2.00E+01
PAH	0.00E+00	1.63E+00	1.84E+00	3.00E+00	2.22E+00	1.60E+00
PAI	0.00E+00	1.63E+00	1.84E+00	0.00E+00	4.24E–01	0.00E+00

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TABLE I.II–1–1 (Continued)

Source Area	Radionuclide Concentrations (pCi/g)						
	Thorium–228	Thorium–230	Thorium–232	Uranium–234	Uranium–235	Uranium–236	Uranium–238
560A	1.52E+00	1.79E+00	1.02E+00	1.30E+01	3.46E–01	1.43E–01	7.80E+00
560B	1.52E+00	4.52E+00	1.47E+00	1.02E+02	2.71E+00	1.12E+00	6.11E+01
560C	1.52E+00	6.50E+00	6.08E+00	1.02E+02	2.71E+00	1.12E+00	6.11E+01
560D	1.52E+00	6.50E+00	6.08E+00	1.02E+02	2.71E+00	1.12E+00	6.11E+01
570A	1.52E+00	6.50E+00	2.30E+00	4.34E+01	1.15E+00	4.76E–01	2.60E+01
570B	1.52E+00	6.50E+00	6.08E+00	1.02E+02	2.71E+00	1.12E+00	6.11E+01
570C	1.52E+00	1.50E+00	8.00E–01	1.99E+01	5.28E–01	2.18E–01	1.19E+01
570D	1.52E+00	6.50E+00	6.08E+00	1.02E+02	2.71E+00	1.12E+00	6.11E+01
570E	1.52E+00	6.50E+00	5.20E+00	3.52E+01	9.36E–01	3.86E–01	2.11E+01
575A	1.52E+00	6.50E+00	8.00E–01	1.25E+01	3.32E–01	1.37E–01	7.49E+00
575B	1.52E+00	1.70E+00	7.00E–01	3.52E+01	9.36E–01	3.86E–01	2.11E+01
580A	1.52E+00	1.20E+00	8.00E–01	3.01E+00	7.98E–02	3.29E–02	1.80E+00
581A	1.52E+00	1.81E+00	9.35E–01	8.80E+00	2.34E–01	9.64E–02	5.27E+00
581B	1.52E+00	6.50E+00	6.08E+00	1.02E+02	2.71E+00	1.12E+00	6.11E+01
581C	1.52E+00	3.36E+00	1.40E+00	2.64E+01	7.00E–01	2.89E–01	1.58E+01
581D	1.52E+00	6.50E+00	6.08E+00	1.02E+02	2.71E+00	1.12E+00	6.11E+01
582A	1.52E+00	2.97E+00	1.16E+00	8.85E+00	2.35E–01	9.70E–02	5.30E+00
582B	1.52E+00	6.50E+00	1.61E+00	1.02E+02	2.71E+00	1.12E+00	6.11E+01
WPAA	1.52E+00	6.50E+00	2.54E+00	1.02E+02	2.71E+00	1.12E+00	6.11E+01
5NEC	1.52E+00	0.00E+00	1.14E+00	1.38E+01	3.67E–01	1.51E–01	8.27E+00
WastePit1	1.52E+00	1.50E+00	1.08E+00	1.81E+00	4.81E–02	1.99E–02	1.09E+00
WastePit2	1.52E+00	1.50E+00	1.08E+00	1.81E+00	4.81E–02	1.99E–02	1.09E+00
WastePit3	1.52E+00	1.50E+00	1.08E+00	1.81E+00	4.81E–02	1.99E–02	1.09E+00
WastePit4	1.52E+00	1.50E+00	1.08E+00	1.81E+00	4.81E–02	1.99E–02	1.09E+00
WastePit5	1.52E+00	1.50E+00	1.08E+00	1.81E+00	4.81E–02	1.99E–02	1.09E+00
WastePit6	1.52E+00	1.50E+00	1.08E+00	1.81E+00	4.81E–02	1.99E–02	1.09E+00
Burnpit	1.52E+00	1.50E+00	1.08E+00	1.81E+00	4.81E–02	1.99E–02	1.09E+00
Clearwell	1.52E+00	1.50E+00	1.08E+00	1.81E+00	4.81E–02	1.99E–02	1.09E+00
SF–GMA	3.30E–01	1.37E+00	3.30E–01	1.10E+00	2.93E–02	1.21E–02	6.60E–01
SF–Till	1.43E+00	4.41E+00	1.33E+00	5.38E+00	1.43E–01	5.89E–02	3.22E+00
SF–Fill	1.52E+00	6.50E+00	1.50E+00	5.38E+00	1.43E–01	5.89E–02	3.22E+00
IFP–GMA	4.10E–01	2.03E+00	3.60E–01	2.41E+00	6.39E–02	2.64E–02	1.44E+00
IFP–Till	8.33E–01	1.62E+00	7.32E–01	1.42E+00	3.77E–02	1.56E–02	8.50E–01
AFP–GMA	1.19E+00	1.42E+00	9.65E–01	1.26E+00	3.34E–02	1.38E–02	7.54E–01
AFP–Till	1.40E+00	3.60E+00	1.35E+00	2.46E+00	6.52E–02	2.69E–02	1.47E+00
SWL–Till	1.10E+00	3.10E+00	9.00E–01	6.01E+00	1.60E–01	6.59E–02	3.60E+00
LSP–Till	9.70E–01	2.49E+00	1.05E+00	1.90E+00	5.06E–02	2.09E–02	1.14E+00
OU4 Soil	1.52E+00	5.01E+00	5.01E+00	3.47E+01	9.22E–01	3.81E–01	2.08E+01
PAA	1.52E+00	6.50E+00	6.08E+00	1.02E+02	2.71E+00	1.12E+00	6.11E+01
PAB	1.52E+00	6.50E+00	5.10E+00	1.02E+02	2.71E+00	1.12E+00	6.11E+01
PAC	1.52E+00	6.50E+00	1.31E+00	1.02E+02	2.71E+00	1.12E+00	6.11E+01
PAD	1.52E+00	6.50E+00	1.70E+00	1.02E+02	2.71E+00	1.12E+00	6.11E+01
PAE	1.52E+00	6.50E+00	6.08E+00	1.02E+02	2.71E+00	1.12E+00	6.11E+01
PAF	1.52E+00	6.50E+00	2.02E+00	1.02E+02	2.71E+00	1.12E+00	6.11E+01
PAG	1.52E+00	6.50E+00	6.08E+00	1.02E+02	2.71E+00	1.12E+00	6.11E+01
PAH	1.52E+00	6.50E+00	6.08E+00	8.77E+01	2.33E+00	9.61E–01	5.25E+01
PAI	1.52E+00	1.50E+00	8.56E–01	9.35E+00	2.48E–01	1.02E–01	5.60E+00

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TABLE I.II–1–2
INORGANIC CONCENTRATIONS IN EXPOSED SOIL

Source	Inorganic Concentrations (mg/kg)				
Area	Antimony	Arsenic	Barium	Beryllium	Boron
560A	3.20E+00	1.21E+01	9.53E+01	1.60E+00	1.43E+01
560B	2.64E+01	8.82E+00	9.94E+01	1.00E+00	1.37E+01
560C	7.60E–01	5.66E+00	8.62E+01	6.30E–01	1.37E+01
560D	7.60E–01	7.30E+00	9.91E+01	7.00E–01	1.37E+01
570A	7.60E–01	2.60E+01	1.05E+02	2.10E+00	1.37E+01
570B	2.74E+01	3.25E+01	8.34E+01	1.01E+00	1.37E+01
570C	2.64E+01	6.23E+00	9.90E+01	1.59E+00	1.37E+01
570D	2.64E+01	6.23E+00	9.90E+01	1.59E+00	1.37E+01
570E	7.60E–01	3.25E+01	1.09E+02	6.00E–01	1.37E+01
575A	7.60E–01	7.30E+00	1.08E+02	1.70E+00	1.37E+01
575B	7.60E–01	3.70E+00	1.09E+02	6.00E–01	1.37E+01
580A	7.60E–01	6.50E+00	7.66E+01	6.00E–01	1.37E+01
581A	4.10E+00	9.84E+00	1.03E+02	1.40E+00	1.43E+01
581B	2.15E+01	6.16E+00	1.37E+02	1.11E+00	1.37E+01
581C	7.60E–01	3.30E+00	7.01E+01	4.80E–01	1.37E+01
581D	2.90E+00	6.90E+00	1.25E+02	1.30E+00	1.37E+01
582A	7.60E–01	8.59E+00	7.48E+01	1.40E+00	1.43E+01
582B	7.60E–01	2.72E+01	1.09E+02	2.10E+00	1.37E+01
WPAA	3.25E+01	6.88E+00	6.38E+01	7.34E–01	1.37E+01
5NEC	0.00E+00	6.10E+00	0.00E+00	8.00E–01	0.00E+00
WastePit1	7.60E–01	5.57E+00	6.77E+01	6.00E–01	1.37E+01
WastePit2	7.60E–01	5.57E+00	6.77E+01	6.00E–01	1.37E+01
WastePit3	7.60E–01	5.57E+00	6.77E+01	6.00E–01	1.37E+01
WastePit4	7.60E–01	5.57E+00	6.77E+01	6.00E–01	1.37E+01
WastePit5	7.60E–01	5.57E+00	6.77E+01	6.00E–01	1.37E+01
WastePit6	7.60E–01	5.57E+00	6.77E+01	6.00E–01	1.37E+01
Burnpit	7.60E–01	5.57E+00	6.77E+01	6.00E–01	1.37E+01
Clearwell	7.60E–01	5.57E+00	6.77E+01	6.00E–01	1.37E+01
SF–GMA	0.00E+00	6.20E+00	0.00E+00	0.00E+00	0.00E+00
SF–Till	0.00E+00	1.19E+01	0.00E+00	8.50E–01	0.00E+00
SF–Fill	0.00E+00	6.98E+00	0.00E+00	8.80E–01	0.00E+00
IFP–GMA	0.00E+00	5.10E+00	0.00E+00	0.00E+00	0.00E+00
IFP–Till	0.00E+00	6.90E+00	0.00E+00	0.00E+00	0.00E+00
AFP–GMA	0.00E+00	1.69E+01	0.00E+00	0.00E+00	0.00E+00
AFP–Till	0.00E+00	1.69E+01	0.00E+00	1.40E+00	0.00E+00
SWL–Till	2.26E+01	7.70E+00	0.00E+00	1.00E+00	0.00E+00
LSP–Till	0.00E+00	1.49E+01	0.00E+00	0.00E+00	0.00E+00
OU4 Soil	3.07E+01	8.00E+00	8.69E+01	9.07E–01	0.00E+00
PAA	3.81E+01	7.67E+00	1.04E+02	6.22E–01	1.37E+01
PAB	7.60E–01	2.31E+01	5.12E+02	1.15E+00	1.37E+01
PAC	2.12E+01	7.98E+00	9.56E+01	2.13E+00	1.37E+01
PAD	7.60E–01	9.60E+00	4.56E+02	8.59E–01	1.37E+01
PAE	7.60E–01	7.70E+00	1.07E+02	1.14E+00	1.37E+01
PAF	7.60E–01	1.16E+01	1.45E+02	3.50E+00	1.37E+01
PAG	7.60E–01	1.22E+01	4.14E+02	1.31E+00	1.37E+01
PAH	7.60E–01	6.09E+00	8.31E+01	1.37E+00	1.37E+01
PAI	7.60E–01	6.40E+00	1.83E+02	1.80E+00	1.37E+01

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5862

TABLE I.II–1–2 (Continued)

Source	Inorganic Concentrations (mg/kg)					
Area	Cadmium	Chromium	Cobalt	Copper	Cyanide	Lead
560A	1.90E+00	1.46E+01	1.36E+01	1.59E+01	5.30E–01	2.18E+01
560B	6.60E+00	3.43E+01	1.05E+01	2.68E+01	3.12E–01	2.20E+02
560C	7.60E+00	1.72E+01	1.39E+01	5.29E+01	1.20E+00	1.14E+02
560D	5.20E–01	1.35E+01	1.05E+01	1.59E+01	1.10E–01	1.82E+01
570A	6.20E+00	1.67E+01	1.12E+01	1.83E+01	4.50E–01	2.38E+01
570B	5.25E+00	1.82E+01	8.00E+00	2.03E+01	1.80E–01	2.24E+01
570C	3.96E+00	2.09E+01	1.47E+01	3.80E+01	5.00E–01	3.37E+01
570D	3.96E+00	2.09E+01	1.47E+01	3.80E+01	5.00E–01	3.37E+01
570E	5.25E+00	1.13E+01	8.00E+00	2.03E+01	4.40E–01	2.24E+01
575A	5.20E–01	1.40E+01	1.15E+01	1.43E+01	3.70E–01	2.24E+01
575B	5.20E–01	1.13E+01	8.00E+00	1.17E+01	4.40E–01	2.24E+01
580A	1.30E+00	1.13E+01	5.80E+00	1.44E+01	2.70E–01	5.48E+01
581A	4.90E–01	1.46E+01	1.13E+01	1.04E+02	9.10E–01	1.82E+03
581B	1.60E+00	2.10E+01	1.13E+01	1.72E+01	8.80E–01	5.70E+02
581C	5.20E–01	9.80E+00	1.13E+01	7.60E+00	2.70E–01	1.50E+01
581D	1.90E+00	1.47E+01	2.07E+00	1.19E+01	6.50E–01	2.99E+01
582A	7.50E–01	1.38E+01	1.14E+01	1.89E+01	4.30E–01	2.31E+01
582B	7.40E–01	1.34E+01	1.15E+01	2.36E+01	3.00E–01	2.55E+01
WPAA	5.90E+00	1.41E+01	1.06E+01	2.69E+01	3.70E–01	2.60E+01
5NEC	0.00E+00	1.76E+01	0.00E+00	2.77E+01	0.00E+00	1.92E+01
WastePit1	8.70E–01	1.16E+01	0.00E+00	8.60E+00	2.70E–01	1.89E+01
WastePit2	8.70E–01	1.16E+01	0.00E+00	8.60E+00	2.70E–01	1.89E+01
WastePit3	8.70E–01	1.16E+01	0.00E+00	8.60E+00	2.70E–01	1.89E+01
WastePit4	8.70E–01	1.16E+01	0.00E+00	8.60E+00	2.70E–01	1.89E+01
WastePit5	8.70E–01	1.16E+01	0.00E+00	8.60E+00	2.70E–01	1.89E+01
WastePit6	8.70E–01	1.16E+01	0.00E+00	8.60E+00	2.70E–01	1.89E+01
Burnpit	8.70E–01	1.16E+01	0.00E+00	8.60E+00	2.70E–01	1.89E+01
Clearwell	8.70E–01	1.16E+01	0.00E+00	8.60E+00	2.70E–01	1.89E+01
SF–GMA	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
SF–Till	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
SF–Fill	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
IFP–GMA	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
IFP–Till	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
AFP–GMA	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
AFP–Till	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
SWL–Till	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
LSP–Till	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
OU4 Soil	5.82E+00	2.84E+01	1.33E+01	2.38E+01	1.98E+00	1.49E+01
PAA	5.90E+00	2.13E+01	1.39E+01	5.16E+01	1.50E+00	2.45E+01
PAB	4.21E+00	3.75E+01	1.18E+01	2.07E+02	6.30E–01	8.60E+01
PAC	6.90E+00	3.81E+01	1.94E+01	3.23E+01	3.00E–01	4.40E+02
PAD	6.70E+00	4.69E+01	1.10E+01	3.76E+01	2.70E–01	2.93E+02
PAE	5.07E+00	2.42E+01	1.09E+01	2.30E+01	1.30E+00	7.65E+01
PAF	1.10E+00	2.43E+01	1.10E+01	2.32E+01	2.70E–01	2.17E+01
PAG	5.40E+00	2.39E+01	1.48E+01	6.94E+01	5.20E–01	5.11E+01
PAH	5.80E+00	3.77E+01	1.07E+01	2.10E+01	6.90E–01	6.34E+01
PAI	5.20E–01	1.97E+01	1.18E+01	1.96E+01	2.70E–01	5.48E+01

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TABLE I.II–1–2 (Continued)

Source	Inorganic Concentrations (mg/kg)					
Area	Manganese	Mercury	Molybdenum	Nickel	Selenium	Silver
560A	8.63E+02	3.00E–01	1.24E+01	1.91E+01	7.10E–01	7.40E+00
560B	8.30E+02	3.00E–01	1.11E+01	2.34E+01	6.20E–01	9.30E+00
560C	4.75E+02	3.00E–01	4.60E+00	2.57E+01	4.87E–01	7.90E+00
560D	7.89E+02	3.00E–01	5.30E+00	1.17E+01	6.20E–01	6.10E+00
570A	7.94E+02	3.00E–01	5.20E+00	2.32E+01	1.20E+00	7.70E+00
570B	5.60E+02	3.00E–01	4.17E+00	2.94E+01	1.20E+00	7.95E+00
570C	7.59E+02	8.00E–02	5.00E+00	2.90E+01	7.20E–01	7.24E+00
570D	7.59E+02	8.00E–02	5.00E+00	2.90E+01	7.20E–01	7.24E+00
570E	5.60E+02	3.00E–01	2.70E+00	1.07E+01	1.20E+00	7.95E+00
575A	1.35E+03	3.00E–01	2.70E+00	1.61E+01	7.20E–01	4.80E–01
575B	1.17E+03	3.00E–01	2.70E+00	1.07E+01	1.20E+00	4.70E–01
580A	4.43E+02	3.00E–01	2.70E+00	1.31E+01	5.30E–01	4.50E–01
581A	3.42E+03	5.70E–01	8.30E–01	2.06E+01	4.10E–01	6.10E+00
581B	1.74E+03	1.20E–01	7.90E+00	2.82E+01	4.10E–01	1.80E+00
581C	9.02E+02	3.00E–01	7.90E+00	1.10E+01	4.10E–01	4.50E–01
581D	2.04E+03	3.00E–01	8.50E+00	1.52E+01	5.50E–01	4.50E–01
582A	6.19E+02	3.00E–01	6.50E+00	1.83E+01	7.20E–01	4.50E–01
582B	4.63E+02	3.00E–01	2.30E+00	2.01E+01	5.90E+00	4.50E–01
WPAA	8.41E+02	2.00E–02	3.55E+00	2.20E+01	6.00E–01	1.02E+01
5NEC	1.17E+03	0.00E+00	1.13E+01	0.00E+00	0.00E+00	0.00E+00
WastePit1	8.14E+02	3.00E–01	2.70E+00	1.27E+01	0.00E+00	4.50E–01
WastePit2	8.14E+02	3.00E–01	2.70E+00	1.27E+01	0.00E+00	4.50E–01
WastePit3	8.14E+02	3.00E–01	2.70E+00	1.27E+01	0.00E+00	4.50E–01
WastePit4	8.14E+02	3.00E–01	2.70E+00	1.27E+01	0.00E+00	4.50E–01
WastePit5	8.14E+02	3.00E–01	2.70E+00	1.27E+01	0.00E+00	4.50E–01
WastePit6	8.14E+02	3.00E–01	2.70E+00	1.27E+01	0.00E+00	4.50E–01
Burnpit	8.14E+02	3.00E–01	2.70E+00	1.27E+01	0.00E+00	4.50E–01
Clearwell	8.14E+02	3.00E–01	2.70E+00	1.27E+01	0.00E+00	4.50E–01
SF–GMA	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
SF–Till	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
SF–Fill	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
IFP–GMA	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
IFP–Till	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
AFP–GMA	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
AFP–Till	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
SWL–Till	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
LSP–Till	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
OU4 Soil	7.32E+02	1.20E–01	1.33E+01	3.38E+01	5.70E+00	1.44E+01
PAA	7.06E+02	2.00E–01	3.56E+00	2.62E+01	4.87E–01	9.30E+00
PAB	9.08E+02	3.20E–01	1.24E+01	3.27E+01	1.51E+00	7.50E+00
PAC	6.17E+02	2.10E+00	1.31E+01	3.97E+01	6.40E–01	1.72E+01
PAD	6.14E+02	1.30E+00	3.70E+00	7.22E+01	7.20E–01	5.90E+00
PAE	6.36E+02	3.70E–01	6.20E+00	2.95E+01	6.79E–01	6.90E+00
PAF	6.92E+02	3.00E–01	2.70E+00	3.79E+01	7.20E–01	4.50E–01
PAG	8.97E+02	1.10E+00	4.70E+00	3.74E+01	3.10E+00	7.00E+00
PAH	1.07E+03	5.30E–01	4.07E+00	2.75E+01	2.80E–01	4.58E+00
PAI	1.72E+03	3.00E–01	2.70E+00	3.37E+01	5.30E–01	4.50E–01

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TABLE I.II–1–2 (Continued)

Source	Inorganic Concentrations (mg/kg)				
Area	Thallium	Thorium	Uranium	Vanadium	Zinc
560A	6.70E–01	9.29E+00	2.34E+01	2.53E+01	5.39E+00
560B	5.80E–01	1.34E+01	8.75E+02	2.69E+01	8.37E+01
560C	5.80E–01	1.04E+02	1.16E+03	2.01E+01	6.73E+01
560D	5.80E–01	7.37E+01	3.63E+02	3.74E+01	8.37E+01
570A	2.20E–01	2.09E+01	7.79E+01	3.45E+01	6.38E+01
570B	5.80E–01	6.00E+01	4.29E+02	2.61E+01	4.29E+01
570C	4.90E–01	7.27E+00	3.57E+01	2.80E+01	5.79E+01
570D	4.90E–01	1.14E+02	3.34E+03	2.80E+01	5.79E+01
570E	5.80E–01	4.73E+01	6.32E+01	2.61E+01	4.29E+01
575A	5.80E–01	7.27E+00	2.24E+01	2.69E+01	5.16E+01
575B	5.80E–01	6.36E+00	6.32E+01	2.31E+01	4.29E+01
580A	5.80E–01	7.27E+00	5.40E+00	2.25E+01	4.29E+01
581A	7.50E–01	8.50E+00	1.58E+01	2.44E+01	9.39E+01
581B	4.70E–01	6.00E+01	7.76E+02	3.71E+01	9.39E+01
581C	5.80E–01	1.27E+01	4.73E+01	2.28E+01	9.39E+01
581D	5.80E–01	5.63E+02	4.43E+03	3.88E+01	6.43E+01
582A	3.20E–01	1.05E+01	1.59E+01	2.32E+01	5.52E+01
582B	7.70E–01	1.46E+01	4.45E+02	2.63E+01	7.83E+00
WPAA	2.70E–01	2.31E+01	1.03E+03	2.27E+01	5.88E+01
5NEC	0.00E+00	1.04E+01	2.48E+01	0.00E+00	0.00E+00
WastePit1	5.80E–01	9.82E+00	3.25E+00	2.23E+01	0.00E+00
WastePit2	5.80E–01	9.82E+00	3.25E+00	2.23E+01	0.00E+00
WastePit3	5.80E–01	9.82E+00	3.25E+00	2.23E+01	0.00E+00
WastePit4	5.80E–01	9.82E+00	3.25E+00	2.23E+01	0.00E+00
WastePit5	5.80E–01	9.82E+00	3.25E+00	2.23E+01	0.00E+00
WastePit6	5.80E–01	9.82E+00	3.25E+00	2.23E+01	0.00E+00
Burnpit	5.80E–01	9.82E+00	3.25E+00	2.23E+01	0.00E+00
Clearwell	5.80E–01	9.82E+00	3.25E+00	2.23E+01	0.00E+00
SF–GMA	0.00E+00	0.00E+00	1.03E+01	0.00E+00	0.00E+00
SF–Till	0.00E+00	0.00E+00	8.00E+00	0.00E+00	0.00E+00
SF–Fill	0.00E+00	0.00E+00	8.00E+00	0.00E+00	0.00E+00
IFP–GMA	0.00E+00	0.00E+00	5.86E+00	0.00E+00	0.00E+00
IFP–Till	0.00E+00	0.00E+00	4.39E+00	0.00E+00	0.00E+00
AFP–GMA	0.00E+00	0.00E+00	8.42E+00	0.00E+00	0.00E+00
AFP–Till	0.00E+00	0.00E+00	7.17E+00	0.00E+00	0.00E+00
SWL–Till	0.00E+00	0.00E+00	7.70E+00	0.00E+00	0.00E+00
LSP–Till	0.00E+00	0.00E+00	1.43E+01	0.00E+00	0.00E+00
OU4 Soil	7.10E–01	2.85E+01	6.23E+01	2.84E+01	5.96E+01
PAA	2.85E–01	2.86E+02	1.23E+04	2.82E+01	6.73E+01
PAB	4.20E–01	4.64E+01	8.27E+02	2.73E+01	1.73E+02
PAC	2.90E–01	1.19E+01	1.67E+03	2.80E+01	1.28E+02
PAD	3.90E–01	1.55E+01	4.20E+02	2.63E+01	2.58E+01
PAE	2.30E–01	3.24E+02	1.64E+04	2.70E+01	1.31E+02
PAF	3.70E–01	1.83E+01	2.36E+02	3.54E+01	2.58E+01
PAG	4.40E–01	2.57E+03	4.29E+04	3.24E+01	3.52E+02
PAH	5.00E–01	1.05E+02	1.57E+02	2.46E+01	5.33E+01
PAI	3.00E–01	7.78E+00	1.68E+01	2.39E+01	7.76E+01

000422

TABLE I.II–1–3
ORGANIC CONCENTRATIONS IN EXPOSED SOIL

Source	Organic Concentrations (mg/kg)				
Area	Aroclor–1221	Aroclor–1248	Aroclor–1254	Aroclor–1260	2–Methylnaphthalene
560A	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
560B	0.00E+00	0.00E+00	2.10E+00	0.00E+00	3.50E–01
560C	0.00E+00	0.00E+00	4.50E–02	1.30E+00	0.00E+00
560D	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
570A	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
570B	0.00E+00	0.00E+00	1.20E–01	0.00E+00	0.00E+00
570C	0.00E+00	0.00E+00	2.40E–01	0.00E+00	0.00E+00
570D	0.00E+00	0.00E+00	2.40E–01	0.00E+00	0.00E+00
570E	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
575A	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
575B	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
580A	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
581A	0.00E+00	0.00E+00	2.00E–01	0.00E+00	0.00E+00
581B	0.00E+00	0.00E+00	1.20E–01	0.00E+00	2.50E–02
581C	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
581D	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
582A	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
582B	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
WPAA	0.00E+00	0.00E+00	1.20E–01	0.00E+00	7.40E–01
5NEC	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
WastePit1	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
WastePit2	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
WastePit3	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
WastePit4	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
WastePit5	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
WastePit6	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Burnpit	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Clearwell	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
SF–GMA	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
SF–Till	0.00E+00	0.00E+00	4.10E–02	0.00E+00	0.00E+00
SF–Fill	0.00E+00	0.00E+00	4.30E–01	3.80E–02	0.00E+00
IFP–GMA	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
IFP–Till	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
AFP–GMA	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
AFP–Till	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
SWL–Till	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
LSP–Till	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
OU4 Soil	0.00E+00	0.00E+00	3.00E–02	0.00E+00	0.00E+00
PAA	0.00E+00	0.00E+00	1.10E+00	0.00E+00	0.00E+00
PAB	0.00E+00	0.00E+00	2.30E+00	5.60E–01	1.30E+00
PAC	0.00E+00	0.00E+00	1.00E+01	0.00E+00	0.00E+00
PAD	0.00E+00	0.00E+00	1.00E+01	0.00E+00	3.20E–01
PAE	0.00E+00	0.00E+00	4.60E–01	1.40E–01	4.90E–02
PAF	0.00E+00	0.00E+00	5.40E–02	0.00E+00	0.00E+00
PAG	0.00E+00	0.00E+00	2.40E+00	1.00E+00	5.80E–02
PAH	0.00E+00	0.00E+00	1.10E+00	2.10E+00	5.10E–01
PAI	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

000423

5862

TABLE I.II-1-3 (Continued)

Source	Organic Concentrations (mg/kg)			
Area	4,4'-DDE	Carbazole	Endrin	2,3,7,8-TCDD (Equiv.)
560A	2.00E-02	0.00E+00	0.00E+00	0.00E+00
560B	0.00E+00	0.00E+00	0.00E+00	0.00E+00
560C	0.00E+00	0.00E+00	0.00E+00	0.00E+00
560D	0.00E+00	0.00E+00	0.00E+00	3.20E-06
570A	0.00E+00	0.00E+00	0.00E+00	0.00E+00
570B	0.00E+00	0.00E+00	0.00E+00	0.00E+00
570C	0.00E+00	4.60E-02	0.00E+00	0.00E+00
570D	0.00E+00	4.60E-02	0.00E+00	0.00E+00
570E	0.00E+00	0.00E+00	0.00E+00	0.00E+00
575A	0.00E+00	7.00E-03	0.00E+00	0.00E+00
575B	0.00E+00	0.00E+00	0.00E+00	0.00E+00
580A	0.00E+00	7.00E-03	0.00E+00	0.00E+00
581A	0.00E+00	0.00E+00	0.00E+00	0.00E+00
581B	0.00E+00	0.00E+00	0.00E+00	0.00E+00
581C	0.00E+00	0.00E+00	0.00E+00	0.00E+00
581D	0.00E+00	0.00E+00	0.00E+00	0.00E+00
582A	0.00E+00	0.00E+00	0.00E+00	0.00E+00
582B	0.00E+00	0.00E+00	0.00E+00	0.00E+00
WPAA	0.00E+00	7.60E-02	0.00E+00	0.00E+00
5NEC	0.00E+00	0.00E+00	0.00E+00	0.00E+00
WastePit1	0.00E+00	0.00E+00	0.00E+00	0.00E+00
WastePit2	0.00E+00	0.00E+00	0.00E+00	0.00E+00
WastePit3	0.00E+00	0.00E+00	0.00E+00	0.00E+00
WastePit4	0.00E+00	0.00E+00	0.00E+00	0.00E+00
WastePit5	0.00E+00	0.00E+00	0.00E+00	0.00E+00
WastePit6	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Burnpit	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Clearwell	0.00E+00	0.00E+00	0.00E+00	0.00E+00
SF-GMA	0.00E+00	0.00E+00	0.00E+00	0.00E+00
SF-Till	0.00E+00	0.00E+00	0.00E+00	0.00E+00
SF-Fill	0.00E+00	0.00E+00	0.00E+00	0.00E+00
IFP-GMA	0.00E+00	0.00E+00	0.00E+00	0.00E+00
IFP-Till	0.00E+00	0.00E+00	0.00E+00	0.00E+00
AFP-GMA	0.00E+00	0.00E+00	0.00E+00	0.00E+00
AFP-Till	0.00E+00	0.00E+00	0.00E+00	0.00E+00
SWL-Till	0.00E+00	2.10E-01	0.00E+00	0.00E+00
LSP-Till	0.00E+00	0.00E+00	0.00E+00	0.00E+00
OU4 Soil	0.00E+00	0.00E+00	0.00E+00	0.00E+00
PAA	0.00E+00	0.00E+00	0.00E+00	0.00E+00
PAB	0.00E+00	6.50E-02	0.00E+00	3.20E-06
PAC	0.00E+00	4.80E-02	0.00E+00	0.00E+00
PAD	0.00E+00	0.00E+00	0.00E+00	0.00E+00
PAE	0.00E+00	5.70E-01	0.00E+00	0.00E+00
PAF	0.00E+00	2.50E-01	0.00E+00	0.00E+00
PAG	0.00E+00	7.40E-02	0.00E+00	0.00E+00
PAH	0.00E+00	1.40E-01	0.00E+00	0.00E+00
PAI	0.00E+00	0.00E+00	0.00E+00	0.00E+00

090424

ATTACHMENT I.II-2

SURFACE SOIL AERODYNAMIC MODAL DIAMETER ANALYSIS

Fernald Environmental
FERMCO
Restoration Management Corporation

INTEROFFICE MEMORANDUM

To:	Tom Anderson Cheri Smyser	Date:	May 11, 1994
Location:	Fernald, T-80	Reference:	
From:	Mark Cherry MJC	FERMCO #:	M:CRU5:94-0212
Location:	Fernald, T-80	Client:	DOE DE-AC05-920R21972
Extension:	738-6816	Subject:	Technical Direction and Clarification for Conducting Surface Soil Sampling

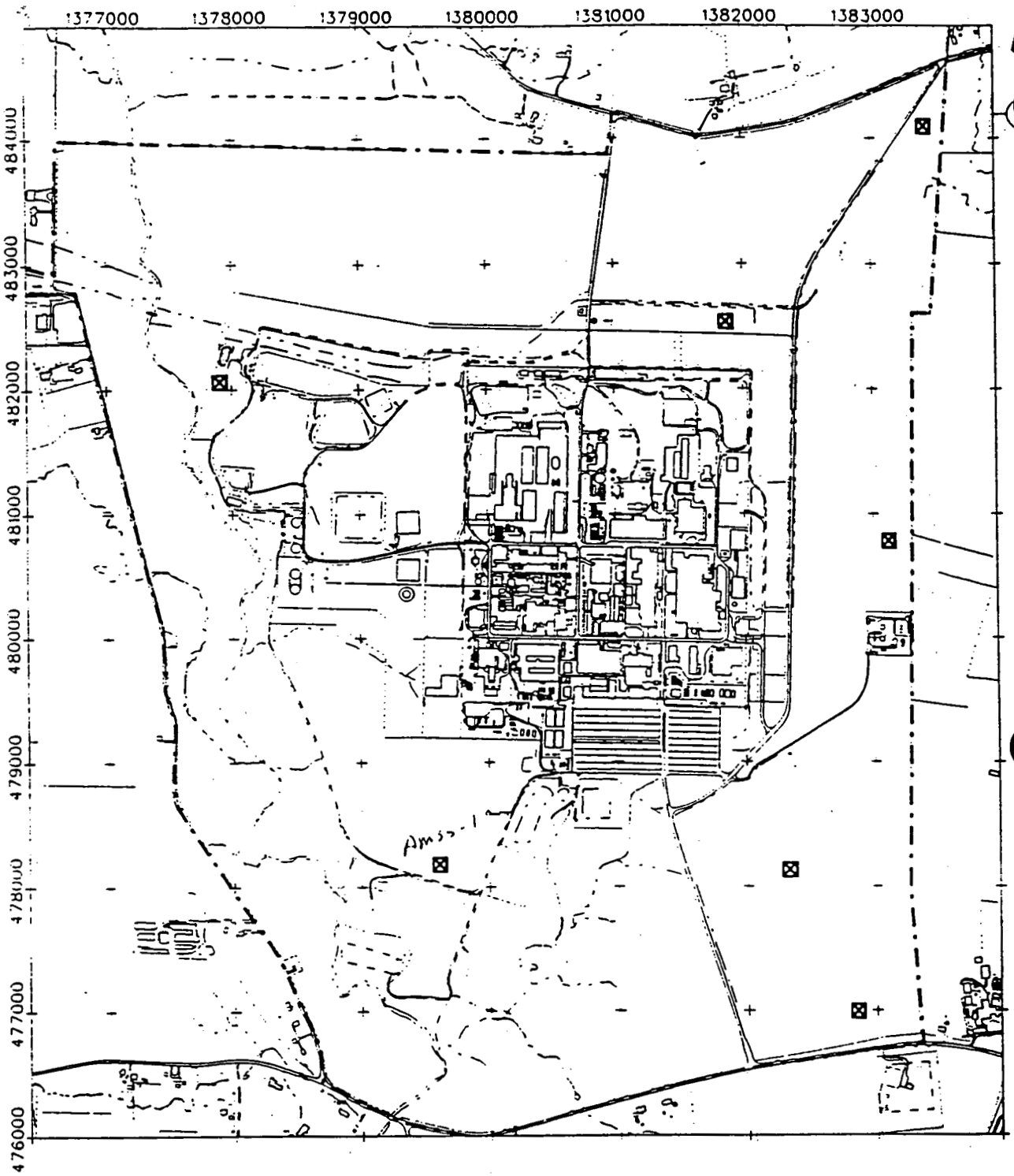
c: File Record Storage Copy 106.4.19

This memo provides technical direction and clarification for conducting surface soil sampling in support of air modeling for the baseline risk assessment.

- Samples should be collected from the seven locations identified on the attached map (Attachment 1).
- Surface soil sampling protocols outlined in the attached EPA procedure (Attachment 2) and Appendix K of the SCQ should be followed.
- All samples should be field screened for beta/gamma activity and recorded in the field log. A Radiation Technician should be present during all sampling activities.
- Samples should be transported to the FERMCO lab for sieving.
- Samples should be split at the lab into two equal fractions. One sample fraction should be sieved immediately and the other should be allowed to air dry for 24 hours prior to sieving.
- Samples should be sieved per the attached EPA procedure (Attachment 2).
- The health and safety requirements defined in the Health and Safety Plan for the Surface and Subsurface Soil Sampling Investigation (WBS No. 50.03.18, June 1993) as amended in the attached memo (Attachment 3) must be followed.

If you have any questions or require additional information, please contact me at your earliest convenience.

ATTACHMENT I



LEGEND:

⊠ SOIL SAMPLING LOCATION

FEMP BOUNDARY

SCALE

1200 600 0 1200FEET

FIGURE 2-X. SURFACE SOIL SAMPLING LOCATIONS TO SUPPORT AIR PATHWAY MODELING

FIELD PROCEDURE FOR DETERMINATION OF THRESHOLD FRICTION VELOCITY*

1. Prepare a nest of sieves with the following openings: 4 mm, 2 mm, 1 mm, 0.5 mm, 0.25 mm. Place a collector pan below the bottom sieve (0.25 mm opening).

2. Collect a sample representing the surface layer of loose particles (approximately 1 cm in depth for an uncrusted surface), removing any rocks larger than about 1 cm in average physical diameter. The area to be sampled should not be less than 30 cm x 30 cm.

3. Pour the sample into the top sieve (4 mm opening), and place a lid on the top.

4. Rotate the covered sieve/pan unit by hand using broad sweeping arm motions in the horizontal plane. Complete 20 rotations at a speed just necessary to achieve some relative horizontal motion between the sieve and the particles.

5. Inspect the relative quantities of catch within each sieve and determine where the mode in the aggregate size distribution lies, i.e., between the opening size of the sieve with the largest catch and the opening size of the next largest sieve.

* Adapted from a laboratory procedure published by W. S. Chepil (1952).

ATTACHMENT II

Fernald Environmental

FERMCO

Restoration Management Corporation

INTEROFFICE MEMORANDUM

To:	Greg Johnson	Date:	May 12, 1994
Location:	Fernald, T-80	Reference:	
From:	Mark Cherry MJC	FERMCO #:	M:CRU5:94-0216
Location:	Fernald, T-80	Client:	DOE DE-AC05-920R21972
Extension:	738-6816	Subject:	Health and Safety Plan

c: File Record Storage Copy 106.4.19
Tom Anderson
Cheri Smyser

The attached health and safety plan is applicable to the air model surface soil sampling with the following modifications:

- In reference to Section 13.1.1: Replace Art Bomberger with Dave Brettschneider as CRU5 Project Director; also, add Mark Cherry as CRU5 Project Manager.
- Replace item 1. on page 19 with the following statement:
  1. The project will consist of collecting soil samples in non-production areas of the FEMP. The soil will be collected at a depth interval of 0-3 inches (maximum).
- Replace item 2.b. on page 20 with the following statement:
  2.b. A RCT will accompany the samples during sampling activities. In addition, all sample team members will be radiological worker trained to the RAD II level.
- Delete item 2.e. on page 20 "Prior to the implementation of..."
- Add to item 2: The samplers shall take care to avoid poison ivy, bees and other bio-hazards; and shall check periodically for ticks.
- Page 24: Provide a map of the sampling locations.

Also attached is a memo describing the work to be performed. If you are in agreement with the terms of this memo, please sign on the line below.

Concurrence: Greg Johnson, CRU5 HSO

000429 MJC:TAA:daz
Attachment

RESULTS

ERNALD
RI/FS

FIELD ACTIVITY DAILY LOG

DAILY L NO. | SHEET | OF 4

PROJECT NAME: SURFACE SOIL SAMPLING: AIR MODELING | PROJECT NO. N/A.

FIELD ACTIVITY SUBJECT: SEVEN SS FOR OUS BASELINE RISK ASSESSMENT

DESCRIPTION OF DAILY ACTIVITIES AND EVENTS:

:00 arrive at AMSS-2 which is located 30 feet northwest of MW cluster 1733. collect 1 gal surface soil sample (AMSS-2). see map below. this is the correct location of AMSS-2.

:40 arrive at AMSS-3 which is located 50 feet north of lysimeters 11130/11131. collect 1 gal of the top cm surface soil.

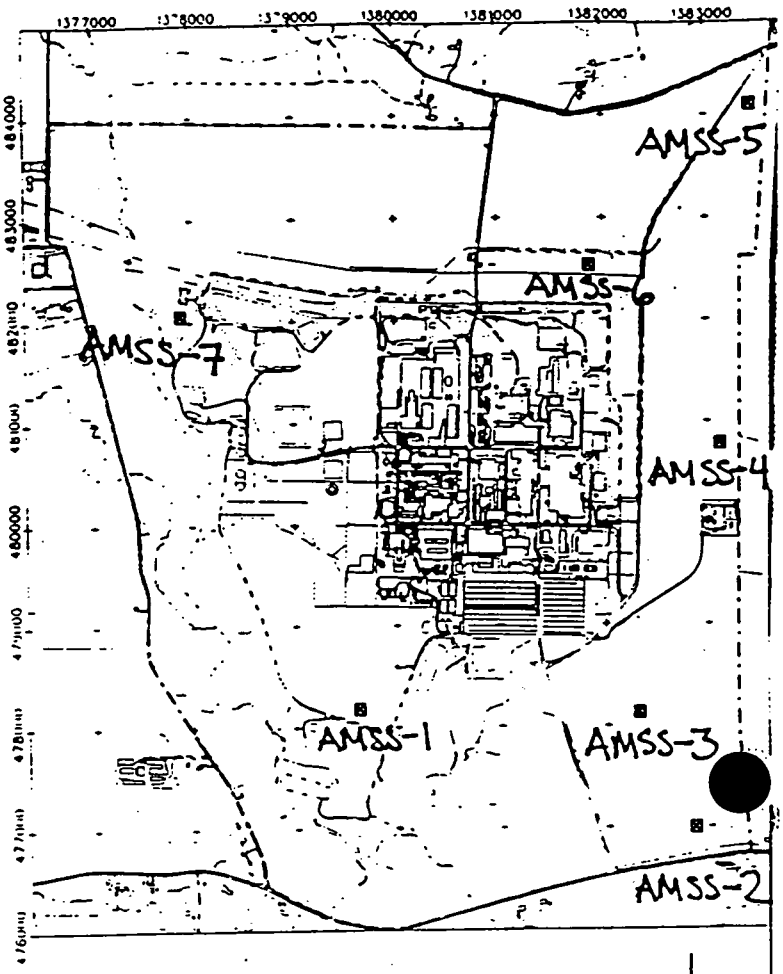
:10 drive at AMSS-4 which is located 25 feet northeast of MW2051 and collect 1 gal of the top cm of surface soil.

:0 arrive at AMSS-5 which is located 50 feet south of MW 2754 and collect 1 gallon of the top centimeter of surface soil.

:57 arrive at AMSS-6 which is located 30 feet northeast of lysimeters 11132/11133 and collect 1 gal of the top cm of surface soil.

: arrive at AMSS-7 which is located 80 feet north of the railroad spur and collect 1 gallon of the top cm of surface soil.

: perform sieve test for threshold friction velocity on undried portion of each sample. see following sheets for results.



CAS 24 May 94

H-NU CALIBRATED BY
ON
USING N/A
LOT #

one gallon provides enough volume for the mass required.

SITORS ON SITE:	CHANGES FROM PLANS AND SPECIFICATIONS, AND OTHER SPECIAL ORDERS AND IMPORTANT DECISIONS.
none	none
ATHER CONDITIONS: 7:30 a.m. 70°F, clear, 69% rel. humidity	IMPORTANT TELEPHONE CALLS: none

PERSONNEL ON SITE: M. Cherry, C. Simpson

PERVISOR: DATE:

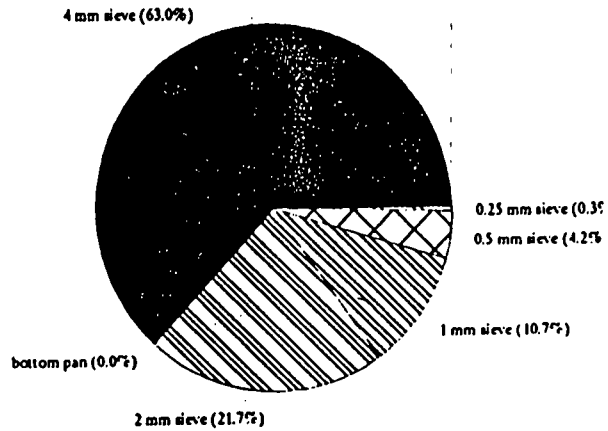
090431

AMSS-1: FIRST ROUND ANALYSIS (UNDRIED SAMPLE)

16 May 1994

	Sieve Size (mm)	Soil Retained (g)	Percent Composition (%)
	4	186.2682	–
	4	150.5971	–
	4	174.5217	–
	4	162.4734	–
	4	130.2578	–
	4	157.4585	–
TOTAL (4 mm)		961.5767	63.0324
	2	158.2942	–
	2	172.7507	–
TOTAL (2 mm)		331.0449	21.7004
	1	163.6233	10.7257
	0.5	63.9924	4.1948
	0.25	4.7865	0.3138
	bottom pan	0.5033	0.0330
GRAND TOTAL		1525.5271	100.0000

AMSS-1 UNDRIED

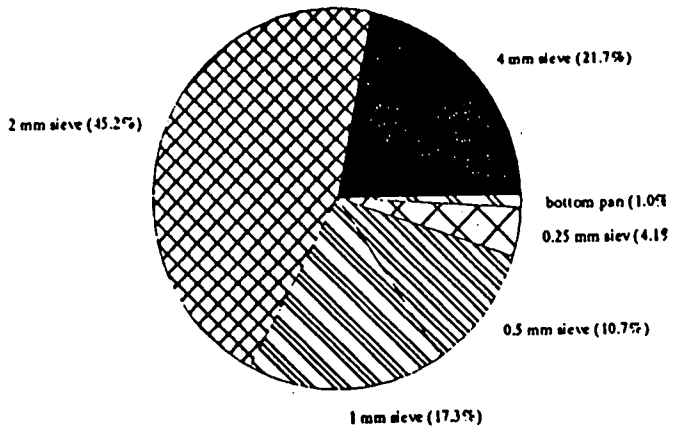


AMSS-1: SECOND ROUND ANALYSIS (DRIED SAMPLE)

17 May 1994

	Sieve Size (mm)	Soil Retained (g)	Percent Composition (%)
	4	109.9244	–
	4	30.2724	–
TOTAL (4 mm)		140.1968	21.7071
	2	142.7920	–
	2	149.3075	–
TOTAL (2 mm)		292.0995	45.2267
	1	111.4850	17.2616
	0.5	69.4273	10.7497
	0.25	26.3671	4.0825
	bottom pan	6.2803	0.9724
GRAND TOTAL		645.8560	100.0000

AMSS-1 DRIED

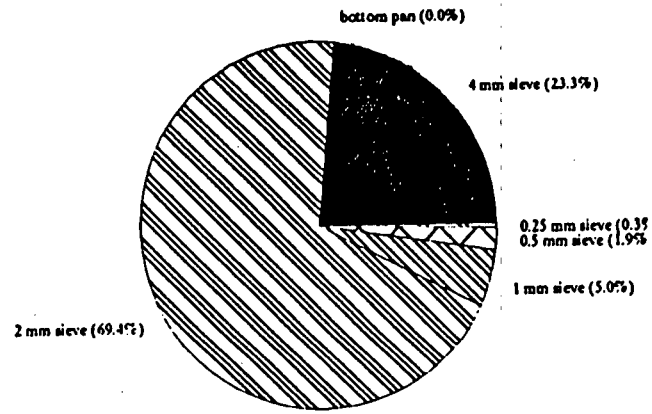


AMSS–2: FIRST ROUND ANALYSIS (UNDRIED SAMPLE)

24 May 1994

	Sieve Size (mm)	Soil Retained (g)	Percent Composition (%)
	4	170.1887	–
	4	120.9280	–
TOTAL (4 mm)		291.1167	23.2821
	2	176.5287	–
	2	148.7673	–
	2	152.7739	–
	2	133.1967	–
	2	154.0193	–
	2	102.4138	–
TOTAL (2 mm)		867.6997	69.3945
	1	62.7759	5.0205
	0.5	24.2857	1.9423
	0.25	3.8942	0.3114
	bottom pan	0.6145	0.0491
GRAND TOTAL		1250.3867	100.0000

AMSS–2 UNDRIED



Bottom Pan 0.04%

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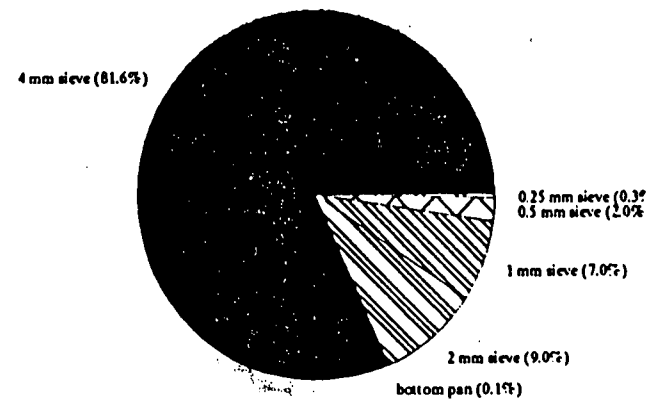
AMSS–2: SECOND ROUND ANALYSIS (DRIED SAMPLE)

25 May 1994

090435

	Sieve Size (mm)	Soil Retained (g)	Percent Composition (%)
	4	136.9347	–
	4	172.6359	–
	4	164.4926	–
	4	182.0699	–
	4	153.4438	–
	4	179.5860	–
TOTAL (4 mm)		989.1629	89.7168
TOTAL (2 mm)	2	109.3867	9.9213
	1	84.5820	7.6716
	0.5	24.2857	2.2027
	0.25	3.8942	0.3532
	bottom pan	0.6145	0.0557
GRAND TOTAL		1102.5393	100.0000

AMSS–2 DRIED

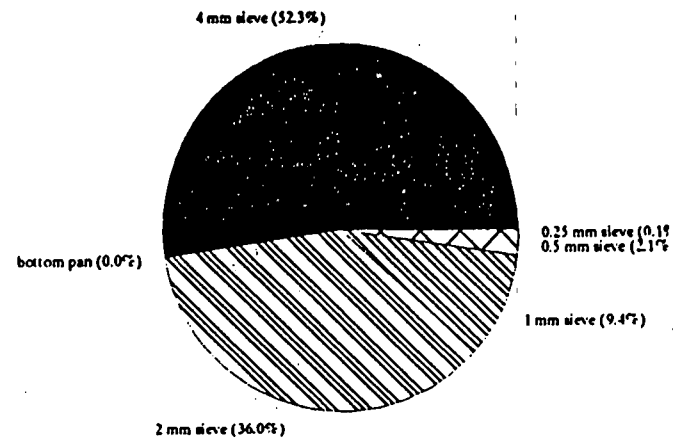


AMSS–3: FIRST ROUND ANALYSIS (UNDRIED SAMPLE)

24 May 1994

	Sieve Size (mm)	Soil Retained (g)	Percent Composition (%)
	4	230.4405	–
	4	292.0446	–
	4	90.651	–
TOTAL (4 mm)		613.1361	52.2689
	2	210.142	–
	2	212.5559	–
TOTAL (2 mm)	2	422.6979	36.0343
	1	110.4759	9.4179
	0.5	24.6021	2.0973
	0.25	1.5620	0.1332
	bottom pan	0.5689	0.0485
GRAND TOTAL		1173.0429	100.0000

AMSS–3 UNDRIED



AMSS–3: SECOND ROUND ANALYSIS (DRIED SAMPLE)

25 May 1994

	Sieve Size (mm)	Soil Retained (g)	Percent Composition (%)
	4	274.4335	–
	4	221.5245	–
	4	201.1976	–
	4	192.5464	–
	4	293.3461	–
	4	217.8029	–
TOTAL (4 mm)		1400.8510	80.8886
	2	84.0198	4.8515
	1	125.8425	7.2665
	0.5	99.1030	5.7225
	0.25	20.8473	1.2038
	bottom pan	1.1642	0.0672
GRAND TOTAL		1731.8278	100.0000

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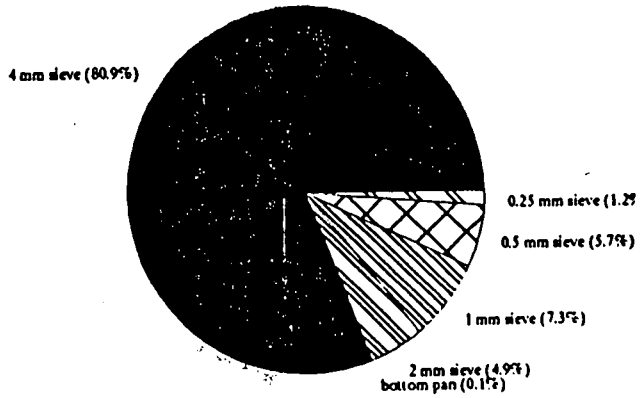
AMSS–3 DRIED

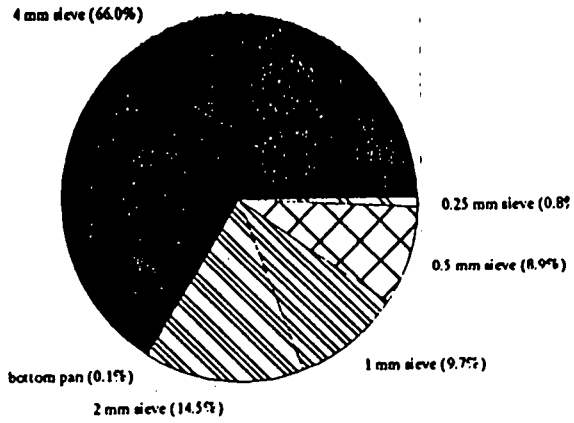


AMSS–4: FIRST ROUND ANALYSIS (UNDRIED SAMPLE)

24 May 1994

	Sieve Size (mm)	Soil Retained (g)	Percent Composition (%)
	4	177.6342	–
	4	232.1742	–
	4	94.2951	–
TOTAL (4 mm)		504.1035	66.0249
	2	110.5028	14.4731
	1	74.2678	9.7272
	0.5	67.6466	8.8600
	0.25	6,0983	0.7987
	bottom pan	0.8856	0.1160
GRAND TOTAL		763.5046	100.0000

AMSS–4 UNDRIED



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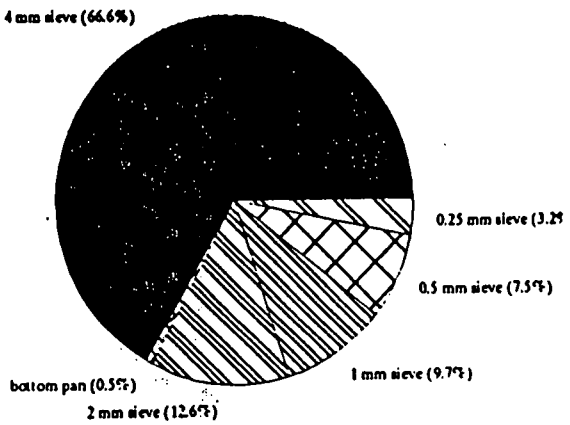
AMSS–4: SECOND ROUND ANALYSIS (DRIED SAMPLE)

25 May 1994

	Sieve Size (mm)	Soil Retained (g)	Percent Composition (%)
	4	182.0931	–
	4	168.0479	–
	4	163.9286	–
	4	150.2297	–
	4	218.2032	–
	4	130.7362	–
TOTAL (4 mm)		1013.2387	66.5481
	2	191.3468	12.5674
	1	147.4421	9.6838
	0.5	114.1321	7.4960
	0.25	48.1184	3.1604
	bottom pan	8.2867	0.5443
GRAND TOTAL		1522.5648	100.0000

AMSS–4 DRIED

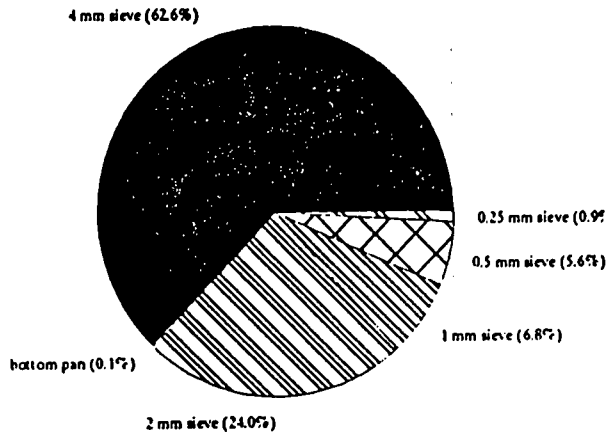


AMSS-5: FIRST ROUND ANALYSIS (UNDRIED SAMPLE)

24 May 1994

	Sieve Size (mm)	Soil Retained (g)	Percent Composition (%)
	4	143.255	–
	4	255.4269	–
	4	231.9034	–
TOTAL (4 mm)		630.5853	62.6198
	2	241.3999	23.9721
	1	68.0887	6.7615
	0.5	56.1226	5.5732
	0.25	9.3301	0.9265
	bottom pan	1.4790	0.1469
GRAND TOTAL		1007.0056	100.0000

AMSS-5 UNDRIED



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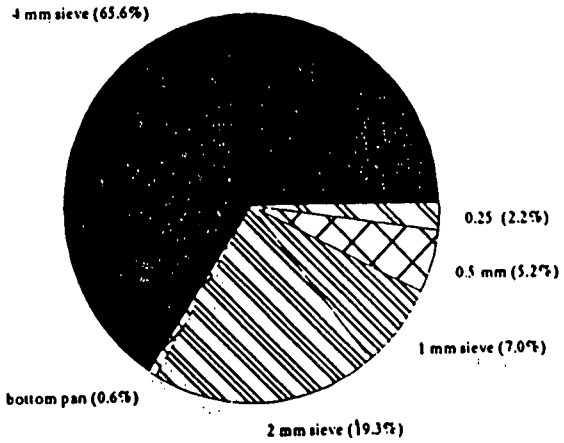
AMSS-5: SECOND ROUND ANALYSIS (DRIED SAMPLE)

25 May 1994

	Sieve Size (mm)	Soil Retained (g)	Percent Composition (%)
	4	187.4928	–
	4	187.1055	–
	4	150.4474	–
	4	253.9621	–
	4	149.2698	–
	4	81.6306	–
TOTAL (4 mm)		1009.9082	65.6314
	2	145.4633	–
	2	152.2052	–
	2	297.6685	19.3447
	1	107.9226	7.0136
	0.5	79.8055	5.1864
	0.25	33.6869	2.1892
	bottom pan	9.7648	0.6346
GRAND TOTAL		1538.7565	100.0000

AMSS-5 DRIED

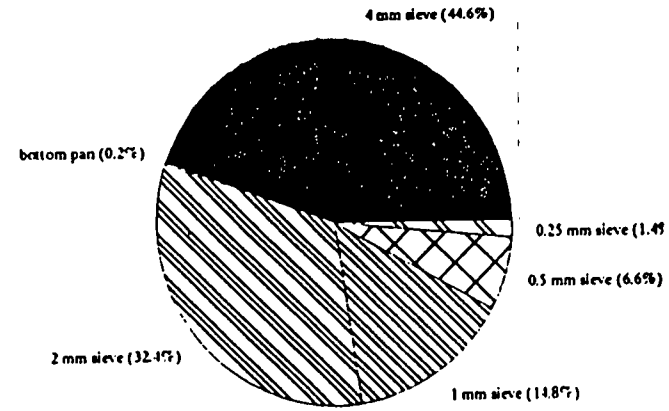


AMSS-6: FIRST ROUND ANALYSIS (UNDRIED SAMPLE)

24 May 1994

	Sieve Size (mm)	Soil Retained (g)	Percent Composition (%)
	4	286.6849	–
	4	233.8654	–
TOTAL (4 mm)		520.5503	44.6282
	2	196.5609	–
	2	181.1500	–
TOTAL (2 mm)	2	377.7109	32.3822
	1	172.8813	14.8216
	0.5	76.6644	6.5726
	0.25	16.6024	1.4234
	bottom pan	2.0067	0.1720
GRAND TOTAL		1166.416	100.0000

AMSS-6 UNDRIED

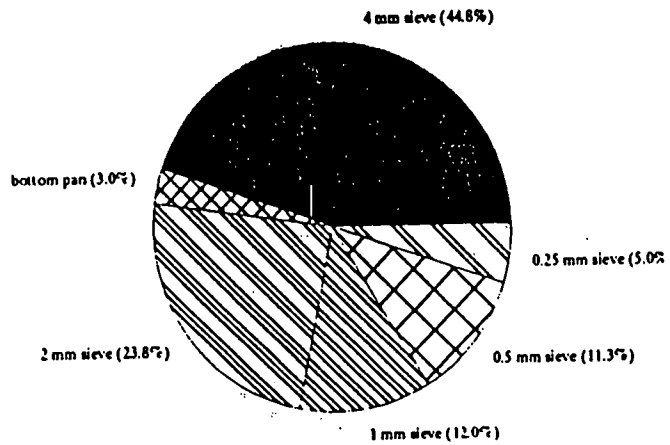


AMSS–6: SECOND ROUND ANALYSIS (DRIED SAMPLE)

25 May 1994

	Sieve Size (mm)	Soil Retained (g)	Percent Composition (%)
	4	229.9556	–
	4	252.4993	–
	4	212.8934	–
	4	174.4352	–
TOTAL (4 mm)		869.7835	44.8151
	2	208.4835	–
	2	253.9685	–
TOTAL (2 mm)	2	462.4520	23.8276
	1	232.5279	11.9809
	0.5	218.8567	11.2765
	0.25	98.0382	5.0514
	bottom pan	59.1696	3.0487
GRAND TOTAL		1940.8279	100.0000

AMSS–6 DRIED

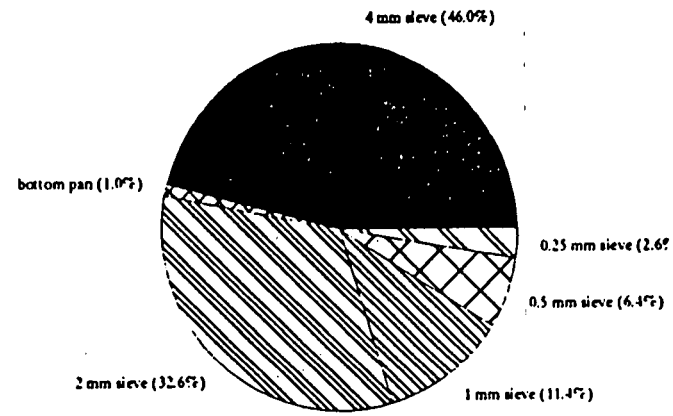


AMSS–7: FIRST ROUND ANALYSIS (UNDRIED SAMPLE)

24 May 1994

	Sieve Size (mm)	Soil Retained (g)	Percent Composition (%)
	4	257.4664	–
	4	236.422	–
	4	98.0572	–
TOTAL (4 mm)		591.9456	46.0001
	2	224.7165	–
	2	194.5663	–
TOTAL (2 mm)	2	419.2828	32.5825
	1	146.9254	11.4176
	0.5	82.1776	6.3860
	0.25	33.3590	2.5923
	bottom pan	13.1439	1.0214
GRAND TOTAL		1286.8343	100.0000

AMSS–7 UNDRIED



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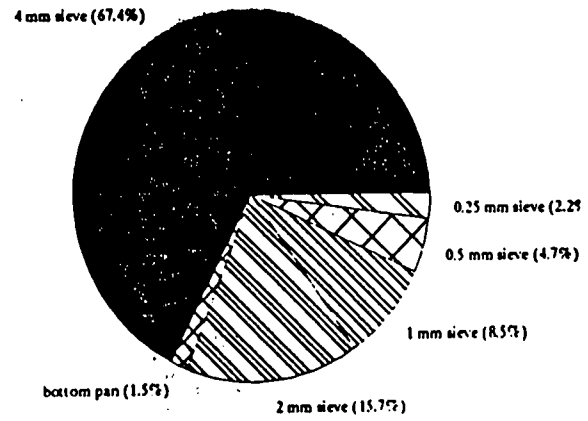
AMSS–7: SECOND ROUND ANALYSIS (DRIED SAMPLE)

25 May 1994

	Sieve Size (mm)	Soil Retained (g)	Percent Composition (%)
	4	204.1471	–
	4	245.4404	–
	4	247.7468	–
	4	295.9912	–
	4	281.8278	–
	4	75.9872	–
TOTAL (4 mm)		1351.1405	67.3694
	2	226.3793	–
	2	88.0032	–
TOTAL (2 mm)	2	314.3825	15.6755
	1	171.1355	8.5330
	0.5	94.7386	4.7238
	0.25	43.6029	2.1741
	bottom pan	30.5702	1.5243
GRAND TOTAL		2005.5702	100.0000

AMSS–7 DRIED



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ATTACHMENT I.II-3

PARTICULATE-PHASE CONTAMINANT AIR EMISSION RATES

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TABLE I.II–3–1
RADIONUCLIDE EMISSION RATES

Source	Radionuclide Emissions (pCi/s/m^2)					
Area	Cesium–137	Lead–210	Neptunium–237	Plutonium–238	Plutonium–239	Plutonium–240
560A	2.08E–08	2.08E–08	1.68E–08	0.00E+00	0.00E+00	0.00E+00
560B	1.45E–08	2.08E–08	0.00E+00	0.00E+00	0.00E+00	0.00E+00
560C	2.91E–08	2.08E–08	0.00E+00	4.58E–08	6.03E–08	2.20E–07
560D	1.25E–08	2.08E–08	0.00E+00	0.00E+00	0.00E+00	0.00E+00
570A	2.70E–08	2.08E–08	1.24E–08	0.00E+00	0.00E+00	0.00E+00
570B	3.00E–08	2.08E–08	0.00E+00	8.32E–09	1.27E–08	4.62E–08
570C	1.04E–08	2.08E–08	0.00E+00	0.00E+00	0.00E+00	0.00E+00
570D	3.00E–08	2.08E–08	4.31E–09	6.86E–08	1.25E–08	4.54E–08
570E	2.08E–08	2.08E–08	0.00E+00	0.00E+00	0.00E+00	0.00E+00
575A	1.25E–08	2.08E–08	0.00E+00	0.00E+00	0.00E+00	0.00E+00
575B	2.29E–08	2.08E–08	0.00E+00	0.00E+00	0.00E+00	0.00E+00
580A	1.04E–08	2.08E–08	0.00E+00	0.00E+00	0.00E+00	0.00E+00
581A	1.66E–08	2.08E–08	0.00E+00	0.00E+00	1.87E–08	6.81E–08
581B	1.24E–08	2.08E–08	0.00E+00	0.00E+00	0.00E+00	0.00E+00
581C	2.09E–08	2.08E–08	0.00E+00	3.12E–08	0.00E+00	0.00E+00
581D	1.48E–08	2.08E–08	0.00E+00	3.14E–06	3.12E–08	1.14E–07
582A	1.66E–08	2.08E–08	0.00E+00	0.00E+00	1.25E–08	4.54E–08
582B	1.91E–08	2.08E–08	0.00E+00	0.00E+00	0.00E+00	0.00E+00
WPAA	1.66E–08	8.28E–08	1.73E–08	1.46E–08	4.43E–09	1.61E–08
5NEC	1.80E–08	1.48E–06	0.00E+00	0.00E+00	0.00E+00	0.00E+00
WastePit1	9.17E–09	2.08E–08	0.00E+00	0.00E+00	0.00E+00	0.00E+00
WastePit2	9.17E–09	2.08E–08	0.00E+00	0.00E+00	0.00E+00	0.00E+00
WastePit3	9.17E–09	2.08E–08	0.00E+00	0.00E+00	0.00E+00	0.00E+00
WastePit4	9.17E–09	2.08E–08	0.00E+00	0.00E+00	0.00E+00	0.00E+00
WastePit5	9.17E–09	2.08E–08	0.00E+00	0.00E+00	0.00E+00	0.00E+00
WastePit6	9.17E–09	2.08E–08	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Burnpit	9.17E–09	2.08E–08	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Clearwell	9.17E–09	2.08E–08	0.00E+00	0.00E+00	0.00E+00	0.00E+00
SF–GMA	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
SF–Till	0.00E+00	0.00E+00	6.05E–09	0.00E+00	0.00E+00	0.00E+00
SF–Fill	1.44E–08	0.00E+00	7.68E–09	0.00E+00	0.00E+00	0.00E+00
IFP–GMA	0.00E+00	0.00E+00	3.74E–09	0.00E+00	0.00E+00	0.00E+00
IFP–Till	0.00E+00	0.00E+00	3.33E–09	0.00E+00	0.00E+00	0.00E+00
AFP–GMA	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
AFP–Till	0.00E+00	0.00E+00	8.94E–10	0.00E+00	0.00E+00	0.00E+00
SWL–Till	0.00E+00	0.00E+00	8.32E–09	4.16E–09	0.00E+00	0.00E+00
LSP–Till	0.00E+00	0.00E+00	2.70E–09	0.00E+00	0.00E+00	0.00E+00
OU4 Soil	4.79E–09	4.08E–07	0.00E+00	0.00E+00	0.00E+00	0.00E+00
PAA	1.04E–08	2.08E–08	0.00E+00	0.00E+00	0.00E+00	0.00E+00
PAB	1.46E–08	2.08E–08	0.00E+00	1.49E–08	1.35E–07	4.92E–07
PAC	5.20E–09	2.08E–08	5.47E–08	0.00E+00	1.48E–08	5.40E–08
PAD	1.25E–08	2.08E–08	0.00E+00	1.77E–08	0.00E+00	0.00E+00
PAE	1.04E–08	2.08E–08	1.48E–08	2.18E–08	3.14E–08	1.14E–07
PAF	1.26E–08	2.08E–08	0.00E+00	3.14E–06	0.00E+00	0.00E+00
PAG	3.00E–08	2.08E–08	0.00E+00	5.33E–09	2.68E–07	9.76E–07
PAH	1.85E–08	2.08E–08	1.41E–08	0.00E+00	0.00E+00	0.00E+00
PAI	9.17E–09	2.08E–08	0.00E+00	0.00E+00	0.00E+00	0.00E+00

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TABLE I.II–3–1 (Continued)

Source	Radionuclide Emissions (pCi/s/m²)					
Area	Proactinium–231	Radium–226	Radium–228	Ruthenium–106	Strontium–90	Technetium–99
560A	0.00E+00	2.03E–08	3.83E–08	0.00E+00	2.91E–08	2.70E–08
560B	0.00E+00	3.29E–08	3.83E–08	0.00E+00	9.57E–08	3.33E–08
560C	0.00E+00	3.39E–08	3.83E–08	0.00E+00	8.82E–09	5.68E–07
560D	0.00E+00	3.39E–08	3.83E–08	0.00E+00	1.35E–07	0.00E+00
570A	0.00E+00	3.39E–08	3.83E–08	0.00E+00	1.87E–08	1.06E–07
570B	0.00E+00	2.77E–08	3.83E–08	6.24E–08	3.74E–08	9.98E–08
570C	0.00E+00	2.08E–08	3.83E–08	0.00E+00	1.46E–08	0.00E+00
570D	0.00E+00	3.39E–08	3.83E–08	0.00E+00	3.54E–08	6.86E–07
570E	0.00E+00	2.50E–08	3.83E–08	0.00E+00	2.29E–08	0.00E+00
575A	0.00E+00	1.46E–08	3.83E–08	0.00E+00	8.82E–09	0.00E+00
575B	0.00E+00	1.04E–08	3.83E–08	0.00E+00	8.82E–09	0.00E+00
580A	0.00E+00	6.24E–09	3.83E–08	1.08E–08	8.82E–09	0.00E+00
581A	0.00E+00	2.70E–08	3.83E–08	0.00E+00	3.18E–08	2.29E–08
581B	0.00E+00	3.39E–08	3.83E–08	0.00E+00	3.52E–08	2.35E–07
581C	0.00E+00	2.48E–08	3.83E–08	0.00E+00	8.94E–08	0.00E+00
581D	1.05E–07	3.39E–08	3.83E–08	0.00E+00	7.70E–08	4.74E–06
582A	0.00E+00	2.25E–08	3.83E–08	0.00E+00	2.50E–08	0.00E+00
582B	0.00E+00	3.39E–08	3.83E–08	0.00E+00	8.82E–09	0.00E+00
WPAA	0.00E+00	3.39E–08	3.83E–08	0.00E+00	2.08E–08	1.10E–07
5NEC	0.00E+00	0.00E+00	3.83E–08	0.00E+00	7.49E–08	0.00E+00
WastePit1	0.00E+00	2.54E–08	3.83E–08	0.00E+00	8.82E–09	0.00E+00
WastePit2	0.00E+00	2.54E–08	3.83E–08	0.00E+00	8.82E–09	0.00E+00
WastePit3	0.00E+00	2.54E–08	3.83E–08	0.00E+00	8.82E–09	0.00E+00
WastePit4	0.00E+00	2.54E–08	3.83E–08	0.00E+00	8.82E–09	0.00E+00
WastePit5	0.00E+00	2.54E–08	3.83E–08	0.00E+00	8.82E–09	0.00E+00
WastePit6	0.00E+00	2.54E–08	3.83E–08	0.00E+00	8.82E–09	0.00E+00
Burnpit	0.00E+00	2.54E–08	3.83E–08	0.00E+00	8.82E–09	0.00E+00
Clearwell	0.00E+00	2.54E–08	3.83E–08	0.00E+00	8.82E–09	0.00E+00
SF–GMA	0.00E+00	1.41E–08	9.59E–09	0.00E+00	1.46E–08	0.00E+00
SF–Till	0.00E+00	3.39E–08	3.00E–08	0.00E+00	2.29E–08	1.87E–08
SF–Fill	0.00E+00	3.39E–08	3.83E–08	0.00E+00	2.83E–08	1.87E–08
IFP–GMA	0.00E+00	1.81E–08	1.10E–08	0.00E+00	0.00E+00	0.00E+00
IFP–Till	0.00E+00	2.10E–08	1.52E–08	0.00E+00	0.00E+00	0.00E+00
AFP–GMA	0.00E+00	1.24E–08	1.12E–08	0.00E+00	1.04E–08	0.00E+00
AFP–Till	0.00E+00	2.97E–08	2.62E–08	0.00E+00	7.51E–08	0.00E+00
SWL–Till	0.00E+00	2.08E–08	1.87E–08	0.00E+00	1.52E–08	0.00E+00
LSP–Till	0.00E+00	2.48E–08	2.31E–08	0.00E+00	1.12E–08	0.00E+00
OU4 Soil	2.85E–07	3.39E–08	3.83E–08	0.00E+00	3.73E–08	7.50E–08
PAA	0.00E+00	3.39E–08	3.83E–08	0.00E+00	6.45E–08	0.00E+00
PAB	0.00E+00	3.39E–08	3.83E–08	0.00E+00	7.07E–08	1.68E–07
PAC	0.00E+00	3.39E–08	3.83E–08	0.00E+00	4.24E–08	1.05E–07
PAD	0.00E+00	2.50E–08	3.83E–08	0.00E+00	2.31E–08	4.58E–08
PAE	0.00E+00	1.74E–08	3.83E–08	0.00E+00	8.63E–08	4.37E–06
PAF	1.05E–07	2.62E–08	3.83E–08	0.00E+00	3.97E–08	4.99E–08
PAG	0.00E+00	3.39E–08	3.83E–08	0.00E+00	8.05E–08	4.16E–07
PAH	0.00E+00	3.39E–08	3.83E–08	6.24E–08	4.62E–08	3.33E–08
PAI	0.00E+00	3.39E–08	3.83E–08	0.00E+00	8.82E–09	0.00E+00

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TABLE I.II–3–1 (Continued)

Source Area	Radionuclide Emissions (pCi/s/m²)						
	Thorium–228	Thorium–230	Thorium–232	Uranium–234	Uranium–235	Uranium–236	Uranium–238
560A	3.16E–08	3.72E–08	2.13E–08	2.71E–07	7.19E–09	2.97E–09	1.62E–07
560B	3.16E–08	9.39E–08	3.06E–08	2.12E–06	5.63E–08	2.32E–08	1.27E–06
560C	3.16E–08	1.35E–07	1.26E–07	2.12E–06	5.63E–08	2.32E–08	1.27E–06
560D	3.16E–08	1.35E–07	1.26E–07	2.12E–06	5.63E–08	2.32E–08	1.27E–06
570A	3.16E–08	1.35E–07	4.78E–08	9.03E–07	2.40E–08	9.90E–09	5.41E–07
570B	3.16E–08	1.35E–07	1.26E–07	2.12E–06	5.63E–08	2.32E–08	1.27E–06
570C	3.16E–08	3.12E–08	1.66E–08	4.13E–07	1.10E–08	4.53E–09	2.48E–07
570D	3.16E–08	1.35E–07	1.26E–07	2.12E–06	5.63E–08	2.32E–08	1.27E–06
570E	3.16E–08	1.35E–07	1.08E–07	7.33E–07	1.95E–08	8.03E–09	4.39E–07
575A	3.16E–08	1.35E–07	1.66E–08	2.60E–07	6.91E–09	2.85E–09	1.56E–07
575B	3.16E–08	3.54E–08	1.46E–08	7.33E–07	1.95E–08	8.03E–09	4.39E–07
580A	3.16E–08	2.50E–08	1.66E–08	6.25E–08	1.66E–09	6.85E–10	3.74E–08
581A	3.16E–08	3.76E–08	1.94E–08	1.83E–07	4.86E–09	2.01E–09	1.10E–07
581B	3.16E–08	1.35E–07	1.26E–07	2.12E–06	5.63E–08	2.32E–08	1.27E–06
581C	3.16E–08	6.99E–08	2.91E–08	5.49E–07	1.46E–08	6.01E–09	3.28E–07
581D	3.16E–08	1.35E–07	1.26E–07	2.12E–06	5.63E–08	2.32E–08	1.27E–06
582A	3.16E–08	6.18E–08	2.41E–08	1.84E–07	4.89E–09	2.02E–09	1.10E–07
582B	3.16E–08	1.35E–07	3.35E–08	2.12E–06	5.63E–08	2.32E–08	1.27E–06
WPAA	3.16E–08	1.35E–07	5.28E–08	2.12E–06	5.63E–08	2.32E–08	1.27E–06
5NEC	3.16E–08	0.00E+00	2.37E–08	2.87E–07	7.62E–09	3.15E–09	1.72E–07
WastePit1	3.16E–08	3.11E–08	2.25E–08	3.77E–08	1.00E–09	4.13E–10	2.26E–08
WastePit2	3.16E–08	3.11E–08	2.25E–08	3.77E–08	1.00E–09	4.13E–10	2.26E–08
WastePit3	3.16E–08	3.11E–08	2.25E–08	3.77E–08	1.00E–09	4.13E–10	2.26E–08
WastePit4	3.16E–08	3.11E–08	2.25E–08	3.77E–08	1.00E–09	4.13E–10	2.26E–08
WastePit5	3.16E–08	3.11E–08	2.25E–08	3.77E–08	1.00E–09	4.13E–10	2.26E–08
WastePit6	3.16E–08	3.11E–08	2.25E–08	3.77E–08	1.00E–09	4.13E–10	2.26E–08
Burnpit	3.16E–08	3.11E–08	2.25E–08	3.77E–08	1.00E–09	4.13E–10	2.26E–08
Clearwell	3.16E–08	3.11E–08	2.25E–08	3.77E–08	1.00E–09	4.13E–10	2.26E–08
SF–GMA	6.86E–09	2.85E–08	6.86E–09	2.29E–08	6.09E–10	2.51E–10	1.37E–08
SF–Till	2.97E–08	9.17E–08	2.77E–08	1.12E–07	2.97E–09	1.23E–09	6.70E–08
SF–Fill	3.16E–08	1.35E–07	3.12E–08	1.12E–07	2.97E–09	1.23E–09	6.70E–08
IFP–GMA	8.53E–09	4.22E–08	7.49E–09	5.00E–08	1.33E–09	5.48E–10	3.00E–08
IFP–Till	1.73E–08	3.37E–08	1.52E–08	2.95E–08	7.84E–10	3.24E–10	1.77E–08
AFP–GMA	2.48E–08	2.95E–08	2.01E–08	2.62E–08	6.95E–10	2.87E–10	1.57E–08
AFP–Till	2.91E–08	7.49E–08	2.81E–08	5.11E–08	1.36E–09	5.60E–10	3.06E–08
SWL–Till	2.29E–08	6.45E–08	1.87E–08	1.25E–07	3.32E–09	1.37E–09	7.49E–08
LSP–Till	2.02E–08	5.18E–08	2.18E–08	3.96E–08	1.05E–09	4.34E–10	2.37E–08
OU4 Soil	3.16E–08	1.04E–07	1.04E–07	7.23E–07	1.92E–08	7.92E–09	4.33E–07
PAA	3.16E–08	1.35E–07	1.26E–07	2.12E–06	5.63E–08	2.32E–08	1.27E–06
PAB	3.16E–08	1.35E–07	1.06E–07	2.12E–06	5.63E–08	2.32E–08	1.27E–06
PAC	3.16E–08	1.35E–07	2.72E–08	2.12E–06	5.63E–08	2.32E–08	1.27E–06
PAD	3.16E–08	1.35E–07	3.54E–08	2.12E–06	5.63E–08	2.32E–08	1.27E–06
PAE	3.16E–08	1.35E–07	1.26E–07	2.12E–06	5.63E–08	2.32E–08	1.27E–06
PAF	3.16E–08	1.35E–07	4.19E–08	2.12E–06	5.63E–08	2.32E–08	1.27E–06
PAG	3.16E–08	1.35E–07	1.26E–07	2.12E–06	5.63E–08	2.32E–08	1.27E–06
PAH	3.16E–08	1.35E–07	1.26E–07	1.82E–06	4.84E–08	2.00E–08	1.09E–06
PAI	3.16E–08	3.12E–08	1.78E–08	1.95E–07	5.17E–09	2.13E–09	1.16E–07

TABLE I.II–3–2
INORGANIC COMPOUND EMISSION RATES

Source	Inorganic Emissions (mg/s/m^2)				
Area	Antimony	Arsenic	Barium	Beryllium	Boron
560A	6.66E–08	2.52E–07	1.98E–06	3.33E–08	2.97E–07
560B	5.49E–07	1.83E–07	2.07E–06	2.08E–08	2.85E–07
560C	1.58E–08	1.18E–07	1.79E–06	1.31E–08	2.85E–07
560D	1.58E–08	1.52E–07	2.06E–06	1.46E–08	2.85E–07
570A	1.58E–08	5.41E–07	2.19E–06	4.37E–08	2.85E–07
570B	5.71E–07	6.76E–07	1.73E–06	2.10E–08	2.85E–07
570C	5.49E–07	1.30E–07	2.06E–06	3.31E–08	2.85E–07
570D	5.49E–07	1.30E–07	2.06E–06	3.31E–08	2.85E–07
570E	1.58E–08	6.76E–07	2.27E–06	1.25E–08	2.85E–07
575A	1.58E–08	1.52E–07	2.25E–06	3.54E–08	2.85E–07
575B	1.58E–08	7.70E–08	2.27E–06	1.25E–08	2.85E–07
580A	1.58E–08	1.35E–07	1.59E–06	1.25E–08	2.85E–07
581A	8.53E–08	2.05E–07	2.15E–06	2.91E–08	2.97E–07
581B	4.47E–07	1.28E–07	2.85E–06	2.31E–08	2.85E–07
581C	1.58E–08	6.86E–08	1.46E–06	9.98E–09	2.85E–07
581D	6.03E–08	1.44E–07	2.60E–06	2.70E–08	2.85E–07
582A	1.58E–08	1.79E–07	1.56E–06	2.91E–08	2.97E–07
582B	1.58E–08	5.66E–07	2.27E–06	4.37E–08	2.85E–07
WPAA	6.76E–07	1.43E–07	1.33E–06	1.53E–08	2.85E–07
5NEC	0.00E+00	1.27E–07	0.00E+00	1.66E–08	0.00E+00
WastePit1	1.58E–08	1.16E–07	1.41E–06	1.25E–08	2.85E–07
WastePit2	1.58E–08	1.16E–07	1.41E–06	1.25E–08	2.85E–07
WastePit3	1.58E–08	1.16E–07	1.41E–06	1.25E–08	2.85E–07
WastePit4	1.58E–08	1.16E–07	1.41E–06	1.25E–08	2.85E–07
WastePit5	1.58E–08	1.16E–07	1.41E–06	1.25E–08	2.85E–07
WastePit6	1.58E–08	1.16E–07	1.41E–06	1.25E–08	2.85E–07
Burnpit	1.58E–08	1.16E–07	1.41E–06	1.25E–08	2.85E–07
Clearwell	1.58E–08	1.16E–07	1.41E–06	1.25E–08	2.85E–07
SF–GMA	0.00E+00	1.29E–07	0.00E+00	0.00E+00	0.00E+00
SF–Till	0.00E+00	2.48E–07	0.00E+00	1.77E–08	0.00E+00
SF–Fill	0.00E+00	1.45E–07	0.00E+00	1.83E–08	0.00E+00
IFP–GMA	0.00E+00	1.06E–07	0.00E+00	0.00E+00	0.00E+00
IFP–Till	0.00E+00	1.44E–07	0.00E+00	0.00E+00	0.00E+00
AFP–GMA	0.00E+00	3.52E–07	0.00E+00	0.00E+00	0.00E+00
AFP–Till	0.00E+00	3.52E–07	0.00E+00	2.91E–08	0.00E+00
SWL–Till	4.70E–07	1.60E–07	0.00E+00	2.08E–08	0.00E+00
LSP–Till	0.00E+00	3.10E–07	0.00E+00	0.00E+00	0.00E+00
OU4 Soil	6.39E–07	1.66E–07	1.81E–06	1.89E–08	0.00E+00
PAA	7.92E–07	1.60E–07	2.17E–06	1.29E–08	2.85E–07
PAB	1.58E–08	4.80E–07	1.06E–05	2.39E–08	2.85E–07
PAC	4.41E–07	1.66E–07	1.99E–06	4.43E–08	2.85E–07
PAD	1.58E–08	2.00E–07	9.48E–06	1.79E–08	2.85E–07
PAE	1.58E–08	1.60E–07	2.22E–06	2.37E–08	2.85E–07
PAF	1.58E–08	2.41E–07	3.02E–06	7.28E–08	2.85E–07
PAG	1.58E–08	2.54E–07	8.61E–06	2.72E–08	2.85E–07
PAH	1.58E–08	1.27E–07	1.73E–06	2.85E–08	2.85E–07
PAI	1.58E–08	1.33E–07	3.81E–06	3.74E–08	2.85E–07

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TABLE I.II-3-2 (Continued)

Source	Inorganic Emissions (mg/s/m^2)					
Area	Cadmium	Chromium	Cobalt	Copper	Cyanide	Lead
560A	3.95E-08	3.03E-07	2.83E-07	3.31E-07	1.10E-08	4.53E-07
560B	1.37E-07	7.13E-07	2.18E-07	5.58E-07	6.49E-09	4.58E-06
560C	1.58E-07	3.58E-07	2.89E-07	1.10E-06	2.50E-08	2.37E-06
560D	1.08E-08	2.81E-07	2.18E-07	3.31E-07	2.29E-09	3.79E-07
570A	1.29E-07	3.47E-07	2.33E-07	3.81E-07	9.36E-09	4.95E-07
570B	1.09E-07	3.79E-07	1.66E-07	4.21E-07	3.74E-09	4.67E-07
570C	8.24E-08	4.36E-07	3.06E-07	7.90E-07	1.04E-08	7.00E-07
570D	8.24E-08	4.36E-07	3.06E-07	7.90E-07	1.04E-08	7.00E-07
570E	1.09E-07	2.35E-07	1.66E-07	4.21E-07	9.15E-09	4.67E-07
575A	1.08E-08	2.91E-07	2.39E-07	2.97E-07	7.70E-09	4.66E-07
575B	1.08E-08	2.35E-07	1.66E-07	2.43E-07	9.15E-09	4.67E-07
580A	2.70E-08	2.35E-07	1.21E-07	3.00E-07	5.62E-09	1.14E-06
581A	1.02E-08	3.05E-07	2.35E-07	2.16E-06	1.89E-08	3.78E-05
581B	3.33E-08	4.37E-07	2.35E-07	3.57E-07	1.83E-08	1.19E-05
581C	1.08E-08	2.04E-07	2.35E-07	1.58E-07	5.62E-09	3.12E-07
581D	3.95E-08	3.06E-07	4.31E-08	2.48E-07	1.35E-08	6.22E-07
582A	1.56E-08	2.86E-07	2.37E-07	3.94E-07	8.94E-09	4.80E-07
582B	1.54E-08	2.79E-07	2.39E-07	4.91E-07	6.24E-09	5.30E-07
WPAA	1.23E-07	2.94E-07	2.20E-07	5.60E-07	7.70E-09	5.41E-07
5NEC	0.00E+00	3.66E-07	0.00E+00	5.76E-07	0.00E+00	3.99E-07
WastePit1	1.81E-08	2.41E-07	0.00E+00	1.79E-07	5.62E-09	3.93E-07
WastePit2	1.81E-08	2.41E-07	0.00E+00	1.79E-07	5.62E-09	3.93E-07
WastePit3	1.81E-08	2.41E-07	0.00E+00	1.79E-07	5.62E-09	3.93E-07
WastePit4	1.81E-08	2.41E-07	0.00E+00	1.79E-07	5.62E-09	3.93E-07
WastePit5	1.81E-08	2.41E-07	0.00E+00	1.79E-07	5.62E-09	3.93E-07
WastePit6	1.81E-08	2.41E-07	0.00E+00	1.79E-07	5.62E-09	3.93E-07
Burnpit	1.81E-08	2.41E-07	0.00E+00	1.79E-07	5.62E-09	3.93E-07
Clearwell	1.81E-08	2.41E-07	0.00E+00	1.79E-07	5.62E-09	3.93E-07
SF-GMA	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
SF-Till	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
SF-Fill	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
IFP-GMA	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
IFP-Till	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
AFP-GMA	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
AFP-Till	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
SWL-Till	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
LSP-Till	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
OU4 Soil	1.21E-07	5.91E-07	2.77E-07	4.95E-07	4.12E-08	3.10E-07
PAA	1.23E-07	4.43E-07	2.89E-07	1.07E-06	3.12E-08	5.09E-07
PAB	8.76E-08	7.80E-07	2.45E-07	4.31E-06	1.31E-08	1.79E-06
PAC	1.44E-07	7.92E-07	4.04E-07	6.72E-07	6.24E-09	9.15E-06
PAD	1.39E-07	9.75E-07	2.29E-07	7.81E-07	5.62E-09	6.10E-06
PAE	1.05E-07	5.03E-07	2.27E-07	4.79E-07	2.70E-08	1.59E-06
PAF	2.29E-08	5.05E-07	2.29E-07	4.83E-07	5.62E-09	4.51E-07
PAG	1.12E-07	4.97E-07	3.08E-07	1.44E-06	1.08E-08	1.06E-06
PAH	1.21E-07	7.84E-07	2.23E-07	4.37E-07	1.44E-08	1.32E-06
PAI	1.08E-08	4.10E-07	2.45E-07	4.08E-07	5.62E-09	1.14E-06

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TABLE I.II–3–2 (Continued)

Source	Inorganic Emissions (mg/s/m²)					
Area	Manganese	Mercury	Molybdenum	Nickel	Selenium	Silver
560A	1.80E–05	6.24E–09	2.58E–07	3.97E–07	1.48E–08	1.54E–07
560B	1.73E–05	6.24E–09	2.31E–07	4.87E–07	1.29E–08	1.93E–07
560C	9.88E–06	6.24E–09	9.57E–08	5.35E–07	1.01E–08	1.64E–07
560D	1.64E–05	6.24E–09	1.10E–07	2.43E–07	1.29E–08	1.27E–07
570A	1.65E–05	6.24E–09	1.08E–07	4.83E–07	2.50E–08	1.60E–07
570B	1.16E–05	6.24E–09	8.67E–08	6.11E–07	2.50E–08	1.65E–07
570C	1.58E–05	1.66E–09	1.04E–07	6.03E–07	1.50E–08	1.51E–07
570D	1.58E–05	1.66E–09	1.04E–07	6.03E–07	1.50E–08	1.51E–07
570E	1.16E–05	6.24E–09	5.62E–08	2.23E–07	2.50E–08	1.65E–07
575A	2.81E–05	6.24E–09	5.62E–08	3.35E–07	1.50E–08	9.98E–09
575B	2.43E–05	6.24E–09	5.62E–08	2.23E–07	2.50E–08	9.78E–09
580A	9.21E–06	6.24E–09	5.62E–08	2.72E–07	1.10E–08	9.36E–09
581A	7.11E–05	1.19E–08	1.73E–08	4.28E–07	8.53E–09	1.27E–07
581B	3.61E–05	2.50E–09	1.64E–07	5.86E–07	8.53E–09	3.74E–08
581C	1.88E–05	6.24E–09	1.64E–07	2.29E–07	8.53E–09	9.36E–09
581D	4.24E–05	6.24E–09	1.77E–07	3.16E–07	1.14E–08	9.36E–09
582A	1.29E–05	6.24E–09	1.35E–07	3.81E–07	1.50E–08	9.36E–09
582B	9.63E–06	6.24E–09	4.78E–08	4.18E–07	1.23E–07	9.36E–09
WPAA	1.75E–05	4.16E–10	7.38E–08	4.58E–07	1.25E–08	2.12E–07
5NEC	2.43E–05	0.00E+00	2.35E–07	0.00E+00	0.00E+00	0.00E+00
WastePit1	1.69E–05	6.24E–09	5.62E–08	2.64E–07	0.00E+00	9.36E–09
WastePit2	1.69E–05	6.24E–09	5.62E–08	2.64E–07	0.00E+00	9.36E–09
WastePit3	1.69E–05	6.24E–09	5.62E–08	2.64E–07	0.00E+00	9.36E–09
WastePit4	1.69E–05	6.24E–09	5.62E–08	2.64E–07	0.00E+00	9.36E–09
WastePit5	1.69E–05	6.24E–09	5.62E–08	2.64E–07	0.00E+00	9.36E–09
WastePit6	1.69E–05	6.24E–09	5.62E–08	2.64E–07	0.00E+00	9.36E–09
Burnpit	1.69E–05	6.24E–09	5.62E–08	2.64E–07	0.00E+00	9.36E–09
Clearwell	1.69E–05	6.24E–09	5.62E–08	2.64E–07	0.00E+00	9.36E–09
SF–GMA	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
SF–Till	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
SF–Fill	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
IFP–GMA	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
IFP–Till	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
AFP–GMA	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
AFP–Till	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
SWL–Till	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
LSP–Till	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
OU4 Soil	1.52E–05	2.50E–09	2.77E–07	7.03E–07	1.19E–07	3.00E–07
PAA	1.47E–05	4.16E–09	7.40E–08	5.45E–07	1.01E–08	1.93E–07
PAB	1.89E–05	6.66E–09	2.58E–07	6.80E–07	3.14E–08	1.56E–07
PAC	1.28E–05	4.37E–08	2.72E–07	8.26E–07	1.33E–08	3.58E–07
PAD	1.28E–05	2.70E–08	7.70E–08	1.50E–06	1.50E–08	1.23E–07
PAE	1.32E–05	7.70E–09	1.29E–07	6.14E–07	1.41E–08	1.44E–07
PAF	1.44E–05	6.24E–09	5.62E–08	7.88E–07	1.50E–08	9.36E–09
PAG	1.87E–05	2.29E–08	9.78E–08	7.78E–07	6.45E–08	1.46E–07
PAH	2.23E–05	1.10E–08	8.46E–08	5.71E–07	5.82E–09	9.53E–08
PAI	3.58E–05	6.24E–09	5.62E–08	7.01E–07	1.10E–08	9.36E–09

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TABLE I.II-3-2 (Continued)

Source	Inorganic Emissions (mg/s/m^2)				
Area	Thallium	Thorium	Uranium	Vanadium	Zinc
560A	1.39E-08	1.93E-07	4.86E-07	5.27E-07	1.12E-07
560B	1.21E-08	2.78E-07	1.82E-05	5.59E-07	1.74E-06
560C	1.21E-08	2.16E-06	2.41E-05	4.18E-07	1.40E-06
560D	1.21E-08	1.53E-06	7.54E-06	7.78E-07	1.74E-06
570A	4.58E-09	4.35E-07	1.62E-06	7.18E-07	1.33E-06
570B	1.21E-08	1.25E-06	8.92E-06	5.42E-07	8.92E-07
570C	1.02E-08	1.51E-07	7.42E-07	5.83E-07	1.20E-06
570D	1.02E-08	2.36E-06	6.94E-05	5.83E-07	1.20E-06
570E	1.21E-08	9.83E-07	1.32E-06	5.42E-07	8.92E-07
575A	1.21E-08	1.51E-07	4.67E-07	5.60E-07	1.07E-06
575B	1.21E-08	1.32E-07	1.32E-06	4.80E-07	8.92E-07
580A	1.21E-08	1.51E-07	1.12E-07	4.68E-07	8.92E-07
581A	1.56E-08	1.77E-07	3.29E-07	5.07E-07	1.95E-06
581B	9.78E-09	1.25E-06	1.61E-05	7.71E-07	1.95E-06
581C	1.21E-08	2.65E-07	9.84E-07	4.74E-07	1.95E-06
581D	1.21E-08	1.17E-05	9.21E-05	8.07E-07	1.34E-06
582A	6.66E-09	2.19E-07	3.30E-07	4.82E-07	1.15E-06
582B	1.60E-08	3.04E-07	9.26E-06	5.47E-07	1.63E-07
WPAA	5.62E-09	4.80E-07	2.13E-05	4.72E-07	1.22E-06
5NEC	0.00E+00	2.16E-07	5.15E-07	0.00E+00	0.00E+00
WastePit1	1.21E-08	2.04E-07	6.77E-08	4.64E-07	0.00E+00
WastePit2	1.21E-08	2.04E-07	6.77E-08	4.64E-07	0.00E+00
WastePit3	1.21E-08	2.04E-07	6.77E-08	4.64E-07	0.00E+00
WastePit4	1.21E-08	2.04E-07	6.77E-08	4.64E-07	0.00E+00
WastePit5	1.21E-08	2.04E-07	6.77E-08	4.64E-07	0.00E+00
WastePit6	1.21E-08	2.04E-07	6.77E-08	4.64E-07	0.00E+00
Burnpit	1.21E-08	2.04E-07	6.77E-08	4.64E-07	0.00E+00
Clearwell	1.21E-08	2.04E-07	6.77E-08	4.64E-07	0.00E+00
SF-GMA	0.00E+00	0.00E+00	2.14E-07	0.00E+00	0.00E+00
SF-Till	0.00E+00	0.00E+00	1.66E-07	0.00E+00	0.00E+00
SF-Fill	0.00E+00	0.00E+00	1.66E-07	0.00E+00	0.00E+00
IFP-GMA	0.00E+00	0.00E+00	1.22E-07	0.00E+00	0.00E+00
IFP-Till	0.00E+00	0.00E+00	9.13E-08	0.00E+00	0.00E+00
AFP-GMA	0.00E+00	0.00E+00	1.75E-07	0.00E+00	0.00E+00
AFP-Till	0.00E+00	0.00E+00	1.49E-07	0.00E+00	0.00E+00
SWL-Till	0.00E+00	0.00E+00	1.60E-07	0.00E+00	0.00E+00
LSP-Till	0.00E+00	0.00E+00	2.97E-07	0.00E+00	0.00E+00
OU4 Soil	1.48E-08	5.93E-07	1.30E-06	5.91E-07	1.24E-06
PAA	5.93E-09	5.94E-06	2.56E-04	5.86E-07	1.40E-06
PAB	8.74E-09	9.64E-07	1.72E-05	5.67E-07	3.60E-06
PAC	6.03E-09	2.48E-07	3.48E-05	5.82E-07	2.66E-06
PAD	8.11E-09	3.21E-07	8.73E-06	5.48E-07	5.37E-07
PAE	4.78E-09	6.73E-06	3.42E-04	5.62E-07	2.72E-06
PAF	7.70E-09	3.81E-07	4.92E-06	7.36E-07	5.37E-07
PAG	9.15E-09	5.35E-05	8.93E-04	6.75E-07	7.32E-06
PAH	1.04E-08	2.17E-06	3.27E-06	5.11E-07	1.11E-06
PAI	6.24E-09	1.62E-07	3.49E-07	4.97E-07	1.61E-06

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TABLE I.II–3–3
ORGANIC COMPOUND EMISSION RATES

Source	Organic Emissions (mg/s/m^2)				
Area	Aroclor–1221	Aroclor–1248	Aroclor–1254	Aroclor–1260	2–Methylnaphthalene
560A	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
560B	0.00E+00	0.00E+00	4.37E–08	0.00E+00	7.28E–09
560C	0.00E+00	0.00E+00	9.36E–10	2.70E–08	0.00E+00
560D	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
570A	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
570B	0.00E+00	0.00E+00	2.50E–09	0.00E+00	0.00E+00
570C	0.00E+00	0.00E+00	4.99E–09	0.00E+00	0.00E+00
570D	0.00E+00	0.00E+00	4.99E–09	0.00E+00	0.00E+00
570E	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
575A	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
575B	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
580A	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
581A	0.00E+00	0.00E+00	4.16E–09	0.00E+00	0.00E+00
581B	0.00E+00	0.00E+00	2.50E–09	0.00E+00	5.20E–10
581C	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
581D	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
582A	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
582B	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
WPAA	0.00E+00	0.00E+00	2.50E–09	0.00E+00	1.54E–08
5NEC	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
WastePit1	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
WastePit2	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
WastePit3	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
WastePit4	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
WastePit5	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
WastePit6	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Burnpit	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Clearwell	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
SF–GMA	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
SF–Till	0.00E+00	0.00E+00	8.53E–10	0.00E+00	0.00E+00
SF–Fill	0.00E+00	0.00E+00	8.94E–09	7.90E–10	0.00E+00
IFP–GMA	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
IFP–Till	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
AFP–GMA	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
AFP–Till	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
SWL–Till	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
LSP–Till	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
OU4 Soil	0.00E+00	0.00E+00	6.24E–10	0.00E+00	0.00E+00
PAA	0.00E+00	0.00E+00	2.29E–08	0.00E+00	0.00E+00
PAB	0.00E+00	0.00E+00	4.78E–08	1.16E–08	2.70E–08
PAC	0.00E+00	0.00E+00	2.08E–07	0.00E+00	0.00E+00
PAD	0.00E+00	0.00E+00	2.08E–07	0.00E+00	6.66E–09
PAE	0.00E+00	0.00E+00	9.57E–09	2.91E–09	1.02E–09
PAF	0.00E+00	0.00E+00	1.12E–09	0.00E+00	0.00E+00
PAG	0.00E+00	0.00E+00	4.99E–08	2.08E–08	1.21E–09
PAH	0.00E+00	0.00E+00	2.29E–08	4.37E–08	1.06E–08
PAI	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

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TABLE I.II–3–3 (Continued)

Source	Organic Emissions (mg/s/m²)			
Area	4,4'–DDE	Carbazole	Endrin	2,3,7,8–TCDD (Equiv.)
560A	4.16E–10	0.00E+00	0.00E+00	0.00E+00
560B	0.00E+00	0.00E+00	0.00E+00	0.00E+00
560C	0.00E+00	0.00E+00	0.00E+00	0.00E+00
560D	0.00E+00	0.00E+00	0.00E+00	6.66E–14
570A	0.00E+00	0.00E+00	0.00E+00	0.00E+00
570B	0.00E+00	0.00E+00	0.00E+00	0.00E+00
570C	0.00E+00	9.57E–10	0.00E+00	0.00E+00
570D	0.00E+00	9.57E–10	0.00E+00	0.00E+00
570E	0.00E+00	0.00E+00	0.00E+00	0.00E+00
575A	0.00E+00	1.46E–10	0.00E+00	0.00E+00
575B	0.00E+00	0.00E+00	0.00E+00	0.00E+00
580A	0.00E+00	1.46E–10	0.00E+00	0.00E+00
581A	0.00E+00	0.00E+00	0.00E+00	0.00E+00
581B	0.00E+00	0.00E+00	0.00E+00	0.00E+00
581C	0.00E+00	0.00E+00	0.00E+00	0.00E+00
581D	0.00E+00	0.00E+00	0.00E+00	0.00E+00
582A	0.00E+00	0.00E+00	0.00E+00	0.00E+00
582B	0.00E+00	0.00E+00	0.00E+00	0.00E+00
WPAA	0.00E+00	1.58E–09	0.00E+00	0.00E+00
5NEC	0.00E+00	0.00E+00	0.00E+00	0.00E+00
WastePit1	0.00E+00	0.00E+00	0.00E+00	0.00E+00
WastePit2	0.00E+00	0.00E+00	0.00E+00	0.00E+00
WastePit3	0.00E+00	0.00E+00	0.00E+00	0.00E+00
WastePit4	0.00E+00	0.00E+00	0.00E+00	0.00E+00
WastePit5	0.00E+00	0.00E+00	0.00E+00	0.00E+00
WastePit6	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Burnpit	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Clearwell	0.00E+00	0.00E+00	0.00E+00	0.00E+00
SF–GMA	0.00E+00	0.00E+00	0.00E+00	0.00E+00
SF–Till	0.00E+00	0.00E+00	0.00E+00	0.00E+00
SF–Fill	0.00E+00	0.00E+00	0.00E+00	0.00E+00
IFP–GMA	0.00E+00	0.00E+00	0.00E+00	0.00E+00
IFP–Till	0.00E+00	0.00E+00	0.00E+00	0.00E+00
AFP–GMA	0.00E+00	0.00E+00	0.00E+00	0.00E+00
AFP–Till	0.00E+00	0.00E+00	0.00E+00	0.00E+00
SWL–Till	0.00E+00	4.37E–09	0.00E+00	0.00E+00
LSP–Till	0.00E+00	0.00E+00	0.00E+00	0.00E+00
OU4 Soil	0.00E+00	0.00E+00	0.00E+00	0.00E+00
PAA	0.00E+00	0.00E+00	0.00E+00	0.00E+00
PAB	0.00E+00	1.35E–09	0.00E+00	6.66E–14
PAC	0.00E+00	9.98E–10	0.00E+00	0.00E+00
PAD	0.00E+00	0.00E+00	0.00E+00	0.00E+00
PAE	0.00E+00	1.19E–08	0.00E+00	0.00E+00
PAF	0.00E+00	5.20E–09	0.00E+00	0.00E+00
PAG	0.00E+00	1.54E–09	0.00E+00	0.00E+00
PAH	0.00E+00	2.91E–09	0.00E+00	0.00E+00
PAI	0.00E+00	0.00E+00	0.00E+00	0.00E+00

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ATTACHMENT I.II-4

RAECOM MODEL INPUT PARAMETERS AND OUTPUT FILES

ATTACHMENT I.II-4A

RAECOM MODEL INPUT PARAMETERS

TABLE I.II-4-1

RAECOM INPUT PARAMETERS AND RESULTS FUTURE LAND USE WITH FEDERAL OWNERSHIP ON-SITE DISPOSAL

Source Area	Ra-226 Conc. Above Bckgrd (pCi/g)	Soil Bulk Density (g/cm^3)	Layer Thickness (cm)	Soil Porosity	Soil Moisture Content (dry Wt%)	Rn-222 Emission Rate ($pCi/s/m^2$)
Residual Soil:						
560a	0.98	1.44	300	0.457	16.9	0.254
560b	1.58	1.44	300	0.457	16.9	0.418
560c	1.63	1.44	300	0.457	16.9	0.436
560d	1.63	1.44	300	0.457	16.9	0.436
570a	1.63	1.44	300	0.457	16.9	0.436
570b	1.33	1.44	300	0.457	16.9	0.345
570c	1.00	1.44	300	0.457	16.9	0.272
570d	1.63	1.44	300	0.457	16.9	0.436
570e	1.20	1.44	300	0.457	16.9	0.327
575a	0.70	1.44	300	0.457	16.9	0.182
575b	0.50	1.44	300	0.457	16.9	0.127
580a	0.30	1.44	300	0.457	16.9	0.073
581a	1.30	1.44	300	0.457	16.9	0.345
581b	1.63	1.44	300	0.457	16.9	0.436
581c	1.19	1.44	300	0.457	16.9	0.309
581d	1.63	1.44	300	0.457	16.9	0.436
582a	1.08	1.44	300	0.457	16.9	0.291
582b	1.63	1.44	300	0.457	16.9	0.436
NEC	0.00	1.44	300	0.457	16.9	0.000

TABLE I.II-4-1 (Continued)

Source Area	Ra-226 Conc. Above Bckgrd (pCi/g)	Soil Bulk Density (g/cm^3)	Layer Thickness (cm)	Soil Porosity	Soil Moisture Content (dry Wt%)	Rn-222 Emission Rate (pCi/s/m^2)
Residual Soil (Continued):						
PAa	1.63	1.44	300	0.457	16.9	0.436
PAb	1.63	1.44	300	0.457	16.9	0.436
PAc	1.63	1.44	300	0.457	16.9	0.436
PAd	1.20	1.44	300	0.457	16.9	0.327
PAe	0.84	1.44	300	0.457	16.9	0.218
PAf	1.26	1.44	300	0.457	16.9	0.327
PAg	1.63	1.44	300	0.457	16.9	0.436
PAh	1.63	1.44	300	0.457	16.9	0.436
PAi	1.63	1.44	300	0.457	16.9	0.436
OU4 Soil	1.63	1.44	300	0.457	16.9	0.436
SF GMA	0.68	1.44	300	0.457	16.9	0.182
SF Till	1.63	1.44	300	0.457	16.9	0.436
SF Fill	1.63	1.44	300	0.457	16.9	0.436
IFP GMA	0.87	1.44	300	0.457	16.9	0.236
IFP Till	1.01	1.44	300	0.457	16.9	0.272
AFP GMA	0.59	1.44	300	0.457	16.9	0.164
AFP Till	1.43	1.44	300	0.457	16.9	0.381
SWL Till	1.00	1.44	300	0.457	16.9	0.272
LSP Till	1.19	1.44	300	0.457	16.9	0.309
WPAa	1.63	1.44	300	0.457	16.9	0.436

090459

ATTACHMENT I.III-4B

RAECOM MODEL OUTPUT FILES

OU1&2 CRARE: RA-226 = 0.30 PCI/G, 580a

********** INPUT PARAMETERS **********

NUMBER OF LAYERS: 1
RADON FLUX INTO LAYER 1: .000 pCi/m2/sec
SURFACE RADON CONCENTRATION: .000 pCi/LITER
BARE SOURCE FLUX (Jo) FROM LAYER 1: .7265E-01pCi/m2/sec

LAYER	THICKNESS (cm)	DIFF COEFF (cm2/SEC)	POROSITY	SOURCE (pCi/cm3/sec)	MOISTURE (dry wt. %)
1	45.	.1044E-01	.4570	.4000E-06	16.90

***** RESULTS OF RADON DIFFUSION CALCULATION*****

LAYER	THICKNESS (cm)	EXIT FLUX (pCi/m2/sec)	EXIT CONC. (pCi/liter)	MIC
1	45.	.7265E-01	.0000E+00	.5988

OU1&2 CRARE: RA-226 = 0.50 PCI/G, 575b

********** INPUT PARAMETERS **********

NUMBER OF LAYERS:	1	
RADON FLUX INTO LAYER 1:	.000	pCi/m2/sec
SURFACE RADON CONCENTRATION:	.000	pCi/LITER
BARE SOURCE FLUX (Jo) FROM LAYER 1:	.1271	pCi/m2/sec

LAYER	THICKNESS (cm)	DIFF COEFF (cm2/SEC)	POROSITY	SOURCE (pCi/cm3/sec)	MOISTURE (dry wt. %)
1	45.	.1044E-01	.4570	.7000E-06	16.90

***** RESULTS OF RADON DIFFUSION CALCULATION*****

LAYER	THICKNESS (cm)	EXIT FLUX (pCi/m2/sec)	EXIT CONC. (pCi/liter)	MIC
1	45.	.1271E+00	.0000E+00	.5988

000462

OU1&2 CRARE: RA-226 = 0.594 PCI/G, AFPg

********** INPUT PARAMETERS **********

NUMBER OF LAYERS:	1	
RADON FLUX INTO LAYER 1:	.000	pCi/m2/sec
SURFACE RADON CONCENTRATION:	.000	pCi/LITER
BARE SOURCE FLUX (Jo) FROM LAYER 1:	.1635	pCi/m2/sec

LAYER	THICKNESS (cm)	DIFF COEFF (cm2/SEC)	POROSITY	SOURCE (pCi/cm3/sec)	MOISTURE (dry wt. %)
1	45.	.1044E-01	.4570	.9000E-06	16.90

***** RESULTS OF RADON DIFFUSION CALCULATION*****

LAYER	THICKNESS (cm)	EXIT FLUX (pCi/m2/sec)	EXIT CONC. (pCi/liter)	MIC
1	45.	.1635E+00	.0000E+00	.5988

OU1&2 CRARE: RA-226 = 0.70 PCI/G, 575a,SFg

********** INPUT PARAMETERS **********

NUMBER OF LAYERS:	1	
RADON FLUX INTO LAYER 1:	.000	pCi/m2/sec
SURFACE RADON CONCENTRATION:	.000	pCi/LITER
BARE SOURCE FLUX (Jo) FROM LAYER 1:	.1816	pCi/m2/sec

LAYER	THICKNESS (cm)	DIFF COEFF (cm2/SEC)	POROSITY	SOURCE (pCi/cm3/sec)	MOISTURE (dry wt. %)
1	45.	.1044E-01	.4570	.1000E-05	16.90

***** RESULTS OF RADON DIFFUSION CALCULATION*****

LAYER	THICKNESS (cm)	EXIT FLUX (pCi/m2/sec)	EXIT CONC. (pCi/liter)	MIC
1	45.	.1816E+00	.0000E+00	.5988

000464

OU1&2 CRARE: RA-226 = 0.836 PCI/G, PAe

********** INPUT PARAMETERS **********

NUMBER OF LAYERS:	1	
RADON FLUX INTO LAYER 1:	.000	pCi/m2/sec
SURFACE RADON CONCENTRATION:	.000	pCi/LITER
BARE SOURCE FLUX (Jo) FROM LAYER 1:	.2180	pCi/m2/sec

LAYER	THICKNESS (cm)	DIFF COEFF (cm2/SEC)	POROSITY	SOURCE (pCi/cm3/sec)	MOISTURE (dry wt. %)
1	45.	.1044E-01	.4570	.1200E-05	16.90

***** RESULTS OF RADON DIFFUSION CALCULATION*****

LAYER	THICKNESS (cm)	EXIT FLUX (pCi/m2/sec)	EXIT CONC. (pCi/liter)	MIC
1	45.	.2180E+00	.0000E+00	.5988

OU1&2 CRARE: RA-226 = 0.87 PCI/G, IFPg

********** INPUT PARAMETERS **********

NUMBER OF LAYERS:	1	
RADON FLUX INTO LAYER 1:	.000	pCi/m2/sec
SURFACE RADON CONCENTRATION:	.000	pCi/LITER
BARE SOURCE FLUX (Jo) FROM LAYER 1:	.2361	pCi/m2/sec

LAYER	THICKNESS (cm)	DIFF COEFF (cm2/SEC)	POROSITY	SOURCE (pCi/cm3/sec)	MOISTURE (dry wt. %)
1	45.	.1044E-01	.4570	.1300E-05	16.90

***** RESULTS OF RADON DIFFUSION CALCULATION*****

LAYER	THICKNESS (cm)	EXIT FLUX (pCi/m2/sec)	EXIT CONC. (pCi/liter)	MIC
1	45.	.2361E+00	.0000E+00	.5988

000466

OU1&2 CRARE: RA-226 = 0.977 PCI/G, 560a

********** INPUT PARAMETERS **********

NUMBER OF LAYERS:	1	
RADON FLUX INTO LAYER 1:	.000	pCi/m2/sec
SURFACE RADON CONCENTRATION:	.000	pCi/LITER
BARE SOURCE FLUX (Jo) FROM LAYER 1:	.2543	pCi/m2/sec

LAYER	THICKNESS (cm)	DIFF COEFF (cm2/SEC)	POROSITY	SOURCE (pCi/cm3/sec)	MOISTURE (dry wt. %)
1	45.	.1044E-01	.4570	.1400E-05	16.90

***** RESULTS OF RADON DIFFUSION CALCULATION*****

LAYER	THICKNESS (cm)	EXIT FLUX (pCi/m2/sec)	EXIT CONC. (pCi/liter)	MIC
1	45.	.2543E+00	.0000E+00	.5988

000467

OU1&2 CRARE: RA-226 = 1.01 PCI/G, 570c,IFPt,SWLt

********** INPUT PARAMETERS **********

NUMBER OF LAYERS:	1	
RADON FLUX INTO LAYER 1:	.000	pCi/m2/sec
SURFACE RADON CONCENTRATION:	.000	pCi/LITER
BARE SOURCE FLUX (Jo) FROM LAYER 1:	.2724	pCi/m2/sec

LAYER	THICKNESS (cm)	DIFF COEFF (cm2/SEC)	POROSITY	SOURCE (pCi/cm3/sec)	MOISTURE (dry wt. %)
1	45.	.1044E-01	.4570	.1500E-05	16.90

***** RESULTS OF RADON DIFFUSION CALCULATION*****

LAYER	THICKNESS (cm)	EXIT FLUX (pCi/m2/sec)	EXIT CONC. (pCi/liter)	MIC
1	45.	.2724E+00	.0000E+00	.5988

000468

OU1&2 CRARE: RA-226 = 1.08 PCI/G, 582a

********** INPUT PARAMETERS **********

NUMBER OF LAYERS:	1	
RADON FLUX INTO LAYER 1:	.000	pCi/m2/sec
SURFACE RADON CONCENTRATION:	.000	pCi/LITER
BARE SOURCE FLUX (Jo) FROM LAYER 1:	.2906	pCi/m2/sec

LAYER	THICKNESS (cm)	DIFF COEFF (cm2/SEC)	POROSITY	SOURCE (pCi/cm3/sec)	MOISTURE (dry wt. %)
1	45.	.1044E-01	.4570	.1600E-05	16.90

***** RESULTS OF RADON DIFFUSION CALCULATION*****

LAYER	THICKNESS (cm)	EXIT FLUX (pCi/m2/sec)	EXIT CONC. (pCi/liter)	MIC
1	45.	.2906E+00	.0000E+00	.5988

OU1&2 CRARE: RA-226 = 1.19 PCI/G, 581c,LSPt

********** INPUT PARAMETERS **********

NUMBER OF LAYERS:	1	
RADON FLUX INTO LAYER 1:	.000	pCi/m2/sec
SURFACE RADON CONCENTRATION:	.000	pCi/LITER
BARE SOURCE FLUX (Jo) FROM LAYER 1:	.3088	pCi/m2/sec

LAYER	THICKNESS (cm)	DIFF COEFF (cm2/SEC)	POROSITY	SOURCE (pCi/cm3/sec)	MOISTURE (dry wt. %)
1	45.	.1044E-01	.4570	.1700E-05	16.90

***** RESULTS OF RADON DIFFUSION CALCULATION*****

LAYER	THICKNESS (cm)	EXIT FLUX (pCi/m2/sec)	EXIT CONC. (pCi/liter)	MIC
1	45.	.3088E+00	.0000E+00	.5988

000470

OU1&2 CRARE: RA-226 = 1.26 PCI/G, 570e,WastePits 1-6,Burn,Clear,PAd,f

********** INPUT PARAMETERS **********

NUMBER OF LAYERS:	1	
RADON FLUX INTO LAYER 1:	.000	pCi/m2/sec
SURFACE RADON CONCENTRATION:	.000	pCi/LITER
BARE SOURCE FLUX (Jo) FROM LAYER 1:	.3269	pCi/m2/sec

LAYER	THICKNESS (cm)	DIFF COEFF (cm2/SEC)	POROSITY	SOURCE (pCi/cm3/sec)	MOISTURE (dry wt. %)
1	45.	.1044E-01	.4570	.1800E-05	16.90

***** RESULTS OF RADON DIFFUSION CALCULATION*****

LAYER	THICKNESS (cm)	EXIT FLUX (pCi/m2/sec)	EXIT CONC. (pCi/liter)	MIC
1	45.	.3269E+00	.0000E+00	.5988

OU1&2 CRARE: RA-226 = 1.33 PCI/G, 570b

********** INPUT PARAMETERS **********

NUMBER OF LAYERS:	1	
RADON FLUX INTO LAYER 1:	.000	pCi/m2/sec
SURFACE RADON CONCENTRATION:	.000	pCi/LITER
BARE SOURCE FLUX (Jo) FROM LAYER 1:	.3451	pCi/m2/sec

LAYER	THICKNESS (cm)	DIFF COEFF (cm2/SEC)	POROSITY	SOURCE (pCi/cm3/sec)	MOISTURE (dry wt. %)
1	45.	.1044E-01	.4570	.1900E-05	16.90

***** RESULTS OF RADON DIFFUSION CALCULATION*****

LAYER	THICKNESS (cm)	EXIT FLUX (pCi/m2/sec)	EXIT CONC. (pCi/liter)	MIC
1	45.	.3451E+00	.0000E+00	.5988

000472

OU1&2 CRARE: RA-226 = 1.43 PCI/G, AFPt

********** INPUT PARAMETERS **********

NUMBER OF LAYERS:	1	
RADON FLUX INTO LAYER 1:	.000	pCi/m2/sec
SURFACE RADON CONCENTRATION:	.000	pCi/LITER
BARE SOURCE FLUX (Jo) FROM LAYER 1:	.3814	pCi/m2/sec

LAYER	THICKNESS (cm)	DIFF COEFF (cm2/SEC)	POROSITY	SOURCE (pCi/cm3/sec)	MOISTURE (dry wt. %)
1	45.	.1044E-01	.4570	.2100E-05	16.90

***** RESULTS OF RADON DIFFUSION CALCULATION*****

LAYER	THICKNESS (cm)	EXIT FLUX (pCi/m2/sec)	EXIT CONC. (pCi/liter)	MIC
1	45.	.3814E+00	.0000E+00	.5988

090473

OU1&2 CRARE: RA-226 = 1.58 PCI/G, 560b

********** INPUT PARAMETERS **********

NUMBER OF LAYERS:	1	
RADON FLUX INTO LAYER 1:	.000	pCi/m2/sec
SURFACE RADON CONCENTRATION:	.000	pCi/LITER
BARE SOURCE FLUX (Jo) FROM LAYER 1:	.4177	pCi/m2/sec

LAYER	THICKNESS (cm)	DIFF COEFF (cm2/SEC)	POROSITY	SOURCE (pCi/cm3/sec)	MOISTURE (dry wt. %)
1	45.	.1044E-01	.4570	.2300E-05	16.90

***** RESULTS OF RADON DIFFUSION CALCULATION*****

LAYER	THICKNESS (cm)	EXIT FLUX (pCi/m2/sec)	EXIT CONC. (pCi/liter)	MIC
1	45.	.4177E+00	.0000E+00	.5988

000474

OU1&2 CRARE: RA-226 = 1.63 PCI/G, 560c,d,70a,d,81b,d,82b,WPAa,SFt,f,PAa,b,c,g,

********** INPUT PARAMETERS **********

NUMBER OF LAYERS:	1	
RADON FLUX INTO LAYER 1:	.000	pCi/m2/sec
SURFACE RADON CONCENTRATION:	.000	pCi/LITER
BARE SOURCE FLUX (Jo) FROM LAYER 1:	.4359	pCi/m2/sec

LAYER	THICKNESS (cm)	DIFF COEFF (cm2/SEC)	POROSITY	SOURCE (pCi/cm3/sec)	MOISTURE (dry wt. %)
1	45.	.1044E-01	.4570	.2400E-05	16.90

***** RESULTS OF RADON DIFFUSION CALCULATION*****

LAYER	THICKNESS (cm)	EXIT FLUX (pCi/m2/sec)	EXIT CONC. (pCi/liter)	MIC
1	45.	.4359E+00	.0000E+00	.5988

OU1&2 CRARE: DISPOSAL CELL

********** INPUT PARAMETERS **********

NUMBER OF LAYERS: 7
RADON FLUX INTO LAYER 1: .000 pCi/m2/sec
SURFACE RADON CONCENTRATION: .000 pCi/LITER

LAYER 3 EXCEEDS SATURATION. MOISTURE CHANGED FROM .285 TO .277

BARE SOURCE FLUX (Jo) FROM LAYER 1: 4.800 pCi/m2/sec

LAYER	THICKNESS (cm)	DIFF COEFF (cm2/SEC)	POROSITY	SOURCE (pCi/cm3/sec)	MOISTURE (dry wt. %)
1	900.	.1044E-01	.4570	.1490E-04	16.90
2	30.	.1044E-01	.4570	.0000E+00	16.90
3	60.	.6184E-04	.4300	.0000E+00	27.66
4	30.	.4845E-01	.4170	.0000E+00	2.95
5	60.	.4845E-01	.4170	.0000E+00	2.95
6	50.	.1044E-01	.4570	.0000E+00	16.90
7	15.	.1044E-01	.4570	.0000E+00	16.90

***** RESULTS OF RADON DIFFUSION CALCULATION*****

LAYER	THICKNESS (cm)	EXIT FLUX (pCi/m2/sec)	EXIT CONC. (pCi/liter)	MIC
1	900.	.1440E+01	.4967E+05	.5988
2	30.	.9826E-01	.4491E+05	.5988
3	60.	.3059E-05	.8428E-02	.2674
4	30.	.2354E-05	.2491E-01	.9176
5	60.	.1197E-05	.1971E-01	.9176
6	50.	.8408E-06	.2605E-02	.5988
7	15.	.8221E-06	.0000E+00	.5988

000476

ATTACHMENT I.II-5

FIVE-YEAR COMPOSITE JOINT FREQUENCY DISTRIBUTION FOR THE FEMP

TABLE I.II-5-1
FEMP STANDARD JOINT FREQUENCY DISTRIBUTION

Stability Class	Wind Direction	Wind Speed (kts) ≤3	≤6	≤10	≤16	≤21	≥21
A	N	0.000263	0.000904	0.000904	0.000058	0.000000	0.000000
	NNE	0.000292	0.001546	0.000671	0.000000	0.000000	0.000000
	NE	0.000817	0.002888	0.001196	0.000029	0.000000	0.000000
	ENE	0.001430	0.004434	0.002042	0.000117	0.000000	0.000000
	E	0.001050	0.002013	0.000204	0.000146	0.000000	0.000000
	ESE	0.000700	0.000817	0.000058	0.000000	0.000000	0.000000
	SE	0.000467	0.000438	0.000000	0.000000	0.000000	0.000000
	SSE	0.000583	0.000554	0.000000	0.000000	0.000000	0.000000
	S	0.000700	0.001575	0.001196	0.000000	0.000000	0.000000
	SSW	0.001021	0.004347	0.003793	0.000146	0.000000	0.000000
	SW	0.001284	0.005076	0.004755	0.000554	0.000000	0.000000
	WSW	0.001750	0.004755	0.003647	0.000204	0.000000	0.000000
	W	0.000992	0.003880	0.003267	0.000467	0.000000	0.000000
	WNW	0.000613	0.001809	0.002626	0.000525	0.000000	0.000000
	NW	0.000583	0.001575	0.001400	0.000117	0.000000	0.000000
	NNW	0.000350	0.001313	0.001284	0.000058	0.000000	0.000000
B	N	0.000029	0.000817	0.000700	0.000117	0.000000	0.000000
	NNE	0.000117	0.000525	0.000496	0.000058	0.000000	0.000000
	NE	0.000350	0.000963	0.000613	0.000058	0.000000	0.000000
	ENE	0.000321	0.001459	0.000554	0.000146	0.000000	0.000000
	E	0.000467	0.000671	0.000175	0.000029	0.000000	0.000000
	ESE	0.000263	0.000263	0.000029	0.000000	0.000000	0.000000
	SE	0.000233	0.000204	0.000029	0.000000	0.000000	0.000000
	SSE	0.000263	0.000467	0.000088	0.000029	0.000000	0.000000
	S	0.000408	0.001138	0.000321	0.000000	0.000000	0.000000
	SSW	0.000525	0.001546	0.001313	0.000175	0.000000	0.000000
	SW	0.000613	0.002042	0.002071	0.000233	0.000000	0.000000
	WSW	0.000613	0.001692	0.001284	0.000175	0.000000	0.000000
	W	0.000671	0.001167	0.001225	0.000146	0.000000	0.000000
	WNW	0.000233	0.000788	0.000875	0.000204	0.000000	0.000000
	NW	0.000263	0.000671	0.001021	0.000204	0.000000	0.000000
	NNW	0.000146	0.000642	0.000904	0.000088	0.000000	0.000000
C	N	0.000204	0.000846	0.001079	0.000233	0.000000	0.000000
	NNE	0.000175	0.001313	0.000729	0.000058	0.000000	0.000000
	NE	0.000408	0.001488	0.001021	0.000088	0.000000	0.000000
	ENE	0.000700	0.001721	0.000438	0.000263	0.000000	0.000000
	E	0.001050	0.000875	0.000204	0.000058	0.000000	0.000000
	ESE	0.000671	0.000583	0.000058	0.000000	0.000000	0.000000
	SE	0.000321	0.000467	0.000088	0.000000	0.000000	0.000000
	SSE	0.000146	0.000467	0.000058	0.000058	0.000000	0.000000
	S	0.000321	0.001167	0.000554	0.000058	0.000000	0.000000
	SSW	0.000554	0.001750	0.001575	0.000058	0.000029	0.000000
	SW	0.000904	0.002742	0.001750	0.000175	0.000000	0.000000
	WSW	0.000759	0.002421	0.001254	0.000204	0.000000	0.000000
	W	0.000788	0.001284	0.001138	0.000321	0.000000	0.000000
	WNW	0.000321	0.001342	0.001254	0.000204	0.000000	0.000000
	NW	0.000233	0.001342	0.001138	0.000117	0.000029	0.000000
	NNW	0.000233	0.001079	0.000963	0.000029	0.000000	0.000000

TABLE I.II-5-1 (Continued)

Stability Class	Wind Direction	Wind Speed (kts) ≤3	≤6	≤10	≤16	≤21	≥21
D	N	0.002101	0.008723	0.009219	0.001079	0.000000	0.000000
	NNE	0.002830	0.010532	0.008256	0.001138	0.000000	0.000000
	NE	0.004464	0.013420	0.007498	0.000496	0.000000	0.000000
	ENE	0.006331	0.017825	0.009161	0.002042	0.000000	0.000000
	E	0.004493	0.006127	0.001079	0.000088	0.000000	0.000000
	ESE	0.003238	0.002976	0.000117	0.000000	0.000000	0.000000
	SE	0.002626	0.002626	0.000350	0.000000	0.000000	0.000000
	SSE	0.002801	0.003618	0.001109	0.000204	0.000000	0.000000
	S	0.003063	0.006593	0.002888	0.000321	0.000000	0.000000
	SSW	0.005806	0.014091	0.007439	0.001809	0.000000	0.000000
	SW	0.007848	0.014470	0.008023	0.001050	0.000058	0.000000
	WSW	0.008373	0.011203	0.006272	0.001167	0.000000	0.000000
	W	0.007060	0.011553	0.009482	0.001430	0.000000	0.000000
	WNW	0.004785	0.010415	0.010619	0.001546	0.000000	0.000000
	NW	0.003734	0.009044	0.007264	0.000963	0.000088	0.000000
	NNW	0.002976	0.008840	0.005631	0.001050	0.000058	0.000000
E	N	0.003618	0.003880	0.000759	0.000029	0.000000	0.000000
	NNE	0.002596	0.003092	0.000788	0.000175	0.000000	0.000000
	NE	0.002976	0.003472	0.000438	0.000000	0.000000	0.000000
	ENE	0.008694	0.009219	0.001809	0.000000	0.000000	0.000000
	E	0.008198	0.002742	0.000233	0.000000	0.000000	0.000000
	ESE	0.004785	0.001254	0.000146	0.000000	0.000000	0.000000
	SE	0.004843	0.001721	0.000292	0.000000	0.000000	0.000000
	SSE	0.005572	0.003413	0.001284	0.000204	0.000000	0.000000
	S	0.006973	0.007673	0.003355	0.000642	0.000000	0.000000
	SSW	0.011582	0.014033	0.006798	0.001692	0.000000	0.000000
	SW	0.018496	0.018263	0.007410	0.000671	0.000000	0.000000
	WSW	0.017796	0.010328	0.003297	0.000642	0.000000	0.000000
	W	0.012486	0.010007	0.004143	0.000146	0.000000	0.000000
	WNW	0.009482	0.007614	0.003297	0.000583	0.000000	0.000000
	NW	0.008344	0.004668	0.001109	0.000175	0.000000	0.000000
	NNW	0.006214	0.003822	0.001079	0.000263	0.000000	0.000000
F	N	0.004988	0.000117	0.000000	0.000000	0.000000	0.000000
	NNE	0.005251	0.000088	0.000029	0.000000	0.000000	0.000000
	NE	0.005076	0.000117	0.000000	0.000000	0.000000	0.000000
	ENE	0.009102	0.001605	0.000117	0.000000	0.000000	0.000000
	E	0.013361	0.000904	0.000000	0.000000	0.000000	0.000000
	ESE	0.008927	0.000058	0.000000	0.000000	0.000000	0.000000
	SE	0.005922	0.000321	0.000000	0.000000	0.000000	0.000000
	SSE	0.005456	0.000175	0.000000	0.000000	0.000000	0.000000
	S	0.007002	0.000467	0.000000	0.000000	0.000000	0.000000
	SSW	0.011815	0.001196	0.000263	0.000000	0.000000	0.000000
	SW	0.019576	0.002101	0.000029	0.000000	0.000000	0.000000
	WSW	0.026811	0.001867	0.000058	0.000000	0.000000	0.000000
	W	0.029757	0.000671	0.000029	0.000000	0.000000	0.000000
	WNW	0.029319	0.000233	0.000029	0.000000	0.000000	0.000000
	NW	0.022785	0.000758	0.000058	0.000000	0.000000	0.000000
	NNW	0.011523	0.000876	0.000058	0.000000	0.000000	0.000000

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I.III

ATTACHMENT I.IV
GROUNDWATER MODEL IMPROVEMENT TASK OBJECTIVES AND TECHNICAL APPROACH ZONATION AND VALUES OF GEOCHEMICAL PARAMETERS

5862

GROUNDWATER MODEL IMPROVEMENT TASK OBJECTIVES AND TECHNICAL APPROACH ZONATION AND VALUES OF GEOCHEMICAL PARAMETERS

Fernald Environmental Management Project

December 1993

U.S. Department of Energy
Fernald Field Office

000481

GROUNDWATER MODEL IMPROVEMENT TASK OBJECTIVES AND TECHNICAL APPROACH ZONATION AND VALUES OF GEOCHEMICAL PARAMETERS

5862

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1.0 TASK OBJECTIVE

The objective of this task is to present the strategy for determining zonation and values of contaminant-specific geochemical parameters in the OU5 groundwater fate and transport modeling. The contaminant-specific geochemical parameters required include 1) percent of extractable contaminant (K_e) in the sources, 2) solid-liquid partition coefficient (K_d) in the sources and the pathway media, and 3) retardation factor (R_d) in the pathway media. These parameters have significant impacts on the estimation of contaminant mass, concentration, loading, and migration rates. Therefore it is important that values of these model parameters are accurately assigned for the RI/FS fate and transport modeling.

Section 1.0 of this Task Objectives and Technical Approach (TO/TA) describes the geochemical parameters. Section 2.0 presents the general approach for determining contaminant-specific zonation and values of these parameters for contaminants of concern. Because uranium is the predominant groundwater contaminant at the FEMP and is the focus of the solute transport model recalibration task, Section 3.0 summarizes the available site-specific information on geochemical parameters for uranium. Results are also presented of the screening model confirmation process for the preliminary parameter values of uranium.

1.1 Geochemical Parameters

In addition to the three above-mentioned geochemical parameters, modeled by using the EQ3/6 model, chemical solubility limits have been used in OU1 and OU4 RI fate and transport modeling as constraints for contaminant leachate concentrations. However, only a small number of inorganic contaminants were affected by their solubility limit constraints. Because of both the high uncertainty associated with geochemical modeling and the relatively low contaminant concentrations found in the Great Miami Aquifer (GMA), area-specific chemical solubility limits will not be developed for OU5 RI modeling. Chemical solubility limits will not be used to constrain the source leachate concentrations in OU5 sources either. Solubility limits developed in OU1 and OU4 RIs will be referenced when necessary.

The three geochemical parameters to be evaluated are described in following subsections.

1.1.1 Percent of Extractable Contaminant in the Waste Materials (K_e)

Although the adsorption/desorption process is usually considered to be reversible in fate and transport modeling, in general, the longer a contaminant remains adsorbed to the surface of a solid the more likely it is to be incorporated into the solid by surface reactions which make it unavailable for desorption under environmental conditions. Therefore, an estimate of the percent of extractable contaminant in the sources (usually solid phase waste or soil) is required to determine the contaminant mass available for transport and estimate leachate concentration. When K_e is applied in the modeling, the solid phase concentration and K_d will only be determined for the extractable portion of the contaminant.

1.1.2 Solid-Liquid Partition Coefficient (K_d)

Solid-liquid partition coefficients are used in fate and transport modeling to simulate the reversible adsorption/desorption processes of contaminants. K_d is commonly defined as the constant ratio between solid phase and dissolved phase concentrations of a chemical at equilibrium in fate and transport models. Chemicals with higher K_d values are more likely to be adsorbed onto soil materials and thus have less potential to migrate in the subsurface.

1.1.3 Retardation Factor (R_d)

The contaminant travel time from a source area to the exposure points is one of the major concerns in risk assessment. For determining the contaminant travel time, the retardation factor is defined as the ratio between the groundwater flow velocity and chemical migration velocity through the soil matrix. Because most contaminants have a higher tendency to adsorb to soil than water, they usually migrate more slowly than water in the subsurface environment. Therefore, R_d is usually greater than 1. In fate and transport modeling R_d is estimated by considering both the contaminant characteristics (i.e., K_d) and the soil properties, such as dry bulk density and moisture content of the soil. Because K_d is the only contaminant-specific geochemical parameter that will determine the value of R_d, the following approach for determining contaminant-specific zonation and values of K_d also apply to R_d and will not be described.

1.2 Zonation

In reality, none of the geochemical parameters discussed here are spatially invariant. However, because of the complexity of the soil matrix, simplifications of the natural systems are necessary in fate and transport modeling. The first simplification process is to determine the zonation of each major geochemical parameter. Zonation of geochemical parameters consists of dividing the modeling domain into manageable zones of different geochemical conditions and assigning values of model parameters based on available chemical and geological information. Zonation for geochemical parameters (i.e., K_d, K_e, and R_d) is chemical-specific and usually is assumed temporally constant. The technical approach for zonation of these three major geochemical parameters is described below.

1.3 Parameter Values

After zones are identified, zone-specific values of each geochemical parameter are assigned for every contaminant of concern. Values are obtained from field tests, laboratory experiments, model calibrations, previous studies with similar conditions, or literature searches.

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2.0 TECHNICAL APPROACH

In order to ensure that the fate and transport modeling results are acceptable for risk assessment, important guidelines to be followed in assigning the values and zonation of contaminant-specific geochemical parameters are:

- Use site-specific values when available;
- Select the most conservative assumption/estimate based on performance measures such as contaminant exposure point concentrations or travel times to exposure points when evaluating parameter/zonation choices; and
- Verify modeling results by comparing with available measured conditions.

Based on these guidelines, the following subsections summarize the general technical approach for zonation and assignment of parameter values in OU5 RI groundwater fate and transport modeling.

2.1 Contaminant-Specific Approach for Assigning Geochemical Parameters

Based on the types and amount of available site-specific data and the extent of contaminants, different approaches will be used to assign contaminant-specific values of geochemical parameters.
The following subsections discuss the approaches to be followed in the contaminant source areas and pathway media.

2.1.1 Source Areas

Contaminant loadings from other OUs which can impact the GMA will be included in the OU5 RI fate and transport modeling. Contaminant-specific mass inventories, leachate concentrations, and loading rates used in previous modeling for OU1, OU2, and OU4 RIs will be directly imported into the OU5 RI fate and transport model. Therefore, geochemical parameters (i.e., K_d and K_e) will remain the same as previously assigned for these source areas. However, batch test results obtained for uranium in contaminated soils from OU4 areas will be used instead of the K_d value assumed in the previous OU4 RI modeling. These batch test results became available after the OU4 RI was completed.

Geochemical parameters for additional contaminant source areas defined in OU5 will be determined by using area-specific contaminant concentrations measured in in-situ leachate, waste material, and/or toxicity characteristic leaching procedure (TCLP) samples. Considerations of the various chemical forms/species in contaminant sources may result in different values of geochemical parameters for the same contaminant in different areas. When no site-specific information is available for determining K_d and K_e for contaminants, conservative assumptions (e.g., 70-year rule) will be made for estimating the source leachate concentration and mass loading rates. When the 70-year rule is applied, the total mass of a contaminant in the source area will be released into the media in 70 years. It is expected that K_e will be assumed to be 100% for all the contaminants except uranium.

2.1.2 Pathway Media

For the RI fate and transport modeling K_e will only be applied during the initial source term determination (i.e., available uranium mass). Therefore, K_e does not apply to the migration media. Contaminant concentrations in both groundwater and soil media will be used to define zonation and values of K_d and R_d. Values and zonation of intermediate parameters such as fraction of organic

content, used in calculating K_d for organic contaminants, and soil porosity and moisture content, used in calculating R_d, will also be defined in the process. When site-specific data are unavailable for a contaminant, conservative literature values will be used to assign K_d values in the migration media.

Parameter values will be assigned to each geological unit separately (i.e., glacial overburden, unsaturated GMA, and saturated GMA). However, uniform contaminant-specific values of K_d and R_d in a geological unit will be used for most of the contaminants. Further zonation of parameter values for a contaminant will only be considered when field data shows significant variations of the parameter in a geological unit (i.e., order-of-magnitude differences).

2.2 Model Calibration and Performance Evaluation

As stated in the Groundwater Model Improvement Plan (DOE 1993a), formal solute transport model calibration will be performed for uranium only during the model improvement process. In order to verify the values of geochemical parameters for other contaminants, fate and transport modeling results will be compared with contaminant concentrations measured in the field during the model applications.

When full model calibrations are not necessary because of relatively small extents of contamination, the modeling results for these contaminants still need to be realistic or conservative when compared to field measured conditions. During the RI fate and transport modeling, model performance evaluations will be conducted for contaminants that have elevated concentrations in the GMA. Model simulated results for these contaminants will be compared with measured concentrations. If necessary, the values of geochemical parameters or mass loading terms will be adjusted to obtain better agreement between modeled and measured concentrations (i.e., within the same order of magnitude). Available measured concentrations for all the contaminants of concern at the current time will be presented together with final simulated concentrations in the modeling documentation. The model performance evaluation and uncertainty analysis are of particular importance for contaminants where site-specific data are available for determining the values of geochemical parameters.

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3.0 GEOCHEMICAL PARAMETERS FOR URANIUM

Because uranium is the predominant contaminant at the FEMP, preliminary zonation and values of K_d and K_e for uranium are summarized in this TO/TA. It is important to note that the GMA solute transport model is being calibrated and additional uranium information for determining the geochemical model parameters will become available from the on-going treatability studies and RI/FS processes of OU5 and other OUs at the FEMP. The zonation and values of uranium geochemical parameters presented here are based on currently available data and will be refined if necessary in future fate and transport modeling.

An ECTran screening-level model confirmation process has been conducted and is described in this document. The objective of this process was to verify that the estimated geochemical parameter values of uranium are reasonable by comparing modeling results, using these parameter values, with measured groundwater and soil conditions at the FEMP.

3.1 Solid-Liquid Partition Coefficient (K_d) of Uranium

3.1.1 Available Data

Available site-specific information that can be used to determine K_d values of uranium include recently completed batch tests with waste materials, contaminated and uncontaminated site soil, previous geochemical studies, and existing analytical data of soil and perched groundwater concentrations measured in the glacial overburden. Figure 3-1 and Table 3-1 summarize the overall ranges and locations of available site-specific uranium K_d values at the FEMP. The following subsections describe this information in more detail. For comparison purposes, a summary of literature K_d values for uranium is also presented.

3.1.1.1 Literature Values

A literature search was performed to determine the possible range of K_d values for uranium. Table 3-2 presents the results of the literature search. As can be seen in the table, the range of K_d values is quite large and the values vary significantly between soil types. The EXP(u) values in Table 3-2 are the geometric means of all the measurements for the same soil type.

3.1.1.2 Analytical Data From Monitoring Wells

When both the soil and groundwater concentrations of uranium at the same location are measured, the K_d value can be determined by simply calculating the ratio of these two concentrations.

Glacial Overburden

There are more than 100 sets of soil and perched water concentrations available from the 1000-series wells installed in the Production Area. These soil and perched water uranium concentrations were used to estimate the site-specific K_d values for uranium in the Production Area. The pair of soil and perched water concentrations for each well used in the calculation represents the average soil and perched water uranium concentrations from all samples taken at about the same time along the screen interval of the well. Because perched water flow velocities are low in the glacial overburden, it is reasonable to assume that the measured soil and liquid phase concentrations are under equilibrium conditions. Before dividing soil concentrations by the corresponding perched water concentrations to determine K_d values, the reported soil concentrations were corrected by subtracting the mass of

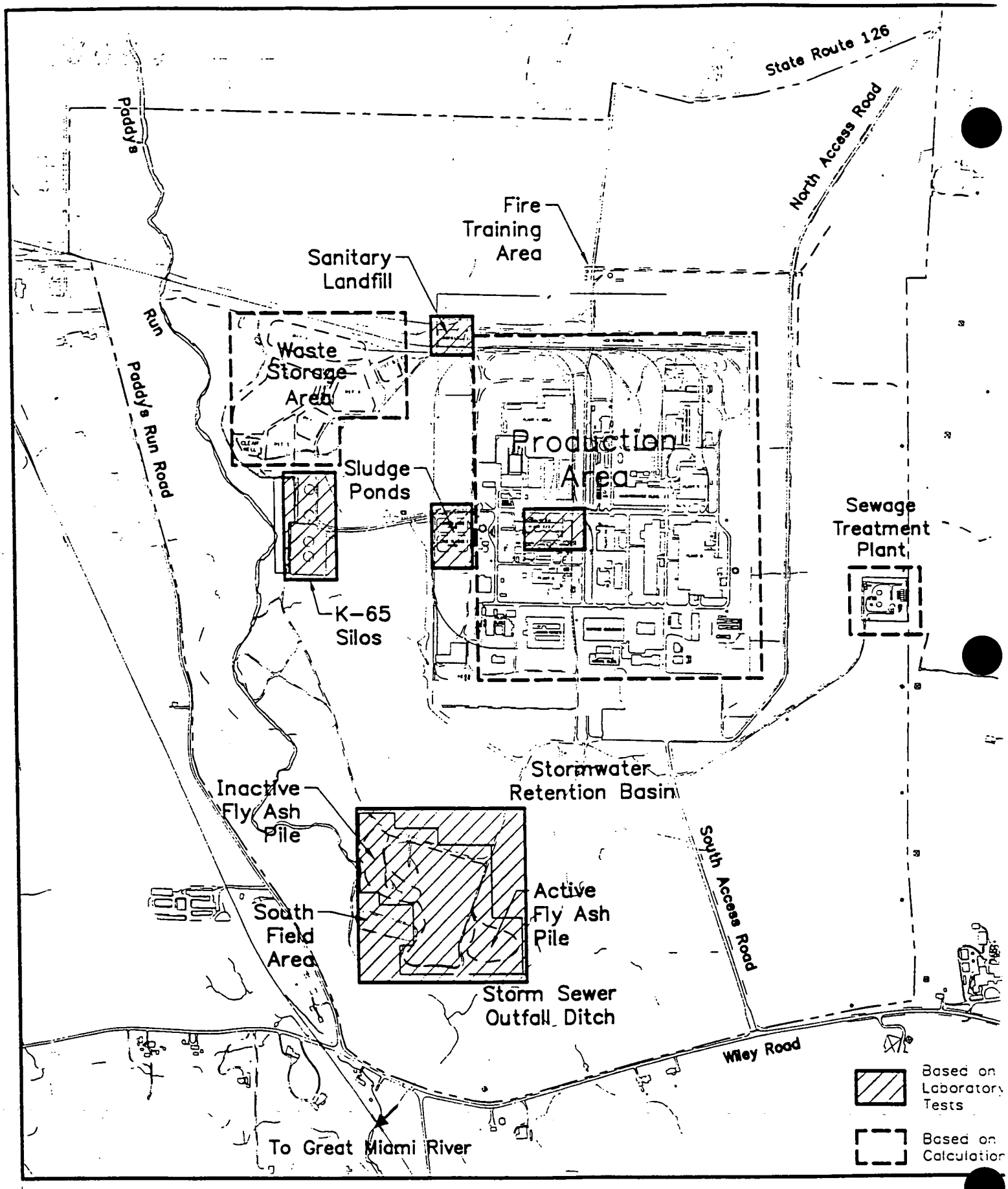

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Figure 3 - 1

Areas with Available Site-Specific Uranium K_d Values

TABLE 3-1
RANGES OF SITE-SPECIFIC K_d VALUES

Waste Materials	K_d (L/kg)
Plant 2/3, Plant 6, and Plant 9 Contaminated Soil	15[a] - 31[b]
Remaining Production Area	222[a]
OU4 Contaminated Soil	12 - 15.4[c]
OU2 Waste	37 - 177[d]
Glacial Overburden	
Contaminated Till (Desorption)	200 - 280[d]
Uncontaminated Till (Adsorption)	12 - 81[d]
Unsaturated Sand and Gravel	
South Field Area	12 - 14[d]
Saturated Sand and Gravel	
Waste Pit Area	12 - 68[e]
South Field Area	8 - 10[d]
South Plume Area	0.76 - 4.39[e]

a Geometric mean of calculated K_d values in 1000-series wells.
b ORNL study (Lee, et al., 1993).
c OU4 batch tests (Appendix A)
d OU2 batch tests (DOE 1993g)
e Issue 3 & 5 study, Appendix A of Groundwater Modeling Report (DOE 1993b)

TABLE 3-2
SUMMARY OF LITERATURE K_d VALUES OF URANIUM

SOIL TYPE	EXP(u) (L/kg)	RANGE (L/kg)	REFERENCE
Clay	1600	46 - 395100	Thibault et al., 1990
Silt	15	0.20 - 4500	Thibault et al., 1990
Sand	35	0.03 - 2200	Thibault et al., 1990
Agricultural Soil and Clay	450	N/A	Baes et al., 1984
Agricultural Soil	45	10.5 - 4400	Baes and Sharp, 1983

N/A: not available

uranium contained in the soil moisture (assuming the moisture content is 20 percent by weight in the saturated soil sample). The perched water and soil concentrations used in this calculation are included in Appendix B.

Table 3-3 summarizes all the calculated K_d values. After reviewing the results, it was determined that there are two groups of K_d values which fall in two ranges of values. Because of the different forms of uranium and geochemical conditions which exist in the Plant 2/3, Plant 6 and Plant 9 areas (Lee and Marsh, 1992), a separate representative K_d value was estimated for these areas. Overall, two representative values corresponding to the two groups of calculated K_d values were developed for the Production Area. The geometric mean of all K_d values calculated for wells in the Plant 2/3, Plant 6, and Plant 9 areas was 15 L/kg. The geometric mean of calculated K_d values in the remaining part of the Production Area was 222 L/kg. Both of these two representative K_d values are within the reported literature ranges summarized in Table 3-2. Because these soil and perched water samples were taken from locations outside but very close to the source of contamination, the estimated K_d values of uranium can be representative of both the glacial overburden and the extractable portion of waste materials in the source areas.

Great Miami Aquifer

Geochemical Programs: Issue 3 and Issue 5 Report, Appendix A, (DOE 1993b) presented a range of uranium K_d values for the GMA sand and gravel materials. One of the approaches used in the study was to calculate the ratios between soil and groundwater uranium concentrations taken from the same GMA monitoring well location. Although soil and groundwater concentrations from various locations at the FEMP were evaluated in the study, the report only formally summarized a range of K_d values for the sand and gravel materials in the South Plume area. A R_d of 12 was selected in subsequent solute transport model calibrations conducted for the South Plume using this range of K_d values (DOE 1993b). The K_d value corresponding to the calibrated retardation factor of 12 is about 1.48 L/kg.

3.1.1.3 Results from Laboratory Tests

ORNL Study

Experimental results reported in an Oak Ridge National Laboratory (ORNL) study on the uranium-contaminated surface soils from the Production Area at the FEMP indicate that the range of K_d is very large (Lee, et al., 1993). This is because of different forms of uranium contaminants (i.e., liquid, particulate, and air deposition) and is consistent with the finding from the perched water wells. Of the two contaminated soil samples tested in the equilibration study, insignificant amounts of uranium leached from sample A-14, which has a significantly higher solid phase concentration. In fact, this soil sample did not reach an equilibrium condition in the 70-day duration of the test. More soluble uranium leached from sample B-16. At the end of the test, sample B-16 was close to equilibrium. Using the results of the B-16 soil sample, a K_d value of 31.45 L/kg was calculated.

OU2 and OU4 Batch Tests

Batch tests have been conducted to measure the K_d of uranium in the waste materials, contaminated soil, and uncontaminated soil collected from OU2 and OU4 areas. Results of these tests show that K_d values of the waste materials, contaminated surface soil and glacial till are in the range of 30 L/kg and higher. Measured K_d results in the aquifer materials are usually lower than 10 L/kg. The experimental procedures and results of these batch tests are summarized in the Uranium Partition Coefficient Evaluation Study (DOE 1993g). Similar tests on waste materials from the OU5 source areas are scheduled to start by the end of 1993.

TABLE 3-3
SUMMARY OF CALCULATED K_d (L/kg) VALUES

REMAINING PRODUCTION AREA

Well No.	Corrected K_d value
1131	97.19
1167	1124.80
1181	186.47
1187	81.68
1198	130.23
1244	1086.76
1245	162.84
1246	3581.36
1250	40.08
1267	185.85
1277	93.55
1280	501.19
1281	129.05
1287	188.48
1338	1824.80
1345	6849.80
1347	144.54
1348	433.91
1354	106.66
1356	276.88
1360	1066.47
1443	1215.40
1448	569.14
1509	48.00
1510	88.16
1513	200.77
1515	608.89
1151	34.38
1266	2727.07
1317	350.45
1339	14.77
1341	186.79
1441	3.03
1447	20.94
Arithmetic Mean:	716.482
Geometric Mean:	221.958

PLANTS 2/3, 6, AND 9 AREAS

Well No.	Corrected K_d value
1154	40.34
1179	20.93
1180	13.67
1182	11.50
1183	20.54
1185	48.53
1186	1.95
1194	30.34
1195	3.68
1196	10.34
1199	29.51
1200	13.34
1201	78.09
1202	44.26
1203	900.61
1204	14.09
1205	22.65
1206	8.47
1207	29.69
1209	1.76
1212	8.35
1213	3.47
1214	216.40
1215	24.33
1216	38.40
1217	13.50
1219	11.50
1220	13.84
1221	24.77
1224	4.94
1225	51.57
1230	13.23
1231	3.57
1232	6.42
1233	1.67
1236	22.05
1240	17.94
1271	21.13
1257	20.17
1145	2.16
1148	34.26
1149	10.71
1324	0.60
Arithmetic Mean:	44.40
Geometric Mean:	14.721

3.1.2 Zonation and Values of Uranium K_d for Modeling

3.1.2.1 Uranium-Contaminated Sources

Uranium mass inventories, leachate concentrations, and loading terms used in previous modeling for OU1 and OU2 RIs will be directly imported to the OU5 RI modeling. Therefore, geochemical parameters in these source areas remain the same as previously assigned. The uranium K_d value of 1.8 L/kg used in the OU4 will be revised according to the batch test results obtained after the OU4 RI modeling was completed.

Geochemical parameters for additional uranium source areas defined within OU5 will be determined by using area-specific uranium concentrations measured in in-situ leachate, waste material, perched water, and/or TCLP samples. Various forms of uranium in contaminant sources may result in different values of K_d and K_e in different source areas. For example, uranium in Plant 2/3, Plant 6, and Plant 9 will be assigned a K_d value of 15 L/kg while uranium contaminated soil in the remaining Production Area will be assigned a K_d value of 222 L/kg. When the delineation of OU5 source areas is finalized, a map showing the source areas and all the area-specific uranium K_d values will be developed. The final values and zonation of uranium K_d will be summarized in the Summary Letter Report for the Model Calibration Task of the groundwater model improvement process.

3.1.2.2 Glacial Overburden and Unsaturated GMA

Uranium K_d in the glacial overburden and unsaturated GMA will be determined using batch test results and ratios between uranium concentrations in soil and perched water. Extrapolation or contouring of available data will also be performed to assign K_d values for areas with less data.

Because of the close proximity to contaminant sources, K_d values in the glacial overburden are highly dependent of the forms of uranium in the sources. The range of available uranium k_d values in the glacial overburden covers two orders of magnitude. It is expected that the modeling for uranium in the glacial overburden will be conducted source area by source area with different values of K_d. At least two types of uranium forms, soluble and non-soluble, and therefore two groups of uranium source areas will be modeled separately with two different K_d values in the glacial overburden.

3.1.2.3 Saturated GMA

Because only the soluble forms of uranium can reach the GMA in significant quantity, K_d values in the GMA are lower and more homogeneous than the glacial overburden and source areas. Complex zonation of uranium K_d values in the GMA is therefore not necessary. Uranium K_d in the saturated GMA will be determined through the solute transport model recalibration task in the groundwater model improvement process. The calibration target is the geostatistically defined 1990 uranium concentrations in the GMA (DOE 1993f). Both the dissolved concentration and total mass of uranium in the GMA will be matched to select the final uranium K_d zonation and values. Based on the spatial trend of available uranium K_d values in the saturated GMA, a simple zonation approach with a higher K_d value to the north and a lower K_d value to the south covering the South Plume area will be tested in the calibration.

3.2 Percent of Extractable Uranium in the Waste Materials (K_e)

3.2.1 Available Information

Available sources of information for percent of extractable uranium used include the ORNL soil characterization and washing study (Lee and Marsh, 1992) and OU2 batch tests (DOE 1993g). Based

on results of these studies, uranium mass in waste materials or contaminated soils at the FEMP is usually not completely extractable by rain water. It has been found that the percent of extractable uranium in untreated FEMP waste materials with 2,500 μg/g or lower total uranium concentrations is usually below 30% by acid extractants. For waste materials with 300 μg/g or less total uranium, the percent of extractable uranium by rain water is below 10%. For waste materials with 5,000 μg/g or higher total uranium, the percent of extractable uranium can be higher than 40% by acid extractants.

3.2.2 Zonation and Values of Uranium K_e for Modeling

For the OU5 RI fate and transport modeling K_e will only be applied during the initial source term determination. Based on the soil treatability study, OU2 batch tests, and current uranium concentrations in the OU5 waste materials, the following two K_e values are selected for modeling purposes:

- For source materials with solid phase total uranium concentrations less than or equal to 2,500 μg/g, the K_e is assumed to be 30%.

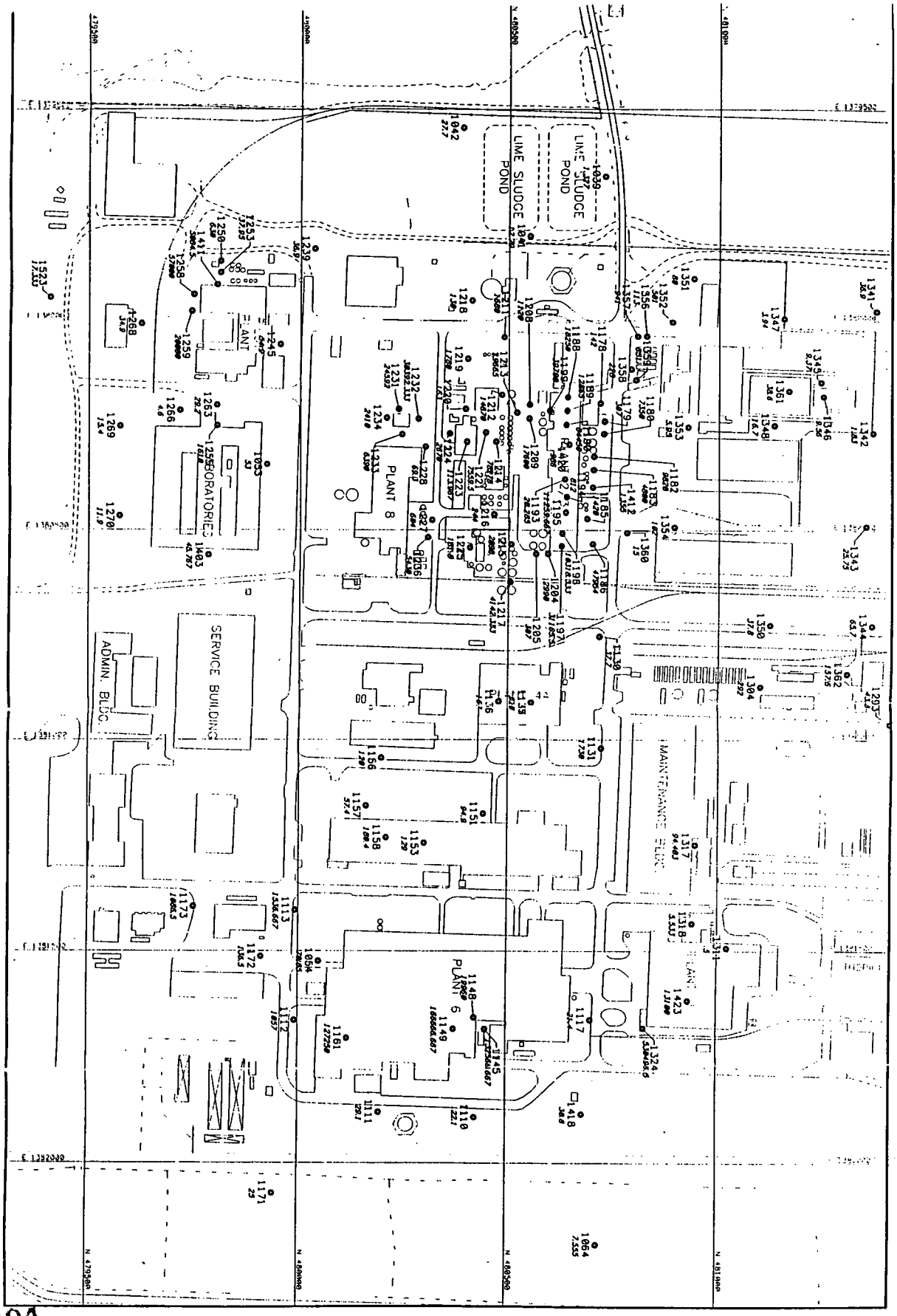
- For source materials with solid phase total uranium concentrations higher than 2,500 μg/g, the K_e is assumed to be 50%.

Accordingly, the zonation of uranium K_e is defined by the current concentrations of uranium in the waste materials or contaminated soils. When delineation of OU5 source areas is finalized (December 1993), a map showing the source areas and all the area-specific uranium K_e values will be developed.

3.3 Screening Model Confirmation for Uranium K_d and K_e

The ECTran screening-level fate and transport model (DOE, 1993c) was used to confirm that the estimated K_d and K_e of uranium are reasonable and can result in the current uranium concentrations in the perched water and the GMA. The confirmation procedure involved: 1) defining the existing hydrogeological conditions and the extent of the source area; 2) inputing a source leachate concentration; 3) obtaining the model's results for concentration in the GMA after 30 years; 4) comparing the results with measured results from the 2000-series wells; and 5) confirming the total solid phase concentrations (calculated using the source leachate concentration, K_d, and K_e) with the measured soil concentrations.

Two contaminated sites in the Production Area were investigated in the vicinity of Plant 2/3 and Plant 6. Representative source leachate concentrations were estimated using the maximum annual average 1000-series well total uranium concentrations in 1990. Uranium source leachate concentrations of 78.3 mg/L (from well 1214) and 166.7 mg/L (from Well 1149) were assigned for Plant 2/3 and Plant 6 source areas, respectively. Area-weighted average perched water concentrations in both areas are more than one order of magnitude lower than these maximum concentrations. Figures 3-2 and 3-3 show the 1990 annual average total uranium concentrations in 1000- and 2000-series wells in the vicinity of Plant 2/3 and Plant 6 utilized in the confirmation modeling. Representative values for all the other hydrogeological parameters for these areas were also assigned. The major parameter values used for the confirmation modeling are summarized in Table 3-4.



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1000 SERIES AVERAGE TOTAL URANIUM 1990 SHEET 2 OF 2 [INSET]
(RI/FS AND NON-RI/FS DATA)
µg/l

Figure 3 - 2

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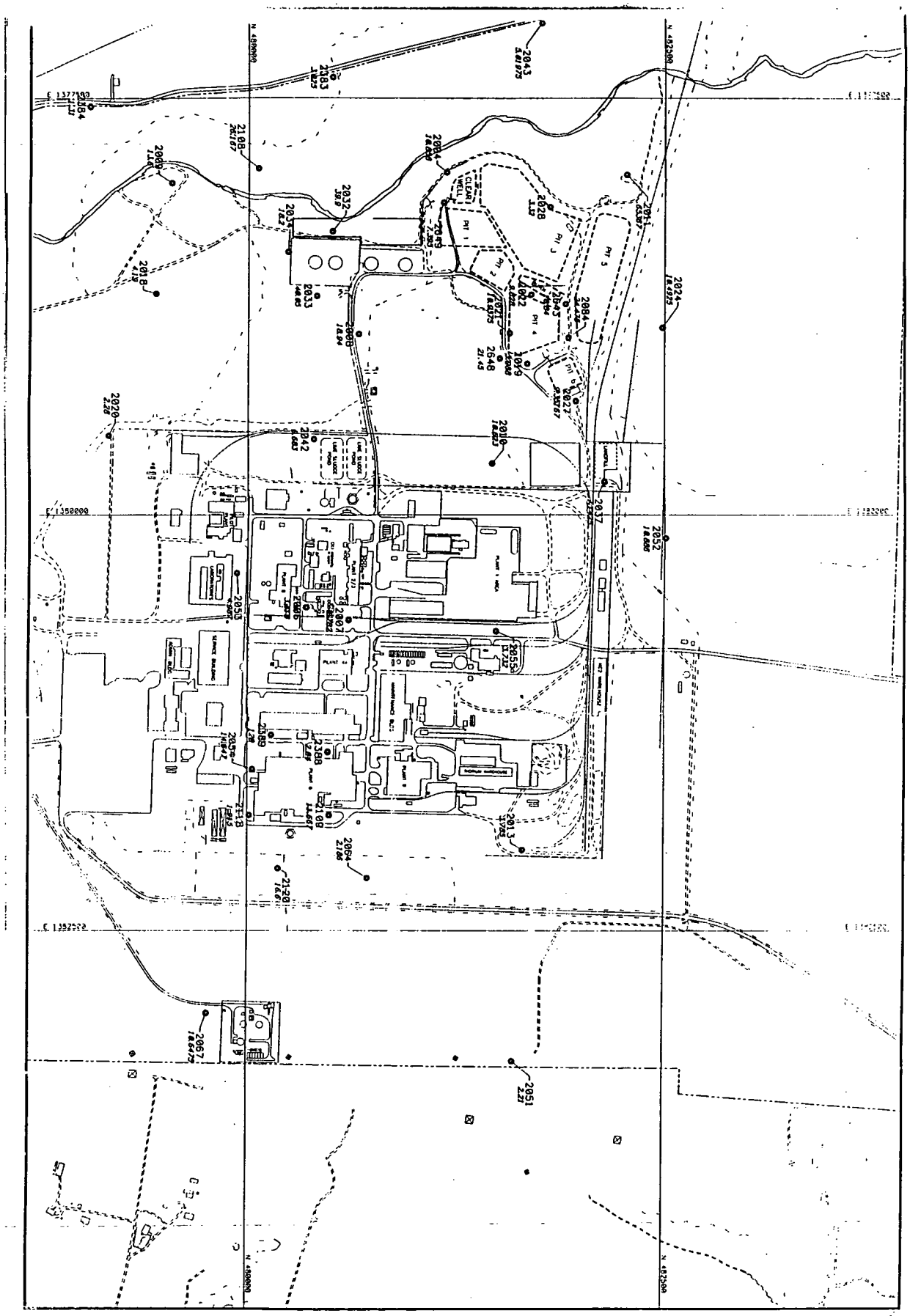

2000 SERIES AVERAGE TOTAL URANIUM 1990 SHEET 3 OF 3
(RI/FS AND NON-RI/FS DATA)
µg/l

Figure 3 - 3

ACAD: 4P94\93107101.DWG 10/21/93 WJJ

TABLE 3-4
SUMMARY OF MAJOR PARAMETERS IN THE CONFIRMATION MODELS

MODEL PARAMETERS	PLANT 2/3 AREA	PLANT 6 AREA
Source loading area size (ft x ft)	500 x 500	500 x 500
Glacial overburden thickness (ft)[a]	17	17
Unsaturated sand and gravel thickness (ft)	35	35
Infiltration rate (in./yr)	3	4.5
Constant source leachate concentration (mg/L)	78.3	166.7
Years of source loading before 1990 (years)	35	30
Distance to the fence line (ft)	3600	2000
GMA groundwater flow velocity (ft/yr)	348	348

[a]Till thicknesses are estimated from the bottom of building foundations to the top of the Great Miami Aquifer.

Two ECTran model outputs are presented in Tables 3-5 and 3-6 for Plant 2/3 and Plant 6, respectively. The comparisons between modeled and measured groundwater concentrations are summarized in Table 3-7. From these results it can be seen that the modeled overburden and GMA results compared very well with the average measured concentrations.

When the source leachate concentrations were converted into the total solid phase concentrations, using the K_d value of 15 L/kg and percent extractable uranium of 50%, the results are about 2,500 and 5,000 Mg/kg for the Plant 2/3 and Plant 6 areas, respectively. These solid phase concentrations are consistent with the ranges of measured maximum soil conditions in these areas.

There is no significant uranium contamination in perched water or the GMA in the remaining Production Area not simulated in the model confirmation process. Also no significant soil contamination was found below 5 feet from the ground surface in the remaining area. This supports the higher K_d values (i.e., 222 L/kg) estimated for the remaining part of the Production Area.

Based on ECTran model confirmation results, the estimated zonation and values of uranium K_d and K_e are reasonable and can represent the actual site conditions at the FEMP.

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Table 3 - 5

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BROWN & ROOT ENVIRONMENTAL

SCREENING-LEVEL EXCEL-CRYSTAL BALL TRANSPORT (ECTran) MODEL

PRODUCTION AREA, Kd TEST
PLANT 2/3 AREA
CURRENT CONDITION

INVESTIGATOR: JDC
DATE: 11/21/93

CONTAMINANT: U238		SPECIFIC ACTIVITY:	3.35E-07
KOC (L/KG):	0.00	WATER CRITERIA (UG/L):	2.98E+00
HALF LIFE (YRS):		LEACHATE CONC. (UG/L)	7.83E+04
LAYER 1:	4.47E+09	SOURCE LEACHATE Kd (L/KG):	1.60E+01
LAYER 2:	4.47E+09	INITIAL LAYER 1 SOIL CONC. (MG/KG):	0.00E+00
GMA:	4.47E+09	INITIAL LAYER 2 SOIL CONC. (MG/KG):	0.00E+00

UNSAT. SOURCE AREA:		LAYER 1 (GLACIAL OVERBURDEN)		LAYER 2 (SAND & GRAVEL)		GREAT MIAMI AQUIFER (SAT. S. & G.)			
						B (FT):	64	Vzo (FT/YR):	0.3899
LENGTH (FT):	500	FOC (KG/KG):	0.005	FOC (KG/KG):	0.0050	GW Q3 (L/DAY):	5.15E+04	FOC (KG/KG):	0.01
WIDTH (FT):	500	Kd (L/KG):	15.00	Kd (L/KG):	1.480	GW V.(FT/YR):	348.20	Kd (L/KG):	1.48
POROSITY 1:	0.34	SATURATION:	0.80	SATURATION:	0.25	H (FT):	12.7100	RETARDATION:	9.781333
POROSITY 2:	0.39	THICKNESS (FT):	17.00	THICKNESS (FT):	35.00	EFF. POROSITY:	0.30	q (FT/YR) :	0
DENSITY 1 (G/CM3):	1.78	DECAY (1/DAY):	4.25E-13	DECAY (1/DAY):	4.25E-13	DISPERSIVITY:		DECAY (1/YR):	1.6E-10
DENSITY 2 (G/CM3):	1.78	CAo (UG/L):	0.00E+00	CBo (PPB):	0.00E+00	Az(FT):	0.67	CU3 (PPB):	0
INFILT. (FT/YR):	0.25	CU1 (PPB):	78278	CU2 (PPB):	0.00E+00	Ax (FT):	100.00	P&T(YEARS):	0
AGE (YEARS):	0	Q1 (L/DAY):	4.85E+03	Q2 (L/DAY):	0.00E+00	Ay (FT):	33.33	DISTANCE TO F.L.(FT):	3600

TIME INTERVAL (YRS)	1	LAYER 1 LEACHATE CONC.	LAYER 2 LEACHATE CONC.	SOURCE AREA CONC.	FENCE LINE CONC.
ELAPSED TIME - YRS	DAYS	(UG/L)	(UG/L)	(UG/L)	(UG/L)
0	0	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1	365	4.27E+01	5.58E-02	5.25E-03	0.00E+00
2	730	8.54E+01	2.23E-01	2.10E-02	0.00E+00
3	1095	1.28E+02	5.01E-01	4.72E-02	0.00E+00
4	1460	1.71E+02	8.90E-01	8.38E-02	0.00E+00
5	1825	2.13E+02	1.39E+00	1.31E-01	0.00E+00
6	2190	2.56E+02	2.00E+00	1.88E-01	0.00E+00
7	2555	2.98E+02	2.72E+00	2.56E-01	0.00E+00
8	2920	3.41E+02	3.54E+00	3.34E-01	0.00E+00
9	3285	3.83E+02	4.48E+00	4.22E-01	0.00E+00
10	3650	4.26E+02	5.53E+00	5.20E-01	0.00E+00
11	4015	4.68E+02	6.68E+00	6.29E-01	0.00E+00
12	4380	5.11E+02	7.94E+00	7.48E-01	0.00E+00
13	4745	5.53E+02	9.31E+00	8.77E-01	0.00E+00
14	5110	5.96E+02	1.08E+01	1.02E+00	0.00E+00
15	5475	6.38E+02	1.24E+01	1.16E+00	0.00E+00
16	5840	6.80E+02	1.41E+01	1.32E+00	0.00E+00
17	6205	7.23E+02	1.59E+01	1.49E+00	0.00E+00
18	6570	7.65E+02	1.78E+01	1.67E+00	0.00E+00
19	6935	8.07E+02	1.98E+01	1.86E+00	1.14E-19
20	7300	8.49E+02	2.19E+01	2.06E+00	2.28E-18
21	7665	8.92E+02	2.41E+01	2.27E+00	2.64E-17
22	8030	9.34E+02	2.64E+01	2.49E+00	2.36E-16
23	8395	9.76E+02	2.88E+01	2.72E+00	1.74E-15
24	8760	1.02E+03	3.14E+01	2.95E+00	1.08E-14
25	9125	1.06E+03	3.40E+01	3.20E+00	5.80E-14
26	9490	1.10E+03	3.67E+01	3.46E+00	2.73E-13
27	9855	1.14E+03	3.96E+01	3.73E+00	1.15E-12
28	10220	1.19E+03	4.25E+01	4.00E+00	4.34E-12
29	10585	1.23E+03	4.56E+01	4.29E+00	1.50E-11
30	10950	1.27E+03	4.87E+01	4.59E+00	4.76E-11
31	11315	1.31E+03	5.20E+01	4.89E+00	1.40E-10
32	11680	1.35E+03	5.53E+01	5.21E+00	3.87E-10
33	12045	1.40E+03	5.88E+01	5.53E+00	1.00E-09
34	12410	1.44E+03	6.23E+01	5.87E+00	2.45E-09
35	12775	1.48E+03	6.60E+01	6.21E+00	5.69E-09
36	13140	1.52E+03	6.97E+01	6.56E+00	1.26E-08
37	13505	1.56E+03	7.36E+01	6.93E+00	2.68E-08
38	13870	1.61E+03	7.75E+01	7.30E+00	5.45E-08
39	14235	1.65E+03	8.16E+01	7.68E+00	1.07E-07
40	14600	1.69E+03	8.57E+01	8.07E+00	2.03E-07
41	14965	1.73E+03	8.99E+01	8.47E+00	3.73E-07
42	15330	1.77E+03	9.43E+01	8.88E+00	6.65E-07
43	15695	1.81E+03	9.87E+01	9.30E+00	1.15E-06
44	16060	1.86E+03	1.03E+02	9.72E+00	1.95E-06
45	16425	1.90E+03	1.08E+02	1.02E+01	3.22E-06
46	16790	1.94E+03	1.13E+02	1.06E+01	5.20E-06
47	17155	1.98E+03	1.17E+02	1.11E+01	8.22E-06
48	17520	2.02E+03	1.22E+02	1.15E+01	1.27E-05
49	17885	2.06E+03	1.27E+02	1.20E+01	1.94E-05
50	18250	2.11E+03	1.33E+02	1.25E+01	2.89E-05
MAXIMUM:		2.11E+03	1.33E+02	1.25E+01	2.89E-05

Table 3 - 6

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BROWN & ROOT ENVIRONMENTAL

SCREENING-LEVEL EXCEL-CRYSTAL BALL TRANSPORT (ECTran) MODEL

SITE:	PRODUCTION AREA, Kd TEST	CONTAMINANT: U238		SPECIFIC ACTIVITY:	3.35E-07
	PLANT 6 AREA	KOC (L/KG):	0.00	WATER CRITERIA (UG/L):	2.98E+00
	CURRENT CONDITION	HALF LIFE (YRS):		LEACHATE CONC. (UG/L)	1.67E+05
		LAYER 1:	4.47E+09	SOURCE LEACHATE Kd (L/KG):	1.60E+01
INVESTIGATOR:	JDC	LAYER 2:	4.47E+09	INITIAL LAYER 1 SOIL CONC. (MG/KG):	0.00E+00
DATE:	11/21/93	GMA:	4.47E+09	INITIAL LAYER 2 SOIL CONC. (MG/KG):	0.00E+00

UNSAT. SOURCE	AREA:	LAYER 1 (GLACIAL OVERBURDEN)		LAYER 2 (SAND & GRAVEL)		GREAT MIAMI AQUIFER (SAT. S. & G.)			
						B (FT):	64	Vzo (FT/YR):	0.3899
LENGTH (FT):	500	FOC (KG/KG):	0.005	FOC (KG/KG):	0.0050	GW Q3 (L/DAY):	5.15E+04	FOC (KG/KG):	0.01
WIDTH (FT):	500	Kd (L/KG):	15.00	Kd (L/KG):	1.480	GW V.(FT/YR):	348.20	Kd (L/KG):	1.48
POROSITY 1:	0.34	SATURATION:	0.80	SATURATION:	0.25	H (FT):	12.7100	RETARDATION:	9.781333
POROSITY 2:	0.39	THICKNESS (FT):	17.00	THICKNESS (FT):	35.00	EFF. POROSITY:	0.30	q (FT/YR) :	0
DENSITY 1 (G/CM3):	1.78	DECAY (1/DAY):	4.25E-13	DECAY (1/DAY):	4.25E-13	DISPERSIVITY:		DECAY (1/YR):	1.6E-10
DENSITY 2 (G/CM3):	1.78	CAo (UG/L):	0.00E+00	CBo (PPB):	0.00E+00	Az(FT):	0.67	CU3 (PPB):	0
INFILT. (FT/YR):	0.375	CU1 (PPB):	166666.7	CU2 (PPB):	0.00E+00	Ax (FT):	100.00	P&T(YEARS):	0
AGE (YEARS):	0	Q1 (L/DAY):	7.27E+03	Q2 (L/DAY):	0.00E+00	Ay (FT):	33.33	DISTANCE TO F.L.(FT):	2000

TIME INTERVAL (YRS)	1	LAYER 1 LEACHATE CONC.	LAYER 2 LEACHATE CONC.	SOURCE AREA CONC.	FENCE LINE CONC.
ELAPSED TIME - YRS	DAYS	(UG/L)	(UG/L)	(UG/L)	(UG/L)
0	0	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1	365	1.36E+02	2.67E-01	3.77E-02	0.00E+00
2	730	2.73E+02	1.07E+00	1.51E-01	0.00E+00
3	1095	4.09E+02	2.40E+00	3.38E-01	0.00E+00
4	1460	5.45E+02	4.25E+00	6.01E-01	0.00E+00
5	1825	6.81E+02	6.64E+00	9.37E-01	0.00E+00
6	2190	8.16E+02	9.54E+00	1.35E+00	0.00E+00
7	2555	9.52E+02	1.30E+01	1.83E+00	0.00E+00
8	2920	1.09E+03	1.69E+01	2.39E+00	4.24E-17
9	3285	1.22E+03	2.14E+01	3.02E+00	6.46E-15
10	3650	1.36E+03	2.63E+01	3.72E+00	3.29E-13
11	4015	1.49E+03	3.18E+01	4.49E+00	7.85E-12
12	4380	1.63E+03	3.78E+01	5.34E+00	1.09E-10
13	4745	1.76E+03	4.43E+01	6.26E+00	1.00E-09
14	5110	1.90E+03	5.13E+01	7.25E+00	6.76E-09
15	5475	2.03E+03	5.88E+01	8.30E+00	3.55E-08
16	5840	2.17E+03	6.68E+01	9.43E+00	1.52E-07
17	6205	2.30E+03	7.53E+01	1.06E+01	5.53E-07
18	6570	2.44E+03	8.43E+01	1.19E+01	1.75E-06
19	6935	2.57E+03	9.38E+01	1.32E+01	4.92E-06
20	7300	2.71E+03	1.04E+02	1.46E+01	1.25E-05
21	7665	2.84E+03	1.14E+02	1.61E+01	2.93E-05
22	8030	2.97E+03	1.25E+02	1.77E+01	6.35E-05
23	8395	3.11E+03	1.37E+02	1.93E+01	1.29E-04
24	8760	3.24E+03	1.48E+02	2.10E+01	2.48E-04
25	9125	3.37E+03	1.61E+02	2.27E+01	4.53E-04
26	9490	3.51E+03	1.74E+02	2.45E+01	7.92E-04
27	9855	3.64E+03	1.87E+02	2.64E+01	1.33E-03
28	10220	3.78E+03	2.01E+02	2.84E+01	2.16E-03
29	10585	3.91E+03	2.15E+02	3.04E+01	3.38E-03
30	10950	4.04E+03	2.30E+02	3.24E+01	5.15E-03
31	11315	4.17E+03	2.45E+02	3.46E+01	7.65E-03
32	11680	4.31E+03	2.61E+02	3.68E+01	1.11E-02
33	12045	4.44E+03	2.77E+02	3.91E+01	1.57E-02
34	12410	4.57E+03	2.93E+02	4.14E+01	2.19E-02
35	12775	4.71E+03	3.10E+02	4.38E+01	2.99E-02
36	13140	4.84E+03	3.28E+02	4.63E+01	4.01E-02
37	13505	4.97E+03	3.46E+02	4.88E+01	5.31E-02
38	13870	5.10E+03	3.64E+02	5.14E+01	6.92E-02
39	14235	5.23E+03	3.83E+02	5.41E+01	8.90E-02
40	14600	5.37E+03	4.02E+02	5.68E+01	1.13E-01
41	14965	5.50E+03	4.22E+02	5.96E+01	1.42E-01
42	15330	5.63E+03	4.42E+02	6.24E+01	1.77E-01
43	15695	5.76E+03	4.63E+02	6.53E+01	2.18E-01
44	16060	5.89E+03	4.84E+02	6.83E+01	2.65E-01
45	16425	6.03E+03	5.05E+02	7.13E+01	3.21E-01
46	16790	6.16E+03	5.27E+02	7.44E+01	3.85E-01
47	17155	6.29E+03	5.49E+02	7.76E+01	4.59E-01
48	17520	6.42E+03	5.72E+02	8.08E+01	5.42E-01
49	17885	6.55E+03	5.95E+02	8.40E+01	6.37E-01
50	18250	6.68E+03	6.19E+02	8.74E+01	7.43E-01
MAXIMUM:		6.68E+03	6.19E+02	8.74E+01	7.43E-01

TABLE 3-7
COMPARISONS OF MODELED AND MEASURED CONCENTRATIONS

SOURCE AREA	PERFORMANCE MEASURES	CONCENTRATION (UG/L)
Plant 2/3	Modeled Perched water Concentration (35th Year)	1,480
	Range of Measured Perched Water Concentration (1990)	20 - 78,278
	Modeled GMA Concentration (35th Year)	6.21
	Average GMA 2000-Series Well Concentration (1990)[a]	5.05
	Range of GMA Concentration (1990)	3.3 - 6.8
Plant 6	Modeled Perched Water Concentration (30th Year)	4,040
	Range of Measured Perched Water Concentration (1990)	22 - 166,700
	Modeled GMA Concentration (30th Year)	32.4
	Average GMA 2000-Series Well Concentration (1990)[b]	30.05
	Range of GMA Concentration (1990)	1.9 - 120

[a] Wells 2007 and 2006.
[b] Wells 2054, 2109, 2118, 2388, and 2389.

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APPENDIX A

OU4 BATCH TEST RESULTS

CRU4 Desorption Test for
Waste Material
Sample #064158

LEACHATE ANALYTICAL PARAMETERS	SAMPLING PERIOD (DAYS)								
	Start 8/19/93	1	4	6	8	11	12	13	14 Final[1]
Total-U Conc. (ug/l)	N/A	4307	3744	3875	3734	3863	3771	3826	3979/ 5150
pH	9.86	9.53	9.56	9.74	9.75	9.69	9.71	9.64	9.61
Oxidation Reduction Potential - E_H (mV)	-209.0	-188.5	-194.4	-202.2	-193.5	-203.0	-206.0	-202.1	-197.4
Specific Conductivity (uMHOS)	350	540	540	520	560	560	560	560	510
Temp. (°C)	23.8	25.5	24.7	23.6	25.9	25.3	N/A	23.4	22.6

Initial Soil Uranium Concentration = 128 ppm (IT) & 110 ppm (FEMP)
Soil Sample Wt. = 400g
Liquid to Soil Ratio = 8.75
Moisture Content = 82.38% solid
N/A - Not Analyzed
[1] - Final sample split and analyzed for total-U by FEMP and IT

CRU4 Desorption Test for Waste Material Sample #064159

LEACHATE ANALYTICAL PARAMETERS	SAMPLING PERIOD (DAYS)									
	Start 8/19/93	1	4	6	8	11	12	13	14	15 Final[1]
Total-U Conc. (ug/l)	N/A	4775	3525	3611	3446	3737	4035	4464	4023	3756/ 4930
pH	9.95	9.73	9.73	9.92	9.94	9.90	9.92	9.83	9.83	9.83
Oxidation Reduction Potential - E_H (mV)	-212.0	-199.9	-204.5	-212.3	-209.8	-215.8	N/A	-212.6	-208.6	-213.2
Specific Conductivity (uMHOS)	380	680	680	680	690	680	680	680	630	650
Temp. (°C)	23.8	25.4	25.1	23.7	25.6	24.9	N/A	23.4	22.8	24.6

Initial Soil Uranium Concentration = 106 ppm (IT) & 100 ppm (FEMP)
Soil Sample Wt. = 400g
Liquid to Soil Ratio = 8.75
Moisture Content = 82.28% solid
N/A - Not Analyzed
[1] - Final sample split and analyzed for total-U by FEMP and IT

Sample #064158

$$Cs = \frac{(128)(400)-(5150)(3.5)}{400} = 82.9 \text{ ug/g}$$

$$Cs' = 82.9 - 3.7 = 79.2 \text{ ug/g}$$

$$Kd = \frac{79.2 \times 1000}{5150} = 15.4 \text{ L/kg}$$

Sample #064159

$$Cs = \frac{(106)(400) - (4930)(3.5)}{400} = 62.9 \text{ ug/g}$$

$$Cs' = 62.9 - 3.7 = 59.2 \text{ ug/g}$$

$$Kd = \frac{59.2 \times 1000}{4930} = 12 \text{ L/kg}$$

Notes: Cs → Final Soil Uranium Concentration

Cs' → Background Corrected Soil Uranium Concentration (using 3.7 ug/g as the background Uranium Concentration)

Final Water Uranium Concentrations (i.e., 5150 ug/L and 4930 ug/L) are from the IT Lab.

APPENDIX B

PERCHED WATER CONCENTRATIONS, SOIL CONCENTRATIONS, AND PRODUCTION AREA K_d CALCULATION

WELL	DATE	SCREEN DEPTH	TOTAL GW U CONC (UG/L) PPB	SOIL DEPTH	SOIL U CONC (UG/G) PPM	SOIL DEPTH	SOIL U CONC (UG/G) PPM	AVE. SOIL U CONC (UG/G) PPM	CORRECTED SOIL U CONC (UG/KG) PPB	CORRECTED Kd (L/KG)
1131	01/16/90	2.5 - 7.5	2180.00	3 - 7	212.30			212.30	211864.00	97.19
1145	10/03/89	10.8 - 19.8	96200.00	10 - 15	227.50			227.50	208260.00	2.16
1148	08/10/89	13.8-18.6	13900.00	10 - 10.5	479.00			479.00	476220.00	34.26
1149	07/19/89	10 - 14.6	13800.00	10 - 15	150.50			150.50	147740.00	10.71
1151	10/26/89	5.5 - 10.1	240.00	5.5 - 7	8.30			8.30	8252.00	34.38
1154	05/05/89	6.9 - 11.7	296.00	10 - 15	12.00			12.00	11940.80	40.34
1167	05/05/89	5 - 9.8	16.00	3 - 5.5	18.00			18.00	17996.80	1124.80
1179	10/18/89	11 - 18	568.00	10 - 15	12.00			12.00	11886.40	20.93
1180	02/16/90	3.6 - 8.5	11100.00	3 - 5.5	148.00	3 - 5.5	160.00	154.00	151780.00	13.67
1181	07/19/89	4 - 9	150.00	3 - 5.5	28.00			28.00	27970.00	186.47
1182	11/01/89	8 - 13	9747.00	10 - 15	114.00			114.00	112050.60	11.50
1183	11/01/89	10.5 - 15.5	8632.00	10 - 15	224.00	15 - 20	134.00	179.00	177273.60	20.54
1185	11/01/89	14 - 19	1020.00	10 - 15	49.70			49.70	49496.00	48.53
1186	07/19/89	10 - 15	48800.00	10 - 15	105.00			105.00	95240.00	1.95
1187	06/07/89	10 - 15	574.00	10 - 15	47.00			47.00	46885.20	81.68
1194	01/21/90	10.3 - 15	812.00	10 - 15	24.80			24.80	24637.60	30.34
1195	01/21/90	11 - 15.7	16000.00	10 - 15	62.00			62.00	58800.00	3.68
1196	01/21/90	9.6 - 14.6	14900.00	10 - 15	157.00			157.00	154020.00	10.34
1198	06/07/89	10 - 15	138.00	10 - 15	18.00			18.00	17972.40	130.23
1199	06/03/89	8 - 18	18690.00	10 - 15	375.50	15 - 20	735.00	555.25	551512.00	29.51
1200	06/03/89	6.5 - 16.5	3286.00	10 - 15	55.00	15 - 20	34.00	44.50	43842.80	13.34
1201	06/03/89	8 - 13.5	281.00	10 - 15	22.00			22.00	21943.80	78.09
1202	06/04/89	6.5 - 16	1372.00	10 - 15	62.00	15 - 20	60.00	61.00	60725.60	44.26
1203	06/04/89	6.5 - 16.5	49.40	10 - 15	65.00	15 - 20	24.00	44.50	44490.12	900.61
1204	01/22/90	13.5 - 18.5	4200.00	10 - 15	60.00			60.00	59160.00	14.09
1205	07/17/89	9.8 - 14.6	1444.00	10 - 15	33.00			33.00	32711.20	22.65
1206	06/06/89	9.8 - 14.6	1846.00	10 - 15	16.00			16.00	15630.80	8.47
1207	06/02/89	4 - 9	736.00	3 - 5.5	22.00			22.00	21852.80	29.69
1209	06/06/89	6.5 - 16.5	21400.00	10 - 15	36.00	15 - 20	48.00	42.00	37720.00	1.76
1212	01/18/90	6.5 - 16	25100.00	10 - 15	170.00	15 - 20	259.00	214.50	209480.00	8.35
1213	06/06/89	4.4 - 9.2	35260.00	3 - 3.5	129.50			129.50	122448.00	3.47

WELL	DATE	SCREEN DEPTH	TOTAL GW U CONC (UG/L) PPB	SOIL DEPTH	SOIL U CONC (UG/G) PPM	SOIL DEPTH	SOIL U CONC (UG/G) PPM	AVE. SOIL U CONC (UG/G) PPM	CORRECTED SOIL U CONC (UG/KG) PPB	CORRECTED Kd (L/KG)
1214	01/16/90	8.9 - 14.1	2156.00	10 - 15	467.00			467.00	466568.80	216.40
1215	11/01/89	10.1 - 15.1	1170.00	10 - 15	28.70			28.70	28466.00	24.33
1216	11/01/89	11.1 - 16.1	215.00	10 - 10.5	8.30			8.30	8257.00	38.40
1217	01/18/90	9.75 - 14.75	3606.00	10 - 15	49.40			49.40	48678.80	13.50
1219	06/02/89	6.5 - 11.5	1539.00	6 - 6.5	18.00			18.00	17692.20	11.50
1220	06/04/89	4.8 - 19.6	4429.00	3 - 5.5	113.50	10 - 20	10.90	62.20	61314.20	13.84
1221	01/16/90	8.8 - 14	1636.00	10 - 10.5	65.20	13.5 - 14	16.50	40.85	40522.80	24.77
1224	06/04/89	9.6 - 19.6	3699.00	10 - 15	11.00	15 - 20	27.00	19.00	18260.20	4.94
1225	08/13/90	11.1 - 16.1	141.00	15 - 20	7.30			7.30	7271.80	51.57
1230	10/23/89	8.0 - 18.0	2010.00	15 - 20	27.00			27.00	26598.00	13.23
1231	11/02/89	8.0 - 20.0	13850.00	10 - 15	16.20	15 - 20	88.24	52.22	49450.00	3.57
1232	10/17/89	4.6 - 19.6	15700.00	10 - 15	104.00			104.00	100860.00	6.42
1233	06/08/89	6.8 - 19.8	21650.00	10 - 15	56.00	15 - 20	35.00	40.50	36170.00	1.67
1236	06/04/89	6.4 - 13.1	9630.00	5.5 - 7.0	373.50	10 - 15	55.00	214.25	212324.00	22.05
1240	06/01/89	8.1 - 13.4	827.00	10 - 15	15.00			15.00	14834.60	17.94
1244	10/25/89	9.7 - 14.6	23.00	10 - 15	25.00			25.00	24995.40	1086.76
1245	10/17/89	11.5 - 16.5	92.00	10.5 - 11	15.00			15.00	14981.60	162.84
1246	08/11/89	5.0 - 15.0	141.00	10 - 15	505.00			505.00	504971.80	3581.36
1250	06/15/90	10.6 - 20.0	427.00	15 - 20	17.20			17.20	17114.60	40.08
1266	10/25/89	10.0 - 20.0	11.00	15 - 20	30.00			30.00	29997.80	2727.07
1267	10/25/89	8.0 - 16.5	86.00	15 - 20	16.00			16.00	15982.80	185.85
1271	07/16/89	4.0 - 9.0	844.00	5.5 - 7.0	18.00			18.00	17831.20	21.13
1277	07/16/89	4.0 - 9.0	544.00	3.0 - 5.5	51.00			51.00	50891.20	93.55
1280	07/16/89	13.0 - 18.0	71.80	10 - 15	36.00			36.00	35985.64	501.19
1281	07/16/89	7.0 - 12.0	147.00	10 - 15	19.00			19.00	18970.60	129.05
1287	08/02/89	5.0 - 14.75	84.80	3.0 - 5.5	16.00			16.00	15983.04	188.48
1317	08/01/90	14.6 - 19.6	15.40	15 - 20	5.40			5.40	5396.92	350.45
1324	07/25/90	5.0 - 13.5	364993.00	3.0 - 5.5	292.00			292.00	219001.40	0.60
1338	10/06/89	5.0 - 10.0	40.00	< 5'	73.00			73.00	72992.00	1824.80
1339	10/17/89	5.0 - 12.0	441.00	3.0 - 5.5	6.60			6.60	6511.80	14.77
1341	07/13/90	14.6 - 19.6	36.90	15 - 20	6.90			6.90	6892.62	186.79
1347	10/06/89	9.8 - 19.8	152.00	10 - 15	22.00			22.00	21969.60	144.54

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WELL	DATE	SCREEN DEPTH	TOTAL GW U CONC (UG/L) PPB	SOIL DEPTH	SOIL U CONC (UG/G) PPM	SOIL DEPTH	SOIL U CONC (UG/G) PPM	AVE. SOIL U CONC (UG/G) PPM	CORRECTED SOIL U CONC (UG/KG) PPB	CORRECTED Kd (L/KG)
1348	07/28/90	15.0 - 19.7	12.90	15 - 20	5.60			5.60	5597.42	433.91
1354	08/26/90	15.0 - 20.0	102.00	15 - 20	10.90			10.90	10879.60	106.66
1356	10/09/89	10.0 - 19.8	240.00	10 - 15	119.00	15 - 20	14.00	66.50	66452.00	276.88
1357	10/09/89	11.5 - 16.5	748.00	10.5 - 11	17.00			17.00	16850.40	22.53
1360	07/28/90	8.0 - 16.5	15.00	15 - 20	16.00			16.00	15997.00	1066.47
1441	05/16/90	7.5 - 17.5	6400.00	10 - 15	20.70			20.70	19420.00	3.03
1443	05/21/90	8.0 - 18.0	43.60	10 - 15	53.00			53.00	52991.28	1215.40
1447	07/17/90	2.5 - 7.5	350.00	3.0 - 5.5	7.40			7.40	7330.00	20.94
1448	05/18/90	4.5 - 14.5	13.70	5.5 - 7.0	7.00	10 - 15	8.60	7.80	7797.26	569.14
1509	05/02/90	4.5 - 19.5	183.00	3 - 3.5	8.82			8.82	8783.40	48.00
1510	05/03/90	3.5 - 8.5	96.20	3.0 - 5.5	8.50			8.50	8480.76	88.16
1513	06/16/90	5.0 - 20.0	103.00	10 - 15	20.70			20.70	20679.40	200.77
1513	05/02/90	3.0 - 5.5	11.00	3.0 - 13.0	6.70			6.70	6697.80	608.89
									Count=	76.00
									Mean=	255.56
									StDev= ±	591.26
									GeoMean=	45.78

(Note: Assumed Water Content by Weight = 20%;
Corrected Soil Concentration = Soil Concentration - (Groundwater Concentration x 200 ml);and,
Corrected Kd = Corrected Soil Concentration / Groundwater Concentration)

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ATTACHMENT I.IV
EXPOSURE CALCULATIONS

ATTACHMENT I.IV-1
INTAKE AND RISK CALCULATIONS

INTAKE AND RISK CALCULATIONS:
CURRENT LAND USE SCENARIO

Table I.IV–1
Summary of Intake Quantitation (chemicals)
Current Land Use with Federal Ownership: Trespassing Child
Via Inhalation of Particulates

Intake Equation = $\frac{CS \times EF \times ED \times IR}{BW \times AT}$

IR	Inhalation rate of gases (RAGS, 1989)	3.3 m^3/day
EF	Exposure frequency	52 days/year
EDn	Exposure duration for non–carcinogens	12 Year
EDc	Exposure duration for carcinogens	12 Year
BW	Body weight	43 kg
ATc	Average time for carcinogens (lifetime)	25550 days
ATn	Average time for non–carcinogens (EDn x 365)	4380 days
CS	Concentration of chemicals in soil	(see table below)

Chemical Concentrations

Compound	Concentration	Units	Compound	Concentration	Units
antimony	2.8E–09	mg/m^3	silver	1.9E–09	mg/m^3
arsenic	4.2E–09	mg/m^3	thallium	1.9E–10	mg/m^3
barium	4.3E–08	mg/m^3	thorium–total	2.3E–08	mg/m^3
beryllium	5.0E–10	mg/m^3	uranium–total	4.5E–07	mg/m^3
boron	5.0E–09	mg/m^3	vanadium	9.6E–09	mg/m^3
cadmium	1.0E–09	mg/m^3	zinc	2.4E–08	mg/m^3
chromium vi	7.1E–09	mg/m^3	2–methylnaphthalene	4.5E–11	mg/m^3
cobalt	4.1E–09	mg/m^3	4,4–dde	9.7E–13	mg/m^3
copper	1.5E–08	mg/m^3	aroclor–1221	0.0E+00	mg/m^3
cyanide	2.1E–10	mg/m^3	aroclor–1248	0.0E+00	mg/m^3
lead	4.9E–07	mg/m^3	aroclor–1254	1.9E–10	mg/m^3
manganese	1.3E–10	mg/m^3	aroclor–1260	5.5E–11	mg/m^3
mercury	1.3E–10	mg/m^3	carbazole	1.1E–11	mg/m^3
molybdenum	2.2E–09	mg/m^3	endrin	0.0E+00	mg/m^3
nickel	8.2E–09	mg/m^3	2,3,7,8–tcdd	4.1E–17	mg/m^3
selenium	2.7E–10	mg/m^3			

References

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Table I.IV-1 (continued)
Summary of Risk Characterization (chemicals)
Current Land Use with Federal Ownership: Trespassing Child
Via Inhalation of Particulates

	HQ Calculation		
Compound	CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
antimony	3.1E-11	NA	NA
arsenic	4.6E-11	NA	NA
barium	4.7E-10	1.4E-04	3.3E-06
beryllium	5.5E-12	NA	NA
boron	5.4E-11	5.7E-03	9.5E-09
cadmium	1.1E-11	NA	NA
chromium vi	7.7E-11	NA	NA
cobalt	4.4E-11	3.0E-07	1.5E-04
copper	1.6E-10	NA	NA
cyanide	2.3E-12	NA	NA
lead	5.3E-09	NA	NA
manganese	1.4E-12	1.4E-05	1.0E-07
mercury	1.4E-12	8.6E-05	1.7E-08
molybdenum	2.4E-11	NA	NA
nickel	9.0E-11	NA	NA
selenium	3.0E-12	NA	NA
silver	2.1E-11	NA	NA
thallium	2.0E-12	NA	NA
thorium-total	2.5E-10	NA	NA
uranium-total	4.9E-09	NA	NA
vanadium	1.1E-10	NA	NA
zinc	2.6E-10	NA	NA
2-methylnaphthalene	4.9E-13	NA	NA
4,4-dde	1.1E-14	NA	NA
aroclor-1221	NA	NA	NA
aroclor-1248	NA	NA	NA
aroclor-1254	2.1E-12	NA	NA
aroclor-1260	6.0E-13	NA	NA
carbazole	1.2E-13	NA	NA
endrin	NA	NA	NA
2,3,7,8-tcdd	4.5E-19	NA	NA
	Hazard Quotient Sum =		1.5E-04

	ILCR Calculation		
Compound	CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	ILCR (unitless)
antimony	5.3E-12	NA	NA
arsenic	7.8E-12	1.5E+01	1.2E-10
barium	8.0E-11	NA	NA
beryllium	9.4E-13	8.4E+00	7.9E-12
boron	9.3E-12	NA	NA
cadmium	1.9E-12	6.3E+00	1.2E-11
chromium vi	1.3E-11	4.1E+01	5.4E-10
cobalt	7.6E-12	NA	NA
copper	2.7E-11	NA	NA
cyanide	4.0E-13	NA	NA
lead	9.1E-10	NA	NA
manganese	2.4E-13	NA	NA
mercury	2.4E-13	NA	NA
molybdenum	4.1E-12	NA	NA
nickel	1.5E-11	8.4E-01	1.3E-11
selenium	5.1E-13	NA	NA
silver	3.6E-12	NA	NA
thallium	3.5E-13	NA	NA
thorium-total	4.2E-11	NA	NA
uranium-total	8.4E-10	NA	NA
vanadium	1.8E-11	NA	NA
zinc	4.5E-11	NA	NA
2-methylnaphthalene	8.4E-14	NA	NA
4,4-dde	1.8E-15	NA	NA
aroclor-1221	NA	NA	NA
aroclor-1248	NA	NA	NA
aroclor-1254	3.6E-13	NA	NA
aroclor-1260	1.0E-13	NA	NA
carbazole	2.1E-14	NA	NA
endrin	NA	NA	NA
2,3,7,8-tcdd	7.7E-20	1.5E+05	1.2E-14
	ILCR Summation =		6.9E-10

Table I.IV–2
Summary of Intake and Risk Quantitation (radionuclides)
Current Land Use with Federal Ownership: Trespassing Child
Via Inhalation of Gases and Particulates

Intake Equation = Ca X EF X EDn X IR

IR	Inhalation rate of gases (RAGS, 1989)	3.3 m^3/day
EF	Exposure frequency	52 days/year
EDn	Exposure duration	12 Year
Ca	Concentration of radionuclides in air	(see table below)

Cs_{137+1d}	3.0E−07	pCi/m^3	Rn_{222+4d}	6.6E+00	pCi/m^3
Pb_{210+2d}	1.1E−06	pCi/m^3	Sr_{90+1d}	6.5E−07	pCi/m^3
Np_{237+1d}	1.0E−07	pCi/m^3	Tc_{99}	2.9E−06	pCi/m^3
Pu_{238}	9.7E−07	pCi/m^3	Th_{228+7d}	5.8E−07	pCi/m^3
Pu_{239}	2.2E−07	pCi/m^3	Th_{230}	1.6E−06	pCi/m^3
Pu_{240}	7.9E−07	pCi/m^3	$Th_{232+10d}$	9.3E−07	pCi/m^3
Pa_{231}	7.0E−08	pCi/m^3	U_{234}	1.7E−05	pCi/m^3
Ra_{226+8d}	4.8E−07	pCi/m^3	U_{235+1d}	4.6E−07	pCi/m^3
Ra_{228+1d}	7.0E−07	pCi/m^3	U_{236}	1.9E−07	pCi/m^3
Ru_{106}	8.4E−08	pCi/m^3	U_{238+2d}	1.0E−05	pCi/m^3

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	ILCR (unitless)
Cs_{137+1d}	6.2E−04	1.9E−11	1.2E−14
Pb_{210+2d}	2.2E−03	4.0E−09	8.8E−12
Np_{237+1d}	2.1E−04	2.9E−08	6.0E−12
Pu_{238}	2.0E−03	3.9E−08	7.8E−11
Pu_{239}	4.5E−04	3.8E−08	1.7E−11
Pu_{240}	1.6E−03	3.8E−08	6.2E−11
Pa_{231}	1.4E−04	3.6E−08	5.2E−12
Ra_{226+8d}	9.9E−04	7.0E−09	6.9E−12
Ra_{228+1d}	1.4E−03	6.9E−10	9.9E−13
Ru_{106}	1.7E−04	4.4E−10	7.6E−14
Rn_{222+4d}	1.4E+04	7.7E−12	1.0E−07
Sr_{90+1d}	1.3E−03	6.2E−11	8.3E−14
Tc_{99}	6.0E−03	8.3E−12	5.0E−14
Th_{228+7d}	1.2E−03	7.8E−08	9.3E−11
Th_{230}	3.3E−03	2.9E−08	9.5E−11
$Th_{232+10d}$	1.9E−03	1.1E−07	2.1E−10
U_{234}	3.5E−02	2.6E−08	9.2E−10
U_{235+1d}	9.4E−04	2.5E−08	2.3E−11
U_{236}	3.9E−04	2.5E−08	9.7E−12
U_{238+2d}	2.1E−02	2.4E−08	5.1E−10
		ILCR Summation =	1.1E−07

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Table I.IV–3
Summary of Intake Quantitation (chemicals)
Current Land Use with Federal Ownership: Trespassing Child
Via Incidental Ingestion of Soil

Intake Equation = $\frac{CS \times EF \times ED \times CF \times IR}{BW \times AT}$

IRs	Ingestion rate of soil (RAGS, 1989)	200 mg/day
CF	Conversion factor	1.0E–06 kg/mg
EF	Exposure frequency	52 days/year
EDn	Exposure duration for non–carcinogens	12 Year
EDc	Exposure duration for carcinogens	12 Year
BW	Body weight	43 kg
ATc	Average time for carcinogens (lifetime)	25550 days
ATn	Average time for non–carcinogens (EDn x 365)	4380 days
CS	Concentration of chemicals in soil	(see table below)

Chemical Concentrations

Compound	Concentration	Units	Compound	Concentration	Units
antimony	5.4E+00	mg/kg	silver	6.0E+00	mg/kg
arsenic	5.1E+00	mg/kg	thallium	5.6E–01	mg/kg
barium	9.7E+01	mg/kg	thorium–total	0.0E+00	mg/kg
beryllium	7.6E–01	mg/kg	uranium–total	0.0E+00	mg/kg
boron	1.1E+02	mg/kg	vanadium	2.6E+01	mg/kg
cadmium	3.5E+00	mg/kg	zinc	6.4E+01	mg/kg
chromium vi	1.6E+01	mg/kg	2–methylnaphthalene	0.0E+00	mg/kg
cobalt	1.2E+01	mg/kg	4,4–dde	0.0E+00	mg/kg
copper	2.0E+01	mg/kg	aroclor–1221	0.0E+00	mg/kg
cyanide	2.5E–01	mg/kg	aroclor–1248	0.0E+00	mg/kg
lead	2.4E+01	mg/kg	aroclor–1254	0.0E+00	mg/kg
manganese	9.8E+02	mg/kg	aroclor–1260	0.0E+00	mg/kg
mercury	2.1E–01	mg/kg	carbazole	0.0E+00	mg/kg
molybdenum	6.5E+00	mg/kg	endrin	0.0E+00	mg/kg
nickel	2.3E+01	mg/kg	2,3,7,8–tcdd	0.0E+00	mg/kg
selenium	6.3E–01	mg/kg			

References

Table I.IV-3 (continued)
Summary of Risk Characterization (chemicals)
Current Land Use with Federal Ownership: Trespassing Child
Via Incidental Ingestion of Soil

Compound	HQ Calculation CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
antimony	3.5E-06	4.0E-04	8.9E-03
arsenic	3.4E-06	3.0E-04	1.1E-02
barium	6.4E-05	7.0E-02	9.2E-04
beryllium	5.0E-07	5.0E-03	1.0E-04
boron	7.4E-05	9.0E-02	8.2E-04
cadmium	2.3E-06	1.0E-03	2.3E-03
chromium vi	1.1E-05	5.0E-03	2.2E-03
cobalt	8.0E-06	6.0E-02	1.3E-04
copper	1.3E-05	NA	NA
cyanide	1.7E-07	2.0E-02	8.3E-06
lead	1.6E-05	NA	NA
manganese	6.5E-04	1.4E-01	4.6E-03
mercury	1.4E-07	3.0E-04	4.7E-04
molybdenum	4.3E-06	5.0E-03	8.6E-04
nickel	1.5E-05	2.0E-02	7.5E-04
selenium	4.2E-07	5.0E-03	8.4E-05
silver	4.0E-06	5.0E-03	8.0E-04
thallium	3.7E-07	8.0E-05	4.6E-03
thorium-total	NA	NA	NA
uranium-total	NA	3.0E-03	0.0E+00
vanadium	1.7E-05	7.0E-03	2.5E-03
zinc	4.2E-05	3.0E-01	1.4E-04
2-methylnaphthalene	NA	NA	NA
4,4-dde	NA	NA	NA
aroclor-1221	NA	NA	NA
aroclor-1248	NA	NA	NA
aroclor-1254	NA	NA	NA
aroclor-1260	NA	NA	NA
carbazole	NA	NA	NA
endrin	NA	3.0E-04	0.0E+00
2,3,7,8-tcdd	NA	NA	NA
	HQ Summation =		4.1E-02

Compound	ILCR Calculation CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	ILCR (unitless)
antimony	6.1E-07	NA	NA
arsenic	5.8E-07	1.8E+00	1.0E-06
barium	1.1E-05	NA	NA
beryllium	8.6E-08	4.3E+00	3.7E-07
boron	1.3E-05	NA	NA
cadmium	4.0E-07	NA	NA
chromium vi	1.9E-06	NA	NA
cobalt	1.4E-06	NA	NA
copper	2.3E-06	NA	NA
cyanide	2.8E-08	NA	NA
lead	2.7E-06	NA	NA
manganese	1.1E-04	NA	NA
mercury	2.4E-08	NA	NA
molybdenum	7.4E-07	NA	NA
nickel	2.6E-06	NA	NA
selenium	7.2E-08	NA	NA
silver	6.8E-07	NA	NA
thallium	6.3E-08	NA	NA
thorium-total	NA	NA	NA
uranium-total	NA	NA	NA
vanadium	3.0E-06	NA	NA
zinc	7.3E-06	NA	NA
2-methylnaphthalene	NA	NA	NA
4,4-dde	NA	3.4E-01	0.0E+00
aroclor-1221	NA	7.7E+00	0.0E+00
aroclor-1248	NA	7.7E+00	0.0E+00
aroclor-1254	NA	7.7E+00	0.0E+00
aroclor-1260	NA	7.7E+00	0.0E+00
carbazole	NA	2.0E-02	0.0E+00
endrin	NA	NA	NA
2,3,7,8-tcdd	NA	1.5E+05	0.0E+00
	ILCR Summation =		1.4E-06

Table I.IV−4
Summary of Intake and Risk Quantitation (radionuclides)
Current Land Use with Federal Ownership: Trespassing Child
Via Incidental Ingestion of Soil

Intake Equation = CS X EF X EDn X FI X IR

IRs	Ingestion rate of soil (RAGS, 1989)	200 mg/day
EF	Exposure frequency	52 days/year
EDn	Exposure Duration	12 Year
FI	Fractional Intake	1 (unitless)
CS	Concentration of radionuclides in soil	

Cs_{137+1d}	7.93E−04	pCi/mg	Rn_{222+4d}	0.00E+00	pCi/mg
Pb_{210+2d}	1.05E−09	pCi/mg	Sr_{90+1d}	8.33E−10	pCi/mg
Np_{237+1d}	8.36E−11	pCi/mg	Tc_{99}	1.87E−09	pCi/mg
Pu_{238}	9.07E−11	pCi/mg	Th_{228+7d}	4.00E−10	pCi/mg
Pu_{239}	1.25E−11	pCi/mg	Th_{230}	5.92E−11	pCi/mg
Pu_{240}	4.55E−11	pCi/mg	$Th_{232+10d}$	5.95E−10	pCi/mg
Pa_{231}	0.00E+00	pCi/mg	U_{234}	2.06E−08	pCi/mg
Ra_{226+8d}	3.99E−10	pCi/mg	U_{235+1d}	9.34E−10	pCi/mg
Ra_{228+1d}	7.00E−10	pCi/mg	U_{236}	6.86E−09	pCi/mg
Ru_{106}	1.33E−10	pCi/mg	U_{238+2d}	1.38E−08	pCi/mg

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	ILCR (unitless)
Cs_{137+1d}	9.90E+01	2.80E−11	2.77E−09
Pb_{210+2d}	1.31E−04	6.60E−10	8.65E−14
Np_{237+1d}	1.04E−05	2.20E−10	2.30E−15
Pu_{238}	1.13E−05	2.20E−10	2.49E−15
Pu_{239}	1.56E−06	2.30E−10	3.59E−16
Pu_{240}	5.68E−06	2.30E−10	1.31E−15
Pa_{231}	NA	9.20E−11	NA
Ra_{226+8d}	4.98E−05	7.80E−10	3.88E−14
Ra_{228+1d}	8.74E−05	1.00E−10	8.74E−15
Ru_{106}	1.66E−05	9.50E−12	1.58E−16
Rn_{222+4d}	NA	1.70E−12	NA
Sr_{90+1d}	1.04E−04	3.60E−11	3.74E−15
Tc_{99}	2.33E−04	1.30E−12	3.03E−16
Th_{228+7d}	4.99E−05	5.50E−11	2.75E−15
Th_{230}	7.39E−06	1.30E−11	9.60E−17
$Th_{232+10d}$	7.43E−05	1.70E−10	1.26E−14
U_{234}	2.57E−03	1.60E−11	4.11E−14
U_{235+1d}	1.17E−04	1.60E−11	1.87E−15
U_{236}	8.56E−04	1.50E−11	1.28E−14
U_{238+2d}	1.72E−03	2.00E−11	3.44E−14
		ILCR Summation =	2.77E−09

Table I.IV–5
Summary of Intake Quantitation (chemicals)
Current Land Use with Federal Ownership: Trespassing Child
Via Dermal Contact with Soil

Intake Equation = $\frac{CS \times EF \times ED \times CF \times ABS \times AF \times SA}{BW \times AT}$

SA	Surface area of exposed skin (50th percentile, hands only)	4200 cm^2/day
AF	Soil to skin adherence factor (RAGS, 1989)	1 mg/cm^2
ABS	chemicals specific absorbtion factor (see table below)	csv
CF	Conversion factor	1E–06 kg/mg
EF	Exposure frequency	52 days/year
EDn	Exposure duration for non–carcinogens	12 Year
EDc	Exposure duration for carcinogens	12 Year
BW	Body weight	43 kg
ATc	Average time for carcinogens (lifetime)	25550 days
ATn	Average time for non–carcinogens (EDn x 365)	4380 days
CS	Concentration of chemicals in soil	

Chemical Concentrations

Compound	ABS	Concentrati	Units
antimony	1.00E–02	5.35E+00	mg/kg
arsenic	1.00E–03	5.09E+00	mg/kg
barium	1.00E–02	9.72E+01	mg/kg
beryllium	1.00E–02	7.55E–01	mg/kg
boron	1.00E–02	1.12E+02	mg/kg
cadmium	1.00E–02	3.48E+00	mg/kg
chromium vi	1.00E–02	1.64E+01	mg/kg
cobalt	1.00E–02	1.21E+01	mg/kg
copper	1.00E–03	2.02E+01	mg/kg
cyanide	1.00E–02	2.50E–01	mg/kg
lead	1.00E–02	2.35E+01	mg/kg
manganese	1.00E–02	9.76E+02	mg/kg
mercury	5.00E–02	2.14E–01	mg/kg
molybdenum	1.00E–02	6.49E+00	mg/kg
nickel	5.00E–04	2.26E+01	mg/kg
selenium	1.00E–02	6.31E–01	mg/kg

Compound		Concentrati	Units
silver	1.00E–02	6.03E+00	mg/kg
thallium	1.00E–02	5.58E–01	mg/kg
thorium–total	1.00E–02	0.00E+00	mg/kg
uranium–total	1.00E–02	0.00E+00	mg/kg
vanadium	1.00E–03	2.60E+01	mg/kg
zinc	1.00E–02	6.41E+01	mg/kg
2–methylnaphthalene	3.00E–01	0.00E+00	mg/kg
4,4–dde	3.00E–01	0.00E+00	mg/kg
aroclor–1221	6.00E–02	0.00E+00	mg/kg
aroclor–1248	6.00E–02	0.00E+00	mg/kg
aroclor–1254	6.00E–02	0.00E+00	mg/kg
aroclor–1260	6.00E–02	0.00E+00	mg/kg
carbazole	3.00E–01	0.00E+00	mg/kg
endrin	3.00E–01	0.00E+00	mg/kg
2,3,7,8–tcdd	3.00E–02	0.00E+00	mg/kg

References

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Table I.IV–5 (continued)
Summary of Risk Characterization (chemicals)
Current Land Use with Federal Ownership: Trespassing Child
Via Dermal Contact with Soil

	HQ Calculation		
Compound	CDI (mg/kg–day)	RfD (mg/kg–day)	HQ (unitless)
antimony	7.44E–07	6.00E–05	1.24E–02
arsenic	7.08E–08	2.85E–04	2.49E–04
barium	1.35E–05	6.37E–02	2.12E–04
beryllium	1.05E–07	5.00E–03	2.10E–05
boron	1.56E–05	4.50E–03	3.46E–03
cadmium	4.84E–07	5.00E–05	9.69E–03
chromium vi	2.28E–06	2.25E–03	1.01E–03
cobalt	1.68E–06	2.70E–02	6.24E–05
copper	2.81E–07	NA	NA
cyanide	3.48E–08	NA	NA
lead	3.27E–06	NA	NA
manganese	1.36E–04	4.20E–03	3.23E–02
mercury	1.49E–07	4.50E–05	3.31E–03
molybdenum	9.03E–07	1.90E–03	4.75E–04
nickel	1.57E–07	2.00E–03	7.86E–05
selenium	8.78E–08	4.00E–03	2.20E–05
silver	8.39E–07	NA	NA
thallium	7.76E–08	8.00E–05	9.71E–04
thorium–total	NA	NA	NA
uranium–total	NA	1.50E–04	0.00E+00
vanadium	3.62E–07	3.50E–04	1.03E–03
zinc	8.92E–06	7.50E–02	1.19E–04
2–methylnaphthalene	NA	NA	NA
4,4–dde	NA	NA	NA
aroclor–1221	NA	NA	NA
aroclor–1248	NA	NA	NA
aroclor–1254	NA	NA	NA
aroclor–1260	NA	NA	NA
carbazole	NA	NA	NA
endrin	NA	2.70E–04	0.00E+00
2,3,7,8–tcdd	NA	NA	NA
	HQ Summation =		6.55E–02

	ILCR Calculation		
Compound	CDI (mg/kg–day)	CSF $(mg/kg–day)^{-1}$	ILCR (unitless)
antimony	1.28E–07	NA	NA
arsenic	1.21E–08	1.90E+00	2.31E–08
barium	2.32E–06	NA	NA
beryllium	1.80E–08	4.30E+00	7.74E–08
boron	2.67E–06	NA	NA
cadmium	8.30E–08	NA	NA
chromium vi	3.91E–07	NA	NA
cobalt	2.89E–07	NA	NA
copper	4.82E–08	NA	NA
cyanide	5.96E–09	NA	NA
lead	5.61E–07	NA	NA
manganese	2.33E–05	NA	NA
mercury	2.55E–08	NA	NA
molybdenum	1.55E–07	NA	NA
nickel	2.70E–08	NA	NA
selenium	1.51E–08	NA	NA
silver	1.44E–07	NA	NA
thallium	1.33E–08	NA	NA
thorium–total	NA	NA	NA
uranium–total	NA	NA	NA
vanadium	6.20E–08	NA	NA
zinc	1.53E–06	NA	NA
2–methylnaphthalene	NA	NA	NA
4,4–dde	NA	3.40E–01	0.00E+00
aroclor–1221	NA	1.03E+01	0.00E+00
aroclor–1248	NA	1.03E+01	0.00E+00
aroclor–1254	NA	1.03E+01	0.00E+00
aroclor–1260	NA	1.03E+01	0.00E+00
carbazole	NA	2.22E–02	0.00E+00
endrin	NA	NA	NA
2,3,7,8–tcdd	NA	3.00E+05	0.00E+00
	ILCR Summation =		1.01E–07

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Table I.IV–6
Summary of Intake Quantitation (chemicals)
Current Land Use with Federal Ownership: Trespassing Child
Via Ingestion While Wading

Intake Equation = $\frac{CS \times EF \times ED \times IR}{BW \times AT}$

IRsw	Ingestion rate of surface water	0.035 l/day
EF	Exposure frequency	52 days/year
EDn	Exposure duration for non–carcinogens	12 Year
EDc	Exposure duration for carcinogens	12 Year
BW	Body weight	43 kg
ATc	Average time for carcinogens (lifetime)	25550 days
ATn	Average time for non–carcinogens (EDn x 365)	4380 days
CS	Concentration of chemicals in surface water	

Chemical Concentrations

Compound	Concentration	Units	Compound	Concentration	Units
antimony	7.64E–05	mg/l	silver	0.00E+00	mg/l
arsenic	1.18E–03	mg/l	thallium	0.00E+00	mg/l
barium	0.00E+00	mg/l	thorium–total	0.00E+00	mg/l
beryllium	3.77E–05	mg/l	uranium–total	3.61E–02	mg/l
boron	0.00E+00	mg/l	vanadium	0.00E+00	mg/l
cadmium	0.00E+00	mg/l	zinc	0.00E+00	mg/l
chromium vi	0.00E+00	mg/l	2–methylnaphthalene	0.00E+00	mg/l
cobalt	0.00E+00	mg/l	4,4–dde	0.00E+00	mg/l
copper	0.00E+00	mg/l	aroclor–1221	0.00E+00	mg/l
cyanide	0.00E+00	mg/l	aroclor–1248	0.00E+00	mg/l
lead	0.00E+00	mg/l	aroclor–1254	0.00E+00	mg/l
manganese	0.00E+00	mg/l	aroclor–1260	0.00E+00	mg/l
mercury	0.00E+00	mg/l	carbazole	0.00E+00	mg/l
molybdenum	0.00E+00	mg/l	endrin	0.00E+00	mg/l
nickel	0.00E+00	mg/l	2,3,7,8–tcdd	0.00E+00	mg/l
selenium	0.00E+00	mg/l			

References

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Table I.IV-6 (continued)
Summary of Risk Characterization (chemicals)
Current Land Use with Federal Ownership: Trespassing Child
Via Ingestion While Wading

	HQ Calculation		
Compound	CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
antimony	8.86E-09	4.00E-04	2.21E-05
arsenic	1.37E-07	3.00E-04	4.56E-04
barium	NA	7.00E-02	NA
beryllium	4.37E-09	5.00E-03	8.74E-07
boron	NA	9.00E-02	NA
cadmium	NA	1.00E-03	NA
chromium vi	NA	5.00E-03	NA
cobalt	NA	6.00E-02	NA
copper	NA	NA	NA
cyanide	NA	2.00E-02	NA
lead	NA	NA	NA
manganese	NA	1.40E-01	NA
mercury	NA	3.00E-04	NA
molybdenum	NA	5.00E-03	NA
nickel	NA	2.00E-02	NA
selenium	NA	5.00E-03	NA
silver	NA	5.00E-03	NA
thallium	NA	8.00E-05	NA
thorium-total	NA	NA	NA
uranium-total	4.18E-06	3.00E-03	1.39E-03
vanadium	NA	7.00E-03	NA
zinc	NA	3.00E-01	NA
2-methylnaphthalene	NA	NA	NA
4,4-dde	NA	NA	NA
aroclor-1221	NA	NA	NA
aroclor-1248	NA	NA	NA
aroclor-1254	NA	NA	NA
aroclor-1260	NA	NA	NA
carbazole	NA	NA	NA
endrin	NA	3.00E-04	NA
2,3,7,8-tcdd	NA	NA	NA
	HQ Summation =		1.87E-03

	ILCR Calculation		
Compound	CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	ILCR (unitless)
antimony	1.52E-09	NA	0.00E+00
arsenic	2.35E-08	1.75E+00	4.11E-08
barium	NA	NA	NA
beryllium	7.49E-10	4.30E+00	3.22E-09
boron	NA	NA	NA
cadmium	NA	NA	NA
chromium vi	NA	NA	NA
cobalt	NA	NA	NA
copper	NA	NA	NA
cyanide	NA	NA	NA
lead	NA	NA	NA
manganese	NA	NA	NA
mercury	NA	NA	NA
molybdenum	NA	NA	NA
nickel	NA	NA	NA
selenium	NA	NA	NA
silver	NA	NA	NA
thallium	NA	NA	NA
thorium-total	NA	NA	NA
uranium-total	7.17E-07	NA	0.00E+00
vanadium	NA	NA	NA
zinc	NA	NA	NA
2-methylnaphthalene	NA	NA	NA
4,4-dde	NA	3.40E-01	NA
aroclor-1221	NA	7.70E+00	NA
aroclor-1248	NA	7.70E+00	NA
aroclor-1254	NA	7.70E+00	NA
aroclor-1260	NA	7.70E+00	NA
carbazole	NA	2.00E-02	NA
endrin	NA	NA	NA
2,3,7,8-tcdd	NA	1.50E+05	NA
	ILCR Summation =		4.43E-08

Table I.IV–7
Summary of Intake Quantitation (chemicals)
Current Land Use with Federal Ownership: Trespassing Child
Via Dermal Contact While Wading

Intake Equation = $\frac{DA \times EF \times ED \times SA}{BW \times AT}$

DA	Dermal absorbed dose	csv mg/cm^2–day
EF	Exposure frequency	52 days/year
EDn	Exposure duration for non–carcinogens	12 Year
EDc	Exposure duration for carcinogens	12 Year
BW	Body weight	43 kg
ATc	Average time for carcinogens (lifetime)	25550 days
ATn	Average time for non–carcinogens (EDn x 365)	4380 days
SA	Skin surface area available for contact	4200 cm^2

Chemical Concentrations

Compound	DA	Units	Compound	DA	Units
antimony	7.64E–05	mg/cm^2–day	silver	0.00E+00	mg/cm^2–day
arsenic	1.18E–03	mg/cm^2–day	thallium	0.00E+00	mg/cm^2–day
barium	0.00E+00	mg/cm^2–day	thorium–total	0.00E+00	mg/cm^2–day
beryllium	3.77E–05	mg/cm^2–day	uranium–total	3.61E–02	mg/cm^2–day
boron	0.00E+00	mg/cm^2–day	vanadium	0.00E+00	mg/cm^2–day
cadmium	0.00E+00	mg/cm^2–day	zinc	0.00E+00	mg/cm^2–day
chromium vi	0.00E+00	mg/cm^2–day	2–methylnaphthalene	0.00E+00	mg/cm^2–day
cobalt	0.00E+00	mg/cm^2–day	4,4–dde	0.00E+00	mg/cm^2–day
copper	0.00E+00	mg/cm^2–day	aroclor–1221	0.00E+00	mg/cm^2–day
cyanide	0.00E+00	mg/cm^2–day	aroclor–1248	0.00E+00	mg/cm^2–day
lead	0.00E+00	mg/cm^2–day	aroclor–1254	0.00E+00	mg/cm^2–day
manganese	0.00E+00	mg/cm^2–day	aroclor–1260	0.00E+00	mg/cm^2–day
mercury	0.00E+00	mg/cm^2–day	carbazole	0.00E+00	mg/cm^2–day
molybdenum	0.00E+00	mg/cm^2–day	endrin	0.00E+00	mg/cm^2–day
nickel	0.00E+00	mg/cm^2–day	2,3,7,8–tcdd	0.00E+00	mg/cm^2–day
selenium	0.00E+00	mg/cm^2–day			

References

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Table I.IV-7 (contintued)
Summary of Risk Characterization (chemicals)
Current Land Use with Federal Ownership: Trespassing Child
Via Dermal Contact While Wading

Compound	HQ Calculation CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
antimony	3.81E-08	6.00E-05	6.35E-04
arsenic	5.88E-07	2.85E-04	2.06E-03
barium	NA	6.37E-02	NA
beryllium	1.88E-08	5.00E-03	3.76E-06
boron	NA	4.50E-03	NA
cadmium	NA	5.00E-05	NA
chromium vi	NA	2.25E-03	NA
cobalt	NA	2.70E-02	NA
copper	NA	NA	NA
cyanide	NA	NA	NA
lead	NA	NA	NA
manganese	NA	4.20E-03	NA
mercury	NA	4.50E-05	NA
molybdenum	NA	1.90E-03	NA
nickel	NA	2.00E-03	NA
selenium	NA	4.00E-03	NA
silver	NA	NA	NA
thallium	NA	8.00E-05	NA
thorium-total	NA	NA	NA
uranium-total	1.80E-05	1.50E-04	1.20E-01
vanadium	NA	3.50E-04	NA
zinc	NA	7.50E-02	NA
2-methylnaphthalene	NA	NA	NA
4,4-dde	NA	NA	NA
aroclor-1221	NA	NA	NA
aroclor-1248	NA	NA	NA
aroclor-1254	NA	NA	NA
aroclor-1260	NA	NA	NA
carbazole	NA	NA	NA
endrin	NA	2.70E-04	NA
2,3,7,8-tcdd	NA	NA	NA
	HQ Summation =		1.23E-01

Compound	ILCR Calculation CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	ILCR (unitless)
antimony	1.82E-09	NA	0.00E+00
arsenic	2.81E-08	1.90E+00	5.35E-08
barium	NA	NA	NA
beryllium	8.99E-10	4.30E+00	3.87E-09
boron	NA	NA	NA
cadmium	NA	NA	NA
chromium vi	NA	NA	NA
cobalt	NA	NA	NA
copper	NA	NA	NA
cyanide	NA	NA	NA
lead	NA	NA	NA
manganese	NA	NA	NA
mercury	NA	NA	NA
molybdenum	NA	NA	NA
nickel	NA	NA	NA
selenium	NA	NA	NA
silver	NA	NA	NA
thallium	NA	NA	NA
thorium-total	NA	NA	NA
uranium-total	8.60E-07	NA	0.00E+00
vanadium	NA	NA	NA
zinc	NA	NA	NA
2-methylnaphthalene	NA	NA	NA
4,4-dde	NA	3.40E-01	NA
aroclor-1221	NA	1.03E+01	NA
aroclor-1248	NA	1.03E+01	NA
aroclor-1254	NA	1.03E+01	NA
aroclor-1260	NA	1.03E+01	NA
carbazole	NA	2.22E-02	NA
endrin	NA	NA	NA
2,3,7,8-tcdd	NA	3.00E+05	NA
	ILCR Summation =		5.73E-08

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Table I.IV–8
Summary of Intake and Risk Quantitation (radionuclides)
Current Land Use with Federal Ownership: Trespassing Child
Via Incidental Ingestion while Wading

Intake Equation = Cs X EF X ED X FI X IR

IRsw	Ingestion rate of surface water	0.035 l/day
EF	Exposure frequency	52 days/year
EDn	Exposure duration for non–carcinogens	12 Year
FI	Fractional intake for radionuclides	1 (Unitless)
Cs	Concentration of radionuclides in surface water	

Cs_{137+1d}	0.00E+00	pCi/l	Rn_{222+4d}	0.00E+00	pCi/l
Pb_{210+2d}	0.00E+00	pCi/l	Sr_{90+1d}	0.00E+00	pCi/l
Np_{237+1d}	1.28E–01	pCi/l	Tc_{99}	8.77E+02	pCi/l
Pu_{238}	0.00E+00	pCi/l	Th_{228+7d}	0.00E+00	pCi/l
Pu_{239}	0.00E+00	pCi/l	Th_{230}	0.00E+00	pCi/l
Pu_{240}	0.00E+00	pCi/l	$Th_{232+10d}$	0.00E+00	pCi/l
Pa_{231}	0.00E+00	pCi/l	U_{234}	2.00E+01	pCi/l
Ra_{226+8d}	1.15E–01	pCi/l	U_{235+1d}	7.04E–02	pCi/l
Ra_{228+1d}	0.00E+00	pCi/l	U_{236}	5.34E–01	pCi/l
Ru_{106}	0.00E+00	pCi/l	U_{238+2d}	1.20E+01	pCi/l

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	ILCR (unitless)
Cs_{137+1d}	NA	2.80E–11	NA
Pb_{210+2d}	NA	6.60E–10	NA
Np_{237+1d}	2.80E+00	2.20E–10	6.15E–10
Pu_{238}	NA	2.20E–10	NA
Pu_{239}	NA	2.30E–10	NA
Pu_{240}	NA	2.30E–10	NA
Pa_{231}	NA	9.20E–11	NA
Ra_{226+8d}	2.51E+00	7.80E–10	1.96E–09
Ra_{228+1d}	NA	1.00E–10	NA
Ru_{106}	NA	9.50E–12	NA
Rn_{222+4d}	NA	1.70E–12	NA
Sr_{90+1d}	NA	3.60E–11	NA
Tc_{99}	1.92E+04	1.30E–12	2.49E–08
Th_{228+7d}	NA	5.50E–11	NA
Th_{230}	NA	1.30E–11	NA
$Th_{232+10d}$	NA	1.70E–10	NA
U_{234}	4.37E+02	1.60E–11	6.99E–09
U_{235+1d}	1.54E+00	1.60E–11	2.46E–11
U_{236}	1.17E+01	1.50E–11	1.75E–10
U_{238+2d}	2.63E+02	2.00E–11	5.25E–09
		ILCR Summation =	3.99E–08

Table I.IV–9
Summary of Intake and Risk Quantitation (radionuclides)
Future Land Use with Federal Ownership: Trespassing Child
Via External Radiation

Dose Equivalency Equat = $[DR \times EF \times EDn \times ET_i \times (1-SH_i)] + [DR \times EF \times EDn \times ET_o \times (1-SH_o)]$

EF	Fraction of year spent exposured	0.14 (unitless)
ED	Exposure duration	12 Year
ET_i	Fraction of day spent indoors	0.17 (unitless)
ET_o	Fraction of day spent outdoors	0 (unitless)
SH_i	Shield factor indoors	0.5 (unitless)
SH_o	Shield factor outdoors	0 (unitless)
DR	Radionuclide specific dose concentrations	(see table below)

Cs_{137+1d}	7.93E−01	pCi/g	Rn_{222+4d}	NA	pCi/g
Pb_{210+2d}	1.05E−06	pCi/g	Sr_{90+1d}	8.33E−07	pCi/g
Np_{237+1d}	8.36E−08	pCi/g	Tc_{99}	1.87E−06	pCi/g
Pu_{238}	9.07E−08	pCi/g	Th_{228+7d}	4.00E−07	pCi/g
Pu_{239}	1.25E−08	pCi/g	Th_{230}	5.92E−08	pCi/g
Pu_{240}	4.55E−08	pCi/g	$Th_{232+10d}$	5.95E−07	pCi/g
Pa_{231}	NA	pCi/g	U_{234}	2.06E−05	pCi/g
Ra_{226+8d}	3.99E−07	pCi/g	U_{235+1d}	9.34E−07	pCi/g
Ra_{228+1d}	7.00E−07	pCi/g	U_{236}	6.86E−06	pCi/g
Ru_{106}	1.33E−07	pCi/g	U_{238+2d}	1.38E−05	pCi/g

Radionuclides	CDI (year pCi/g)	CSF $(g/pCi-year)^{-1}$	ILCR (unitless)
Cs_{137+1d}	1.1E−01	2.0E−06	2.3E−07
Pb_{210+2d}	1.5E−07	1.6E−10	2.4E−17
Np_{237+1d}	1.2E−08	4.3E−07	5.1E−15
Pu_{238}	1.3E−08	2.8E−11	3.6E−19
Pu_{239}	1.8E−09	1.7E−11	3.0E−20
Pu_{240}	6.5E−09	2.7E−11	1.8E−19
Pa_{231}	NA	2.6E−08	NA
Ra_{226+8d}	5.7E−08	6.0E−06	3.4E−13
Ra_{228+1d}	1.0E−07	2.9E−06	2.9E−13
Ru_{106}	1.9E−08	NA	0.0E+00
Rn_{222+4d}	NA	5.9E−06	NA
Sr_{90+1d}	1.2E−07	NA	0.0E+00
Tc_{99}	2.7E−07	6.0E−13	1.6E−19
Th_{228+7d}	5.7E−08	5.6E−06	3.2E−13
Th_{230}	8.5E−09	5.4E−11	4.6E−19
$Th_{232+10d}$	8.5E−08	8.5E−06	7.2E−13
U_{234}	2.9E−06	3.0E−11	8.8E−17
U_{235+1d}	1.3E−07	2.4E−07	3.2E−14
U_{236}	9.8E−07	2.4E−11	2.4E−17
U_{238+2d}	2.0E−06	5.1E−08	1.0E−13
		ILCR Summation =	2.3E−07

Table I.IV–10
Summary of Intake Quantitation (chemicals)
Current Land Use with Federal Ownership: Groundskeeper
Via Inhalation of Particulates

Intake Equation = $\frac{CS \times EF \times ED \times IR}{BW \times AT}$

IR	Inhalation rate of gases (RAGS, 1989)	20 m^3/day
EF	Exposure frequency	250 days/year
EDn	Exposure duration for non–carcinogens	25 Year
EDc	Exposure duration for carcinogens	70 Year
BW	Body weight	70 kg
ATc	Average time for carcinogens (lifetime)	25550 days
ATn	Average time for non–carcinogens (EDn x 365)	9125 days
CS	Concentration of chemicals in soil	(see table below)

Chemical Concentrations

Compound	Concentration	Units	Compound	Concentration	Units
antimony	2.8E–09	mg/m^3	silver	1.9E–09	mg/m^3
arsenic	4.2E–09	mg/m^3	thallium	1.9E–10	mg/m^3
barium	4.3E–08	mg/m^3	thorium–total	2.3E–08	mg/m^3
beryllium	5.0E–10	mg/m^3	uranium–total	4.5E–07	mg/m^3
boron	5.0E–09	mg/m^3	vanadium	9.6E–09	mg/m^3
cadmium	1.0E–09	mg/m^3	zinc	2.4E–08	mg/m^3
chromium vi	7.1E–09	mg/m^3	2–methylnaphthalene	4.5E–11	mg/m^3
cobalt	4.1E–09	mg/m^3	4,4–dde	9.7E–13	mg/m^3
copper	1.5E–08	mg/m^3	aroclor–1221	NA	mg/m^3
cyanide	2.1E–10	mg/m^3	aroclor–1248	NA	mg/m^3
lead	4.9E–07	mg/m^3	aroclor–1254	1.9E–10	mg/m^3
manganese	1.3E–10	mg/m^3	aroclor–1260	5.5E–11	mg/m^3
mercury	1.3E–10	mg/m^3	carbazole	1.1E–11	mg/m^3
molybdenum	2.2E–09	mg/m^3	endrin	NA	mg/m^3
nickel	8.2E–09	mg/m^3	2,3,7,8–tcdd	4.1E–17	mg/m^3
selenium	2.7E–10	mg/m^3			

References

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Table I.IV-10 (continued)
Summary of Risk Characterization (chemicals)
Current Land Use with Federal Ownership: Groundskeeper
Via Inhalation of Particulates

Compound	HQ Calculation CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
antimony	5.5E-10	NA	NA
arsenic	8.2E-10	NA	NA
barium	8.4E-09	1.4E-04	5.8E-05
beryllium	9.9E-11	NA	NA
boron	9.7E-10	5.7E-03	1.7E-07
cadmium	2.0E-10	NA	NA
chromium vi	1.4E-09	NA	NA
cobalt	8.0E-10	3.0E-07	2.7E-03
copper	2.8E-09	NA	NA
cyanide	4.1E-11	NA	NA
lead	9.5E-08	NA	NA
manganese	2.5E-11	1.4E-05	1.8E-06
mercury	2.5E-11	8.6E-05	3.0E-07
molybdenum	4.3E-10	NA	NA
nickel	1.6E-09	NA	NA
selenium	5.3E-11	NA	NA
silver	3.7E-10	NA	NA
thallium	3.6E-11	NA	NA
thorium-total	4.4E-09	NA	NA
uranium-total	8.8E-08	NA	NA
vanadium	1.9E-09	NA	NA
zinc	4.7E-09	NA	NA
2-methylnaphthalene	8.8E-12	NA	NA
4,4-dde	1.9E-13	NA	NA
aroclor-1221	NA	NA	NA
aroclor-1248	NA	NA	NA
aroclor-1254	3.8E-11	NA	NA
aroclor-1260	1.1E-11	NA	NA
carbazole	2.2E-12	NA	NA
endrin	NA	NA	NA
2,3,7,8-tcdd	8.1E-18	NA	NA
	Hazard Quotient Sum =		2.7E-03

Compound	ILCR Calculation CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	ILCR (unitless)
antimony	5.5E-10	NA	NA
arsenic	8.2E-10	1.5E+01	1.2E-08
barium	8.4E-09	NA	NA
beryllium	9.9E-11	8.4E+00	8.3E-10
boron	9.7E-10	NA	NA
cadmium	2.0E-10	6.3E+00	1.2E-09
chromium vi	1.4E-09	4.1E+01	5.7E-08
cobalt	8.0E-10	NA	NA
copper	2.8E-09	NA	NA
cyanide	4.1E-11	NA	NA
lead	9.5E-08	NA	NA
manganese	2.5E-11	NA	NA
mercury	2.5E-11	NA	NA
molybdenum	4.3E-10	NA	NA
nickel	1.6E-09	8.4E-01	1.4E-09
selenium	5.3E-11	NA	NA
silver	3.7E-10	NA	NA
thallium	3.6E-11	NA	NA
thorium-total	4.4E-09	NA	NA
uranium-total	8.8E-08	NA	NA
vanadium	1.9E-09	NA	NA
zinc	4.7E-09	NA	NA
2-methylnaphthalene	8.8E-12	NA	NA
4,4-dde	1.9E-13	NA	NA
aroclor-1221	NA	NA	NA
aroclor-1248	NA	NA	NA
aroclor-1254	3.8E-11	NA	NA
aroclor-1260	1.1E-11	NA	NA
carbazole	2.2E-12	NA	NA
endrin	NA	NA	NA
2,3,7,8-tcdd	8.1E-18	1.5E+05	1.2E-12
	ILCR Summation =		7.2E-08

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Table I.IV–11
Summary of Intake and Risk Quantitation (radionuclides)
Current Land Use with Federal Ownership: Groundskeeper
Via Inhalation of Gases and Particulates

Intake Equation = Ca X EF X EDn X IR

IR	Inhalation rate of gases (RAGS, 1989)	20 m^3/day
EF	Exposure frequency	250 days/year
EDn	Exposure duration	25 Year
Ca	Concentration of radionuclides in air	(see table below)

Cs_{137+1d}	3.0E–07	pCi/m^3	Rn_{222+4d}	6.6E+00	pCi/m^3
Pb_{210+2d}	1.1E–06	pCi/m^3	Sr_{90+1d}	6.5E–07	pCi/m^3
Np_{237+1d}	1.0E–07	pCi/m^3	Tc_{99}	2.9E–06	pCi/m^3
Pu_{238}	9.7E–07	pCi/m^3	Th_{228+7d}	5.8E–07	pCi/m^3
Pu_{239}	2.2E–07	pCi/m^3	Th_{230}	1.6E–06	pCi/m^3
Pu_{240}	7.9E–07	pCi/m^3	$Th_{232+10d}$	9.3E–07	pCi/m^3
Pa_{231}	7.0E–08	pCi/m^3	U_{234}	1.7E–05	pCi/m^3
Ra_{226+8d}	4.8E–07	pCi/m^3	U_{235+1d}	4.6E–07	pCi/m^3
Ra_{228+1d}	7.0E–07	pCi/m^3	U_{236}	1.9E–07	pCi/m^3
Ru_{106}	8.4E–08	pCi/m^3	U_{238+2d}	1.0E–05	pCi/m^3

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	ILCR (unitless)
Cs_{137+1d}	1.1E–01	1.9E–11	2.0E–12
Pb_{210+2d}	3.7E–01	4.0E–09	1.5E–09
Np_{237+1d}	3.5E–02	2.9E–08	1.0E–09
Pu_{238}	3.4E–01	3.9E–08	1.3E–08
Pu_{239}	7.6E–02	3.8E–08	2.9E–09
Pu_{240}	2.8E–01	3.8E–08	1.0E–08
Pa_{231}	2.5E–02	3.6E–08	8.8E–10
Ra_{226+8d}	1.7E–01	7.0E–09	1.2E–09
Ra_{228+1d}	2.4E–01	6.9E–10	1.7E–10
Ru_{106}	2.9E–02	4.4E–10	1.3E–11
Rn_{222+4d}	2.3E+06	7.7E–12	1.8E–05
Sr_{90+1d}	2.3E–01	6.2E–11	1.4E–11
Tc_{99}	1.0E+00	8.3E–12	8.4E–12
Th_{228+7d}	2.0E–01	7.8E–08	1.6E–08
Th_{230}	5.6E–01	2.9E–08	1.6E–08
$Th_{232+10d}$	3.3E–01	1.1E–07	3.6E–08
U_{234}	6.0E+00	2.6E–08	1.6E–07
U_{235+1d}	1.6E–01	2.5E–08	4.0E–09
U_{236}	6.6E–02	2.5E–08	1.6E–09
U_{238+2d}	3.6E+00	2.4E–08	8.7E–08
		ILCR Summation =	1.8E–05

Table I.IV–12
Summary of Intake Quantitation (chemicals)
Current Land Use with Federal Ownership: Groundskeeper
Via Incidental Ingestion of Soil

Intake Equation = $\frac{CS \times EF \times ED \times CF \times IR}{BW \times AT}$

IRs	Ingestion rate of soil (RAGS, 1989)	100 mg/day
CF	Conversion factor	1.0E–06 kg/mg
EF	Exposure frequency	250 days/year
EDn	Exposure duration for non–carcinogens	25 Year
EDc	Exposure duration for carcinogens	70 Year
BW	Body weight	70 kg
ATc	Average time for carcinogens (lifetime)	25550 days
ATn	Average time for non–carcinogens (EDn x 365)	9125 days
CS	Concentration of chemicals in soil	(see table below)

Chemical Concentrations

Compound	Concentration	Units	Compound	Concentration	Units
antimony	5.4E+00	mg/kg	silver	6.0E+00	mg/kg
arsenic	5.1E+00	mg/kg	thallium	5.6E–01	mg/kg
barium	9.7E+01	mg/kg	thorium–total	NA	mg/kg
beryllium	7.6E–01	mg/kg	uranium–total	NA	mg/kg
boron	1.1E+02	mg/kg	vanadium	2.6E+01	mg/kg
cadmium	3.5E+00	mg/kg	zinc	6.4E+01	mg/kg
chromium vi	1.6E+01	mg/kg	2–methylnaphthalene	NA	mg/kg
cobalt	1.2E+01	mg/kg	4,4–dde	NA	mg/kg
copper	2.0E+01	mg/kg	aroclor–1221	NA	mg/kg
cyanide	2.5E–01	mg/kg	aroclor–1248	NA	mg/kg
lead	2.4E+01	mg/kg	aroclor–1254	NA	mg/kg
manganese	9.8E+02	mg/kg	aroclor–1260	NA	mg/kg
mercury	2.1E–01	mg/kg	carbazole	NA	mg/kg
molybdenum	6.5E+00	mg/kg	endrin	NA	mg/kg
nickel	2.3E+01	mg/kg	2,3,7,8–tcdd	NA	mg/kg
selenium	6.3E–01	mg/kg			

References

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Table I.IV-12 (continued)
Summary of Risk Characterization (chemicals)
Current Land Use with Federal Ownership: Groundskeeper
Via Incidental Ingestion of Soil

	HQ Calculation		
Compound	CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
antimony	5.2E-06	4.0E-04	1.3E-02
arsenic	5.0E-06	3.0E-04	1.7E-02
barium	9.5E-05	7.0E-02	1.4E-03
beryllium	7.4E-07	5.0E-03	1.5E-04
boron	1.1E-04	9.0E-02	1.2E-03
cadmium	3.4E-06	1.0E-03	3.4E-03
chromium vi	1.6E-05	5.0E-03	3.2E-03
cobalt	1.2E-05	6.0E-02	2.0E-04
copper	2.0E-05	NA	NA
cyanide	2.4E-07	2.0E-02	1.2E-05
lead	2.3E-05	NA	NA
manganese	9.5E-04	1.4E-01	6.8E-03
mercury	2.1E-07	3.0E-04	7.0E-04
molybdenum	6.4E-06	5.0E-03	1.3E-03
nickel	2.2E-05	2.0E-02	1.1E-03
selenium	6.2E-07	5.0E-03	1.2E-04
silver	5.9E-06	5.0E-03	1.2E-03
thallium	5.5E-07	8.0E-05	6.8E-03
thorium-total	NA	NA	NA
uranium-total	NA	3.0E-03	NA
vanadium	2.5E-05	7.0E-03	3.6E-03
zinc	6.3E-05	3.0E-01	2.1E-04
2-methylnaphthalene	NA	NA	NA
4,4-dde	NA	NA	NA
aroclor-1221	NA	NA	NA
aroclor-1248	NA	NA	NA
aroclor-1254	NA	NA	NA
aroclor-1260	NA	NA	NA
carbazole	NA	NA	NA
endrin	NA	3.0E-04	NA
2,3,7,8-tcdd	NA	NA	NA
	HQ Summation =		6.1E-02

	ILCR Calculation		
Compound	CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	ILCR (unitless)
antimony	5.2E-06	NA	NA
arsenic	5.0E-06	1.8E+00	8.7E-06
barium	9.5E-05	NA	NA
beryllium	7.4E-07	4.3E+00	3.2E-06
boron	1.1E-04	NA	NA
cadmium	3.4E-06	NA	NA
chromium vi	1.6E-05	NA	NA
cobalt	1.2E-05	NA	NA
copper	2.0E-05	NA	NA
cyanide	2.4E-07	NA	NA
lead	2.3E-05	NA	NA
manganese	9.5E-04	NA	NA
mercury	2.1E-07	NA	NA
molybdenum	6.4E-06	NA	NA
nickel	2.2E-05	NA	NA
selenium	6.2E-07	NA	NA
silver	5.9E-06	NA	NA
thallium	5.5E-07	NA	NA
thorium-total	NA	NA	NA
uranium-total	NA	NA	NA
vanadium	2.5E-05	NA	NA
zinc	6.3E-05	NA	NA
2-methylnaphthalene	NA	NA	NA
4,4-dde	NA	3.4E-01	NA
aroclor-1221	NA	7.7E+00	NA
aroclor-1248	NA	7.7E+00	NA
aroclor-1254	NA	7.7E+00	NA
aroclor-1260	NA	7.7E+00	NA
carbazole	NA	2.0E-02	NA
endrin	NA	NA	NA
2,3,7,8-tcdd	NA	1.5E+05	NA
	ILCR Summation =		1.2E-05

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Table I.IV-13
Summary of Intake and Risk Quantitation (radionuclides)
Current Land Use with Federal Ownership: Groundskeeper
Via Incidental Ingestion of Soil

Intake Equation = CS X EF X EDn X FI X IR

IRs	Ingestion rate of soil (RAGS, 1989)	100 mg/day
EF	Exposure frequency	250 days/year
EDn	Exposure Duration	25 Year
FI	Fractional Intake	1 (unitless)
CS	Concentration of radionuclides in soil	

Cs_{137+1d}	5.85E-10	pCi/mg	Rn_{222+4d}	NA	pCi/mg
Pb_{210+2d}	1.05E-09	pCi/mg	Sr_{90+1d}	8.33E-10	pCi/mg
Np_{237+1d}	8.36E-11	pCi/mg	Tc_{99}	1.87E-09	pCi/mg
Pu_{238}	9.07E-11	pCi/mg	Th_{228+7d}	4.00E-10	pCi/mg
Pu_{239}	1.25E-11	pCi/mg	Th_{230}	5.92E-11	pCi/mg
Pu_{240}	4.55E-11	pCi/mg	$Th_{232+10d}$	5.95E-10	pCi/mg
Pa_{231}	NA	pCi/mg	U_{234}	2.06E-08	pCi/mg
Ra_{226+8d}	3.99E-10	pCi/mg	U_{235+1d}	9.34E-10	pCi/mg
Ra_{228+1d}	7.00E-10	pCi/mg	U_{236}	6.86E-09	pCi/mg
Ru_{106}	1.33E-10	pCi/mg	U_{238+2d}	1.38E-08	pCi/mg

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	ILCR (unitless)
Cs_{137+1d}	1.02E-03	2.80E-11	2.87E-14
Pb_{210+2d}	1.84E-03	6.60E-10	1.21E-12
Np_{237+1d}	1.46E-04	2.20E-10	3.22E-14
Pu_{238}	1.59E-04	2.20E-10	3.49E-14
Pu_{239}	2.19E-05	2.30E-10	5.03E-15
Pu_{240}	7.96E-05	2.30E-10	1.83E-14
Pa_{231}	NA	9.20E-11	NA
Ra_{226+8d}	6.98E-04	7.80E-10	5.45E-13
Ra_{228+1d}	1.23E-03	1.00E-10	1.23E-13
Ru_{106}	2.33E-04	9.50E-12	2.21E-15
Rn_{222+4d}	NA	1.70E-12	NA
Sr_{90+1d}	1.46E-03	3.60E-11	5.25E-14
Tc_{99}	3.27E-03	1.30E-12	4.25E-15
Th_{228+7d}	7.00E-04	5.50E-11	3.85E-14
Th_{230}	1.04E-04	1.30E-11	1.35E-15
$Th_{232+10d}$	1.04E-03	1.70E-10	1.77E-13
U_{234}	3.61E-02	1.60E-11	5.77E-13
U_{235+1d}	1.63E-03	1.60E-11	2.62E-14
U_{236}	1.20E-02	1.50E-11	1.80E-13
U_{238+2d}	2.42E-02	2.00E-11	4.83E-13
		ILCR Summation =	3.54E-12

Table I.IV–14
Summary of Intake Quantitation (chemicals)
Current Land Use with Federal Ownership: Groundskeeper
Via Dermal Contact with Soil

Intake Equation = $\frac{CS \times EF \times ED \times CF \times ABS \times AF \times SA}{BW \times AT}$

SA	Surface area of exposed skin (50th percentile, hands only)	5750 cm^2/day
AF	Soil to skin adherence factor (RAGS, 1989)	1 mg/cm^2
ABS	chemicals specific absorbtion factor (see table below)	csv
CF	Conversion factor	1E–06 kg/mg
EF	Exposure frequency	250 days/year
EDn	Exposure duration for non–carcinogens	25 Year
EDc	Exposure duration for carcinogens	70 Year
BW	Body weight	70 kg
ATc	Average time for carcinogens (lifetime)	25550 days
ATn	Average time for non–carcinogens (EDn x 365)	9125 days
CS	Concentration of chemicals in soil	

Chemical Concentrations

Compound	ABS	Concentrati	Units
antimony	1.00E–02	5.35E+00	mg/kg
arsenic	1.00E–03	5.09E+00	mg/kg
barium	1.00E–02	9.72E+01	mg/kg
beryllium	1.00E–02	7.55E–01	mg/kg
boron	1.00E–02	1.12E+02	mg/kg
cadmium	1.00E–02	3.48E+00	mg/kg
chromium vi	1.00E–02	1.64E+01	mg/kg
cobalt	1.00E–02	1.21E+01	mg/kg
copper	1.00E–03	2.02E+01	mg/kg
cyanide	1.00E–02	2.50E–01	mg/kg
lead	1.00E–02	2.35E+01	mg/kg
manganese	1.00E–02	9.76E+02	mg/kg
mercury	5.00E–02	2.14E–01	mg/kg
molybdenum	1.00E–02	6.49E+00	mg/kg
nickel	5.00E–04	2.26E+01	mg/kg
selenium	1.00E–02	6.31E–01	mg/kg

Compound		Concentrati	Units
silver	1.00E–02	6.03E+00	mg/kg
thallium	1.00E–02	5.58E–01	mg/kg
thorium–total	1.00E–02	NA	mg/kg
uranium–total	1.00E–02	NA	mg/kg
vanadium	1.00E–03	2.60E+01	mg/kg
zinc	1.00E–02	6.41E+01	mg/kg
2–methylnaphthalene	3.00E–01	NA	mg/kg
4,4–dde	3.00E–01	NA	mg/kg
aroclor–1221	6.00E–02	NA	mg/kg
aroclor–1248	6.00E–02	NA	mg/kg
aroclor–1254	6.00E–02	NA	mg/kg
aroclor–1260	6.00E–02	NA	mg/kg
carbazole	3.00E–01	NA	mg/kg
endrin	3.00E–01	NA	mg/kg
2,3,7,8–tcdd	3.00E–02	NA	mg/kg

References

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Table I.IV-14 (continued)
Summary of Risk Characterization (chemicals)
Current Land Use with Federal Ownership: Groundskeeper
Via Dermal Contact with Soil

	HQ Calculation		
Compound	CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
antimony	3.01E-06	6.00E-05	5.02E-02
arsenic	2.86E-07	2.85E-04	1.00E-03
barium	5.47E-05	6.37E-02	8.59E-04
beryllium	4.25E-07	5.00E-03	8.50E-05
boron	6.30E-05	4.50E-03	1.40E-02
cadmium	1.96E-06	5.00E-05	3.92E-02
chromium vi	9.23E-06	2.25E-03	4.10E-03
cobalt	6.81E-06	2.70E-02	2.52E-04
copper	1.14E-06	NA	NA
cyanide	1.41E-07	NA	NA
lead	1.32E-05	NA	NA
manganese	5.49E-04	4.20E-03	1.31E-01
mercury	6.02E-07	4.50E-05	1.34E-02
molybdenum	3.65E-06	1.90E-03	1.92E-03
nickel	6.36E-07	2.00E-03	3.18E-04
selenium	3.55E-07	4.00E-03	8.88E-05
silver	3.39E-06	NA	NA
thallium	3.14E-07	8.00E-05	3.92E-03
thorium-total	NA	NA	NA
uranium-total	NA	1.50E-04	NA
vanadium	1.46E-06	3.50E-04	4.18E-03
zinc	3.61E-05	7.50E-02	4.81E-04
2-methylnaphthalene	NA	NA	NA
4,4-dde	NA	NA	NA
aroclor-1221	NA	NA	NA
aroclor-1248	NA	NA	NA
aroclor-1254	NA	NA	NA
aroclor-1260	NA	NA	NA
carbazole	NA	NA	NA
endrin	NA	2.70E-04	NA
2,3,7,8-tcdd	NA	NA	NA
	HQ Summation =		2.65E-01

	ILCR Calculation		
Compound	CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	ILCR (unitless)
antimony	3.01E-06	NA	NA
arsenic	2.86E-07	1.90E+00	5.44E-07
barium	5.47E-05	NA	NA
beryllium	4.25E-07	4.30E+00	1.83E-06
boron	6.30E-05	NA	NA
cadmium	1.96E-06	NA	NA
chromium vi	9.23E-06	NA	NA
cobalt	6.81E-06	NA	NA
copper	1.14E-06	NA	NA
cyanide	1.41E-07	NA	NA
lead	1.32E-05	NA	NA
manganese	5.49E-04	NA	NA
mercury	6.02E-07	NA	NA
molybdenum	3.65E-06	NA	NA
nickel	6.36E-07	NA	NA
selenium	3.55E-07	NA	NA
silver	3.39E-06	NA	NA
thallium	3.14E-07	NA	NA
thorium-total	NA	NA	NA
uranium-total	NA	NA	NA
vanadium	1.46E-06	NA	NA
zinc	3.61E-05	NA	NA
2-methylnaphthalene	NA	NA	NA
4,4-dde	NA	3.40E-01	NA
aroclor-1221	NA	1.03E+01	NA
aroclor-1248	NA	1.03E+01	NA
aroclor-1254	NA	1.03E+01	NA
aroclor-1260	NA	1.03E+01	NA
carbazole	NA	2.22E-02	NA
endrin	NA	NA	NA
2,3,7,8-tcdd	NA	3.00E+05	NA
	ILCR Summation =		2.37E-06

000533

Table I.IV–15
Summary of Intake and Risk Quantitation (radionuclides)
Current Land Use with Federal Ownership: Groundskeeper
Via External Radiation

Dose Equivalency Equat = $[DR \times EF \times EDn \times ET_i \times (1-SH_i)] + [DR \times EF \times EDn \times ET_o \times (1-SH_o)]$

EF	Fraction of year spent exposured	0.68 (unitless)
ED	Exposure duration	25 Year
ET_i	Fraction of day spent indoors	NA (unitless)
ET_o	Fraction of day spent outdoors	0.33 (unitless)
SH_i	Shield factor indoors	0.5 (unitless)
SH_o	Shield factor outdoors	NA (unitless)
DR	Radionuclide specific dose concentrations	(see table below)

Cs_{137+1d}	5.85E−07	pCi/g	Rn_{222+4d}	NA	pCi/g
Pb_{210+2d}	1.05E−06	pCi/g	Sr_{90+1d}	8.33E−07	pCi/g
Np_{237+1d}	8.36E−08	pCi/g	Tc_{99}	1.87E−06	pCi/g
Pu_{238}	9.07E−08	pCi/g	Th_{228+7d}	4.00E−07	pCi/g
Pu_{239}	1.25E−08	pCi/g	Th_{230}	NA	pCi/g
Pu_{240}	4.55E−08	pCi/g	$Th_{232+10d}$	NA	pCi/g
Pa_{231}	NA	pCi/g	U_{234}	NA	pCi/g
Ra_{226+8d}	3.99E−07	pCi/g	U_{235+1d}	NA	pCi/g
Ra_{228+1d}	7.00E−07	pCi/g	U_{236}	NA	pCi/g
Ru_{106}	1.33E−07	pCi/g	U_{238+2d}	NA	pCi/g

Radionuclides	CDI (year pCi/g)	CSF $(g/pCi-year)^{-1}$	ILCR (unitless)
Cs_{137+1d}	3.3E−06	2.0E−06	6.6E−12
Pb_{210+2d}	5.9E−06	1.6E−10	9.4E−16
Np_{237+1d}	4.7E−07	4.3E−07	2.0E−13
Pu_{238}	5.1E−07	2.8E−11	1.4E−17
Pu_{239}	7.0E−08	1.7E−11	1.2E−18
Pu_{240}	2.6E−07	2.7E−11	6.9E−18
Pa_{231}	NA	2.6E−08	NA
Ra_{226+8d}	2.2E−06	6.0E−06	1.3E−11
Ra_{228+1d}	3.9E−06	2.9E−06	1.1E−11
Ru_{106}	7.5E−07	NA	NA
Rn_{222+4d}	NA	5.9E−06	NA
Sr_{90+1d}	4.7E−06	NA	NA
Tc_{99}	1.0E−05	6.0E−13	6.3E−18
Th_{228+7d}	2.2E−06	5.6E−06	1.3E−11
Th_{230}	NA	5.4E−11	NA
$Th_{232+10d}$	NA	8.5E−06	NA
U_{234}	NA	3.0E−11	NA
U_{235+1d}	NA	2.4E−07	NA
U_{236}	NA	2.4E−11	NA
U_{238+2d}	NA	5.1E−08	NA
		ILCR Summation =	4.4E−11

000535

Table I.IV–16
Summary of Intake Quantitation (chemicals)
Current Land Use with Federal Ownership: Off–Property Farmer (Adult)
Via Inhalation of Particulates

Intake Equation = $\frac{CS \times EF \times ED \times IR}{BW \times AT}$

IR	Inhalation rate of gases (RAGS, 1989)	20 m^3/day
EF	Exposure frequency	350 days/year
EDn	Exposure duration for non–carcinogens	70 Year
EDc	Exposure duration for carcinogens	70 Year
BW	Body weight	70 kg
ATc	Average time for carcinogens (lifetime)	25550 days
ATn	Average time for non–carcinogens (EDn x 365)	25550 days
CS	Concentration of chemicals in soil	(see table below)

Chemical Concentrations

Compound	Concentration	Units	Compound	Concentration	Units
antimony	7.5E–09	mg/m^3	silver	2.7E–09	mg/m^3
arsenic	5.3E–09	mg/m^3	thallium	3.3E–10	mg/m^3
barium	8.2E–08	mg/m^3	thorium–total	7.5E–08	mg/m^3
beryllium	7.8E–10	mg/m^3	uranium–total	1.0E–06	mg/m^3
boron	8.5E–09	mg/m^3	vanadium	2.0E–08	mg/m^3
cadmium	1.3E–09	mg/m^3	zinc	5.1E–08	mg/m^3
chromium vi	1.2E–08	mg/m^3	2–methylnaphthalene	6.0E–11	mg/m^3
cobalt	6.3E–09	mg/m^3	4,4–dde	4.3E–12	mg/m^3
copper	3.8E–08	mg/m^3	aroclor–1221	NA	mg/m^3
cyanide	4.6E–10	mg/m^3	aroclor–1248	NA	mg/m^3
lead	1.3E–06	mg/m^3	aroclor–1254	2.7E–10	mg/m^3
manganese	2.4E–10	mg/m^3	aroclor–1260	6.4E–11	mg/m^3
mercury	2.4E–10	mg/m^3	carbazole	1.7E–11	mg/m^3
molybdenum	4.1E–09	mg/m^3	endrin	NA	mg/m^3
nickel	1.5E–08	mg/m^3	2,3,7,8–tcdd	8.8E–17	mg/m^3
selenium	3.4E–10	mg/m^3			

References

Table I.IV–16 (continued)
Summary of Risk Characterization (chemicals)
Current Land Use with Federal Ownership: Off–Property Farmer (Adult)
Via Inhalation of Particulates

	HQ Calculation		
Compound	CDI (mg/kg–day)	RfD (mg/kg–day)	HQ (unitless)
antimony	2.1E–09	NA	NA
arsenic	1.5E–09	NA	NA
barium	2.2E–08	1.4E–04	1.6E–04
beryllium	2.1E–10	NA	NA
boron	2.3E–09	5.7E–03	4.1E–07
cadmium	3.6E–10	NA	NA
chromium vi	3.4E–09	NA	NA
cobalt	1.7E–09	3.0E–07	5.8E–03
copper	1.0E–08	NA	NA
cyanide	1.3E–10	NA	NA
lead	3.5E–07	NA	NA
manganese	6.6E–11	1.4E–05	4.7E–06
mercury	6.6E–11	8.6E–05	7.7E–07
molybdenum	1.1E–09	NA	NA
nickel	4.2E–09	NA	NA
selenium	9.2E–11	NA	NA
silver	7.3E–10	NA	NA
thallium	9.0E–11	NA	NA
thorium–total	2.1E–08	NA	NA
uranium–total	2.7E–07	NA	NA
vanadium	5.4E–09	NA	NA
zinc	1.4E–08	NA	NA
2–methylnaphthalene	1.6E–11	NA	NA
4,4–dde	1.2E–12	NA	NA
aroclor–1221	NA	NA	NA
aroclor–1248	NA	NA	NA
aroclor–1254	7.3E–11	NA	NA
aroclor–1260	1.8E–11	NA	NA
carbazole	4.5E–12	NA	NA
endrin	NA	NA	NA
2,3,7,8–tcdd	2.4E–17	NA	NA
	Hazard Quotient Sum =		6.0E–03

	ILCR Calculation		
Compound	CDI (mg/kg–day)	CSF $(mg/kg–day)^{-1}$	ILCR (unitless)
antimony	2.1E–09	NA	NA
arsenic	1.5E–09	1.5E+01	2.2E–08
barium	2.2E–08	NA	NA
beryllium	2.1E–10	8.4E+00	1.8E–09
boron	2.3E–09	NA	NA
cadmium	3.6E–10	6.3E+00	2.2E–09
chromium vi	3.4E–09	4.1E+01	1.4E–07
cobalt	1.7E–09	NA	NA
copper	1.0E–08	NA	NA
cyanide	1.3E–10	NA	NA
lead	3.5E–07	NA	NA
manganese	6.6E–11	NA	NA
mercury	6.6E–11	NA	NA
molybdenum	1.1E–09	NA	NA
nickel	4.2E–09	8.4E–01	3.5E–09
selenium	9.2E–11	NA	NA
silver	7.3E–10	NA	NA
thallium	9.0E–11	NA	NA
thorium–total	2.1E–08	NA	NA
uranium–total	2.7E–07	NA	NA
vanadium	5.4E–09	NA	NA
zinc	1.4E–08	NA	NA
2–methylnaphthalene	1.6E–11	NA	NA
4,4–dde	1.2E–12	NA	NA
aroclor–1221	NA	NA	NA
aroclor–1248	NA	NA	NA
aroclor–1254	7.3E–11	NA	NA
aroclor–1260	1.8E–11	NA	NA
carbazole	4.5E–12	NA	NA
endrin	NA	NA	NA
2,3,7,8–tcdd	2.4E–17	1.5E+05	3.6E–12
	ILCR Summation =		1.7E–07

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Table I.IV–17
Summary of Intake and Risk Quantitation (radionuclides)
Current Land Use with Federal Ownership: Off–Property Farmer (Adult)
Via Inhalation of Gases and Particulates

Intake Equation = Ca X EF X EDn X IR

IR	Inhalation rate of gases (RAGS, 1989)	20 m^3/day
EF	Exposure frequency	350 days/year
EDn	Exposure duration	70 Year
Ca	Concentration of radionuclides in air	(see table below)

Cs_{137+1d}	4.3E−07	pCi/m^3	Rn_{222+4d}	1.3E+01	pCi/m^3
Pb_{210+2d}	1.1E−05	pCi/m^3	Sr_{90+1d}	1.4E−06	pCi/m^3
Np_{237+1d}	2.0E−07	pCi/m^3	Tc_{99}	2.3E−05	pCi/m^3
Pu_{238}	1.2E−05	pCi/m^3	Th_{228+7d}	9.5E−07	pCi/m^3
Pu_{239}	3.9E−07	pCi/m^3	Th_{230}	3.3E−06	pCi/m^3
Pu_{240}	1.4E−06	pCi/m^3	$Th_{232+10d}$	2.7E−06	pCi/m^3
Pa_{231}	4.1E−07	pCi/m^3	U_{234}	4.6E−05	pCi/m^3
Ra_{226+8d}	9.1E−07	pCi/m^3	U_{235+1d}	1.2E−06	pCi/m^3
Ra_{228+1d}	1.1E−06	pCi/m^3	U_{236}	5.1E−07	pCi/m^3
Ru_{106}	7.8E−08	pCi/m^3	U_{238+2d}	2.8E−05	pCi/m^3

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	ILCR (unitless)
Cs_{137+1d}	2.1E−01	1.9E−11	4.0E−12
Pb_{210+2d}	5.6E+00	4.0E−09	2.2E−08
Np_{237+1d}	9.7E−02	2.9E−08	2.8E−09
Pu_{238}	5.8E+00	3.9E−08	2.3E−07
Pu_{239}	1.9E−01	3.8E−08	7.3E−09
Pu_{240}	7.0E−01	3.8E−08	2.7E−08
Pa_{231}	2.0E−01	3.6E−08	7.3E−09
Ra_{226+8d}	4.5E−01	7.0E−09	3.1E−09
Ra_{228+1d}	5.6E−01	6.9E−10	3.9E−10
Ru_{106}	3.8E−02	4.4E−10	1.7E−11
Rn_{222+4d}	6.2E+06	7.7E−12	4.8E−05
Sr_{90+1d}	6.9E−01	6.2E−11	4.3E−11
Tc_{99}	1.1E+01	8.3E−12	9.4E−11
Th_{228+7d}	4.6E−01	7.8E−08	3.6E−08
Th_{230}	1.6E+00	2.9E−08	4.6E−08
$Th_{232+10d}$	1.3E+00	1.1E−07	1.5E−07
U_{234}	2.3E+01	2.6E−08	5.9E−07
U_{235+1d}	6.0E−01	2.5E−08	1.5E−08
U_{236}	2.5E−01	2.5E−08	6.2E−09
U_{238+2d}	1.4E+01	2.4E−08	3.3E−07
		ILCR Summation =	4.9E−05

Table I.IV-18
Summary of Intake Quantitation (chemicals)
Current Land Use with Federal Ownership: Off-Property Farmer (Adult)
Via Drinking Water Ingestion

Intake Equation = $\frac{CS \times EF \times ED \times IR}{BW \times AT}$

IR	Ingestion rate of groundwater (RAGS, 1989)	2 l/day
EF	Exposure frequency	350 days/year
EDn	Exposure duration for non-carcinogens	70 Year
EDc	Exposure duration for carcinogens	70 Year
BW	Body weight	70 kg
ATc	Average time for carcinogens (lifetime)	25550 days
ATn	Average time for non-carcinogens (EDn x 365)	25550 days
CS	Concentration of chemicals in groundwater	

Chemical Concentrations

Compound	Concentration	Units	Compound	Concentration	Units
antimony	3.05E-07	mg/l	silver	NA	mg/l
arsenic	NA	mg/l	thallium	NA	mg/l
barium	NA	mg/l	thorium-total	NA	mg/l
beryllium	NA	mg/l	uranium-total	5.58E-03	mg/l
boron	NA	mg/l	vanadium	NA	mg/l
cadmium	4.07E-31	mg/l	zinc	NA	mg/l
chromium vi	NA	mg/l	2-methylnaphthalene	NA	mg/l
cobalt	NA	mg/l	4,4-dde	NA	mg/l
copper	NA	mg/l	aroclor-1221	2.21E-34	mg/l
cyanide	NA	mg/l	aroclor-1248	NA	mg/l
lead	NA	mg/l	aroclor-1254	NA	mg/l
manganese	NA	mg/l	aroclor-1260	NA	mg/l
mercury	NA	mg/l	carbazole	NA	mg/l
molybdenum	NA	mg/l	endrin	NA	mg/l
nickel	NA	mg/l	2,3,7,8-tcdd	NA	mg/l
selenium	NA	mg/l			

References

Table I.IV–18 (continued)
Summary of Risk Characterization (chemicals)
Current Land Use with Federal Ownership: Off–Property Farmer (Adult)
Via Drinking Water Ingestion

Compound	HQ Calculation CDI (mg/kg–day)	RfD (mg/kg–day)	HQ (unitless)
antimony	8.36E–09	4.00E–04	2.09E–05
arsenic	NA	3.00E–04	NA
barium	NA	7.00E–02	NA
beryllium	NA	5.00E–03	NA
boron	NA	9.00E–02	NA
cadmium	1.12E–32	1.00E–03	1.12E–29
chromium vi	NA	5.00E–03	NA
cobalt	NA	6.00E–02	NA
copper	NA	NA	NA
cyanide	NA	2.00E–02	NA
lead	NA	NA	NA
manganese	NA	1.40E–01	NA
mercury	NA	3.00E–04	NA
molybdenum	NA	5.00E–03	NA
nickel	NA	2.00E–02	NA
selenium	NA	5.00E–03	NA
silver	NA	5.00E–03	NA
thallium	NA	8.00E–05	NA
thorium–total	NA	NA	NA
uranium–total	1.53E–04	3.00E–03	5.10E–02
vanadium	NA	7.00E–03	NA
zinc	NA	3.00E–01	NA
2–methylnaphthalene	NA	NA	NA
4,4–dde	NA	NA	NA
aroclor–1221	6.05E–36	NA	NA
aroclor–1248	NA	NA	NA
aroclor–1254	NA	NA	NA
aroclor–1260	NA	NA	NA
carbazole	NA	NA	NA
endrin	NA	3.00E–04	NA
2,3,7,8–tcdd	NA	NA	NA
	HQ Summation =		5.10E–02

Compound	ILCR Calculation CDI (mg/kg–day)	CSF $(mg/kg–day)^{-1}$	ILCR (unitless)
antimony	8.36E–09	NA	NA
arsenic	NA	1.75E+00	NA
barium	NA	NA	NA
beryllium	NA	4.30E+00	NA
boron	NA	NA	NA
cadmium	1.12E–32	NA	NA
chromium vi	NA	NA	NA
cobalt	NA	NA	NA
copper	NA	NA	NA
cyanide	NA	NA	NA
lead	NA	NA	NA
manganese	NA	NA	NA
mercury	NA	NA	NA
molybdenum	NA	NA	NA
nickel	NA	NA	NA
selenium	NA	NA	NA
silver	NA	NA	NA
thallium	NA	NA	NA
thorium–total	NA	NA	NA
uranium–total	1.53E–04	NA	NA
vanadium	NA	NA	NA
zinc	NA	NA	NA
2–methylnaphthalene	NA	NA	NA
4,4–dde	NA	3.40E–01	NA
aroclor–1221	6.05E–36	7.70E+00	4.66E–35
aroclor–1248	NA	7.70E+00	NA
aroclor–1254	NA	7.70E+00	NA
aroclor–1260	NA	7.70E+00	NA
carbazole	NA	2.00E–02	NA
endrin	NA	NA	NA
2,3,7,8–tcdd	NA	1.50E+05	NA
	ILCR Summation =		4.66E–35

Table I.IV–19
Summary of Intake and Risk Quantitation (radionuclides)
Current Land Use with Federal Ownership: Off–Property Farmer (Adult)
Via Ingestion of Drinking Water

Intake Equation = Cw X EF X EDn X FI X IR

IR	Ingestion rate of groundwater (RAGS, 1989)	2 l/day
EF	Exposure frequency	350 days/year
EDn	Exposure duration	70 Year
FI	Fractional intake for radionuclides	1 (Unitless)
Cw	Concentration of radionuclides in groundwater	(see table below)

Cs_{137+1d}	NA	pCi/l	Rn_{222+4d}	NA	pCi/l
Pb_{210+2d}	NA	pCi/l	Sr_{90+1d}	NA	pCi/l
Np_{237+1d}	7.7E−03	pCi/l	Tc_{99}	4.1E+02	pCi/l
Pu_{238}	NA	pCi/l	Th_{228+7d}	NA	pCi/l
Pu_{239}	NA	pCi/l	Th_{230}	NA	pCi/l
Pu_{240}	NA	pCi/l	$Th_{232+10d}$	NA	pCi/l
Pa_{231}	NA	pCi/l	U_{234}	9.3E+00	pCi/l
Ra_{226+8d}	NA	pCi/l	U_{235+1d}	2.5E−01	pCi/l
Ra_{228+1d}	NA	pCi/l	U_{236}	1.0E−01	pCi/l
Ru_{106}	NA	pCi/l	U_{238+2d}	5.5E+00	pCi/l

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	ILCR (unitless)
Cs_{137+1d}	NA	2.8E−11	NA
Pb_{210+2d}	NA	6.6E−10	NA
Np_{237+1d}	3.8E+02	2.2E−10	8.3E−08
Pu_{238}	NA	2.2E−10	NA
Pu_{239}	NA	2.3E−10	NA
Pu_{240}	NA	2.3E−10	NA
Pa_{231}	NA	9.2E−11	NA
Ra_{226+8d}	NA	7.8E−10	NA
Ra_{228+1d}	NA	1.0E−10	NA
Ru_{106}	NA	9.5E−12	NA
Rn_{222+4d}	NA	1.7E−12	NA
Sr_{90+1d}	NA	3.6E−11	NA
Tc_{99}	2.0E+07	1.3E−12	2.6E−05
Th_{228+7d}	NA	5.5E−11	NA
Th_{230}	NA	1.3E−11	NA
$Th_{232+10d}$	NA	1.7E−10	NA
U_{234}	4.5E+05	1.6E−11	7.3E−06
U_{235+1d}	1.2E+04	1.6E−11	1.9E−07
U_{236}	4.9E+03	1.5E−11	7.4E−08
U_{238+2d}	2.7E+05	2.0E−11	5.4E−06
		ILCR Summation =	3.9E−05

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Table I.IV–20
Summary of Intake Quantitation (chemicals)
Current Land Use with Federal Ownership: Off–Property Farmer (Adult)
Via Dermal Contact while Bathing

Intake Equation = $\frac{DA \times EF \times ED \times SA}{BW \times AT}$

DA	Dermal absorbed dose	csv mg/cm^2–day
EF	Exposure frequency	350 days/year
EDn	Exposure duration for non–carcinogens	70 Year
EDc	Exposure duration for carcinogens	70 Year
BW	Body weight	70 kg
ATc	Average time for carcinogens (lifetime)	25550 days
ATn	Average time for non–carcinogens (EDn x 365)	25550 days
SA	Skin surface area available for contact	23000 cm^2

Chemical Concentrations

Compound	DA	Units	Compound	DA	Units
antimony	7.63E–13	mg/cm^2–day	silver	NA	mg/cm^2–day
arsenic	NA	mg/cm^2–day	thallium	NA	mg/cm^2–day
barium	NA	mg/cm^2–day	thorium–total	NA	mg/cm^2–day
beryllium	NA	mg/cm^2–day	uranium–total	1.40E–09	mg/cm^2–day
boron	NA	mg/cm^2–day	vanadium	NA	mg/cm^2–day
cadmium	1.02E–37	mg/cm^2–day	zinc	NA	mg/cm^2–day
chromium vi	NA	mg/cm^2–day	2–methylnaphthalene	NA	mg/cm^2–day
cobalt	NA	mg/cm^2–day	4,4–dde	NA	mg/cm^2–day
copper	NA	mg/cm^2–day	aroclor–1221	1.80E–37	mg/cm^2–day
cyanide	NA	mg/cm^2–day	aroclor–1248	NA	mg/cm^2–day
lead	NA	mg/cm^2–day	aroclor–1254	NA	mg/cm^2–day
manganese	NA	mg/cm^2–day	aroclor–1260	NA	mg/cm^2–day
mercury	NA	mg/cm^2–day	carbazole	NA	mg/cm^2–day
molybdenum	NA	mg/cm^2–day	endrin	NA	mg/cm^2–day
nickel	NA	mg/cm^2–day	2,3,7,8–tcdd	NA	mg/cm^2–day
selenium	NA	mg/cm^2–day			

References

Table I.IV-20 (continued)
Summary of Risk Characterization (chemicals)
Current Land Use with Federal Ownership: Off-Property Farmer (Adult)
Via Dermal Contact while Showering

Compound	HQ Calculation CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
antimony	2.40E-10	6.00E-05	4.00E-06
arsenic	NA	2.85E-04	NA
barium	NA	6.37E-02	NA
beryllium	NA	5.00E-03	NA
boron	NA	4.50E-03	NA
cadmium	3.21E-35	5.00E-05	6.41E-31
chromium vi	NA	2.25E-03	NA
cobalt	NA	2.70E-02	NA
copper	NA	NA	NA
cyanide	NA	NA	NA
lead	NA	NA	NA
manganese	NA	4.20E-03	NA
mercury	NA	4.50E-05	NA
molybdenum	NA	1.90E-03	NA
nickel	NA	2.00E-03	NA
selenium	NA	4.00E-03	NA
silver	NA	NA	NA
thallium	NA	8.00E-05	NA
thorium-total	NA	NA	NA
uranium-total	4.40E-07	1.50E-04	2.93E-03
vanadium	NA	3.50E-04	NA
zinc	NA	7.50E-02	NA
2-methylnaphthalene	NA	NA	NA
4,4-dde	NA	NA	NA
aroclor-1221	5.66E-35	NA	NA
aroclor-1248	NA	NA	NA
aroclor-1254	NA	NA	NA
aroclor-1260	NA	NA	NA
carbazole	NA	NA	NA
endrin	NA	2.70E-04	NA
2,3,7,8-tcdd	NA	NA	NA
	HQ Summation =		2.93E-03

Compound	ILCR Calculation CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	ILCR (unitless)
antimony	2.40E-10	NA	NA
arsenic	NA	1.90E+00	NA
barium	NA	NA	NA
beryllium	NA	4.30E+00	NA
boron	NA	NA	NA
cadmium	3.21E-35	NA	NA
chromium vi	NA	NA	NA
cobalt	NA	NA	NA
copper	NA	NA	NA
cyanide	NA	NA	NA
lead	NA	NA	NA
manganese	NA	NA	NA
mercury	NA	NA	NA
molybdenum	NA	NA	NA
nickel	NA	NA	NA
selenium	NA	NA	NA
silver	NA	NA	NA
thallium	NA	NA	NA
thorium-total	NA	NA	NA
uranium-total	4.40E-07	NA	NA
vanadium	NA	NA	NA
zinc	NA	NA	NA
2-methylnaphthalene	NA	NA	NA
4,4-dde	NA	3.40E-01	NA
aroclor-1221	5.66E-35	1.03E+01	5.81E-34
aroclor-1248	NA	1.03E+01	NA
aroclor-1254	NA	1.03E+01	NA
aroclor-1260	NA	1.03E+01	NA
carbazole	NA	2.22E-02	NA
endrin	NA	NA	NA
2,3,7,8-tcdd	NA	3.00E+05	NA
	ILCR Summation =		5.81E-34

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Table I.IV–21
Summary of Intake Quantitation (chemicals)
Current Land Use with Federal Ownership: Off–Property Farmer (Adult)
Via Ingestion of Meat Products

Intake Equation = $\frac{CS \times EF \times ED \times FI \times IR}{BW \times AT}$

IR	Ingestion rate of meat	0.101 kg/day
FI	Fraction ingested from contaminated source	0.75 (Unitless)
EF	Exposure frequency	350 days/year
EDn	Exposure duration for non–carcinogens	70 Year
EDc	Exposure duration for carcinogens	70 Year
BW	Body weight	70 kg
ATc	Average time for carcinogens (lifetime)	25550 days
ATn	Average time for non–carcinogens (EDn x 365)	25550 days
CS	Concentration of chemicals in meat	

Chemical Concentrations

Compound	Concentration	Units	Compound	Concentration	Units
antimony	9.7E–07	mg/kg	silver	1.2E–05	mg/kg
arsenic	3.8E–06	mg/kg	thallium	1.8E–06	mg/kg
barium	2.3E–06	mg/kg	thorium–total	4.1E–08	mg/kg
beryllium	1.2E–07	mg/kg	uranium–total	7.1E–05	mg/kg
boron	6.3E–07	mg/kg	vanadium	5.6E–06	mg/kg
cadmium	2.3E–07	mg/kg	zinc	5.4E–02	mg/kg
chromium vi	6.5E–06	mg/kg	2–methylnaphthalene	6.5E–09	mg/kg
cobalt	1.5E–05	mg/kg	4,4–dde	4.1E–09	mg/kg
copper	2.3E–04	mg/kg	aroclor–1221	3.4E–36	mg/kg
cyanide	5.1E–12	mg/kg	aroclor–1248	NA	mg/kg
lead	5.4E–05	mg/kg	aroclor–1254	1.5E–06	mg/kg
manganese	5.3E–08	mg/kg	aroclor–1260	6.3E–06	mg/kg
mercury	2.5E–05	mg/kg	carbazole	1.0E–10	mg/kg
molybdenum	2.4E–06	mg/kg	endrin	NA	mg/kg
nickel	6.6E–05	mg/kg	2,3,7,8–tcdd	9.2E–13	mg/kg
selenium	1.1E–06	mg/kg			

References

Table I.IV-21 (continued)
Summary of Risk Characterization (chemicals)
Current Land Use with Federal Ownership: Off-Property Farmer (Adult)
Via Ingestion of Meat Products

	HQ Calculation		
Compound	CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
antimony	1.0E-09	4.0E-04	2.5E-06
arsenic	3.9E-09	3.0E-04	1.3E-05
barium	2.4E-09	7.0E-02	3.4E-08
beryllium	1.3E-10	5.0E-03	2.6E-08
boron	6.5E-10	9.0E-02	7.2E-09
cadmium	2.4E-10	1.0E-03	2.4E-07
chromium vi	6.7E-09	5.0E-03	1.3E-06
cobalt	1.6E-08	6.0E-02	2.6E-07
copper	2.4E-07	NA	NA
cyanide	5.3E-15	2.0E-02	2.7E-13
lead	5.6E-08	NA	NA
manganese	5.5E-11	1.4E-01	4.0E-10
mercury	2.6E-08	3.0E-04	8.8E-05
molybdenum	2.5E-09	5.0E-03	5.0E-07
nickel	6.9E-08	2.0E-02	3.4E-06
selenium	1.1E-09	5.0E-03	2.2E-07
silver	1.2E-08	5.0E-03	2.4E-06
thallium	1.9E-09	8.0E-05	2.4E-05
thorium-total	4.2E-11	NA	NA
uranium-total	7.4E-08	3.0E-03	2.5E-05
vanadium	5.8E-09	7.0E-03	8.3E-07
zinc	5.6E-05	3.0E-01	1.9E-04
2-methylnaphthalene	6.7E-12	NA	NA
4,4-dde	4.2E-12	NA	NA
aroclor-1221	3.5E-39	NA	NA
aroclor-1248	NA	NA	NA
aroclor-1254	1.5E-09	NA	NA
aroclor-1260	6.5E-09	NA	NA
carbazole	1.1E-13	NA	NA
endrin	NA	3.0E-04	NA
2,3,7,8-tcdd	9.6E-16	NA	NA
	HQ Summation =		3.5E-04

	ILCR Calculation		
Compound	CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	ILCR (unitless)
antimony	1.0E-09	NA	NA
arsenic	3.9E-09	1.8E+00	6.8E-09
barium	2.4E-09	NA	NA
beryllium	1.3E-10	4.3E+00	5.5E-10
boron	6.5E-10	NA	NA
cadmium	2.4E-10	NA	NA
chromium vi	6.7E-09	NA	NA
cobalt	1.6E-08	NA	NA
copper	2.4E-07	NA	NA
cyanide	5.3E-15	NA	NA
lead	5.6E-08	NA	NA
manganese	5.5E-11	NA	NA
mercury	2.6E-08	NA	NA
molybdenum	2.5E-09	NA	NA
nickel	6.9E-08	NA	NA
selenium	1.1E-09	NA	NA
silver	1.2E-08	NA	NA
thallium	1.9E-09	NA	NA
thorium-total	4.2E-11	NA	NA
uranium-total	7.4E-08	NA	NA
vanadium	5.8E-09	NA	NA
zinc	5.6E-05	NA	NA
2-methylnaphthalene	6.7E-12	NA	NA
4,4-dde	4.2E-12	3.4E-01	1.4E-12
aroclor-1221	3.5E-39	7.7E+00	2.7E-38
aroclor-1248	NA	7.7E+00	NA
aroclor-1254	1.5E-09	7.7E+00	1.2E-08
aroclor-1260	6.5E-09	7.7E+00	5.0E-08
carbazole	1.1E-13	2.0E-02	2.2E-15
endrin	NA	NA	NA
2,3,7,8-tcdd	9.6E-16	1.5E+05	1.4E-10
	ILCR Summation =		6.9E-08

Table I.IV–22
Summary of Intake and Risk Quantitation (radionuclides)
Current Land Use with Federal Ownership: Off–Property Farmer (Adult)
Via Ingestion of Meat Products

Intake Equation = Cf X EF X EDn X FI X IR

IR	Ingestion rate of meat	0.101 kg/day
FI	Fraction ingested from contaminated source	0.75 (Unitless)
EF	Exposure frequency	350 days/year
EDn	Exposure duration	70 Year
Cf	Concentration of radionuclides in meat	

Cs_{137+1d}	1.2E–03	pCi/kg	Rn_{222+4d}	ERR	pCi/kg
Pb_{210+2d}	3.2E–04	pCi/kg	Sr_{90+1d}	1.2E–04	pCi/kg
Np_{237+1d}	2.2E–05	pCi/kg	Tc_{99}	1.7E+02	pCi/kg
Pu_{238}	4.5E–07	pCi/kg	Th_{228+7d}	4.2E–07	pCi/kg
Pu_{239}	1.5E–08	pCi/kg	Th_{230}	1.5E–06	pCi/kg
Pu_{240}	NA	pCi/kg	$Th_{232+10d}$	1.2E–06	pCi/kg
Pa_{231}	3.2E–07	pCi/kg	U_{234}	7.0E–04	pCi/kg
Ra_{226+8d}	3.0E–05	pCi/kg	U_{235+1d}	1.9E–05	pCi/kg
Ra_{228+1d}	2.2E–05	pCi/kg	U_{236}	7.7E–06	pCi/kg
Ru_{106}	1.1E–05	pCi/kg	U_{238+2d}	4.2E–04	pCi/kg

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	ILCR (unitless)
Cs_{137+1d}	2.3E+00	2.8E–11	6.3E–11
Pb_{210+2d}	6.0E–01	6.6E–10	3.9E–10
Np_{237+1d}	4.1E–02	2.2E–10	9.0E–12
Pu_{238}	8.4E–04	2.2E–10	1.8E–13
Pu_{239}	2.8E–05	2.3E–10	6.5E–15
Pu_{240}	NA	2.3E–10	NA
Pa_{231}	6.0E–04	9.2E–11	5.5E–14
Ra_{226+8d}	5.5E–02	7.8E–10	4.3E–11
Ra_{228+1d}	4.1E–02	1.0E–10	4.1E–12
Ru_{106}	2.1E–02	9.5E–12	2.0E–13
Rn_{222+4d}	NA	1.7E–12	NA
Sr_{90+1d}	2.3E–01	3.6E–11	8.3E–12
Tc_{99}	3.2E+05	1.3E–12	4.2E–07
Th_{228+7d}	7.8E–04	5.5E–11	4.3E–14
Th_{230}	2.7E–03	1.3E–11	3.6E–14
$Th_{232+10d}$	2.3E–03	1.7E–10	3.8E–13
U_{234}	1.3E+00	1.6E–11	2.1E–11
U_{235+1d}	3.4E–02	1.6E–11	5.5E–13
U_{236}	1.4E–02	1.5E–11	2.1E–13
U_{238+2d}	7.8E–01	2.0E–11	1.6E–11
		ILCR Summation =	4.2E–07

Table I.IV–23
Summary of Intake Quantitation (chemicals)
Current Land Use with Federal Ownership: Off–Property Farmer (Adult)
Via Ingestion of Dairy Products

Intake Equation = $\frac{CS \times EF \times ED \times FI \times IR}{BW \times AT}$

IR	Ingestion rate of dairy products	0.4 l/day
FI	Fraction ingested from contaminated source	0.75 (Unitless)
EF	Exposure frequency	350 days/year
EDn	Exposure duration for non–carcinogens	70 Year
EDc	Exposure duration for carcinogens	70 Year
BW	Body weight	70 kg
ATc	Average time for carcinogens (lifetime)	25550 days
ATn	Average time for non–carcinogens (EDn x 365)	25550 days
CS	Concentration of chemicals in animal products	

Chemical Concentrations

Compound	Concentration	Units	Compound	Concentration	Units
antimony	9.7E–08	mg/kg	silver	7.7E–05	mg/kg
arsenic	1.1E–07	mg/kg	thallium	9.2E–08	mg/kg
barium	5.4E–06	mg/kg	thorium–total	3.4E–08	mg/kg
beryllium	1.1E–10	mg/kg	uranium–total	2.5E–04	mg/kg
boron	1.2E–06	mg/kg	vanadium	4.5E–08	mg/kg
cadmium	4.3E–07	mg/kg	zinc	5.4E–03	mg/kg
chromium vi	1.8E–06	mg/kg	2–methylnaphthalene	2.1E–09	mg/kg
cobalt	1.5E–06	mg/kg	4,4–dde	1.3E–09	mg/kg
copper	3.4E–05	mg/kg	aroclor–1221	1.3E–36	mg/kg
cyanide	1.6E–12	mg/kg	aroclor–1248	NA	mg/kg
lead	4.5E–05	mg/kg	aroclor–1254	4.6E–07	mg/kg
manganese	4.7E–08	mg/kg	aroclor–1260	NA	mg/kg
mercury	NA	mg/kg	carbazole	3.3E–11	mg/kg
molybdenum	6.0E–07	mg/kg	endrin	NA	mg/kg
nickel	1.1E–05	mg/kg	2,3,7,8–tcdd	3.3E–13	mg/kg
selenium	2.9E–07	mg/kg			

References

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Table I.IV–23 (continued)
Summary of Risk Characterization (chemicals)
Current Land Use with Federal Ownership: Off–Property Farmer (Adult)
Via Ingestion of Dairy Products

Compound	HQ Calculation CDI (mg/kg–day)	RfD (mg/kg–day)	HQ (unitless)
antimony	4.0E–10	4.0E–04	1.0E–06
arsenic	4.6E–10	3.0E–04	1.5E–06
barium	2.2E–08	7.0E–02	3.2E–07
beryllium	4.6E–13	5.0E–03	9.1E–11
boron	4.8E–09	9.0E–02	5.4E–08
cadmium	1.8E–09	1.0E–03	1.8E–06
chromium vi	7.3E–09	5.0E–03	1.5E–06
cobalt	6.3E–09	6.0E–02	1.0E–07
copper	1.4E–07	NA	NA
cyanide	6.6E–15	2.0E–02	3.3E–13
lead	1.8E–07	NA	NA
manganese	1.9E–10	1.4E–01	1.4E–09
mercury	NA	3.0E–04	NA
molybdenum	2.5E–09	5.0E–03	4.9E–07
nickel	4.5E–08	2.0E–02	2.3E–06
selenium	1.2E–09	5.0E–03	2.4E–07
silver	3.2E–07	5.0E–03	6.3E–05
thallium	3.8E–10	8.0E–05	4.7E–06
thorium–total	1.4E–10	NA	NA
uranium–total	1.0E–06	3.0E–03	3.4E–04
vanadium	1.8E–10	7.0E–03	2.6E–08
zinc	2.2E–05	3.0E–01	7.4E–05
2–methylnaphthalene	8.4E–12	NA	NA
4,4–dde	5.3E–12	NA	NA
aroclor–1221	5.3E–39	NA	NA
aroclor–1248	NA	NA	NA
aroclor–1254	1.9E–09	NA	NA
aroclor–1260	NA	NA	NA
carbazole	1.3E–13	NA	NA
endrin	NA	3.0E–04	NA
2,3,7,8–tcdd	1.3E–15	NA	NA
	HQ Summation =		4.9E–04

Compound	ILCR Calculation CDI (mg/kg–day)	CSF $(mg/kg–day)^{-1}$	ILCR (unitless)
antimony	4.0E–10	NA	NA
arsenic	4.6E–10	1.8E+00	8.1E–10
barium	2.2E–08	NA	NA
beryllium	4.6E–13	4.3E+00	2.0E–12
boron	4.8E–09	NA	NA
cadmium	1.8E–09	NA	NA
chromium vi	7.3E–09	NA	NA
cobalt	6.3E–09	NA	NA
copper	1.4E–07	NA	NA
cyanide	6.6E–15	NA	NA
lead	1.8E–07	NA	NA
manganese	1.9E–10	NA	NA
mercury	NA	NA	NA
molybdenum	2.5E–09	NA	NA
nickel	4.5E–08	NA	NA
selenium	1.2E–09	NA	NA
silver	3.2E–07	NA	NA
thallium	3.8E–10	NA	NA
thorium–total	1.4E–10	NA	NA
uranium–total	1.0E–06	NA	NA
vanadium	1.8E–10	NA	NA
zinc	2.2E–05	NA	NA
2–methylnaphthalene	8.4E–12	NA	NA
4,4–dde	5.3E–12	3.4E–01	1.8E–12
aroclor–1221	5.3E–39	7.7E+00	4.1E–38
aroclor–1248	NA	7.7E+00	NA
aroclor–1254	1.9E–09	7.7E+00	1.5E–08
aroclor–1260	NA	7.7E+00	NA
carbazole	1.3E–13	2.0E–02	2.7E–15
endrin	NA	NA	NA
2,3,7,8–tcdd	1.3E–15	1.5E+05	2.0E–10
	ILCR Summation =		1.6E–08

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Table I.IV–24
Summary of Intake and Risk Quantitation (radionuclides)
Current Land Use with Federal Ownership: Off–Property Farmer (Adult)
Via Ingestion of Dairy Products

Intake Equation = Cp X EF X EDn X FI X IR

IR	Ingestion rate of dairy products	0.4 l/day
FI	Fraction ingested from contaminated source	0.75 (Unitless)
EF	Exposure frequency	350 days/year
EDn	Exposure duration	70 Year
Cp	Concentration of radionuclides in animal products	

Cs_{137+1d}	4.3E–04	pCi/kg	Rn_{222+4d}	ERR	pCi/kg
Pb_{210+2d}	2.7E–04	pCi/kg	Sr_{90+1d}	6.2E–04	pCi/kg
Np_{237+1d}	2.4E–06	pCi/kg	Tc_{99}	2.4E+02	pCi/kg
Pu_{238}	9.0E–08	pCi/kg	Th_{228+7d}	3.5E–07	pCi/kg
Pu_{239}	3.0E–09	pCi/kg	Th_{230}	1.2E–06	pCi/kg
Pu_{240}	NA	pCi/kg	$Th_{232+10d}$	1.0E–06	pCi/kg
Pa_{231}	1.6E–05	pCi/kg	U_{234}	2.1E–03	pCi/kg
Ra_{226+8d}	5.3E–05	pCi/kg	U_{235+1d}	5.6E–05	pCi/kg
Ra_{228+1d}	4.0E–05	pCi/kg	U_{236}	2.3E–05	pCi/kg
Ru_{106}	3.5E–09	pCi/kg	U_{238+2d}	1.3E–03	pCi/kg

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	ILCR (unitless)
Cs_{137+1d}	3.1E+00	2.8E–11	8.8E–11
Pb_{210+2d}	2.0E+00	6.6E–10	1.3E–09
Np_{237+1d}	1.7E–02	2.2E–10	3.8E–12
Pu_{238}	6.6E–04	2.2E–10	1.5E–13
Pu_{239}	2.2E–05	2.3E–10	5.1E–15
Pu_{240}	NA	2.3E–10	NA
Pa_{231}	1.2E–01	9.2E–11	1.1E–11
Ra_{226+8d}	3.9E–01	7.8E–10	3.1E–10
Ra_{228+1d}	2.9E–01	1.0E–10	2.9E–11
Ru_{106}	2.6E–05	9.5E–12	2.5E–16
Rn_{222+4d}	NA	1.7E–12	NA
Sr_{90+1d}	4.6E+00	3.6E–11	1.6E–10
Tc_{99}	1.8E+06	1.3E–12	2.3E–06
Th_{228+7d}	2.6E–03	5.5E–11	1.4E–13
Th_{230}	9.0E–03	1.3E–11	1.2E–13
$Th_{232+10d}$	7.5E–03	1.7E–10	1.3E–12
U_{234}	1.5E+01	1.6E–11	2.5E–10
U_{235+1d}	4.1E–01	1.6E–11	6.5E–12
U_{236}	1.7E–01	1.5E–11	2.5E–12
U_{238+2d}	9.2E+00	2.0E–11	1.8E–10
		ILCR Summation =	2.3E–06

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Table I.IV–25
Summary of Intake Quantitation (chemicals)
Current Land Use with Federal Ownership: Off–Property Farmer (Adult)
Via Ingestion of Vegetables and Fruits

Intake Equation = $\frac{CS \times EF \times ED \times FI \times IR}{BW \times AT}$

IR	Ingestion rate of fruits or vegetables	0.122 kg/day
FI	Fraction ingested from contaminated source	1 (Unitless)
EF	Exposure frequency	350 days/year
EDn	Exposure duration for non–carcinogens	70 Year
EDc	Exposure duration for carcinogens	70 Year
BW	Body weight	70 kg
ATc	Average time for carcinogens (lifetime)	25550 days
ATn	Average time for non–carcinogens (EDn x 365)	25550 days
CS	Concentration of chemicals in vegetables	

Chemical Concentrations

Compound	Concentration	Units	Compound	Concentration	Units
antimony	1.2E–05	mg/kg	silver	3.4E–05	mg/kg
arsenic	1.8E–05	mg/kg	thallium	5.0E–07	mg/kg
barium	1.6E–04	mg/kg	thorium–total	8.3E–05	mg/kg
beryllium	1.3E–06	mg/kg	uranium–total	2.8E–02	mg/kg
boron	9.5E–06	mg/kg	vanadium	2.6E–05	mg/kg
cadmium	4.1E–06	mg/kg	zinc	4.6E–03	mg/kg
chromium vi	1.4E–05	mg/kg	2–methylnaphthalene	3.3E–07	mg/kg
cobalt	8.7E–06	mg/kg	4,4–dde	4.2E–09	mg/kg
copper	2.1E–04	mg/kg	aroclor–1221	1.1E–33	mg/kg
cyanide	9.3E–07	mg/kg	aroclor–1248	NA	mg/kg
lead	2.0E–03	mg/kg	aroclor–1254	5.6E–07	mg/kg
manganese	1.2E–06	mg/kg	aroclor–1260	1.7E–07	mg/kg
mercury	9.5E–07	mg/kg	carbazole	1.6E–08	mg/kg
molybdenum	4.8E–06	mg/kg	endrin	NA	mg/kg
nickel	9.9E–05	mg/kg	2,3,7,8–tcdd	8.5E–14	mg/kg
selenium	7.3E–07	mg/kg			

References

Table I.IV–25 (continued)
Summary of Risk Characterization (chemicals)
Current Land Use with Federal Ownership: Off–Property Farmer (Adult)
Via Ingestion of Vegetables and Fruits

	HQ Calculation		
Compound	CDI (mg/kg–day)	RfD (mg/kg–day)	HQ (unitless)
antimony	2.0E–08	4.0E–04	5.1E–05
arsenic	3.0E–08	3.0E–04	1.0E–04
barium	2.7E–07	7.0E–02	3.8E–06
beryllium	2.2E–09	5.0E–03	4.4E–07
boron	1.6E–08	9.0E–02	1.8E–07
cadmium	6.8E–09	1.0E–03	6.8E–06
chromium vi	2.4E–08	5.0E–03	4.8E–06
cobalt	1.5E–08	6.0E–02	2.4E–07
copper	3.5E–07	NA	NA
cyanide	1.6E–09	2.0E–02	7.8E–08
lead	3.3E–06	NA	NA
manganese	2.0E–09	1.4E–01	1.5E–08
mercury	1.6E–09	3.0E–04	5.3E–06
molybdenum	8.0E–09	5.0E–03	1.6E–06
nickel	1.7E–07	2.0E–02	8.3E–06
selenium	1.2E–09	5.0E–03	2.4E–07
silver	5.6E–08	5.0E–03	1.1E–05
thallium	8.4E–10	8.0E–05	1.1E–05
thorium–total	1.4E–07	NA	NA
uranium–total	4.7E–05	3.0E–03	1.6E–02
vanadium	4.3E–08	7.0E–03	6.2E–06
zinc	7.8E–06	3.0E–01	2.6E–05
2–methylnaphthalene	5.4E–10	NA	NA
4,4–dde	7.0E–12	NA	NA
aroclor–1221	1.8E–36	NA	NA
aroclor–1248	NA	NA	NA
aroclor–1254	9.3E–10	NA	NA
aroclor–1260	2.9E–10	NA	NA
carbazole	2.8E–11	NA	NA
endrin	NA	3.0E–04	NA
2,3,7,8–tcdd	1.4E–16	NA	NA
	HQ Summation =		1.6E–02

	ILCR Calculation		
Compound	CDI (mg/kg–day)	CSF $(mg/kg–day)^{-1}$	ILCR (unitless)
antimony	2.0E–08	NA	NA
arsenic	3.0E–08	1.8E+00	5.2E–08
barium	2.7E–07	NA	NA
beryllium	2.2E–09	4.3E+00	9.5E–09
boron	1.6E–08	NA	NA
cadmium	6.8E–09	NA	NA
chromium vi	2.4E–08	NA	NA
cobalt	1.5E–08	NA	NA
copper	3.5E–07	NA	NA
cyanide	1.6E–09	NA	NA
lead	3.3E–06	NA	NA
manganese	2.0E–09	NA	NA
mercury	1.6E–09	NA	NA
molybdenum	8.0E–09	NA	NA
nickel	1.7E–07	NA	NA
selenium	1.2E–09	NA	NA
silver	5.6E–08	NA	NA
thallium	8.4E–10	NA	NA
thorium–total	1.4E–07	NA	NA
uranium–total	4.7E–05	NA	NA
vanadium	4.3E–08	NA	NA
zinc	7.8E–06	NA	NA
2–methylnaphthalene	5.4E–10	NA	NA
4,4–dde	7.0E–12	3.4E–01	2.4E–12
aroclor–1221	1.8E–36	7.7E+00	1.4E–35
aroclor–1248	NA	7.7E+00	NA
aroclor–1254	9.3E–10	7.7E+00	7.2E–09
aroclor–1260	2.9E–10	7.7E+00	2.2E–09
carbazole	2.8E–11	2.0E–02	5.5E–13
endrin	NA	NA	NA
2,3,7,8–tcdd	1.4E–16	1.5E+05	2.1E–11
	ILCR Summation =		7.1E–08

Table I.IV–26
Summary of Intake and Risk Quantitation (radionuclides)
Current Land Use with Federal Ownership: Off–Property Farmer (Adult)
Via Ingestion of Vegetables and Fruits

Intake Equation = Cv X EF X EDn X FI X IR

IR	Ingestion rate of fruits or vegetables	0.122 kg/day
FI	Fraction ingested from contaminated source	1 (Unitless)
EF	Exposure frequency	350 days/year
EDn	Exposure duration	70 Year
Cv	Concentration of radionuclides in vegetables	

Cs_{137+1d}	6.7E–04	pCi/kg	Rn_{222+4d}	ERR	pCi/kg
Pb_{210+2d}	1.3E–02	pCi/kg	Sr_{90+1d}	4.0E–03	pCi/kg
Np_{237+1d}	3.8E–02	pCi/kg	Tc_{99}	2.2E+03	pCi/kg
Pu_{238}	1.2E–02	pCi/kg	Th_{228+7d}	9.2E–04	pCi/kg
Pu_{239}	3.9E–04	pCi/kg	Th_{230}	3.6E–03	pCi/kg
Pu_{240}	1.4E–03	pCi/kg	$Th_{232+10d}$	3.0E–03	pCi/kg
Pa_{231}	4.1E–04	pCi/kg	U_{234}	4.6E–02	pCi/kg
Ra_{226+8d}	1.3E–03	pCi/kg	U_{235+1d}	1.2E–03	pCi/kg
Ra_{228+1d}	1.1E–03	pCi/kg	U_{236}	5.0E–04	pCi/kg
Ru_{106}	7.6E–05	pCi/kg	U_{238+2d}	2.7E–02	pCi/kg

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	ILCR (unitless)
Cs_{137+1d}	2.0E+00	2.8E–11	5.6E–11
Pb_{210+2d}	3.9E+01	6.6E–10	2.6E–08
Np_{237+1d}	1.1E+02	2.2E–10	2.5E–08
Pu_{238}	3.5E+01	2.2E–10	7.7E–09
Pu_{239}	1.2E+00	2.3E–10	2.7E–10
Pu_{240}	4.2E+00	2.3E–10	9.8E–10
Pa_{231}	1.2E+00	9.2E–11	1.1E–10
Ra_{226+8d}	4.0E+00	7.8E–10	3.1E–09
Ra_{228+1d}	3.4E+00	1.0E–10	3.4E–10
Ru_{106}	2.3E–01	9.5E–12	2.2E–12
Rn_{222+4d}	NA	1.7E–12	NA
Sr_{90+1d}	1.2E+01	3.6E–11	4.3E–10
Tc_{99}	6.7E+06	1.3E–12	8.7E–06
Th_{228+7d}	2.8E+00	5.5E–11	1.5E–10
Th_{230}	1.1E+01	1.3E–11	1.4E–10
$Th_{232+10d}$	8.9E+00	1.7E–10	1.5E–09
U_{234}	1.4E+02	1.6E–11	2.2E–09
U_{235+1d}	3.6E+00	1.6E–11	5.8E–11
U_{236}	1.5E+00	1.5E–11	2.2E–11
U_{238+2d}	8.2E+01	2.0E–11	1.6E–09
		ILCR Summation =	8.8E–06

Table I.IV–27
Summary of Intake Quantitation (chemicals)
Current Land Use with Federal Ownership: Off–Property Farmer (Child)
Via Inhalation of Particulates

Intake Equation = $\frac{CS \times EF \times ED \times IR}{BW \times AT}$

IR	Inhalation rate of gases (RAGS, 1989)	15 m^3/day
EF	Exposure frequency	350 days/year
EDn	Exposure duration for non–carcinogens	6 Year
EDc	Exposure duration for carcinogens	6 Year
BW	Body weight	15 kg
ATc	Average time for carcinogens (lifetime)	25550 days
ATn	Average time for non–carcinogens (EDn x 365)	2190 days
CS	Concentration of chemicals in soil	(see table below)

Chemical Concentrations

Compound	Concentration	Units	Compound	Concentration	Units
antimony	7.5E–09	mg/m^3	silver	2.7E–09	mg/m^3
arsenic	5.3E–09	mg/m^3	thallium	3.3E–10	mg/m^3
barium	8.2E–08	mg/m^3	thorium–total	7.5E–08	mg/m^3
beryllium	7.8E–10	mg/m^3	uranium–total	1.0E–06	mg/m^3
boron	8.5E–09	mg/m^3	vanadium	2.0E–08	mg/m^3
cadmium	1.3E–09	mg/m^3	zinc	5.1E–08	mg/m^3
chromium vi	1.2E–08	mg/m^3	2–methylnaphthalene	6.0E–11	mg/m^3
cobalt	6.3E–09	mg/m^3	4,4–dde	4.3E–12	mg/m^3
copper	3.8E–08	mg/m^3	aroclor–1221	NA	mg/m^3
cyanide	4.6E–10	mg/m^3	aroclor–1248	NA	mg/m^3
lead	1.3E–06	mg/m^3	aroclor–1254	2.7E–10	mg/m^3
manganese	2.4E–10	mg/m^3	aroclor–1260	6.4E–11	mg/m^3
mercury	2.4E–10	mg/m^3	carbazole	1.7E–11	mg/m^3
molybdenum	4.1E–09	mg/m^3	endrin	NA	mg/m^3
nickel	1.5E–08	mg/m^3	2,3,7,8–tcdd	8.8E–17	mg/m^3
selenium	3.4E–10	mg/m^3			

References

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Table I.IV-27 (continued)
Summary of Risk Characterization (chemicals)
Current Land Use with Federal Ownership: Off-Property Farmer (Child)
Via Inhalation of Particulates

Compound	HQ Calculation CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
antimony	7.2E-09	NA	NA
arsenic	5.1E-09	NA	NA
barium	7.8E-08	1.4E-04	5.5E-04
beryllium	7.5E-10	NA	NA
boron	8.1E-09	5.7E-03	1.4E-06
cadmium	1.2E-09	NA	NA
chromium vi	1.2E-08	NA	NA
cobalt	6.1E-09	3.0E-07	2.0E-02
copper	3.6E-08	NA	NA
cyanide	4.4E-10	NA	NA
lead	1.2E-06	NA	NA
manganese	2.3E-10	1.4E-05	1.7E-05
mercury	2.3E-10	8.6E-05	2.7E-06
molybdenum	3.9E-09	NA	NA
nickel	1.5E-08	NA	NA
selenium	3.2E-10	NA	NA
silver	2.6E-09	NA	NA
thallium	3.2E-10	NA	NA
thorium-total	7.2E-08	NA	NA
uranium-total	9.6E-07	NA	NA
vanadium	1.9E-08	NA	NA
zinc	4.9E-08	NA	NA
2-methylnaphthalene	5.8E-11	NA	NA
4,4-dde	4.1E-12	NA	NA
aroclor-1221	NA	NA	NA
aroclor-1248	NA	NA	NA
aroclor-1254	2.5E-10	NA	NA
aroclor-1260	6.1E-11	NA	NA
carbazole	1.6E-11	NA	NA
endrin	NA	NA	NA
2,3,7,8-tcdd	8.4E-17	NA	NA
	Hazard Quotient Sum =		2.1E-02

Compound	ILCR Calculation CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	ILCR (unitless)
antimony	6.2E-10	NA	NA
arsenic	4.4E-10	1.5E+01	6.5E-09
barium	6.7E-09	NA	NA
beryllium	6.4E-11	8.4E+00	5.4E-10
boron	7.0E-10	NA	NA
cadmium	1.1E-10	6.3E+00	6.7E-10
chromium vi	1.0E-09	4.1E+01	4.2E-08
cobalt	5.2E-10	NA	NA
copper	3.1E-09	NA	NA
cyanide	3.8E-11	NA	NA
lead	1.1E-07	NA	NA
manganese	2.0E-11	NA	NA
mercury	2.0E-11	NA	NA
molybdenum	3.3E-10	NA	NA
nickel	1.2E-09	8.4E-01	1.0E-09
selenium	2.8E-11	NA	NA
silver	2.2E-10	NA	NA
thallium	2.7E-11	NA	NA
thorium-total	6.2E-09	NA	NA
uranium-total	8.2E-08	NA	NA
vanadium	1.6E-09	NA	NA
zinc	4.2E-09	NA	NA
2-methylnaphthalene	4.9E-12	NA	NA
4,4-dde	3.5E-13	NA	NA
aroclor-1221	NA	NA	NA
aroclor-1248	NA	NA	NA
aroclor-1254	2.2E-11	NA	NA
aroclor-1260	5.3E-12	NA	NA
carbazole	1.4E-12	NA	NA
endrin	NA	NA	NA
2,3,7,8-tcdd	7.2E-18	1.5E+05	1.1E-12
	ILCR Summation =		5.1E-08

Table I.IV–28
Summary of Intake and Risk Quantitation (radionuclides)
Current Land Use with Federal Ownership: Off–Property Farmer (Child)
Via Inhalation of Gases and Particulates

Intake Equation = Ca X EF X EDn X IR

IR	Inhalation rate of gases (RAGS, 1989)	15 m^3/day
EF	Exposure frequency	350 days/year
EDn	Exposure duration	6 Year
Ca	Concentration of radionuclides in air	(see table below)

Cs_{137+1d}	4.3E–07	pCi/m^3	Rn_{222+4d}	1.3E+01	pCi/m^3
Pb_{210+2d}	1.1E–05	pCi/m^3	Sr_{90+1d}	1.4E–06	pCi/m^3
Np_{237+1d}	2.0E–07	pCi/m^3	Tc_{99}	2.3E–05	pCi/m^3
Pu_{238}	1.2E–05	pCi/m^3	Th_{228+7d}	9.5E–07	pCi/m^3
Pu_{239}	3.9E–07	pCi/m^3	Th_{230}	3.3E–06	pCi/m^3
Pu_{240}	1.4E–06	pCi/m^3	$Th_{232+10d}$	2.7E–06	pCi/m^3
Pa_{231}	4.1E–07	pCi/m^3	U_{234}	4.6E–05	pCi/m^3
Ra_{226+8d}	9.1E–07	pCi/m^3	U_{235+1d}	1.2E–06	pCi/m^3
Ra_{228+1d}	1.1E–06	pCi/m^3	U_{236}	5.1E–07	pCi/m^3
Ru_{106}	7.8E–08	pCi/m^3	U_{238+2d}	2.8E–05	pCi/m^3

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	ILCR (unitless)
Cs_{137+1d}	1.4E–02	1.9E–11	2.6E–13
Pb_{210+2d}	3.6E–01	4.0E–09	1.4E–09
Np_{237+1d}	6.2E–03	2.9E–08	1.8E–10
Pu_{238}	3.7E–01	3.9E–08	1.5E–08
Pu_{239}	1.2E–02	3.8E–08	4.7E–10
Pu_{240}	4.5E–02	3.8E–08	1.7E–09
Pa_{231}	1.3E–02	3.6E–08	4.7E–10
Ra_{226+8d}	2.9E–02	7.0E–09	2.0E–10
Ra_{228+1d}	3.6E–02	6.9E–10	2.5E–11
Ru_{106}	2.4E–03	4.4E–10	1.1E–12
Rn_{222+4d}	4.0E+05	7.7E–12	3.1E–06
Sr_{90+1d}	4.4E–02	6.2E–11	2.7E–12
Tc_{99}	7.3E–01	8.3E–12	6.0E–12
Th_{228+7d}	3.0E–02	7.8E–08	2.3E–09
Th_{230}	1.0E–01	2.9E–08	3.0E–09
$Th_{232+10d}$	8.5E–02	1.1E–07	9.4E–09
U_{234}	1.5E+00	2.6E–08	3.8E–08
U_{235+1d}	3.9E–02	2.5E–08	9.7E–10
U_{236}	1.6E–02	2.5E–08	4.0E–10
U_{238+2d}	8.8E–01	2.4E–08	2.1E–08
		ILCR Summation =	3.2E–06

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Table I.IV–29
Summary of Intake Quantitation (chemicals)
Current Land Use with Federal Ownership: Off–Property Farmer (Child)
Via Drinking Water Ingestion

Intake Equation = $\frac{CS \times EF \times ED \times IR}{BW \times AT}$

IR	Ingestion rate of groundwater (RAGS, 1989)	1 l/day
EF	Exposure frequency	350 days/year
EDn	Exposure duration for non–carcinogens	6 Year
EDc	Exposure duration for carcinogens	6 Year
BW	Body weight	15 kg
ATc	Average time for carcinogens (lifetime)	25550 days
ATn	Average time for non–carcinogens (EDn x 365)	2190 days
CS	Concentration of chemicals in groundwater	

Chemical Concentrations

Compound	Concentration	Units	Compound	Concentration	Units
antimony	3.05E–07	mg/l	silver	NA	mg/l
arsenic	NA	mg/l	thallium	NA	mg/l
barium	NA	mg/l	thorium–total	NA	mg/l
beryllium	NA	mg/l	uranium–total	5.58E–03	mg/l
boron	NA	mg/l	vanadium	NA	mg/l
cadmium	4.07E–31	mg/l	zinc	NA	mg/l
chromium vi	NA	mg/l	2–methylnaphthalene	NA	mg/l
cobalt	NA	mg/l	4,4–dde	NA	mg/l
copper	NA	mg/l	aroclor–1221	2.21E–34	mg/l
cyanide	NA	mg/l	aroclor–1248	NA	mg/l
lead	NA	mg/l	aroclor–1254	NA	mg/l
manganese	NA	mg/l	aroclor–1260	NA	mg/l
mercury	NA	mg/l	carbazole	NA	mg/l
molybdenum	NA	mg/l	endrin	NA	mg/l
nickel	NA	mg/l	2,3,7,8–tcdd	NA	mg/l
selenium	NA	mg/l			

References

Table I.IV–29 (continued)
Summary of Risk Characterization (chemicals)
Current Land Use with Federal Ownership: Off–Property Farmer (Child)
Via Drinking Water Ingestion

Compound	HQ Calculation CDI (mg/kg–day)	RfD (mg/kg–day)	HQ (unitless)
antimony	1.95E–08	4.00E–04	4.87E–05
arsenic	NA	3.00E–04	NA
barium	NA	7.00E–02	NA
beryllium	NA	5.00E–03	NA
boron	NA	9.00E–02	NA
cadmium	2.60E–32	1.00E–03	2.60E–29
chromium vi	NA	5.00E–03	NA
cobalt	NA	6.00E–02	NA
copper	NA	NA	NA
cyanide	NA	2.00E–02	NA
lead	NA	NA	NA
manganese	NA	1.40E–01	NA
mercury	NA	3.00E–04	NA
molybdenum	NA	5.00E–03	NA
nickel	NA	2.00E–02	NA
selenium	NA	5.00E–03	NA
silver	NA	5.00E–03	NA
thallium	NA	8.00E–05	NA
thorium–total	NA	NA	NA
uranium–total	3.57E–04	3.00E–03	1.19E–01
vanadium	NA	7.00E–03	NA
zinc	NA	3.00E–01	NA
2–methylnaphthalene	NA	NA	NA
4,4–dde	NA	NA	NA
aroclor–1221	1.41E–35	NA	NA
aroclor–1248	NA	NA	NA
aroclor–1254	NA	NA	NA
aroclor–1260	NA	NA	NA
carbazole	NA	NA	NA
endrin	NA	3.00E–04	NA
2,3,7,8–tcdd	NA	NA	NA
	HQ Summation =		1.19E–01

Compound	ILCR Calculation CDI (mg/kg–day)	CSF $(mg/kg–day)^{-1}$	ILCR (unitless)
antimony	1.67E–09	NA	NA
arsenic	NA	1.75E+00	NA
barium	NA	NA	NA
beryllium	NA	4.30E+00	NA
boron	NA	NA	NA
cadmium	2.23E–33	NA	NA
chromium vi	NA	NA	NA
cobalt	NA	NA	NA
copper	NA	NA	NA
cyanide	NA	NA	NA
lead	NA	NA	NA
manganese	NA	NA	NA
mercury	NA	NA	NA
molybdenum	NA	NA	NA
nickel	NA	NA	NA
selenium	NA	NA	NA
silver	NA	NA	NA
thallium	NA	NA	NA
thorium–total	NA	NA	NA
uranium–total	3.06E–05	NA	NA
vanadium	NA	NA	NA
zinc	NA	NA	NA
2–methylnaphthalene	NA	NA	NA
4,4–dde	NA	3.40E–01	NA
aroclor–1221	1.21E–36	7.70E+00	9.32E–36
aroclor–1248	NA	7.70E+00	NA
aroclor–1254	NA	7.70E+00	NA
aroclor–1260	NA	7.70E+00	NA
carbazole	NA	2.00E–02	NA
endrin	NA	NA	NA
2,3,7,8–tcdd	NA	1.50E+05	NA
	ILCR Summation =		9.32E–36

Table I.IV–30
Summary of Intake and Risk Quantitation (radionuclides)
Current Land Use with Federal Ownership: Off–Property Farmer (Child)
Via Ingestion of Drinking Water

Intake Equation = Cw X EF X EDn X FI X IR

IR	Ingestion rate of groundwater (RAGS, 1989)	1 l/day
EF	Exposure frequency	350 days/year
EDn	Exposure duration	6 Year
FI	Fractional intake for radionuclides	1 (Unitless)
Cw	Concentration of radionuclides in groundwater	(see table below)

Cs_{137+1d}	NA	pCi/l	Rn_{222+4d}	NA	pCi/l
Pb_{210+2d}	NA	pCi/l	Sr_{90+1d}	NA	pCi/l
Np_{237+1d}	7.7E−03	pCi/l	Tc_{99}	4.1E+02	pCi/l
Pu_{238}	NA	pCi/l	Th_{228+7d}	NA	pCi/l
Pu_{239}	NA	pCi/l	Th_{230}	NA	pCi/l
Pu_{240}	NA	pCi/l	$Th_{232+10d}$	NA	pCi/l
Pa_{231}	NA	pCi/l	U_{234}	9.3E+00	pCi/l
Ra_{226+8d}	NA	pCi/l	U_{235+1d}	2.5E−01	pCi/l
Ra_{228+1d}	NA	pCi/l	U_{236}	1.0E−01	pCi/l
Ru_{106}	NA	pCi/l	U_{238+2d}	5.5E+00	pCi/l

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	ILCR (unitless)
Cs_{137+1d}	NA	2.8E−11	NA
Pb_{210+2d}	NA	6.6E−10	NA
Np_{237+1d}	1.6E+01	2.2E−10	3.5E−09
Pu_{238}	NA	2.2E−10	NA
Pu_{239}	NA	2.3E−10	NA
Pu_{240}	NA	2.3E−10	NA
Pa_{231}	NA	9.2E−11	NA
Ra_{226+8d}	NA	7.8E−10	NA
Ra_{228+1d}	NA	1.0E−10	NA
Ru_{106}	NA	9.5E−12	NA
Rn_{222+4d}	NA	1.7E−12	NA
Sr_{90+1d}	NA	3.6E−11	NA
Tc_{99}	8.5E+05	1.3E−12	1.1E−06
Th_{228+7d}	NA	5.5E−11	NA
Th_{230}	NA	1.3E−11	NA
$Th_{232+10d}$	NA	1.7E−10	NA
U_{234}	1.9E+04	1.6E−11	3.1E−07
U_{235+1d}	5.2E+02	1.6E−11	8.3E−09
U_{236}	2.1E+02	1.5E−11	3.2E−09
U_{238+2d}	1.2E+04	2.0E−11	2.3E−07
		ILCR Summation =	1.7E−06

Table I.IV–31
Summary of Intake Quantitation (chemicals)
Current Land Use with Federal Ownership: Off–Property Farmer (Child)
Via Dermal Contact while Bathing

Intake Equation = $\frac{DA \times EF \times ED \times SA}{BW \times AT}$

DA	Dermal absorbed dose	csv	mg/cm^2–day
EF	Exposure frequency	350	days/year
EDn	Exposure duration for non–carcinogens	6	Year
EDc	Exposure duration for carcinogens	6	Year
BW	Body weight	15	kg
ATc	Average time for carcinogens (lifetime)	25550	days
ATn	Average time for non–carcinogens (EDn x 365)	2190	days
SA	Skin surface area available for contact	8000	cm^2

Chemical Concentrations

Compound	DA	Units	Compound	DA	Units
antimony	7.63E–13	mg/cm^2–day	silver	NA	mg/cm^2–day
arsenic	NA	mg/cm^2–day	thallium	NA	mg/cm^2–day
barium	NA	mg/cm^2–day	thorium–total	NA	mg/cm^2–day
beryllium	NA	mg/cm^2–day	uranium–total	1.40E–09	mg/cm^2–day
boron	NA	mg/cm^2–day	vanadium	NA	mg/cm^2–day
cadmium	1.02E–37	mg/cm^2–day	zinc	NA	mg/cm^2–day
chromium vi	NA	mg/cm^2–day	2–methylnaphthalene	NA	mg/cm^2–day
cobalt	NA	mg/cm^2–day	4,4–dde	NA	mg/cm^2–day
copper	NA	mg/cm^2–day	aroclor–1221	1.80E–37	mg/cm^2–day
cyanide	NA	mg/cm^2–day	aroclor–1248	NA	mg/cm^2–day
lead	NA	mg/cm^2–day	aroclor–1254	NA	mg/cm^2–day
manganese	NA	mg/cm^2–day	aroclor–1260	NA	mg/cm^2–day
mercury	NA	mg/cm^2–day	carbazole	NA	mg/cm^2–day
molybdenum	NA	mg/cm^2–day	endrin	NA	mg/cm^2–day
nickel	NA	mg/cm^2–day	2,3,7,8–tcdd	NA	mg/cm^2–day
selenium	NA	mg/cm^2–day			

References

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Table I.IV-31 (continued)
Summary of Risk Characterization (chemicals)
Current Land Use with Federal Ownership: Off-Property Farmer (Child)
Via Dermal Contact while Bathing

Compound	HQ Calculation		
	CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
antimony	3.90E-10	6.00E-05	6.50E-06
arsenic	NA	2.85E-04	NA
barium	NA	6.37E-02	NA
beryllium	NA	5.00E-03	NA
boron	NA	4.50E-03	NA
cadmium	5.20E-35	5.00E-05	1.04E-30
chromium vi	NA	2.25E-03	NA
cobalt	NA	2.70E-02	NA
copper	NA	NA	NA
cyanide	NA	NA	NA
lead	NA	NA	NA
manganese	NA	4.20E-03	NA
mercury	NA	4.50E-05	NA
molybdenum	NA	1.90E-03	NA
nickel	NA	2.00E-03	NA
selenium	NA	4.00E-03	NA
silver	NA	NA	NA
thallium	NA	8.00E-05	NA
thorium-total	NA	NA	NA
uranium-total	7.13E-07	1.50E-04	4.76E-03
vanadium	NA	3.50E-04	NA
zinc	NA	7.50E-02	NA
2-methylnaphthalene	NA	NA	NA
4,4-dde	NA	NA	NA
aroclor-1221	9.19E-35	NA	NA
aroclor-1248	NA	NA	NA
aroclor-1254	NA	NA	NA
aroclor-1260	NA	NA	NA
carbazole	NA	NA	NA
endrin	NA	2.70E-04	NA
2,3,7,8-tcdd	NA	NA	NA
	HQ Summation =		4.76E-03

Compound	ILCR Calculation		
	CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	ILCR (unitless)
antimony	3.34E-11	NA	NA
arsenic	NA	1.90E+00	NA
barium	NA	NA	NA
beryllium	NA	4.30E+00	NA
boron	NA	NA	NA
cadmium	4.46E-36	NA	NA
chromium vi	NA	NA	NA
cobalt	NA	NA	NA
copper	NA	NA	NA
cyanide	NA	NA	NA
lead	NA	NA	NA
manganese	NA	NA	NA
mercury	NA	NA	NA
molybdenum	NA	NA	NA
nickel	NA	NA	NA
selenium	NA	NA	NA
silver	NA	NA	NA
thallium	NA	NA	NA
thorium-total	NA	NA	NA
uranium-total	6.12E-08	NA	NA
vanadium	NA	NA	NA
zinc	NA	NA	NA
2-methylnaphthalene	NA	NA	NA
4,4-dde	NA	3.40E-01	NA
aroclor-1221	7.87E-36	1.03E+01	8.08E-35
aroclor-1248	NA	1.03E+01	NA
aroclor-1254	NA	1.03E+01	NA
aroclor-1260	NA	1.03E+01	NA
carbazole	NA	2.22E-02	NA
endrin	NA	NA	NA
2,3,7,8-tcdd	NA	3.00E+05	NA
	ILCR Summation =		8.08E-35

Table I.IV–32
Summary of Intake Quantitation (chemicals)
Current Land Use with Federal Ownership: Off–Property Farmer (Child)
Via Ingestion of Meat Products

Intake Equation = $\frac{CS \times EF \times ED \times FI \times IR}{BW \times AT}$

IR	Ingestion rate of meat	0.039	kg/day
FI	Fraction ingested from contaminated source	0.75	(Unitless)
EF	Exposure frequency	350	days/year
EDn	Exposure duration for non–carcinogens	6	Year
EDc	Exposure duration for carcinogens	6	Year
BW	Body weight	15	kg
ATc	Average time for carcinogens (lifetime)	25550	days
ATn	Average time for non–carcinogens (EDn x 365)	2190	days
CS	Concentration of chemicals in meat		

Chemical Concentrations

Compound	Concentration	Units	Compound	Concentration	Units
antimony	9.7E–07	mg/kg	silver	1.2E–05	mg/kg
arsenic	3.8E–06	mg/kg	thallium	1.8E–06	mg/kg
barium	2.3E–06	mg/kg	thorium–total	4.1E–08	mg/kg
beryllium	1.2E–07	mg/kg	uranium–total	7.1E–05	mg/kg
boron	6.3E–07	mg/kg	vanadium	5.6E–06	mg/kg
cadmium	2.3E–07	mg/kg	zinc	5.4E–02	mg/kg
chromium vi	6.5E–06	mg/kg	2–methylnaphthalene	6.5E–09	mg/kg
cobalt	1.5E–05	mg/kg	4,4–dde	4.1E–09	mg/kg
copper	2.3E–04	mg/kg	aroclor–1221	3.4E–36	mg/kg
cyanide	5.1E–12	mg/kg	aroclor–1248	NA	mg/kg
lead	5.4E–05	mg/kg	aroclor–1254	1.5E–06	mg/kg
manganese	5.3E–08	mg/kg	aroclor–1260	6.3E–06	mg/kg
mercury	2.5E–05	mg/kg	carbazole	1.0E–10	mg/kg
molybdenum	2.4E–06	mg/kg	endrin	NA	mg/kg
nickel	6.6E–05	mg/kg	2,3,7,8–tcdd	9.2E–13	mg/kg
selenium	1.1E–06	mg/kg			

References

Table I.IV−32 (continued)
Summary of Risk Characterization (chemicals)
Current Land Use with Federal Ownership: Off−Property Farmer (Child)
Via Ingestion of Meat Products

	HQ Calculation		
Compound	CDI (mg/kg−day)	RfD (mg/kg−day)	HQ (unitless)
antimony	1.8E−09	4.0E−04	4.5E−06
arsenic	7.0E−09	3.0E−04	2.3E−05
barium	4.3E−09	7.0E−02	6.2E−08
beryllium	2.3E−10	5.0E−03	4.6E−08
boron	1.2E−09	9.0E−02	1.3E−08
cadmium	4.4E−10	1.0E−03	4.4E−07
chromium vi	1.2E−08	5.0E−03	2.4E−06
cobalt	2.9E−08	6.0E−02	4.8E−07
copper	4.3E−07	NA	NA
cyanide	9.6E−15	2.0E−02	4.8E−13
lead	1.0E−07	NA	NA
manganese	1.0E−10	1.4E−01	7.1E−10
mercury	4.8E−08	3.0E−04	1.6E−04
molybdenum	4.5E−09	5.0E−03	8.9E−07
nickel	1.2E−07	2.0E−02	6.2E−06
selenium	2.0E−09	5.0E−03	4.0E−07
silver	2.2E−08	5.0E−03	4.3E−06
thallium	3.4E−09	8.0E−05	4.3E−05
thorium−total	7.6E−11	NA	NA
uranium−total	1.3E−07	3.0E−03	4.4E−05
vanadium	1.1E−08	7.0E−03	1.5E−06
zinc	1.0E−04	3.0E−01	3.4E−04
2−methylnaphthalene	1.2E−11	NA	NA
4,4−dde	7.6E−12	NA	NA
aroclor−1221	6.4E−39	NA	NA
aroclor−1248	NA	NA	NA
aroclor−1254	2.7E−09	NA	NA
aroclor−1260	1.2E−08	NA	NA
carbazole	1.9E−13	NA	NA
endrin	NA	3.0E−04	NA
2,3,7,8−tcdd	1.7E−15	NA	NA
	HQ Summation =		6.3E−04

	ILCR Calculation		
Compound	CDI (mg/kg−day)	CSF $(mg/kg-day)^{-1}$	ILCR (unitless)
antimony	1.6E−10	NA	NA
arsenic	6.0E−10	1.8E+00	1.1E−09
barium	3.7E−10	NA	NA
beryllium	2.0E−11	4.3E+00	8.5E−11
boron	1.0E−10	NA	NA
cadmium	3.8E−11	NA	NA
chromium vi	1.0E−09	NA	NA
cobalt	2.5E−09	NA	NA
copper	3.7E−08	NA	NA
cyanide	8.2E−16	NA	NA
lead	8.6E−09	NA	NA
manganese	8.5E−12	NA	NA
mercury	4.1E−09	NA	NA
molybdenum	3.8E−10	NA	NA
nickel	1.1E−08	NA	NA
selenium	1.7E−10	NA	NA
silver	1.8E−09	NA	NA
thallium	3.0E−10	NA	NA
thorium−total	6.5E−12	NA	NA
uranium−total	1.1E−08	NA	NA
vanadium	9.0E−10	NA	NA
zinc	8.7E−06	NA	NA
2−methylnaphthalene	1.0E−12	NA	NA
4,4−dde	6.5E−13	3.4E−01	2.2E−13
aroclor−1221	5.5E−40	7.7E+00	4.2E−39
aroclor−1248	NA	7.7E+00	NA
aroclor−1254	2.3E−10	7.7E+00	1.8E−09
aroclor−1260	1.0E−09	7.7E+00	7.7E−09
carbazole	1.7E−14	2.0E−02	3.3E−16
endrin	NA	NA	NA
2,3,7,8−tcdd	1.5E−16	1.5E+05	2.2E−11
	ILCR Summation =		1.1E−08

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Table I.IV–33
Summary of Intake and Risk Quantitation (radionuclides)
Current Land Use with Federal Ownership: Off–Property Farmer (Child)
Via Ingestion of Meat Products

Intake Equation = Cf X EF X EDn X FI X IR

IR	Ingestion rate of meat	0.039 kg/day
FI	Fraction ingested from contaminated source	0.75 (Unitless)
EF	Exposure frequency	350 days/year
EDn	Exposure duration	6 Year
Cf	Concentration of radionuclides in meat	

Cs_{137+1d}	1.2E–03	pCi/kg	Rn_{222+4d}	ERR	pCi/kg
Pb_{210+2d}	3.2E–04	pCi/kg	Sr_{90+1d}	1.2E–04	pCi/kg
Np_{237+1d}	2.2E–05	pCi/kg	Tc_{99}	1.7E+02	pCi/kg
Pu_{238}	4.5E–07	pCi/kg	Th_{228+7d}	4.2E–07	pCi/kg
Pu_{239}	1.5E–08	pCi/kg	Th_{230}	1.5E–06	pCi/kg
Pu_{240}	NA	pCi/kg	$Th_{232+10d}$	1.2E–06	pCi/kg
Pa_{231}	3.2E–07	pCi/kg	U_{234}	7.0E–04	pCi/kg
Ra_{226+8d}	3.0E–05	pCi/kg	U_{235+1d}	1.9E–05	pCi/kg
Ra_{228+1d}	2.2E–05	pCi/kg	U_{236}	7.7E–06	pCi/kg
Ru_{106}	1.1E–05	pCi/kg	U_{238+2d}	4.2E–04	pCi/kg

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	ILCR (unitless)
Cs_{137+1d}	7.5E–02	2.8E–11	2.1E–12
Pb_{210+2d}	2.0E–02	6.6E–10	1.3E–11
Np_{237+1d}	1.3E–03	2.2E–10	3.0E–13
Pu_{238}	2.8E–05	2.2E–10	6.1E–15
Pu_{239}	9.3E–07	2.3E–10	2.1E–16
Pu_{240}	NA	2.3E–10	NA
Pa_{231}	2.0E–05	9.2E–11	1.8E–15
Ra_{226+8d}	1.8E–03	7.8E–10	1.4E–12
Ra_{228+1d}	1.3E–03	1.0E–10	1.3E–13
Ru_{106}	7.0E–04	9.5E–12	6.6E–15
Rn_{222+4d}	NA	1.7E–12	NA
Sr_{90+1d}	7.6E–03	3.6E–11	2.7E–13
Tc_{99}	1.1E+04	1.3E–12	1.4E–08
Th_{228+7d}	2.6E–05	5.5E–11	1.4E–15
Th_{230}	9.1E–05	1.3E–11	1.2E–15
$Th_{232+10d}$	7.5E–05	1.7E–10	1.3E–14
U_{234}	4.3E–02	1.6E–11	6.9E–13
U_{235+1d}	1.1E–03	1.6E–11	1.8E–14
U_{236}	4.7E–04	1.5E–11	7.1E–15
U_{238+2d}	2.6E–02	2.0E–11	5.1E–13
		ILCR Summation =	1.4E–08

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Table I.IV–34
Summary of Intake Quantitation (chemicals)
Current Land Use with Federal Ownership: Off–Property Farmer (Child)
Via Ingestion of Dairy Products

Intake Equation = $\frac{CS \times EF \times ED \times FI \times IR}{BW \times AT}$

IR	Ingestion rate of dairy products	0.9 l/day
FI	Fraction ingested from contaminated source	0.75 (Unitless)
EF	Exposure frequency	350 days/year
EDn	Exposure duration for non–carcinogens	6 Year
EDc	Exposure duration for carcinogens	6 Year
BW	Body weight	15 kg
ATc	Average time for carcinogens (lifetime)	25550 days
ATn	Average time for non–carcinogens (EDn x 365)	2190 days
CS	Concentration of chemicals in animal products	

Chemical Concentrations

Compound	Concentration	Units	Compound	Concentration	Units
antimony	9.7E–08	mg/kg	silver	7.7E–05	mg/kg
arsenic	1.1E–07	mg/kg	thallium	9.2E–08	mg/kg
barium	5.4E–06	mg/kg	thorium–total	3.4E–08	mg/kg
beryllium	1.1E–10	mg/kg	uranium–total	2.5E–04	mg/kg
boron	1.2E–06	mg/kg	vanadium	4.5E–08	mg/kg
cadmium	4.3E–07	mg/kg	zinc	5.4E–03	mg/kg
chromium vi	1.8E–06	mg/kg	2–methylnaphthalene	2.1E–09	mg/kg
cobalt	1.5E–06	mg/kg	4,4–dde	1.3E–09	mg/kg
copper	3.4E–05	mg/kg	aroclor–1221	1.3E–36	mg/kg
cyanide	1.6E–12	mg/kg	aroclor–1248	NA	mg/kg
lead	4.5E–05	mg/kg	aroclor–1254	4.6E–07	mg/kg
manganese	4.7E–08	mg/kg	aroclor–1260	NA	mg/kg
mercury	NA	mg/kg	carbazole	3.3E–11	mg/kg
molybdenum	6.0E–07	mg/kg	endrin	NA	mg/kg
nickel	1.1E–05	mg/kg	2,3,7,8–tcdd	3.3E–13	mg/kg
selenium	2.9E–07	mg/kg			

References

Table I.IV–34 (continued)
Summary of Risk Characterization (chemicals)
Current Land Use with Federal Ownership: Off–Property Farmer (Child)
Via Ingestion of Dairy Products

	HQ Calculation		
Compound	CDI (mg/kg–day)	RfD (mg/kg–day)	HQ (unitless)
antimony	4.2E–09	4.0E–04	1.0E–05
arsenic	4.9E–09	3.0E–04	1.6E–05
barium	2.3E–07	7.0E–02	3.3E–06
beryllium	4.8E–12	5.0E–03	9.6E–10
boron	5.1E–08	9.0E–02	5.6E–07
cadmium	1.8E–08	1.0E–03	1.8E–05
chromium vi	7.6E–08	5.0E–03	1.5E–05
cobalt	6.6E–08	6.0E–02	1.1E–06
copper	1.5E–06	NA	NA
cyanide	7.0E–14	2.0E–02	3.5E–12
lead	1.9E–06	NA	NA
manganese	2.0E–09	1.4E–01	1.4E–08
mercury	NA	3.0E–04	NA
molybdenum	2.6E–08	5.0E–03	5.2E–06
nickel	4.8E–07	2.0E–02	2.4E–05
selenium	1.2E–08	5.0E–03	2.5E–06
silver	3.3E–06	5.0E–03	6.6E–04
thallium	4.0E–09	8.0E–05	5.0E–05
thorium–total	1.5E–09	NA	NA
uranium–total	1.1E–05	3.0E–03	3.5E–03
vanadium	1.9E–09	7.0E–03	2.8E–07
zinc	2.3E–04	3.0E–01	7.8E–04
2–methylnaphthalene	8.9E–11	NA	NA
4,4–dde	5.5E–11	NA	NA
aroclor–1221	5.6E–38	NA	NA
aroclor–1248	NA	NA	NA
aroclor–1254	2.0E–08	NA	NA
aroclor–1260	NA	NA	NA
carbazole	1.4E–12	NA	NA
endrin	NA	3.0E–04	NA
2,3,7,8–tcdd	1.4E–14	NA	NA
	HQ Summation =		5.1E–03

	ILCR Calculation		
Compound	CDI (mg/kg–day)	CSF $(mg/kg–day)^{-1}$	ILCR (unitless)
antimony	3.6E–10	NA	NA
arsenic	4.2E–10	1.8E+00	7.3E–10
barium	2.0E–08	NA	NA
beryllium	4.1E–13	4.3E+00	1.8E–12
boron	4.3E–09	NA	NA
cadmium	1.6E–09	NA	NA
chromium vi	6.5E–09	NA	NA
cobalt	5.7E–09	NA	NA
copper	1.3E–07	NA	NA
cyanide	6.0E–15	NA	NA
lead	1.7E–07	NA	NA
manganese	1.7E–10	NA	NA
mercury	NA	NA	NA
molybdenum	2.2E–09	NA	NA
nickel	4.1E–08	NA	NA
selenium	1.1E–09	NA	NA
silver	2.8E–07	NA	NA
thallium	3.4E–10	NA	NA
thorium–total	1.2E–10	NA	NA
uranium–total	9.1E–07	NA	NA
vanadium	1.7E–10	NA	NA
zinc	2.0E–05	NA	NA
2–methylnaphthalene	7.6E–12	NA	NA
4,4–dde	4.7E–12	3.4E–01	1.6E–12
aroclor–1221	4.8E–39	7.7E+00	3.7E–38
aroclor–1248	NA	7.7E+00	NA
aroclor–1254	1.7E–09	7.7E+00	1.3E–08
aroclor–1260	NA	7.7E+00	NA
carbazole	1.2E–13	2.0E–02	2.4E–15
endrin	NA	NA	NA
2,3,7,8–tcdd	1.2E–15	1.5E+05	1.8E–10
	ILCR Summation =		1.4E–08

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Table I.IV–35
Summary of Intake and Risk Quantitation (radionuclides)
Current Land Use with Federal Ownership: Off–Property Farmer (Child)
Via Ingestion of Dairy Products

Intake Equation = Cp X EF X EDn X FI X IR

IR	Ingestion rate of dairy products	0.9 l/day
FI	Fraction ingested from contaminated source	0.75 (Unitless)
EF	Exposure frequency	350 days/year
EDn	Exposure duration	6 Year
Cp	Concentration of radionuclides in animal products	

Cs_{137+1d}	4.3E–04	pCi/kg	Rn_{222+4d}	ERR	pCi/kg
Pb_{210+2d}	2.7E–04	pCi/kg	Sr_{90+1d}	6.2E–04	pCi/kg
Np_{237+1d}	2.4E–06	pCi/kg	Tc_{99}	2.4E+02	pCi/kg
Pu_{238}	9.0E–08	pCi/kg	Th_{228+7d}	3.5E–07	pCi/kg
Pu_{239}	3.0E–09	pCi/kg	Th_{230}	1.2E–06	pCi/kg
Pu_{240}	NA	pCi/kg	$Th_{232+10d}$	1.0E–06	pCi/kg
Pa_{231}	1.6E–05	pCi/kg	U_{234}	2.1E–03	pCi/kg
Ra_{226+8d}	5.3E–05	pCi/kg	U_{235+1d}	5.6E–05	pCi/kg
Ra_{228+1d}	4.0E–05	pCi/kg	U_{236}	2.3E–05	pCi/kg
Ru_{106}	3.5E–09	pCi/kg	U_{238+2d}	1.3E–03	pCi/kg

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	ILCR (unitless)
Cs_{137+1d}	6.0E–01	2.8E–11	1.7E–11
Pb_{210+2d}	3.8E–01	6.6E–10	2.5E–10
Np_{237+1d}	3.4E–03	2.2E–10	7.4E–13
Pu_{238}	1.3E–04	2.2E–10	2.8E–14
Pu_{239}	4.3E–06	2.3E–10	9.9E–16
Pu_{240}	NA	2.3E–10	NA
Pa_{231}	2.3E–02	9.2E–11	2.1E–12
Ra_{226+8d}	7.6E–02	7.8E–10	5.9E–11
Ra_{228+1d}	5.6E–02	1.0E–10	5.6E–12
Ru_{106}	5.0E–06	9.5E–12	4.7E–17
Rn_{222+4d}	NA	1.7E–12	NA
Sr_{90+1d}	8.8E–01	3.6E–11	3.2E–11
Tc_{99}	3.5E+05	1.3E–12	4.5E–07
Th_{228+7d}	5.0E–04	5.5E–11	2.8E–14
Th_{230}	1.7E–03	1.3E–11	2.3E–14
$Th_{232+10d}$	1.4E–03	1.7E–10	2.4E–13
U_{234}	3.0E+00	1.6E–11	4.7E–11
U_{235+1d}	7.9E–02	1.6E–11	1.3E–12
U_{236}	3.3E–02	1.5E–11	4.9E–13
U_{238+2d}	1.8E+00	2.0E–11	3.6E–11
		ILCR Summation =	4.5E–07

Table I.IV–36
Summary of Intake Quantitation (chemicals)
Current Land Use with Federal Ownership: Off–Property Farmer (Child)
Via Ingestion of Vegetables and Fruits

Intake Equation = $\frac{CS \times EF \times ED \times FI \times IR}{BW \times AT}$

IR	Ingestion rate of fruits or vegetables	0.1 kg/day
FI	Fraction ingested from contaminated source	1 (Unitless)
EF	Exposure frequency	350 days/year
EDn	Exposure duration for non–carcinogens	6 Year
EDc	Exposure duration for carcinogens	6 Year
BW	Body weight	15 kg
ATc	Average time for carcinogens (lifetime)	25550 days
ATn	Average time for non–carcinogens (EDn x 365)	2190 days
CS	Concentration of chemicals in vegetables	

Chemical Concentrations

Compound	Concentration	Units	Compound	Concentration	Units
antimony	1.2E–05	mg/kg	silver	3.4E–05	mg/kg
arsenic	1.8E–05	mg/kg	thallium	5.0E–07	mg/kg
barium	1.6E–04	mg/kg	thorium–total	8.3E–05	mg/kg
beryllium	1.3E–06	mg/kg	uranium–total	2.8E–02	mg/kg
boron	9.5E–06	mg/kg	vanadium	2.6E–05	mg/kg
cadmium	4.1E–06	mg/kg	zinc	4.6E–03	mg/kg
chromium vi	1.4E–05	mg/kg	2–methylnaphthalene	3.3E–07	mg/kg
cobalt	8.7E–06	mg/kg	4,4–dde	4.2E–09	mg/kg
copper	2.1E–04	mg/kg	aroclor–1221	1.1E–33	mg/kg
cyanide	9.3E–07	mg/kg	aroclor–1248	NA	mg/kg
lead	2.0E–03	mg/kg	aroclor–1254	5.6E–07	mg/kg
manganese	1.2E–06	mg/kg	aroclor–1260	1.7E–07	mg/kg
mercury	9.5E–07	mg/kg	carbazole	1.6E–08	mg/kg
molybdenum	4.8E–06	mg/kg	endrin	NA	mg/kg
nickel	9.9E–05	mg/kg	2,3,7,8–tcdd	8.5E–14	mg/kg
selenium	7.3E–07	mg/kg			

References

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Table I.IV–36 (continued)
Summary of Risk Characterization (chemicals)
Current Land Use with Federal Ownership: Off–Property Farmer (Child)
Via Ingestion of Vegetables and Fruits

Compound	HQ Calculation CDI (mg/kg–day)	RfD (mg/kg–day)	HQ (unitless)
antimony	7.8E–08	4.0E–04	1.9E–04
arsenic	1.1E–07	3.0E–04	3.8E–04
barium	1.0E–06	7.0E–02	1.5E–05
beryllium	8.4E–09	5.0E–03	1.7E–06
boron	6.1E–08	9.0E–02	6.8E–07
cadmium	2.6E–08	1.0E–03	2.6E–05
chromium vi	9.1E–08	5.0E–03	1.8E–05
cobalt	5.5E–08	6.0E–02	9.2E–07
copper	1.3E–06	NA	NA
cyanide	6.0E–09	2.0E–02	3.0E–07
lead	1.3E–05	NA	NA
manganese	7.8E–09	1.4E–01	5.6E–08
mercury	6.1E–09	3.0E–04	2.0E–05
molybdenum	3.1E–08	5.0E–03	6.1E–06
nickel	6.4E–07	2.0E–02	3.2E–05
selenium	4.6E–09	5.0E–03	9.3E–07
silver	2.2E–07	5.0E–03	4.3E–05
thallium	3.2E–09	8.0E–05	4.0E–05
thorium–total	5.3E–07	NA	NA
uranium–total	1.8E–04	3.0E–03	6.0E–02
vanadium	1.7E–07	7.0E–03	2.4E–05
zinc	3.0E–05	3.0E–01	9.9E–05
2–methylnaphthalene	2.1E–09	NA	NA
4,4–dde	2.7E–11	NA	NA
aroclor–1221	7.0E–36	NA	NA
aroclor–1248	NA	NA	NA
aroclor–1254	3.6E–09	NA	NA
aroclor–1260	1.1E–09	NA	NA
carbazole	1.1E–10	NA	NA
endrin	NA	3.0E–04	NA
2,3,7,8–tcdd	5.5E–16	NA	NA
	HQ Summation =		6.1E–02

Compound	ILCR Calculation CDI (mg/kg–day)	CSF (mg/kg–day)$^{-1}$	ILCR (unitless)
antimony	6.7E–09	NA	NA
arsenic	9.8E–09	1.8E+00	1.7E–08
barium	8.8E–08	NA	NA
beryllium	7.2E–10	4.3E+00	3.1E–09
boron	5.2E–09	NA	NA
cadmium	2.2E–09	NA	NA
chromium vi	7.8E–09	NA	NA
cobalt	4.8E–09	NA	NA
copper	1.1E–07	NA	NA
cyanide	5.1E–10	NA	NA
lead	1.1E–06	NA	NA
manganese	6.7E–10	NA	NA
mercury	5.2E–10	NA	NA
molybdenum	2.6E–09	NA	NA
nickel	5.4E–08	NA	NA
selenium	4.0E–10	NA	NA
silver	1.9E–08	NA	NA
thallium	2.8E–10	NA	NA
thorium–total	4.5E–08	NA	NA
uranium–total	1.5E–05	NA	NA
vanadium	1.4E–08	NA	NA
zinc	2.5E–06	NA	NA
2–methylnaphthalene	1.8E–10	NA	NA
4,4–dde	2.3E–12	3.4E–01	7.8E–13
aroclor–1221	6.0E–37	7.7E+00	4.6E–36
aroclor–1248	NA	7.7E+00	NA
aroclor–1254	3.0E–10	7.7E+00	2.3E–09
aroclor–1260	9.5E–11	7.7E+00	7.3E–10
carbazole	9.0E–12	2.0E–02	1.8E–13
endrin	NA	NA	NA
2,3,7,8–tcdd	4.7E–17	1.5E+05	7.0E–12
	ILCR Summation =		2.3E–08

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Table I.IV–37
Summary of Intake and Risk Quantitation (radionuclides)
Current Land Use with Federal Ownership: Off–Property Farmer (Child)
Via Ingestion of Vegetables and Fruits

Intake Equation = Cv X EF X EDn X FI X IR

IR	Ingestion rate of fruits or vegetables	0.1 kg/day
FI	Fraction ingested from contaminated source	1 (Unitless)
EF	Exposure frequency	350 days/year
EDn	Exposure duration	6 Year
Cv	Concentration of radionuclides in vegetables	

Cs_{137+1d}	6.7E–04	pCi/kg	Rn_{222+4d}	ERR	pCi/kg
Pb_{210+2d}	1.3E–02	pCi/kg	Sr_{90+1d}	4.0E–03	pCi/kg
Np_{237+1d}	3.8E–02	pCi/kg	Tc_{99}	2.2E+03	pCi/kg
Pu_{238}	1.2E–02	pCi/kg	Th_{228+7d}	9.2E–04	pCi/kg
Pu_{239}	3.9E–04	pCi/kg	Th_{230}	3.6E–03	pCi/kg
Pu_{240}	1.4E–03	pCi/kg	$Th_{232+10d}$	3.0E–03	pCi/kg
Pa_{231}	4.1E–04	pCi/kg	U_{234}	4.6E–02	pCi/kg
Ra_{226+8d}	1.3E–03	pCi/kg	U_{235+1d}	1.2E–03	pCi/kg
Ra_{228+1d}	1.1E–03	pCi/kg	U_{236}	5.0E–04	pCi/kg
Ru_{106}	7.6E–05	pCi/kg	U_{238+2d}	2.7E–02	pCi/kg

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	ILCR (unitless)
Cs_{137+1d}	1.4E–01	2.8E–11	3.9E–12
Pb_{210+2d}	2.7E+00	6.6E–10	1.8E–09
Np_{237+1d}	7.9E+00	2.2E–10	1.7E–09
Pu_{238}	2.5E+00	2.2E–10	5.4E–10
Pu_{239}	8.2E–02	2.3E–10	1.9E–11
Pu_{240}	3.0E–01	2.3E–10	6.9E–11
Pa_{231}	8.7E–02	9.2E–11	8.0E–12
Ra_{226+8d}	2.8E–01	7.8E–10	2.2E–10
Ra_{228+1d}	2.4E–01	1.0E–10	2.4E–11
Ru_{106}	1.6E–02	9.5E–12	1.5E–13
Rn_{222+4d}	NA	1.7E–12	NA
Sr_{90+1d}	8.4E–01	3.6E–11	3.0E–11
Tc_{99}	4.7E+05	1.3E–12	6.1E–07
Th_{228+7d}	1.9E–01	5.5E–11	1.1E–11
Th_{230}	7.6E–01	1.3E–11	9.9E–12
$Th_{232+10d}$	6.3E–01	1.7E–10	1.1E–10
U_{234}	9.6E+00	1.6E–11	1.5E–10
U_{235+1d}	2.5E–01	1.6E–11	4.1E–12
U_{236}	1.1E–01	1.5E–11	1.6E–12
U_{238+2d}	5.7E+00	2.0E–11	1.1E–10
		ILCR Summation =	6.2E–07

INTAKE AND RISK CALCULATIONS:
FUTURE LAND USE WITH FEDERAL OWNERSHIP SCENARIO

Table I.IV–38
Summary of Intake Quantitation (chemicals)
Future Land Use with Federal Ownership: Trespassing Child
Via Inhalation of Particulates

Intake Equation = $\frac{CS \times EF \times ED \times IR}{BW \times AT}$

IR	Inhalation rate of gases (RAGS, 1989)	3.3 m^3/day
EF	Exposure frequency	52 days/year
EDn	Exposure duration for non–carcinogens	12 Year
EDc	Exposure duration for carcinogens	12 Year
BW	Body weight	43 kg
ATc	Average time for carcinogens (lifetime)	25550 days
ATn	Average time for non–carcinogens (EDn x 365)	4380 days
CS	Concentration of chemicals in soil	(see table below)

Chemical Concentrations

Compound	Concentration	Units	Compound	Concentration	Units
antimony	2.8E–09	mg/m^3	silver	1.9E–09	mg/m^3
arsenic	4.2E–09	mg/m^3	thallium	1.9E–10	mg/m^3
barium	4.3E–08	mg/m^3	thorium–total	2.3E–08	mg/m^3
beryllium	5.0E–10	mg/m^3	uranium–total	4.5E–07	mg/m^3
boron	5.0E–09	mg/m^3	vanadium	9.6E–09	mg/m^3
cadmium	1.0E–09	mg/m^3	zinc	2.4E–08	mg/m^3
chromium vi	7.1E–09	mg/m^3	2–methylnaphthalene	4.5E–11	mg/m^3
cobalt	4.1E–09	mg/m^3	4,4–dde	9.7E–13	mg/m^3
copper	1.5E–08	mg/m^3	aroclor–1221	0.0E+00	mg/m^3
cyanide	2.1E–10	mg/m^3	aroclor–1248	0.0E+00	mg/m^3
lead	4.9E–07	mg/m^3	aroclor–1254	1.9E–10	mg/m^3
manganese	1.3E–10	mg/m^3	aroclor–1260	5.5E–11	mg/m^3
mercury	1.3E–10	mg/m^3	carbazole	1.1E–11	mg/m^3
molybdenum	2.2E–09	mg/m^3	endrin	0.0E+00	mg/m^3
nickel	8.2E–09	mg/m^3	2,3,7,8–tcdd	4.1E–17	mg/m^3
selenium	2.7E–10	mg/m^3			

References

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Table I.IV−38 (continued)
Summary of Risk Characterization (chemicals)
Future Land Use with Federal Ownership: Trespassing Child
Via Inhalation of Particulates

	HQ Calculation		
Compound	CDI (mg/kg−day)	RfD (mg/kg−day)	HQ (unitless)
antimony	3.1E−11	NA	NA
arsenic	4.6E−11	NA	NA
barium	4.7E−10	1.4E−04	3.3E−06
beryllium	5.5E−12	NA	NA
boron	5.4E−11	5.7E−03	9.5E−09
cadmium	1.1E−11	NA	NA
chromium vi	7.7E−11	NA	NA
cobalt	4.4E−11	3.0E−07	1.5E−04
copper	1.6E−10	NA	NA
cyanide	2.3E−12	NA	NA
lead	5.3E−09	NA	NA
manganese	1.4E−12	1.4E−05	1.0E−07
mercury	1.4E−12	8.6E−05	1.7E−08
molybdenum	2.4E−11	NA	NA
nickel	9.0E−11	NA	NA
selenium	3.0E−12	NA	NA
silver	2.1E−11	NA	NA
thallium	2.0E−12	NA	NA
thorium−total	2.5E−10	NA	NA
uranium−total	4.9E−09	NA	NA
vanadium	1.1E−10	NA	NA
zinc	2.6E−10	NA	NA
2−methylnaphthalene	4.9E−13	NA	NA
4,4−dde	1.1E−14	NA	NA
aroclor−1221	NA	NA	NA
aroclor−1248	NA	NA	NA
aroclor−1254	2.1E−12	NA	NA
aroclor−1260	6.0E−13	NA	NA
carbazole	1.2E−13	NA	NA
endrin	NA	NA	NA
2,3,7,8−tcdd	4.5E−19	NA	NA
	Hazard Quotient Sum =		1.5E−04

	ILCR Calculation		
Compound	CDI (mg/kg−day)	CSF $(mg/kg-day)^{-1}$	ILCR (unitless)
antimony	5.3E−12	NA	NA
arsenic	7.8E−12	1.5E+01	1.2E−10
barium	8.0E−11	NA	NA
beryllium	9.4E−13	8.4E+00	7.9E−12
boron	9.3E−12	NA	NA
cadmium	1.9E−12	6.3E+00	1.2E−11
chromium vi	1.3E−11	4.1E+01	5.4E−10
cobalt	7.6E−12	NA	NA
copper	2.7E−11	NA	NA
cyanide	4.0E−13	NA	NA
lead	9.1E−10	NA	NA
manganese	2.4E−13	NA	NA
mercury	2.4E−13	NA	NA
molybdenum	4.1E−12	NA	NA
nickel	1.5E−11	8.4E−01	1.3E−11
selenium	5.1E−13	NA	NA
silver	3.6E−12	NA	NA
thallium	3.5E−13	NA	NA
thorium−total	4.2E−11	NA	NA
uranium−total	8.4E−10	NA	NA
vanadium	1.8E−11	NA	NA
zinc	4.5E−11	NA	NA
2−methylnaphthalene	8.4E−14	NA	NA
4,4−dde	1.8E−15	NA	NA
aroclor−1221	NA	NA	NA
aroclor−1248	NA	NA	NA
aroclor−1254	3.6E−13	NA	NA
aroclor−1260	1.0E−13	NA	NA
carbazole	2.1E−14	NA	NA
endrin	NA	NA	NA
2,3,7,8−tcdd	7.7E−20	1.5E+05	1.2E−14
	ILCR Summation =		6.9E−10

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Table I.IV–39
Summary of Intake and Risk Quantitation (radionuclides)
Future Land Use with Federal Ownership: Trespassing Child
Via Inhalation of Gases and Particulates

Intake Equation = Ca X EF X EDn X IR

IR	Inhalation rate of gases (RAGS, 1989)	3.3 m^3/day
EF	Exposure frequency	52 days/year
EDn	Exposure duration	12 Year
Ca	Concentration of radionuclides in air	(see table below)

Cs_{137+1d}	3.0E−07	pCi/m^3	Rn_{222+4d}	6.6E+00	pCi/m^3
Pb_{210+2d}	1.1E−06	pCi/m^3	Sr_{90+1d}	6.5E−07	pCi/m^3
Np_{237+1d}	1.0E−07	pCi/m^3	Tc_{99}	2.9E−06	pCi/m^3
Pu_{238}	9.7E−07	pCi/m^3	Th_{228+7d}	5.8E−07	pCi/m^3
Pu_{239}	2.2E−07	pCi/m^3	Th_{230}	1.6E−06	pCi/m^3
Pu_{240}	7.9E−07	pCi/m^3	$Th_{232+10d}$	9.3E−07	pCi/m^3
Pa_{231}	7.0E−08	pCi/m^3	U_{234}	1.7E−05	pCi/m^3
Ra_{226+8d}	4.8E−07	pCi/m^3	U_{235+1d}	4.6E−07	pCi/m^3
Ra_{228+1d}	7.0E−07	pCi/m^3	U_{236}	1.9E−07	pCi/m^3
Ru_{106}	8.4E−08	pCi/m^3	U_{238+2d}	1.0E−05	pCi/m^3

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	ILCR (unitless)
Cs_{137+1d}	6.2E−04	1.9E−11	1.2E−14
Pb_{210+2d}	2.2E−03	4.0E−09	8.8E−12
Np_{237+1d}	2.1E−04	2.9E−08	6.0E−12
Pu_{238}	2.0E−03	3.9E−08	7.8E−11
Pu_{239}	4.5E−04	3.8E−08	1.7E−11
Pu_{240}	1.6E−03	3.8E−08	6.2E−11
Pa_{231}	1.4E−04	3.6E−08	5.2E−12
Ra_{226+8d}	9.9E−04	7.0E−09	6.9E−12
Ra_{228+1d}	1.4E−03	6.9E−10	9.9E−13
Ru_{106}	1.7E−04	4.4E−10	7.6E−14
Rn_{222+4d}	1.4E+04	7.7E−12	1.0E−07
Sr_{90+1d}	1.3E−03	6.2E−11	8.3E−14
Tc_{99}	6.0E−03	8.3E−12	5.0E−14
Th_{228+7d}	1.2E−03	7.8E−08	9.3E−11
Th_{230}	3.3E−03	2.9E−08	9.5E−11
$Th_{232+10d}$	1.9E−03	1.1E−07	2.1E−10
U_{234}	3.5E−02	2.6E−08	9.2E−10
U_{235+1d}	9.4E−04	2.5E−08	2.3E−11
U_{236}	3.9E−04	2.5E−08	9.7E−12
U_{238+2d}	2.1E−02	2.4E−08	5.1E−10
		ILCR Summation =	1.1E−07

000513

Table I.IV–40
Summary of Intake Quantitation (chemicals)
Future Land Use with Federal Ownership: Trespassing Child
Via Incidental Ingestion of Soil

Intake Equation = $\frac{CS \times EF \times ED \times CF \times IR}{BW \times AT}$

IRs	Ingestion rate of soil (RAGS, 1989)	200 mg/day
CF	Conversion factor	1.0E–06 kg/mg
EF	Exposure frequency	52 days/year
EDn	Exposure duration for non–carcinogens	12 Year
EDc	Exposure duration for carcinogens	12 Year
BW	Body weight	43 kg
ATc	Average time for carcinogens (lifetime)	25550 days
ATn	Average time for non–carcinogens (EDn x 365)	4380 days
CS	Concentration of chemicals in soil	(see table below)

Chemical Concentrations

Compound	Concentration	Units	Compound	Concentration	Units
antimony	5.4E+00	mg/kg	silver	6.0E+00	mg/kg
arsenic	5.1E+00	mg/kg	thallium	5.6E–01	mg/kg
barium	9.7E+01	mg/kg	thorium–total	0.0E+00	mg/kg
beryllium	7.6E–01	mg/kg	uranium–total	0.0E+00	mg/kg
boron	1.1E+02	mg/kg	vanadium	2.6E+01	mg/kg
cadmium	3.5E+00	mg/kg	zinc	6.4E+01	mg/kg
chromium vi	1.6E+01	mg/kg	2–methylnaphthalene	0.0E+00	mg/kg
cobalt	1.2E+01	mg/kg	4,4–dde	0.0E+00	mg/kg
copper	2.0E+01	mg/kg	aroclor–1221	0.0E+00	mg/kg
cyanide	2.5E–01	mg/kg	aroclor–1248	0.0E+00	mg/kg
lead	2.4E+01	mg/kg	aroclor–1254	0.0E+00	mg/kg
manganese	9.8E+02	mg/kg	aroclor–1260	0.0E+00	mg/kg
mercury	2.1E–01	mg/kg	carbazole	0.0E+00	mg/kg
molybdenum	6.5E+00	mg/kg	endrin	0.0E+00	mg/kg
nickel	2.3E+01	mg/kg	2,3,7,8–tcdd	0.0E+00	mg/kg
selenium	6.3E–01	mg/kg			

References

Table I.IV-40 (continued)
Summary of Risk Characterization (chemicals)
Future Land Use with Federal Ownership: Trespassing Child
Via Incidental Ingestion of Soil

	HQ Calculation		
Compound	CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
antimony	3.5E-06	4.0E-04	8.9E-03
arsenic	3.4E-06	3.0E-04	1.1E-02
barium	6.4E-05	7.0E-02	9.2E-04
beryllium	5.0E-07	5.0E-03	1.0E-04
boron	7.4E-05	9.0E-02	8.2E-04
cadmium	2.3E-06	1.0E-03	2.3E-03
chromium vi	1.1E-05	5.0E-03	2.2E-03
cobalt	8.0E-06	6.0E-02	1.3E-04
copper	1.3E-05	NA	NA
cyanide	1.7E-07	2.0E-02	8.3E-06
lead	1.6E-05	NA	NA
manganese	6.5E-04	1.4E-01	4.6E-03
mercury	1.4E-07	3.0E-04	4.7E-04
molybdenum	4.3E-06	5.0E-03	8.6E-04
nickel	1.5E-05	2.0E-02	7.5E-04
selenium	4.2E-07	5.0E-03	8.4E-05
silver	4.0E-06	5.0E-03	8.0E-04
thallium	3.7E-07	8.0E-05	4.6E-03
thorium-total	NA	NA	NA
uranium-total	NA	3.0E-03	0.0E+00
vanadium	1.7E-05	7.0E-03	2.5E-03
zinc	4.2E-05	3.0E-01	1.4E-04
2-methylnaphthalene	NA	NA	NA
4,4-dde	NA	NA	NA
aroclor-1221	NA	NA	NA
aroclor-1248	NA	NA	NA
aroclor-1254	NA	NA	NA
aroclor-1260	NA	NA	NA
carbazole	NA	NA	NA
endrin	NA	3.0E-04	0.0E+00
2,3,7,8-tcdd	NA	NA	NA
	HQ Summation =		4.1E-02

	ILCR Calculation		
Compound	CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	ILCR (unitless)
antimony	6.1E-07	NA	NA
arsenic	5.8E-07	1.8E+00	1.0E-06
barium	1.1E-05	NA	NA
beryllium	8.6E-08	4.3E+00	3.7E-07
boron	1.3E-05	NA	NA
cadmium	4.0E-07	NA	NA
chromium vi	1.9E-06	NA	NA
cobalt	1.4E-06	NA	NA
copper	2.3E-06	NA	NA
cyanide	2.8E-08	NA	NA
lead	2.7E-06	NA	NA
manganese	1.1E-04	NA	NA
mercury	2.4E-08	NA	NA
molybdenum	7.4E-07	NA	NA
nickel	2.6E-06	NA	NA
selenium	7.2E-08	NA	NA
silver	6.8E-07	NA	NA
thallium	6.3E-08	NA	NA
thorium-total	NA	NA	NA
uranium-total	NA	NA	NA
vanadium	3.0E-06	NA	NA
zinc	7.3E-06	NA	NA
2-methylnaphthalene	NA	NA	NA
4,4-dde	NA	3.4E-01	0.0E+00
aroclor-1221	NA	7.7E+00	0.0E+00
aroclor-1248	NA	7.7E+00	0.0E+00
aroclor-1254	NA	7.7E+00	0.0E+00
aroclor-1260	NA	7.7E+00	0.0E+00
carbazole	NA	2.0E-02	0.0E+00
endrin	NA	NA	NA
2,3,7,8-tcdd	NA	1.5E+05	0.0E+00
	ILCR Summation =		1.4E-06

Table I.IV–41
Summary of Intake and Risk Quantitation (radionuclides)
Future Land Use with Federal Ownership: Trespassing Child
Via Incidental Ingestion of Soil

Intake Equation = CS X EF X EDn X FI X IR

IRs	Ingestion rate of soil (RAGS, 1989)	200 mg/day
EF	Exposure frequency	52 days/year
EDn	Exposure Duration	12 Year
FI	Fractional Intake	1 (unitless)
CS	Concentration of radionuclides in soil	

Cs_{137+1d}	7.93E−04	pCi/mg	Rn_{222+4d}	0.00E+00	pCi/mg
Pb_{210+2d}	1.05E−09	pCi/mg	Sr_{90+1d}	8.33E−10	pCi/mg
Np_{237+1d}	8.36E−11	pCi/mg	Tc_{99}	1.87E−09	pCi/mg
Pu_{238}	9.07E−11	pCi/mg	Th_{228+7d}	4.00E−10	pCi/mg
Pu_{239}	1.25E−11	pCi/mg	Th_{230}	5.92E−11	pCi/mg
Pu_{240}	4.55E−11	pCi/mg	$Th_{232+10d}$	5.95E−10	pCi/mg
Pa_{231}	0.00E+00	pCi/mg	U_{234}	2.06E−08	pCi/mg
Ra_{226+8d}	3.99E−10	pCi/mg	U_{235+1d}	9.34E−10	pCi/mg
Ra_{228+1d}	7.00E−10	pCi/mg	U_{236}	6.86E−09	pCi/mg
Ru_{106}	1.33E−10	pCi/mg	U_{238+2d}	1.38E−08	pCi/mg

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	ILCR (unitless)
Cs_{137+1d}	9.90E+01	2.80E−11	2.77E−09
Pb_{210+2d}	1.31E−04	6.60E−10	8.65E−14
Np_{237+1d}	1.04E−05	2.20E−10	2.30E−15
Pu_{238}	1.13E−05	2.20E−10	2.49E−15
Pu_{239}	1.56E−06	2.30E−10	3.59E−16
Pu_{240}	5.68E−06	2.30E−10	1.31E−15
Pa_{231}	NA	9.20E−11	NA
Ra_{226+8d}	4.98E−05	7.80E−10	3.88E−14
Ra_{228+1d}	8.74E−05	1.00E−10	8.74E−15
Ru_{106}	1.66E−05	9.50E−12	1.58E−16
Rn_{222+4d}	NA	1.70E−12	NA
Sr_{90+1d}	1.04E−04	3.60E−11	3.74E−15
Tc_{99}	2.33E−04	1.30E−12	3.03E−16
Th_{228+7d}	4.99E−05	5.50E−11	2.75E−15
Th_{230}	7.39E−06	1.30E−11	9.60E−17
$Th_{232+10d}$	7.43E−05	1.70E−10	1.26E−14
U_{234}	2.57E−03	1.60E−11	4.11E−14
U_{235+1d}	1.17E−04	1.60E−11	1.87E−15
U_{236}	8.56E−04	1.50E−11	1.28E−14
U_{238+2d}	1.72E−03	2.00E−11	3.44E−14
		ILCR Summation =	2.77E−09

Table I.IV–42
Summary of Intake Quantitation (chemicals)
Future Land Use with Federal Ownership: Trespassing Child
Via Dermal Contact with Soil

Intake Equation = $\frac{CS \times EF \times ED \times CF \times ABS \times AF \times SA}{BW \times AT}$

SA	Surface area of exposed skin (50th percentile, hands only)	4200 cm^2/day
AF	Soil to skin adherence factor (RAGS, 1989)	1 mg/cm^2
ABS	chemicals specific absorbtion factor (see table below)	csv
CF	Conversion factor	1E–06 kg/mg
EF	Exposure frequency	52 days/year
EDn	Exposure duration for non–carcinogens	12 Year
EDc	Exposure duration for carcinogens	12 Year
BW	Body weight	43 kg
ATc	Average time for carcinogens (lifetime)	25550 days
ATn	Average time for non–carcinogens (EDn x 365)	4380 days
CS	Concentration of chemicals in soil	

Chemical Concentrations

Compound	ABS	Concentrati	Units
antimony	1.00E–02	5.35E+00	mg/kg
arsenic	1.00E–03	5.09E+00	mg/kg
barium	1.00E–02	9.72E+01	mg/kg
beryllium	1.00E–02	7.55E–01	mg/kg
boron	1.00E–02	1.12E+02	mg/kg
cadmium	1.00E–02	3.48E+00	mg/kg
chromium vi	1.00E–02	1.64E+01	mg/kg
cobalt	1.00E–02	1.21E+01	mg/kg
copper	1.00E–03	2.02E+01	mg/kg
cyanide	1.00E–02	2.50E–01	mg/kg
lead	1.00E–02	2.35E+01	mg/kg
manganese	1.00E–02	9.76E+02	mg/kg
mercury	5.00E–02	2.14E–01	mg/kg
molybdenum	1.00E–02	6.49E+00	mg/kg
nickel	5.00E–04	2.26E+01	mg/kg
selenium	1.00E–02	6.31E–01	mg/kg

Compound		Concentrati	Units
silver	1.00E–02	6.03E+00	mg/kg
thallium	1.00E–02	5.58E–01	mg/kg
thorium–total	1.00E–02	0.00E+00	mg/kg
uranium–total	1.00E–02	0.00E+00	mg/kg
vanadium	1.00E–03	2.60E+01	mg/kg
zinc	1.00E–02	6.41E+01	mg/kg
2–methylnaphthalene	3.00E–01	0.00E+00	mg/kg
4,4–dde	3.00E–01	0.00E+00	mg/kg
aroclor–1221	6.00E–02	0.00E+00	mg/kg
aroclor–1248	6.00E–02	0.00E+00	mg/kg
aroclor–1254	6.00E–02	0.00E+00	mg/kg
aroclor–1260	6.00E–02	0.00E+00	mg/kg
carbazole	3.00E–01	0.00E+00	mg/kg
endrin	3.00E–01	0.00E+00	mg/kg
2,3,7,8–tcdd	3.00E–02	0.00E+00	mg/kg

References

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Table I.IV-42
Summary of Risk Characterization (chemicals)
Future Land Use with Federal Ownership: Trespassing Child
Via Dermal Contact with Soil

Compound	HQ Calculation CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
antimony	7.44E-07	6.00E-05	1.24E-02
arsenic	7.08E-08	2.85E-04	2.49E-04
barium	1.35E-05	6.37E-02	2.12E-04
beryllium	1.05E-07	5.00E-03	2.10E-05
boron	1.56E-05	4.50E-03	3.46E-03
cadmium	4.84E-07	5.00E-05	9.69E-03
chromium vi	2.28E-06	2.25E-03	1.01E-03
cobalt	1.68E-06	2.70E-02	6.24E-05
copper	2.81E-07	NA	NA
cyanide	3.48E-08	NA	NA
lead	3.27E-06	NA	NA
manganese	1.36E-04	4.20E-03	3.23E-02
mercury	1.49E-07	4.50E-05	3.31E-03
molybdenum	9.03E-07	1.90E-03	4.75E-04
nickel	1.57E-07	2.00E-03	7.86E-05
selenium	8.78E-08	4.00E-03	2.20E-05
silver	8.39E-07	NA	NA
thallium	7.76E-08	8.00E-05	9.71E-04
thorium-total	NA	NA	NA
uranium-total	NA	1.50E-04	0.00E+00
vanadium	3.62E-07	3.50E-04	1.03E-03
zinc	8.92E-06	7.50E-02	1.19E-04
2-methylnaphthalene	NA	NA	NA
4,4-dde	NA	NA	NA
aroclor-1221	NA	NA	NA
aroclor-1248	NA	NA	NA
aroclor-1254	NA	NA	NA
aroclor-1260	NA	NA	NA
carbazole	NA	NA	NA
endrin	NA	2.70E-04	0.00E+00
2,3,7,8-tcdd	NA	NA	NA
	HQ Summation =		6.55E-02

Compound	ILCR Calculation CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	ILCR (unitless)
antimony	1.28E-07	NA	NA
arsenic	1.21E-08	1.90E+00	2.31E-08
barium	2.32E-06	NA	NA
beryllium	1.80E-08	4.30E+00	7.74E-08
boron	2.67E-06	NA	NA
cadmium	8.30E-08	NA	NA
chromium vi	3.91E-07	NA	NA
cobalt	2.89E-07	NA	NA
copper	4.82E-08	NA	NA
cyanide	5.96E-09	NA	NA
lead	5.61E-07	NA	NA
manganese	2.33E-05	NA	NA
mercury	2.55E-08	NA	NA
molybdenum	1.55E-07	NA	NA
nickel	2.70E-08	NA	NA
selenium	1.51E-08	NA	NA
silver	1.44E-07	NA	NA
thallium	1.33E-08	NA	NA
thorium-total	NA	NA	NA
uranium-total	NA	NA	NA
vanadium	6.20E-08	NA	NA
zinc	1.53E-06	NA	NA
2-methylnaphthalene	NA	NA	NA
4,4-dde	NA	3.40E-01	0.00E+00
aroclor-1221	NA	1.03E+01	0.00E+00
aroclor-1248	NA	1.03E+01	0.00E+00
aroclor-1254	NA	1.03E+01	0.00E+00
aroclor-1260	NA	1.03E+01	0.00E+00
carbazole	NA	2.22E-02	0.00E+00
endrin	NA	NA	NA
2,3,7,8-tcdd	NA	3.00E+05	0.00E+00
	ILCR Summation =		1.01E-07

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Table I.IV–43
Summary of Intake Quantitation (chemicals)
Future Land Use with Federal Ownership: Trespassing Child
Via Ingestion While Wading

Intake Equation = $\frac{CS \times EF \times ED \times IR}{BW \times AT}$

IRsw	Ingestion rate of surface water	0.035 l/day
EF	Exposure frequency	52 days/year
EDn	Exposure duration for non–carcinogens	12 Year
EDc	Exposure duration for carcinogens	12 Year
BW	Body weight	43 kg
ATc	Average time for carcinogens (lifetime)	25550 days
ATn	Average time for non–carcinogens (EDn x 365)	4380 days
CS	Concentration of chemicals in surface water	

Chemical Concentrations

Compound	Concentration	Units	Compound	Concentration	Units
antimony	7.64E–05	mg/l	silver	0.00E+00	mg/l
arsenic	1.18E–03	mg/l	thallium	0.00E+00	mg/l
barium	0.00E+00	mg/l	thorium–total	0.00E+00	mg/l
beryllium	3.77E–05	mg/l	uranium–total	3.61E–02	mg/l
boron	0.00E+00	mg/l	vanadium	0.00E+00	mg/l
cadmium	0.00E+00	mg/l	zinc	0.00E+00	mg/l
chromium vi	0.00E+00	mg/l	2–methylnaphthalene	0.00E+00	mg/l
cobalt	0.00E+00	mg/l	4,4–dde	0.00E+00	mg/l
copper	0.00E+00	mg/l	aroclor–1221	0.00E+00	mg/l
cyanide	0.00E+00	mg/l	aroclor–1248	0.00E+00	mg/l
lead	0.00E+00	mg/l	aroclor–1254	0.00E+00	mg/l
manganese	0.00E+00	mg/l	aroclor–1260	0.00E+00	mg/l
mercury	0.00E+00	mg/l	carbazole	0.00E+00	mg/l
molybdenum	0.00E+00	mg/l	endrin	0.00E+00	mg/l
nickel	0.00E+00	mg/l	2,3,7,8–tcdd	0.00E+00	mg/l
selenium	0.00E+00	mg/l			

References

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Table I.IV-43 (continued)
Summary of Risk Characterization (chemicals)
Future Land Use with Federal Ownership: Trespassing Child
Via Ingestion While Wading

Compound	HQ Calculation CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
antimony	8.86E-09	4.00E-04	2.21E-05
arsenic	1.37E-07	3.00E-04	4.56E-04
barium	NA	7.00E-02	NA
beryllium	4.37E-09	5.00E-03	8.74E-07
boron	NA	9.00E-02	NA
cadmium	NA	1.00E-03	NA
chromium vi	NA	5.00E-03	NA
cobalt	NA	6.00E-02	NA
copper	NA	NA	NA
cyanide	NA	2.00E-02	NA
lead	NA	NA	NA
manganese	NA	1.40E-01	NA
mercury	NA	3.00E-04	NA
molybdenum	NA	5.00E-03	NA
nickel	NA	2.00E-02	NA
selenium	NA	5.00E-03	NA
silver	NA	5.00E-03	NA
thallium	NA	8.00E-05	NA
thorium-total	NA	NA	NA
uranium-total	4.18E-06	3.00E-03	1.39E-03
vanadium	NA	7.00E-03	NA
zinc	NA	3.00E-01	NA
2-methylnaphthalene	NA	NA	NA
4,4-dde	NA	NA	NA
aroclor-1221	NA	NA	NA
aroclor-1248	NA	NA	NA
aroclor-1254	NA	NA	NA
aroclor-1260	NA	NA	NA
carbazole	NA	NA	NA
endrin	NA	3.00E-04	NA
2,3,7,8-tcdd	NA	NA	NA
	HQ Summation =		1.87E-03

Compound	ILCR Calculation CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	ILCR (unitless)
antimony	1.52E-09	NA	0.00E+00
arsenic	2.35E-08	1.75E+00	4.11E-08
barium	NA	NA	NA
beryllium	7.49E-10	4.30E+00	3.22E-09
boron	NA	NA	NA
cadmium	NA	NA	NA
chromium vi	NA	NA	NA
cobalt	NA	NA	NA
copper	NA	NA	NA
cyanide	NA	NA	NA
lead	NA	NA	NA
manganese	NA	NA	NA
mercury	NA	NA	NA
molybdenum	NA	NA	NA
nickel	NA	NA	NA
selenium	NA	NA	NA
silver	NA	NA	NA
thallium	NA	NA	NA
thorium-total	NA	NA	NA
uranium-total	7.17E-07	NA	0.00E+00
vanadium	NA	NA	NA
zinc	NA	NA	NA
2-methylnaphthalene	NA	NA	NA
4,4-dde	NA	3.40E-01	NA
aroclor-1221	NA	7.70E+00	NA
aroclor-1248	NA	7.70E+00	NA
aroclor-1254	NA	7.70E+00	NA
aroclor-1260	NA	7.70E+00	NA
carbazole	NA	2.00E-02	NA
endrin	NA	NA	NA
2,3,7,8-tcdd	NA	1.50E+05	NA
	ILCR Summation =		4.43E-08

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Table I.IV–44
Summary of Intake Quantitation (chemicals)
Future Land Use with Federal Ownership: Trespassing Child
Via Dermal Contact While Wading

Intake Equation = $\frac{DA \times EF \times ED \times SA}{BW \times AT}$

DA	Dermal absorbed dose	csv mg/cm^2–day
EF	Exposure frequency	52 days/year
EDn	Exposure duration for non–carcinogens	12 Year
EDc	Exposure duration for carcinogens	12 Year
BW	Body weight	43 kg
ATc	Average time for carcinogens (lifetime)	25550 days
ATn	Average time for non–carcinogens (EDn x 365)	4380 days
SA	Skin surface area available for contact	4200 cm^2

Chemical Concentrations

Compound	DA	Units	Compound	DA	Units
antimony	7.64E–05	mg/cm^2–day	silver	0.00E+00	mg/cm^2–day
arsenic	1.18E–03	mg/cm^2–day	thallium	0.00E+00	mg/cm^2–day
barium	0.00E+00	mg/cm^2–day	thorium–total	0.00E+00	mg/cm^2–day
beryllium	3.77E–05	mg/cm^2–day	uranium–total	3.61E–02	mg/cm^2–day
boron	0.00E+00	mg/cm^2–day	vanadium	0.00E+00	mg/cm^2–day
cadmium	0.00E+00	mg/cm^2–day	zinc	0.00E+00	mg/cm^2–day
chromium vi	0.00E+00	mg/cm^2–day	2–methylnaphthalene	0.00E+00	mg/cm^2–day
cobalt	0.00E+00	mg/cm^2–day	4,4–dde	0.00E+00	mg/cm^2–day
copper	0.00E+00	mg/cm^2–day	aroclor–1221	0.00E+00	mg/cm^2–day
cyanide	0.00E+00	mg/cm^2–day	aroclor–1248	0.00E+00	mg/cm^2–day
lead	0.00E+00	mg/cm^2–day	aroclor–1254	0.00E+00	mg/cm^2–day
manganese	0.00E+00	mg/cm^2–day	aroclor–1260	0.00E+00	mg/cm^2–day
mercury	0.00E+00	mg/cm^2–day	carbazole	0.00E+00	mg/cm^2–day
molybdenum	0.00E+00	mg/cm^2–day	endrin	0.00E+00	mg/cm^2–day
nickel	0.00E+00	mg/cm^2–day	2,3,7,8–tcdd	0.00E+00	mg/cm^2–day
selenium	0.00E+00	mg/cm^2–day			

References

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Table I.IV-44 (continued)
Summary of Risk Characterization (chemicals)
Future Land Use with Federal Ownership: Trespassing Child
Via Dermal Contact While Wading

Compound	HQ Calculation		
	CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
antimony	3.81E-08	6.00E-05	6.35E-04
arsenic	5.88E-07	2.85E-04	2.06E-03
barium	NA	6.37E-02	NA
beryllium	1.88E-08	5.00E-03	3.76E-06
boron	NA	4.50E-03	NA
cadmium	NA	5.00E-05	NA
chromium vi	NA	2.25E-03	NA
cobalt	NA	2.70E-02	NA
copper	NA	NA	NA
cyanide	NA	NA	NA
lead	NA	NA	NA
manganese	NA	4.20E-03	NA
mercury	NA	4.50E-05	NA
molybdenum	NA	1.90E-03	NA
nickel	NA	2.00E-03	NA
selenium	NA	4.00E-03	NA
silver	NA	NA	NA
thallium	NA	8.00E-05	NA
thorium-total	NA	NA	NA
uranium-total	1.80E-05	1.50E-04	1.20E-01
vanadium	NA	3.50E-04	NA
zinc	NA	7.50E-02	NA
2-methylnaphthalene	NA	NA	NA
4,4-dde	NA	NA	NA
aroclor-1221	NA	NA	NA
aroclor-1248	NA	NA	NA
aroclor-1254	NA	NA	NA
aroclor-1260	NA	NA	NA
carbazole	NA	NA	NA
endrin	NA	2.70E-04	NA
2,3,7,8-tcdd	NA	NA	NA
	HQ Summation =		1.23E-01

Compound	ILCR Calculation		
	CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	ILCR (unitless)
antimony	1.82E-09	NA	0.00E+00
arsenic	2.81E-08	1.90E+00	5.35E-08
barium	NA	NA	NA
beryllium	8.99E-10	4.30E+00	3.87E-09
boron	NA	NA	NA
cadmium	NA	NA	NA
chromium vi	NA	NA	NA
cobalt	NA	NA	NA
copper	NA	NA	NA
cyanide	NA	NA	NA
lead	NA	NA	NA
manganese	NA	NA	NA
mercury	NA	NA	NA
molybdenum	NA	NA	NA
nickel	NA	NA	NA
selenium	NA	NA	NA
silver	NA	NA	NA
thallium	NA	NA	NA
thorium-total	NA	NA	NA
uranium-total	8.60E-07	NA	0.00E+00
vanadium	NA	NA	NA
zinc	NA	NA	NA
2-methylnaphthalene	NA	NA	NA
4,4-dde	NA	3.40E-01	NA
aroclor-1221	NA	1.03E+01	NA
aroclor-1248	NA	1.03E+01	NA
aroclor-1254	NA	1.03E+01	NA
aroclor-1260	NA	1.03E+01	NA
carbazole	NA	2.22E-02	NA
endrin	NA	NA	NA
2,3,7,8-tcdd	NA	3.00E+05	NA
	ILCR Summation =		5.73E-08

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Table I.IV–45
Summary of Intake and Risk Quantitation (radionuclides)
Future Land Use with Federal Ownership: Trespassing Child
Via Incidental Ingestion while Wading

Intake Equation = Cs X EF X ED X FI X IR

IRsw	Ingestion rate of surface water	0.035 l/day
EF	Exposure frequency	52 days/year
EDn	Exposure duration for non–carcinogens	12 Year
FI	Fractional intake for radionuclides	1 (Unitless)
Cs	Concentration of radionuclides in surface water	

Cs_{137+1d}	0.00E+00	pCi/l	Rn_{222+4d}	0.00E+00	pCi/l
Pb_{210+2d}	0.00E+00	pCi/l	Sr_{90+1d}	0.00E+00	pCi/l
Np_{237+1d}	1.28E–01	pCi/l	Tc_{99}	8.77E+02	pCi/l
Pu_{238}	0.00E+00	pCi/l	Th_{228+7d}	0.00E+00	pCi/l
Pu_{239}	0.00E+00	pCi/l	Th_{230}	0.00E+00	pCi/l
Pu_{240}	0.00E+00	pCi/l	$Th_{232+10d}$	0.00E+00	pCi/l
Pa_{231}	0.00E+00	pCi/l	U_{234}	2.00E+01	pCi/l
Ra_{226+8d}	1.15E–01	pCi/l	U_{235+1d}	7.04E–02	pCi/l
Ra_{228+1d}	0.00E+00	pCi/l	U_{236}	5.34E–01	pCi/l
Ru_{106}	0.00E+00	pCi/l	U_{238+2d}	1.20E+01	pCi/l

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	ILCR (unitless)
Cs_{137+1d}	NA	2.80E–11	NA
Pb_{210+2d}	NA	6.60E–10	NA
Np_{237+1d}	2.80E+00	2.20E–10	6.15E–10
Pu_{238}	NA	2.20E–10	NA
Pu_{239}	NA	2.30E–10	NA
Pu_{240}	NA	2.30E–10	NA
Pa_{231}	NA	9.20E–11	NA
Ra_{226+8d}	2.51E+00	7.80E–10	1.96E–09
Ra_{228+1d}	NA	1.00E–10	NA
Ru_{106}	NA	9.50E–12	NA
Rn_{222+4d}	NA	1.70E–12	NA
Sr_{90+1d}	NA	3.60E–11	NA
Tc_{99}	1.92E+04	1.30E–12	2.49E–08
Th_{228+7d}	NA	5.50E–11	NA
Th_{230}	NA	1.30E–11	NA
$Th_{232+10d}$	NA	1.70E–10	NA
U_{234}	4.37E+02	1.60E–11	6.99E–09
U_{235+1d}	1.54E+00	1.60E–11	2.46E–11
U_{236}	1.17E+01	1.50E–11	1.75E–10
U_{238+2d}	2.63E+02	2.00E–11	5.25E–09
		ILCR Summation =	3.99E–08

Table I.IV–46
Summary of Intake and Risk Quantitation (radionuclides)
Future Land Use with Federal Ownership: Trespassing Child
Via External Radiation

Dose Equivalency Equat = $[DR \times EF \times EDn \times ET_i \times (1-SH_i)] + [DR \times EF \times EDn \times ET_o \times (1-SH_o)]$

EF	Fraction of year spent exposured	0.14 (unitless)
ED	Exposure duration	12 Year
ET_i	Fraction of day spent indoors	0.17 (unitless)
ET_o	Fraction of day spent outdoors	0 (unitless)
SH_i	Shield factor indoors	0.5 (unitless)
SH_o	Shield factor outdoors	0 (unitless)
DR	Radionuclide specific dose concentrations	(see table below)

Cs_{137+1d}	7.93E−01	pCi/g	Rn_{222+4d}	NA	pCi/g
Pb_{210+2d}	1.05E−06	pCi/g	Sr_{90+1d}	8.33E−07	pCi/g
Np_{237+1d}	8.36E−08	pCi/g	Tc_{99}	1.87E−06	pCi/g
Pu_{238}	9.07E−08	pCi/g	Th_{228+7d}	4.00E−07	pCi/g
Pu_{239}	1.25E−08	pCi/g	Th_{230}	5.92E−08	pCi/g
Pu_{240}	4.55E−08	pCi/g	$Th_{232+10d}$	5.95E−07	pCi/g
Pa_{231}	NA	pCi/g	U_{234}	2.06E−05	pCi/g
Ra_{226+8d}	3.99E−07	pCi/g	U_{235+1d}	9.34E−07	pCi/g
Ra_{228+1d}	7.00E−07	pCi/g	U_{236}	6.86E−06	pCi/g
Ru_{106}	1.33E−07	pCi/g	U_{238+2d}	1.38E−05	pCi/g

Radionuclides	CDI (year pCi/g)	CSF $(g/pCi-year)^{-1}$	ILCR (unitless)
Cs_{137+1d}	1.1E−01	2.0E−06	2.3E−07
Pb_{210+2d}	1.5E−07	1.6E−10	2.4E−17
Np_{237+1d}	1.2E−08	4.3E−07	5.1E−15
Pu_{238}	1.3E−08	2.8E−11	3.6E−19
Pu_{239}	1.8E−09	1.7E−11	3.0E−20
Pu_{240}	6.5E−09	2.7E−11	1.8E−19
Pa_{231}	NA	2.6E−08	NA
Ra_{226+8d}	5.7E−08	6.0E−06	3.4E−13
Ra_{228+1d}	1.0E−07	2.9E−06	2.9E−13
Ru_{106}	1.9E−08	NA	0.0E+00
Rn_{222+4d}	NA	5.9E−06	NA
Sr_{90+1d}	1.2E−07	NA	0.0E+00
Tc_{99}	2.7E−07	6.0E−13	1.6E−19
Th_{228+7d}	5.7E−08	5.6E−06	3.2E−13
Th_{230}	8.5E−09	5.4E−11	4.6E−19
$Th_{232+10d}$	8.5E−08	8.5E−06	7.2E−13
U_{234}	2.9E−06	3.0E−11	8.8E−17
U_{235+1d}	1.3E−07	2.4E−07	3.2E−14
U_{236}	9.8E−07	2.4E−11	2.4E−17
U_{238+2d}	2.0E−06	5.1E−08	1.0E−13
		ILCR Summation =	2.3E−07

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Table I.IV–47
Summary of Intake Quantitation (chemicals)
Future Land Use with Federal Ownership: Expanded Trespasser
Via Inhalation of Particulates

Intake Equation

$$= \frac{CS \times EFa \times EDa \times IR \times ETa}{BWa \times ATa} + \frac{CS \times EFc \times EDc \times IR \times ETc}{BWc \times ATc}$$

IR	Inhalation rate of gases	0.83 m^3/hour
ETa	Exposure time (adult)	1 hour/day
ETc	Exposure time (child)	2 hour/day
EFa	Exposure frequency (adult)	40 days/year
EFc	Exposure frequency (child)	110 days/year
EDa	Exposure duration (adult)	32 Year
EDc	Exposure duration (child)	12 Year
BWa	Body weight (adult)	70 kg
BWc	Body weight (child)	43 kg
AT	Average time for carcinogens	25550 days
ATa	Average time for non–carcinogens (adult)	11680 days
ATc	Average time for non–carcinogens (child)	4380 days
CS	Concentration of chemicals in particulate as modeled	(see table below)

Chemical Concentrations

Compound	Concentration	Units
antimony	2.8E–09	mg/m^3
arsenic	4.2E–09	mg/m^3
barium	4.3E–08	mg/m^3
beryllium	5.0E–10	mg/m^3
boron	5.0E–09	mg/m^3
cadmium	1.0E–09	mg/m^3
chromium vi	7.1E–09	mg/m^3
cobalt	4.1E–09	mg/m^3
copper	1.5E–08	mg/m^3
cyanide	2.1E–10	mg/m^3
lead	4.9E–07	mg/m^3
manganese	1.3E–10	mg/m^3
mercury	1.3E–10	mg/m^3
molybdenum	2.2E–09	mg/m^3
nickel	8.2E–09	mg/m^3
selenium	2.7E–10	mg/m^3

Compound	Concentration	Units
silver	1.9E–09	mg/m^3
thallium	1.9E–10	mg/m^3
thorium–total	2.3E–08	mg/m^3
uranium–total	4.5E–07	mg/m^3
vanadium	9.6E–09	mg/m^3
zinc	2.4E–08	mg/m^3
2–methylnaphthalene	4.5E–11	mg/m^3
4,4–dde	9.7E–13	mg/m^3
aroclor–1221	NA	mg/m^3
aroclor–1248	NA	mg/m^3
aroclor–1254	1.9E–10	mg/m^3
aroclor–1260	5.5E–11	mg/m^3
carbazole	1.1E–11	mg/m^3
endrin	NA	mg/m^3
2,3,7,8–tcdd	4.1E–17	mg/m^3

References

Table I.IV-47 (continued)
Summary of Risk Characterization (chemicals)
Future Land Use with Federal Ownership: Expanded Trespasser
Via Inhalation of Particulates

	HQ Calculation		
Compound	CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
antimony	3.7E-11	NA	NA
arsenic	5.4E-11	NA	NA
barium	5.5E-10	1.4E-04	3.9E-06
beryllium	6.5E-12	NA	NA
boron	6.4E-11	5.7E-03	1.1E-08
cadmium	1.3E-11	NA	NA
chromium vi	9.1E-11	NA	NA
cobalt	5.3E-11	3.0E-07	1.8E-04
copper	1.9E-10	NA	NA
cyanide	2.7E-12	NA	NA
lead	6.3E-09	NA	NA
manganese	1.7E-12	1.4E-05	1.2E-07
mercury	1.7E-12	8.6E-05	2.0E-08
molybdenum	2.9E-11	NA	NA
nickel	1.1E-10	NA	NA
selenium	3.5E-12	NA	NA
silver	2.5E-11	NA	NA
thallium	2.4E-12	NA	NA
thorium-total	2.9E-10	NA	NA
uranium-total	5.8E-09	NA	NA
vanadium	1.2E-10	NA	NA
zinc	3.1E-10	NA	NA
2-methylnaphthalene	5.8E-13	NA	NA
4,4-dde	1.3E-14	NA	NA
aroclor-1221	NA	NA	NA
aroclor-1248	NA	NA	NA
aroclor-1254	2.5E-12	NA	NA
aroclor-1260	7.1E-13	NA	NA
carbazole	1.4E-13	NA	NA
endrin	NA	NA	NA
2,3,7,8-tcdd	5.3E-19	NA	NA
	HQ Summation =		1.8E-04

	ILCR Calculation		
Compound	CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	ILCR (unitless)
antimony	7.3E-12	NA	NA
arsenic	1.1E-11	1.5E+01	1.6E-10
barium	1.1E-10	NA	NA
beryllium	1.3E-12	8.4E+00	1.1E-11
boron	1.3E-11	NA	NA
cadmium	2.6E-12	6.3E+00	1.6E-11
chromium vi	1.8E-11	4.1E+01	7.5E-10
cobalt	1.1E-11	NA	NA
copper	3.8E-11	NA	NA
cyanide	5.5E-13	NA	NA
lead	1.3E-09	NA	NA
manganese	3.4E-13	NA	NA
mercury	3.4E-13	NA	NA
molybdenum	5.7E-12	NA	NA
nickel	2.1E-11	8.4E-01	1.8E-11
selenium	7.0E-13	NA	NA
silver	4.9E-12	NA	NA
thallium	4.8E-13	NA	NA
thorium-total	5.8E-11	NA	NA
uranium-total	1.2E-09	NA	NA
vanadium	2.5E-11	NA	NA
zinc	6.2E-11	NA	NA
2-methylnaphthalene	1.2E-13	NA	NA
4,4-dde	2.5E-15	NA	NA
aroclor-1221	NA	NA	NA
aroclor-1248	NA	NA	NA
aroclor-1254	5.0E-13	NA	NA
aroclor-1260	1.4E-13	NA	NA
carbazole	2.9E-14	NA	NA
endrin	NA	NA	NA
2,3,7,8-tcdd	1.1E-19	1.5E+05	1.6E-14
	ILCR Summation =		9.6E-10

Table I.IV–48
Summary of Intake and Risk Quantitation (radionuclides)
Future Land Use with Federal Ownership: Expanded Trespasser
Via Inhalation of Gases and Particulates

Intake Equation = CA X EFa X EDa X IR X ETa + CA X EFc EDc X IR X ETc

IR	Inhalation rate of gases	0.83 m^3/hour
EFa	Exposure frequency (adult)	40 days/year
EFc	Exposure frequency (child)	110 days/year
EDa	Exposure duration	32 Year
EDc	Exposure duration	12 Year
ETa	Exposure time (adult)	1 hour/day
ETc	Exposure time (child)	2 hour/day
CA	Concentration of radionuclides in air	(see table below)

Cs_{137+1d}	3.0E–07	pCi/m^3	Rn_{222+4d}	6.6E+00	pCi/m^3
Pb_{210+2d}	1.1E–06	pCi/m^3	Sr_{90+1d}	6.5E–07	pCi/m^3
Np_{237+1d}	1.0E–07	pCi/m^3	Tc_{99}	2.9E–06	pCi/m^3
Pu_{238}	9.7E–07	pCi/m^3	Th_{228+7d}	5.8E–07	pCi/m^3
Pu_{239}	2.2E–07	pCi/m^3	Th_{230}	1.6E–06	pCi/m^3
Pu_{240}	7.9E–07	pCi/m^3	$Th_{232+10d}$	9.3E–07	pCi/m^3
Pa_{231}	7.0E–08	pCi/m^3	NA	NA	pCi/m^3
Ra_{226+8d}	4.8E–07	pCi/m^3	U_{235+1d}	4.6E–07	pCi/m^3
Ra_{228+1d}	7.0E–07	pCi/m^3	U_{236}	1.9E–07	pCi/m^3
Ru_{106}	8.4E–08	pCi/m^3	U_{238+2d}	1.0E–05	pCi/m^3

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	ILCR (unitless)
Cs_{137+1d}	9.9E–04	1.9E–11	1.9E–14
Pb_{210+2d}	3.5E–03	4.0E–09	1.4E–11
Np_{237+1d}	3.3E–04	2.9E–08	9.5E–12
Pu_{238}	3.1E–03	3.9E–08	1.2E–10
Pu_{239}	7.1E–04	3.8E–08	2.7E–11
Pu_{240}	2.6E–03	3.8E–08	9.7E–11
Pa_{231}	2.3E–04	3.6E–08	8.2E–12
Ra_{226+8d}	1.6E–03	7.0E–09	1.1E–11
Ra_{228+1d}	2.3E–03	6.9E–10	1.6E–12
Ru_{106}	2.7E–04	4.4E–10	1.2E–13
Rn_{222+4d}	2.2E+04	7.7E–12	1.7E–07
Sr_{90+1d}	2.1E–03	6.2E–11	1.3E–13
Tc_{99}	9.4E–03	8.3E–12	7.8E–14
Th_{228+7d}	1.9E–03	7.8E–08	1.5E–10
Th_{230}	5.2E–03	2.9E–08	1.5E–10
$Th_{232+10d}$	3.0E–03	1.1E–07	3.3E–10
NA	NA	NA	NA
U_{235+1d}	1.5E–03	2.5E–08	3.7E–11
U_{236}	6.1E–04	2.5E–08	1.5E–11
U_{238+2d}	3.4E–02	2.4E–08	8.0E–10
		ILCR Summation =	1.7E–07

Table I.IV–49
Summary of Intake Quantitation (chemicals)
Future Land Use with Federal Ownership: Expanded Trespasser
Via Incidental Ingestion of Soil/Sediment

Intake Equation

$$= \frac{CS \times EFa \times EDa \times CF \times IRa}{BWa \times ATa} + \frac{CS \times EFc \times EDc \times CF \times IRc}{BWc \times ATc}$$

IRa	Ingestion rate of soil (adult)	12.5 mg/day
IRc	Ingestion rate of soil (child)	12.5 mg/day
CF	Conversion factor	1.00E–06 kg/mg
EFa	Exposure frequency (adult)	40 days/year
EFc	Exposure frequency (child)	110 days/year
EDa	Exposure duration (adult)	32 Year
EDc	Exposure duration (child)	12 Year
BWa	Body weight (adult)	70 kg
BWc	Body weight (child)	43 kg
AT	Average time for carcinogens	25550 days
ATa	Average time for non–carcinogens (adult)	11680 days
ATc	Average time for non–carcinogens (child)	4380 days
CS	Concentration of chemicals in soil	(see table below)

Chemical Concentrations

Compound	Concentration	Units	Compound	Concentration	Units
antimony	5.4E+00	mg/kg	silver	6.0E+00	mg/kg
arsenic	5.1E+00	mg/kg	thallium	5.6E–01	mg/kg
barium	9.7E+01	mg/kg	thorium–total	NA	mg/kg
beryllium	7.6E–01	mg/kg	uranium–total	NA	mg/kg
boron	1.1E+02	mg/kg	vanadium	2.6E+01	mg/kg
cadmium	3.5E+00	mg/kg	zinc	6.4E+01	mg/kg
chromium vi	1.6E+01	mg/kg	2–methylnaphthalene	NA	mg/kg
cobalt	1.2E+01	mg/kg	4,4–dde	NA	mg/kg
copper	2.0E+01	mg/kg	aroclor–1221	NA	mg/kg
cyanide	2.5E–01	mg/kg	aroclor–1248	NA	mg/kg
lead	2.4E+01	mg/kg	aroclor–1254	NA	mg/kg
manganese	9.8E+02	mg/kg	aroclor–1260	NA	mg/kg
mercury	2.1E–01	mg/kg	carbazole	NA	mg/kg
molybdenum	6.5E+00	mg/kg	endrin	NA	mg/kg
nickel	2.3E+01	mg/kg	2,3,7,8–tcdd	NA	mg/kg
selenium	6.3E–01	mg/kg			

References

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Table I.IV–49 (continued)
Summary of Risk Characterization (chemicals)
Future Land Use with Federal Ownership: Expanded Trespasser
Via Incidental Ingestion of Soil/Sediment

	HQ Calculation		
Compound	CDI (mg/kg–day)	RfD (mg/kg–day)	HQ (unitless)
antimony	5.7E–07	4.0E–04	1.4E–03
arsenic	5.5E–07	3.0E–04	1.8E–03
barium	1.0E–05	7.0E–02	1.5E–04
beryllium	8.1E–08	5.0E–03	1.6E–05
boron	1.2E–05	9.0E–02	1.3E–04
cadmium	3.7E–07	1.0E–03	3.7E–04
chromium vi	1.8E–06	5.0E–03	3.5E–04
cobalt	1.3E–06	6.0E–02	2.2E–05
copper	2.2E–06	NA	NA
cyanide	2.7E–08	2.0E–02	1.3E–06
lead	2.5E–06	NA	NA
manganese	1.0E–04	1.4E–01	7.5E–04
mercury	2.3E–08	3.0E–04	7.6E–05
molybdenum	7.0E–07	5.0E–03	1.4E–04
nickel	2.4E–06	2.0E–02	1.2E–04
selenium	6.8E–08	5.0E–03	1.4E–05
silver	6.5E–07	5.0E–03	1.3E–04
thallium	6.0E–08	8.0E–05	7.5E–04
thorium–total	NA	NA	NA
uranium–total	NA	3.0E–03	NA
vanadium	2.8E–06	7.0E–03	4.0E–04
zinc	6.9E–06	3.0E–01	2.3E–05
2–methylnaphthalene	NA	NA	NA
4,4–dde	NA	NA	NA
aroclor–1221	NA	NA	NA
aroclor–1248	NA	NA	NA
aroclor–1254	NA	NA	NA
aroclor–1260	NA	NA	NA
carbazole	NA	NA	NA
endrin	NA	3.0E–04	NA
2,3,7,8–tcdd	NA	NA	NA
	HQ Summation =		6.7E–03

	ILCR Calculation		
Compound	CDI (mg/kg–day)	CSF $(mg/kg–day)^{-1}$	ILCR (unitless)
antimony	1.3E–07	NA	NA
arsenic	1.2E–07	1.8E+00	2.1E–07
barium	2.3E–06	NA	NA
beryllium	1.8E–08	4.3E+00	7.8E–08
boron	2.7E–06	NA	NA
cadmium	8.3E–08	NA	NA
chromium vi	3.9E–07	NA	NA
cobalt	2.9E–07	NA	NA
copper	4.8E–07	NA	NA
cyanide	6.0E–09	NA	NA
lead	5.6E–07	NA	NA
manganese	2.3E–05	NA	NA
mercury	5.1E–09	NA	NA
molybdenum	1.6E–07	NA	NA
nickel	5.4E–07	NA	NA
selenium	1.5E–08	NA	NA
silver	1.4E–07	NA	NA
thallium	1.3E–08	NA	NA
thorium–total	NA	NA	NA
uranium–total	NA	NA	NA
vanadium	6.2E–07	NA	NA
zinc	1.5E–06	NA	NA
2–methylnaphthalene	NA	NA	NA
4,4–dde	NA	3.4E–01	NA
aroclor–1221	NA	7.7E+00	NA
aroclor–1248	NA	7.7E+00	NA
aroclor–1254	NA	7.7E+00	NA
aroclor–1260	NA	7.7E+00	NA
carbazole	NA	2.0E–02	NA
endrin	NA	NA	NA
2,3,7,8–tcdd	NA	1.5E+05	NA
	ILCR Summation =		2.9E–07

000588

Table I.IV–50
Summary of Intake and Risk Quantitation (radionuclides)
Future Land Use with Federal Ownership: Expanded Trespasser
Via Incidental Ingestion of Soil/Sediment

Intake Equation = CS X EFa X EDa X FI X IRa + CS X EFc X EDc X FI X IRc

IRa	Ingestion rate of soil (adult)	12.5 mg/day
IRc	Ingestion rate of soil (child)	12.5 mg/day
EFa	Exposure frequency (adult)	40 days/year
EFc	Exposure frequency (child)	110 days/year
EDa	Exposure Duration	32 Year
EDc	Exposure Duration	12 Year
FI	Fractional Intake	1 (unitless)
CS	Concentration of radionuclides in soil	(see table below)

Cs_{137+1d}	7.9E–04	pCi/mg	Rn_{222+4d}	NA	pCi/mg
Pb_{210+2d}	1.1E–09	pCi/mg	Sr_{90+1d}	8.3E–10	pCi/mg
Np_{237+1d}	8.4E–11	pCi/mg	Tc_{99}	1.9E–09	pCi/mg
Pu_{238}	9.1E–11	pCi/mg	Th_{228+7d}	4.0E–10	pCi/mg
Pu_{239}	1.3E–11	pCi/mg	Th_{230}	5.9E–11	pCi/mg
Pu_{240}	4.6E–11	pCi/mg	$Th_{232+10d}$	6.0E–10	pCi/mg
Pa_{231}	NA	pCi/mg	NA	NA	pCi/mg
Ra_{226+8d}	4.0E–10	pCi/mg	U_{235+1d}	9.3E–10	pCi/mg
Ra_{228+1d}	7.0E–10	pCi/mg	U_{236}	6.9E–09	pCi/mg
Ru_{106}	1.3E–10	pCi/mg	U_{238+2d}	1.4E–08	pCi/mg

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	ILCR (unitless)
Cs_{137+1d}	2.6E+01	2.8E–11	7.2E–10
Pb_{210+2d}	3.4E–05	6.6E–10	2.3E–14
Np_{237+1d}	2.7E–06	2.2E–10	6.0E–16
Pu_{238}	2.9E–06	2.2E–10	6.5E–16
Pu_{239}	4.1E–07	2.3E–10	9.3E–17
Pu_{240}	1.5E–06	2.3E–10	3.4E–16
Pa_{231}	NA	9.2E–11	NA
Ra_{226+8d}	1.3E–05	7.8E–10	1.0E–14
Ra_{228+1d}	2.3E–05	1.0E–10	2.3E–15
Ru_{106}	4.3E–06	9.5E–12	4.1E–17
Rn_{222+4d}	NA	1.7E–12	NA
Sr_{90+1d}	2.7E–05	3.6E–11	9.7E–16
Tc_{99}	6.1E–05	1.3E–12	7.9E–17
Th_{228+7d}	1.3E–05	5.5E–11	7.2E–16
Th_{230}	1.9E–06	1.3E–11	2.5E–17
$Th_{232+10d}$	1.9E–05	1.7E–10	3.3E–15
NA	NA	NA	NA
U_{235+1d}	3.0E–05	1.6E–11	4.9E–16
U_{236}	2.2E–04	1.5E–11	3.3E–15
U_{238+2d}	4.5E–04	2.0E–11	9.0E–15

ILCR Summation = 7.2E–10

009590

Table I.IV–51
Summary of Intake Quantitation (chemicals)
Future Land Use with Federal Ownership: Expanded Trespasser
Via Dermal Contact with Soil/Sediment

Intake Equation $= \frac{CS \times EFa \times EDa \times CF \times ABS \times AF \times SAa}{BWa \times ATa} + \frac{CS \times EFc \times EDc \times CF \times ABS \times AF \times SAc}{BWc \times ATc}$

SA	Surface area of exposed skin (adult)	5750 cm^2/day
SA	Surface area of exposed skin (child)	4200 cm^2/day
AF	Soil to skin adherence factor	1 mg/cm^2
ABS	chemicals specific absorbtion factor (see table below)	csv
CF	Conversion factor	1E–06 kg/mg
EFa	Exposure frequency (adult)	40 days/year
EFc	Exposure frequency (child)	110 days/year
EDa	Exposure duration (adult)	32 Year
EDc	Exposure duration (child)	12 Year
BWa	Body weight (adult)	70 kg
BWc	Body weight (child)	43 kg
AT	Average time for carcinogens	25550 days
ATa	Average time for non–carcinogens (adult)	11680 days
ATc	Average time for non–carcinogens (child)	4380 days
CS	Concentration of chemicals in soil	(see table below)

Chemical Concentrations

Compound	ABS	Concentrati	Units
antimony	1.0E–02	5.4E+00	mg/kg
arsenic	1.0E–03	5.1E+00	mg/kg
barium	1.0E–02	9.7E+01	mg/kg
beryllium	1.0E–02	7.6E–01	mg/kg
boron	1.0E–02	1.1E+02	mg/kg
cadmium	1.0E–02	3.5E+00	mg/kg
chromium vi	1.0E–02	1.6E+01	mg/kg
cobalt	1.0E–02	1.2E+01	mg/kg
copper	1.0E–03	2.0E+01	mg/kg
cyanide	1.0E–02	2.5E–01	mg/kg
lead	1.0E–02	2.4E+01	mg/kg
manganese	1.0E–02	9.8E+02	mg/kg
mercury	5.0E–02	2.1E–01	mg/kg
molybdenum	1.0E–02	6.5E+00	mg/kg
nickel	5.0E–04	2.3E+01	mg/kg
selenium	1.0E–02	6.3E–01	mg/kg

Compound	ABS	Concentrati	Units
silver	1.0E–02	6.0E+00	mg/kg
thallium	1.0E–02	5.6E–01	mg/kg
thorium–total	1.0E–02	NA	mg/kg
uranium–total	1.0E–02	NA	mg/kg
vanadium	1.0E–03	2.6E+01	mg/kg
zinc	1.0E–02	6.4E+01	mg/kg
2–methylnaphthalene	3.0E–01	NA	mg/kg
4,4–dde	3.0E–01	NA	mg/kg
aroclor–1221	6.0E–02	NA	mg/kg
aroclor–1248	6.0E–02	NA	mg/kg
aroclor–1254	6.0E–02	NA	mg/kg
aroclor–1260	6.0E–02	NA	mg/kg
carbazole	3.0E–01	NA	mg/kg
endrin	3.0E–01	NA	mg/kg
2,3,7,8–tcdd	3.0E–02	NA	mg/kg

References

Table I.IV-51 (continued)
Summary of Risk Characterization (chemicals)
Future Land Use with Federal Ownership: Expanded Trespasser
Via Dermal Contact with Soil/Sediment

	HQ Calculation		
Compound	CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
antimony	2.1E-06	6.0E-05	3.4E-02
arsenic	2.0E-07	2.9E-04	6.9E-04
barium	3.7E-05	6.4E-02	5.9E-04
beryllium	2.9E-07	5.0E-03	5.8E-05
boron	4.3E-05	4.5E-03	9.6E-03
cadmium	1.3E-06	5.0E-05	2.7E-02
chromium vi	6.3E-06	2.3E-03	2.8E-03
cobalt	4.7E-06	2.7E-02	1.7E-04
copper	7.8E-07	NA	NA
cyanide	9.6E-08	NA	NA
lead	9.0E-06	NA	NA
manganese	3.8E-04	4.2E-03	8.9E-02
mercury	4.1E-07	4.5E-05	9.1E-03
molybdenum	2.5E-06	1.9E-03	1.3E-03
nickel	4.3E-07	2.0E-03	2.2E-04
selenium	2.4E-07	4.0E-03	6.1E-05
silver	2.3E-06	NA	NA
thallium	2.1E-07	8.0E-05	2.7E-03
thorium-total	NA	NA	NA
uranium-total	NA	1.5E-04	NA
vanadium	1.0E-06	3.5E-04	2.9E-03
zinc	2.5E-05	7.5E-02	3.3E-04
2-methylnaphthalene	NA	NA	NA
4,4-dde	NA	NA	NA
aroclor-1221	NA	NA	NA
aroclor-1248	NA	NA	NA
aroclor-1254	NA	NA	NA
aroclor-1260	NA	NA	NA
carbazole	NA	NA	NA
endrin	NA	2.7E-04	NA
2,3,7,8-tcdd	NA	NA	NA
	HQ Summation =		1.8E-01

	ILCR Calculation		
Compound	CDI (mg/kg-day)	CSF $(mg/kg\text{-}day)^{-1}$	ILCR (unitless)
antimony	4.9E-07	NA	NA
arsenic	4.7E-08	1.9E+00	8.9E-08
barium	8.9E-06	NA	NA
beryllium	6.9E-08	4.3E+00	3.0E-07
boron	1.0E-05	NA	NA
cadmium	3.2E-07	NA	NA
chromium vi	1.5E-06	NA	NA
cobalt	1.1E-06	NA	NA
copper	1.9E-07	NA	NA
cyanide	2.3E-08	NA	NA
lead	2.2E-06	NA	NA
manganese	8.9E-05	NA	NA
mercury	9.8E-08	NA	NA
molybdenum	5.9E-07	NA	NA
nickel	1.0E-07	NA	NA
selenium	5.8E-08	NA	NA
silver	5.5E-07	NA	NA
thallium	5.1E-08	NA	NA
thorium-total	NA	NA	NA
uranium-total	NA	NA	NA
vanadium	2.4E-07	NA	NA
zinc	5.9E-06	NA	NA
2-methylnaphthalene	NA	NA	NA
4,4-dde	NA	3.4E-01	NA
aroclor-1221	NA	1.0E+01	NA
aroclor-1248	NA	1.0E+01	NA
aroclor-1254	NA	1.0E+01	NA
aroclor-1260	NA	1.0E+01	NA
carbazole	NA	2.2E-02	NA
endrin	NA	NA	NA
2,3,7,8-tcdd	NA	3.0E+05	NA
	ILCR Summation =		3.9E-07

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Table I.IV–52
Summary of Intake Quantitation (chemicals)
Future Land Use with Federal Ownership: Expanded Trespasser
Via Ingestion While Wading

Intake Equation $= \frac{CS \times EF \times ED \times IR}{BW \times AT} + \frac{CS \times EF \times ED \times IR}{BW \times AT}$

IRsw	Ingestion rate of surface water	0.035	l/day
EFa	Exposure frequency (adult)	NA	days/year
EFc	Exposure frequency (child)	52	days/year
EDa	Exposure duration (adult)	NA	Year
EDc	Exposure duration (child)	12	Year
BWa	Body weight (adult)	70	kg
BWc	Body weight (child)	43	kg
AT	Average time for carcinogens	25550	days
ATa	Average time for non–carcinogens (adult)	11680	days
ATc	Average time for non–carcinogens (child)	4380	days
CS	Concentration of chemicals in surface water		

Chemical Concentrations

Compound	Concentration	Units	Compound	Concentration	Units
antimony	7.64E–05	mg/l	silver	NA	mg/l
arsenic	1.18E–03	mg/l	thallium	NA	mg/l
barium	NA	mg/l	thorium–total	NA	mg/l
beryllium	3.77E–05	mg/l	uranium–total	3.61E–02	mg/l
boron	NA	mg/l	vanadium	NA	mg/l
cadmium	NA	mg/l	zinc	NA	mg/l
chromium vi	NA	mg/l	2–methylnaphthalene	NA	mg/l
cobalt	NA	mg/l	4,4–dde	NA	mg/l
copper	NA	mg/l	aroclor–1221	NA	mg/l
cyanide	NA	mg/l	aroclor–1248	NA	mg/l
lead	NA	mg/l	aroclor–1254	NA	mg/l
manganese	NA	mg/l	aroclor–1260	NA	mg/l
mercury	NA	mg/l	carbazole	NA	mg/l
molybdenum	NA	mg/l	endrin	NA	mg/l
nickel	NA	mg/l	2,3,7,8–tcdd	NA	mg/l
selenium	NA	mg/l			

References

Table I.IV–52
Summary of Risk Characterization (chemicals)
Future Land Use with Federal Ownership: Expanded Trespasser
Via Ingestion While Wading

	HQ Calculation		
Compound	CDI (mg/kg–day)	RfD (mg/kg–day)	HQ (unitless)
antimony	8.86E–09	4.00E–04	2.21E–05
arsenic	1.37E–07	3.00E–04	4.56E–04
barium	NA	7.00E–02	NA
beryllium	4.37E–09	5.00E–03	8.74E–07
boron	NA	9.00E–02	NA
cadmium	NA	1.00E–03	NA
chromium vi	NA	5.00E–03	NA
cobalt	NA	6.00E–02	NA
copper	NA	NA	NA
cyanide	NA	2.00E–02	NA
lead	NA	NA	NA
manganese	NA	1.40E–01	NA
mercury	NA	3.00E–04	NA
molybdenum	NA	5.00E–03	NA
nickel	NA	2.00E–02	NA
selenium	NA	5.00E–03	NA
silver	NA	5.00E–03	NA
thallium	NA	8.00E–05	NA
thorium–total	NA	NA	NA
uranium–total	4.18E–06	3.00E–03	1.39E–03
vanadium	NA	7.00E–03	NA
zinc	NA	3.00E–01	NA
2–methylnaphthalene	NA	NA	NA
4,4–dde	NA	NA	NA
aroclor–1221	NA	NA	NA
aroclor–1248	NA	NA	NA
aroclor–1254	NA	NA	NA
aroclor–1260	NA	NA	NA
carbazole	NA	NA	NA
endrin	NA	3.00E–04	NA
2,3,7,8–tcdd	NA	NA	NA
	HQ Summation =		1.87E–03

	ILCR Calculation		
Compound	CDI (mg/kg–day)	CSF $(mg/kg–day)^{-1}$	ILCR (unitless)
antimony	1.52E–09	NA	NA
arsenic	2.35E–08	1.75E+00	4.11E–08
barium	NA	NA	NA
beryllium	7.49E–10	4.30E+00	3.22E–09
boron	NA	NA	NA
cadmium	NA	NA	NA
chromium vi	NA	NA	NA
cobalt	NA	NA	NA
copper	NA	NA	NA
cyanide	NA	NA	NA
lead	NA	NA	NA
manganese	NA	NA	NA
mercury	NA	NA	NA
molybdenum	NA	NA	NA
nickel	NA	NA	NA
selenium	NA	NA	NA
silver	NA	NA	NA
thallium	NA	NA	NA
thorium–total	NA	NA	NA
uranium–total	NA	NA	NA
vanadium	NA	NA	NA
zinc	NA	NA	NA
2–methylnaphthalene	NA	NA	NA
4,4–dde	NA	3.40E–01	NA
aroclor–1221	NA	7.70E+00	NA
aroclor–1248	NA	7.70E+00	NA
aroclor–1254	NA	7.70E+00	NA
aroclor–1260	NA	7.70E+00	NA
carbazole	NA	2.00E–02	NA
endrin	NA	NA	NA
2,3,7,8–tcdd	NA	1.50E+05	NA
	ILCR Summation =		4.43E–08

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Table I.IV-53
Summary of Intake Quantitation (chemicals)
Future Land Use with Federal Ownership: Expanded Trespasser
Via Dermal Contact While Wading

Intake Equation $= \frac{EF \times ED \times DA \times SA}{BW \times AT} + \frac{EF \times ED \times DA \times SA}{BW \times AT}$

EFa	Exposure frequency (adult)	NA days/year
EFc	Exposure frequency (child)	52 days/year
EDa	Exposure duration (adult)	NA Year
EDc	Exposure duration (child)	12 Year
BWa	Body weight (adult)	70 kg
BWc	Body weight (child)	43 kg
AT	Average time for carcinogens	25550 days
ATa	Average time for non-carcinogens (adult)	11680 days
ATc	Average time for non-carcinogens (child)	4380 days
DA	chemicals specific dermal absorbed dose (see table below)	csv
SAa	Skin surface area (adult)	NA cm^2
SAc	Skin surface area (child)	5130 cm^2

Chemical Concentrations

Compound	DA	Units	Compound	DA	Units
antimony	7.64E-10	mg/cm^2-day	silver	NA	mg/cm^2-day
arsenic	1.18E-08	mg/cm^2-day	thallium	NA	mg/cm^2-day
barium	NA	mg/cm^2-day	thorium-total	NA	mg/cm^2-day
beryllium	3.77E-10	mg/cm^2-day	uranium-total	3.61E-07	mg/cm^2-day
boron	NA	mg/cm^2-day	vanadium	NA	mg/cm^2-day
cadmium	NA	mg/cm^2-day	zinc	NA	mg/cm^2-day
chromium vi	NA	mg/cm^2-day	2-methylnaphthalene	NA	mg/cm^2-day
cobalt	NA	mg/cm^2-day	4,4-dde	NA	mg/cm^2-day
copper	NA	mg/cm^2-day	aroclor-1221	NA	mg/cm^2-day
cyanide	NA	mg/cm^2-day	aroclor-1248	NA	mg/cm^2-day
lead	NA	mg/cm^2-day	aroclor-1254	NA	mg/cm^2-day
manganese	NA	mg/cm^2-day	aroclor-1260	NA	mg/cm^2-day
mercury	NA	mg/cm^2-day	carbazole	NA	mg/cm^2-day
molybdenum	NA	mg/cm^2-day	endrin	NA	mg/cm^2-day
nickel	NA	mg/cm^2-day	2,3,7,8-tcdd	NA	mg/cm^2-day
selenium	NA	mg/cm^2-day			

References

Table I.IV–53 (continued)
Summary of Risk Characterization (chemicals)
Future Land Use with Federal Ownership: Expanded Trespasser
Via Dermal Contact While Wading

Compound	HQ Calculation		
	CDI (mg/kg–day)	RfD (mg/kg–day)	HQ (unitless)
antimony	1.30E–08	6.00E–05	2.16E–04
arsenic	2.01E–07	2.85E–04	7.04E–04
barium	NA	6.37E–02	NA
beryllium	6.41E–09	5.00E–03	1.28E–06
boron	NA	4.50E–03	NA
cadmium	NA	5.00E–05	NA
chromium vi	NA	2.25E–03	NA
cobalt	NA	2.70E–02	NA
copper	NA	NA	NA
cyanide	NA	NA	NA
lead	NA	NA	NA
manganese	NA	4.20E–03	NA
mercury	NA	4.50E–05	NA
molybdenum	NA	1.90E–03	NA
nickel	NA	2.00E–03	NA
selenium	NA	4.00E–03	NA
silver	NA	NA	NA
thallium	NA	8.00E–05	NA
thorium–total	NA	NA	NA
uranium–total	6.13E–06	1.50E–04	4.08E–02
vanadium	NA	3.50E–04	NA
zinc	NA	7.50E–02	NA
2–methylnaphthalene	NA	NA	NA
4,4–dde	NA	NA	NA
aroclor–1221	NA	NA	NA
aroclor–1248	NA	NA	NA
aroclor–1254	NA	NA	NA
aroclor–1260	NA	NA	NA
carbazole	NA	NA	NA
endrin	NA	2.70E–04	NA
2,3,7,8–tcdd	NA	NA	NA
	HQ Summation =		4.18E–02

Compound	ILCR Calculation		
	CDI (mg/kg–day)	CSF $(mg/kg–day)^{-1}$	ILCR (unitless)
antimony	2.23E–09	NA	NA
arsenic	3.44E–08	1.90E+00	6.53E–08
barium	NA	NA	NA
beryllium	1.10E–09	4.30E+00	4.72E–09
boron	NA	NA	NA
cadmium	NA	NA	NA
chromium vi	NA	NA	NA
cobalt	NA	NA	NA
copper	NA	NA	NA
cyanide	NA	NA	NA
lead	NA	NA	NA
manganese	NA	NA	NA
mercury	NA	NA	NA
molybdenum	NA	NA	NA
nickel	NA	NA	NA
selenium	NA	NA	NA
silver	NA	NA	NA
thallium	NA	NA	NA
thorium–total	NA	NA	NA
uranium–total	1.05E–06	NA	NA
vanadium	NA	NA	NA
zinc	NA	NA	NA
2–methylnaphthalene	NA	NA	NA
4,4–dde	NA	3.40E–01	NA
aroclor–1221	NA	1.03E+01	NA
aroclor–1248	NA	1.03E+01	NA
aroclor–1254	NA	1.03E+01	NA
aroclor–1260	NA	1.03E+01	NA
carbazole	NA	2.22E–02	NA
endrin	NA	NA	NA
2,3,7,8–tcdd	NA	3.00E+05	NA
	ILCR Summation =		7.00E–08

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Table I.IV–54
Summary of Intake and Risk Quantitation (radionuclides)
Future Land Use with Federal Ownership: Expanded Trespasser
Via Incidental Ingestion while Wading

Intake Equation = CS X EFa X EDa X FI X IRsw + CS X EFc X EDc X FI X IRsw

IRsw	Ingestion rate of surface water	0.035 l/day
EFa	Exposure frequency (adult)	NA days/year
EFc	Exposure frequency (child)	52 days/year
EDa	Exposure duration (adult)	NA Year
EDc	Exposure duration (child)	12 Year
FI	Fractional intake for radionuclides	1 (Unitless)
Cs	Concentration of radionuclides in surface water	(see table below)

Cs_{137+1d}	NA	pCi/l	Rn_{222+4d}	NA	pCi/l
Pb_{210+2d}	NA	pCi/l	Sr_{90+1d}	NA	pCi/l
Np_{237+1d}	1.3E−01	pCi/l	Tc_{99}	8.8E+02	pCi/l
Pu_{238}	NA	pCi/l	Th_{228+7d}	NA	pCi/l
Pu_{239}	NA	pCi/l	Th_{230}	NA	pCi/l
Pu_{240}	NA	pCi/l	$Th_{232+10d}$	NA	pCi/l
Pa_{231}	NA	pCi/l	NA	NA	pCi/l
Ra_{226+8d}	1.2E−01	pCi/l	U_{235+1d}	7.0E−02	pCi/l
Ra_{228+1d}	NA	pCi/l	U_{236}	5.3E−01	pCi/l
Ru_{106}	NA	pCi/l	U_{238+2d}	1.2E+01	pCi/l

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	ILCR (unitless)
Cs_{137+1d}	NA	2.8E−11	NA
Pb_{210+2d}	NA	6.6E−10	NA
Np_{237+1d}	2.8E+00	2.2E−10	6.2E−10
Pu_{238}	NA	2.2E−10	NA
Pu_{239}	NA	2.3E−10	NA
Pu_{240}	NA	2.3E−10	NA
Pa_{231}	NA	9.2E−11	NA
Ra_{226+8d}	2.5E+00	7.8E−10	2.0E−09
Ra_{228+1d}	NA	1.0E−10	NA
Ru_{106}	NA	9.5E−12	NA
Rn_{222+4d}	NA	1.7E−12	NA
Sr_{90+1d}	NA	3.6E−11	NA
Tc_{99}	1.9E+04	1.3E−12	2.5E−08
Th_{228+7d}	NA	5.5E−11	NA
Th_{230}	NA	1.3E−11	NA
$Th_{232+10d}$	NA	1.7E−10	NA
NA	NA	NA	NA
U_{235+1d}	1.5E+00	1.6E−11	2.5E−11
U_{236}	1.2E+01	1.5E−11	1.7E−10
U_{238+2d}	2.6E+02	2.0E−11	5.3E−09
		ILCR Summation =	3.3E−08

Table I.IV–55
Summary of Risk Quantitation (radionuclides)
Future Land Use with Federal Ownership: Expanded Trespasser
Via External Radiation

Exposure Equation = $[CR \times EFa \times EDa \times ET_{oa} \times (1-SH_o)] + [CR \times EFc \times EDc \times ET_{oc} \times (1-SH_o)]$

EFa	Fraction of year spent exposured (adult)	0.11 (unitless)
EFc	Fraction of year spent exposured (child)	0.3 (unitless)
EDa	Exposure duration (adult)	32 Year
EDc	Exposure duration (child)	12 Year
ET_{oa}	Fraction of day spent outdoors (adult)	0.04 (unitless)
ET_{oc}	Fraction of day spent outdoors (child)	0.08 (unitless)
SH_o	Shield factor outdoors	NA (unitless)
CR	Radionuclide specific concentrations	(see table below)

Cs_{137+1d}	7.9E–01	pCi/g	Rn_{222+4d}	NA	pCi/g
Pb_{210+2d}	1.1E–06	pCi/g	Sr_{90+1d}	8.3E–07	pCi/g
Np_{237+1d}	8.4E–08	pCi/g	Tc_{99}	1.9E–06	pCi/g
Pu_{238}	9.1E–08	pCi/g	Th_{228+7d}	4.0E–07	pCi/g
Pu_{239}	1.3E–08	pCi/g	Th_{230}	5.9E–08	pCi/g
Pu_{240}	4.6E–08	pCi/g	$Th_{232+10d}$	NA	pCi/g
Pa_{231}	NA	pCi/g	NA	NA	pCi/g
Ra_{226+8d}	4.0E–07	pCi/g	U_{235+1d}	9.3E–07	pCi/g
Ra_{228+1d}	7.0E–07	pCi/g	U_{236}	6.9E–06	pCi/g
Ru_{106}	1.3E–07	pCi/g	U_{238+2d}	1.4E–05	pCi/g

Radionuclides	CDI (year pCi/g)	CSF $(g/pCi-year)^{-1}$	ILCR (unitless)
Cs_{137+1d}	3.4E–01	2.0E–06	6.8E–07
Pb_{210+2d}	4.5E–07	1.6E–10	7.2E–17
Np_{237+1d}	3.6E–08	4.3E–07	1.5E–14
Pu_{238}	3.9E–08	2.8E–11	1.1E–18
Pu_{239}	5.4E–09	1.7E–11	9.1E–20
Pu_{240}	2.0E–08	2.7E–11	5.3E–19
Pa_{231}	NA	2.6E–08	NA
Ra_{226+8d}	1.7E–07	6.0E–06	1.0E–12
Ra_{228+1d}	3.0E–07	2.9E–06	8.7E–13
Ru_{106}	5.7E–08	NA	NA
Rn_{222+4d}	NA	5.9E–06	NA
Sr_{90+1d}	3.6E–07	NA	NA
Tc_{99}	8.0E–07	6.0E–13	4.8E–19
Th_{228+7d}	1.7E–07	5.6E–06	9.6E–13
Th_{230}	2.5E–08	5.4E–11	1.4E–18
$Th_{232+10d}$	NA	8.5E–06	NA
NA	NA	NA	NA
U_{235+1d}	4.0E–07	2.4E–07	9.6E–14
U_{236}	2.9E–06	2.4E–11	7.1E–17
U_{238+2d}	5.9E–06	5.1E–08	3.0E–13
		ILCR Summation =	6.8E–07

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Table I.IV–56
Summary of Intake Quantitation (chemicals)
Future Land Use with Federal Ownership: Off–Property Farmer (Adult)
Via Inhalation of Particulates

Intake Equation = $\frac{CS \times EF \times ED \times IR}{BW \times AT}$

IR	Inhalation rate of gases (RAGS, 1989)	20 m^3/day
EF	Exposure frequency	350 days/year
EDn	Exposure duration for non–carcinogens	70 Year
EDc	Exposure duration for carcinogens	70 Year
BW	Body weight	70 kg
ATc	Average time for carcinogens (lifetime)	25550 days
ATn	Average time for non–carcinogens (EDn x 365)	25550 days
CS	Concentration of chemicals in soil	(see table below)

Chemical Concentrations

Compound	Concentration	Units	Compound	Concentration	Units
antimony	7.5E–09	mg/m^3	silver	2.7E–09	mg/m^3
arsenic	5.3E–09	mg/m^3	thallium	3.3E–10	mg/m^3
barium	8.2E–08	mg/m^3	thorium–total	7.5E–08	mg/m^3
beryllium	7.8E–10	mg/m^3	uranium–total	1.0E–06	mg/m^3
boron	8.5E–09	mg/m^3	vanadium	2.0E–08	mg/m^3
cadmium	1.3E–09	mg/m^3	zinc	5.1E–08	mg/m^3
chromium vi	1.2E–08	mg/m^3	2–methylnaphthalene	6.0E–11	mg/m^3
cobalt	6.3E–09	mg/m^3	4,4–dde	4.3E–12	mg/m^3
copper	3.8E–08	mg/m^3	aroclor–1221	NA	mg/m^3
cyanide	4.6E–10	mg/m^3	aroclor–1248	NA	mg/m^3
lead	1.3E–06	mg/m^3	aroclor–1254	2.7E–10	mg/m^3
manganese	2.4E–10	mg/m^3	aroclor–1260	6.4E–11	mg/m^3
mercury	2.4E–10	mg/m^3	carbazole	1.7E–11	mg/m^3
molybdenum	4.1E–09	mg/m^3	endrin	NA	mg/m^3
nickel	1.5E–08	mg/m^3	2,3,7,8–tcdd	8.8E–17	mg/m^3
selenium	3.4E–10	mg/m^3			

References

Table I.IV-56 (continued)
Summary of Risk Characterization (chemicals)
Future Land Use with Federal Ownership: Off-Property Farmer (Adult)
Via Inhalation of Particulates

	HQ Calculation		
Compound	CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
antimony	2.1E-09	NA	NA
arsenic	1.5E-09	NA	NA
barium	2.2E-08	1.4E-04	1.6E-04
beryllium	2.1E-10	NA	NA
boron	2.3E-09	5.7E-03	4.1E-07
cadmium	3.6E-10	NA	NA
chromium vi	3.4E-09	NA	NA
cobalt	1.7E-09	3.0E-07	5.8E-03
copper	1.0E-08	NA	NA
cyanide	1.3E-10	NA	NA
lead	3.5E-07	NA	NA
manganese	6.6E-11	1.4E-05	4.7E-06
mercury	6.6E-11	8.6E-05	7.7E-07
molybdenum	1.1E-09	NA	NA
nickel	4.2E-09	NA	NA
selenium	9.2E-11	NA	NA
silver	7.3E-10	NA	NA
thallium	9.0E-11	NA	NA
thorium-total	2.1E-08	NA	NA
uranium-total	2.7E-07	NA	NA
vanadium	5.4E-09	NA	NA
zinc	1.4E-08	NA	NA
2-methylnaphthalene	1.6E-11	NA	NA
4,4-dde	1.2E-12	NA	NA
aroclor-1221	NA	NA	NA
aroclor-1248	NA	NA	NA
aroclor-1254	7.3E-11	NA	NA
aroclor-1260	1.8E-11	NA	NA
carbazole	4.5E-12	NA	NA
endrin	NA	NA	NA
2,3,7,8-tcdd	2.4E-17	NA	NA
	Hazard Quotient Sum =		6.0E-03

	ILCR Calculation		
Compound	CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	ILCR (unitless)
antimony	2.1E-09	NA	NA
arsenic	1.5E-09	1.5E+01	2.2E-08
barium	2.2E-08	NA	NA
beryllium	2.1E-10	8.4E+00	1.8E-09
boron	2.3E-09	NA	NA
cadmium	3.6E-10	6.3E+00	2.2E-09
chromium vi	3.4E-09	4.1E+01	1.4E-07
cobalt	1.7E-09	NA	NA
copper	1.0E-08	NA	NA
cyanide	1.3E-10	NA	NA
lead	3.5E-07	NA	NA
manganese	6.6E-11	NA	NA
mercury	6.6E-11	NA	NA
molybdenum	1.1E-09	NA	NA
nickel	4.2E-09	8.4E-01	3.5E-09
selenium	9.2E-11	NA	NA
silver	7.3E-10	NA	NA
thallium	9.0E-11	NA	NA
thorium-total	2.1E-08	NA	NA
uranium-total	2.7E-07	NA	NA
vanadium	5.4E-09	NA	NA
zinc	1.4E-08	NA	NA
2-methylnaphthalene	1.6E-11	NA	NA
4,4-dde	1.2E-12	NA	NA
aroclor-1221	NA	NA	NA
aroclor-1248	NA	NA	NA
aroclor-1254	7.3E-11	NA	NA
aroclor-1260	1.8E-11	NA	NA
carbazole	4.5E-12	NA	NA
endrin	NA	NA	NA
2,3,7,8-tcdd	2.4E-17	1.5E+05	3.6E-12
	ILCR Summation =		1.7E-07

Table I.IV–57
Summary of Intake and Risk Quantitation (radionuclides)
Future Land Use with Federal Ownership: Off–Property Farmer (Adult)
Via Inhalation of Gases and Particulates

Intake Equation = Ca X EF X EDn X IR

IR	Inhalation rate of gases (RAGS, 1989)	20 m^3/day
EF	Exposure frequency	350 days/year
EDn	Exposure duration	70 Year
Ca	Concentration of radionuclides in air	(see table below)

Cs_{137+1d}	4.3E−07	pCi/m^3	Rn_{222+4d}	1.3E+01	pCi/m^3
Pb_{210+2d}	1.1E−05	pCi/m^3	Sr_{90+1d}	1.4E−06	pCi/m^3
Np_{237+1d}	2.0E−07	pCi/m^3	Tc_{99}	2.3E−05	pCi/m^3
Pu_{238}	1.2E−05	pCi/m^3	Th_{228+7d}	9.5E−07	pCi/m^3
Pu_{239}	3.9E−07	pCi/m^3	Th_{230}	3.3E−06	pCi/m^3
Pu_{240}	1.4E−06	pCi/m^3	$Th_{232+10d}$	2.7E−06	pCi/m^3
Pa_{231}	4.1E−07	pCi/m^3	U_{234}	4.6E−05	pCi/m^3
Ra_{226+8d}	9.1E−07	pCi/m^3	U_{235+1d}	1.2E−06	pCi/m^3
Ra_{228+1d}	1.1E−06	pCi/m^3	U_{236}	5.1E−07	pCi/m^3
Ru_{106}	7.8E−08	pCi/m^3	U_{238+2d}	2.8E−05	pCi/m^3

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	ILCR (unitless)
Cs_{137+1d}	2.1E−01	1.9E−11	4.0E−12
Pb_{210+2d}	5.6E+00	4.0E−09	2.2E−08
Np_{237+1d}	9.7E−02	2.9E−08	2.8E−09
Pu_{238}	5.8E+00	3.9E−08	2.3E−07
Pu_{239}	1.9E−01	3.8E−08	7.3E−09
Pu_{240}	7.0E−01	3.8E−08	2.7E−08
Pa_{231}	2.0E−01	3.6E−08	7.3E−09
Ra_{226+8d}	4.5E−01	7.0E−09	3.1E−09
Ra_{228+1d}	5.6E−01	6.9E−10	3.9E−10
Ru_{106}	3.8E−02	4.4E−10	1.7E−11
Rn_{222+4d}	6.2E+06	7.7E−12	4.8E−05
Sr_{90+1d}	6.9E−01	6.2E−11	4.3E−11
Tc_{99}	1.1E+01	8.3E−12	9.4E−11
Th_{228+7d}	4.6E−01	7.8E−08	3.6E−08
Th_{230}	1.6E+00	2.9E−08	4.6E−08
$Th_{232+10d}$	1.3E+00	1.1E−07	1.5E−07
U_{234}	2.3E+01	2.6E−08	5.9E−07
U_{235+1d}	6.0E−01	2.5E−08	1.5E−08
U_{236}	2.5E−01	2.5E−08	6.2E−09
U_{238+2d}	1.4E+01	2.4E−08	3.3E−07
		ILCR Summation =	4.9E−05

Table I.IV–58
Summary of Intake Quantitation (chemicals)
Future Land Use with Federal Ownership: Off–Property Farmer (Adult)
Via Drinking Water Ingestion

Intake Equation = $\frac{CS \times EF \times ED \times IR}{BW \times AT}$

IR	Ingestion rate of groundwater (RAGS, 1989)	2 l/day
EF	Exposure frequency	350 days/year
EDn	Exposure duration for non–carcinogens	70 Year
EDc	Exposure duration for carcinogens	70 Year
BW	Body weight	70 kg
ATc	Average time for carcinogens (lifetime)	25550 days
ATn	Average time for non–carcinogens (EDn x 365)	25550 days
CS	Concentration of chemicals in groundwater	

Chemical Concentrations

Compound	Concentration	Units	Compound	Concentration	Units
antimony	6.90E–08	mg/l	silver	NA	mg/l
arsenic	1.79E–06	mg/l	thallium	NA	mg/l
barium	NA	mg/l	thorium–total	NA	mg/l
beryllium	8.86E–09	mg/l	uranium–total	4.50E–02	mg/l
boron	NA	mg/l	vanadium	NA	mg/l
cadmium	1.71E–24	mg/l	zinc	NA	mg/l
chromium vi	NA	mg/l	2–methylnaphthalene	NA	mg/l
cobalt	NA	mg/l	4,4–dde	NA	mg/l
copper	NA	mg/l	aroclor–1221	1.03E–27	mg/l
cyanide	NA	mg/l	aroclor–1248	NA	mg/l
lead	NA	mg/l	aroclor–1254	NA	mg/l
manganese	NA	mg/l	aroclor–1260	NA	mg/l
mercury	NA	mg/l	carbazole	NA	mg/l
molybdenum	NA	mg/l	endrin	NA	mg/l
nickel	NA	mg/l	2,3,7,8–tcdd	NA	mg/l
selenium	NA	mg/l			

References

Table I.IV-58 (continued)
Summary of Risk Characterization (chemicals)
Future Land Use with Federal Ownership: Off-Property Farmer (Adult)
Via Drinking Water Ingestion

Compound	HQ Calculation CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
antimony	1.89E-09	4.00E-04	4.73E-06
arsenic	4.90E-08	3.00E-04	1.63E-04
barium	NA	7.00E-02	NA
beryllium	2.43E-10	5.00E-03	4.85E-08
boron	NA	9.00E-02	NA
cadmium	4.68E-26	1.00E-03	4.68E-23
chromium vi	NA	5.00E-03	NA
cobalt	NA	6.00E-02	NA
copper	NA	NA	NA
cyanide	NA	2.00E-02	NA
lead	NA	NA	NA
manganese	NA	1.40E-01	NA
mercury	NA	3.00E-04	NA
molybdenum	NA	5.00E-03	NA
nickel	NA	2.00E-02	NA
selenium	NA	5.00E-03	NA
silver	NA	5.00E-03	NA
thallium	NA	8.00E-05	NA
thorium-total	NA	NA	NA
uranium-total	1.23E-03	3.00E-03	4.11E-01
vanadium	NA	7.00E-03	NA
zinc	NA	3.00E-01	NA
2-methylnaphthalene	NA	NA	NA
4,4-dde	NA	NA	NA
aroclor-1221	2.82E-29	NA	NA
aroclor-1248	NA	NA	NA
aroclor-1254	NA	NA	NA
aroclor-1260	NA	NA	NA
carbazole	NA	NA	NA
endrin	NA	3.00E-04	NA
2,3,7,8-tcdd	NA	NA	NA
	HQ Summation =		4.11E-01

Compound	ILCR Calculation CDI (mg/kg-day)	CSF (mg/kg-day)$^{-1}$	ILCR (unitless)
antimony	1.89E-09	NA	NA
arsenic	4.90E-08	1.75E+00	8.58E-08
barium	NA	NA	NA
beryllium	2.43E-10	4.30E+00	1.04E-09
boron	NA	NA	NA
cadmium	4.68E-26	NA	NA
chromium vi	NA	NA	NA
cobalt	NA	NA	NA
copper	NA	NA	NA
cyanide	NA	NA	NA
lead	NA	NA	NA
manganese	NA	NA	NA
mercury	NA	NA	NA
molybdenum	NA	NA	NA
nickel	NA	NA	NA
selenium	NA	NA	NA
silver	NA	NA	NA
thallium	NA	NA	NA
thorium-total	NA	NA	NA
uranium-total	1.23E-03	NA	NA
vanadium	NA	NA	NA
zinc	NA	NA	NA
2-methylnaphthalene	NA	NA	NA
4,4-dde	NA	3.40E-01	NA
aroclor-1221	2.82E-29	7.70E+00	2.17E-28
aroclor-1248	NA	7.70E+00	NA
aroclor-1254	NA	7.70E+00	NA
aroclor-1260	NA	7.70E+00	NA
carbazole	NA	2.00E-02	NA
endrin	NA	NA	NA
2,3,7,8-tcdd	NA	1.50E+05	NA
	ILCR Summation =		8.69E-08

090602

Table I.IV–59
Summary of Intake and Risk Quantitation (radionuclides)
Future Land Use with Federal Ownership: Off–Property Farmer (Adult)
Via Ingestion of Drinking Water

Intake Equation = Cw X EF X EDn X FI X IR

IR	Ingestion rate of groundwater (RAGS, 1989)	2 l/day
EF	Exposure frequency	350 days/year
EDn	Exposure duration	70 Year
FI	Fractional intake for radionuclides	1 (Unitless)
Cw	Concentration of radionuclides in groundwater	(see table below)

Cs_{137+1d}	NA	pCi/l	Rn_{222+4d}	NA	pCi/l
Pb_{210+2d}	NA	pCi/l	Sr_{90+1d}	NA	pCi/l
Np_{237+1d}	8.0E–02	pCi/l	Tc_{99}	1.2E+03	pCi/l
Pu_{238}	NA	pCi/l	Th_{228+7d}	NA	pCi/l
Pu_{239}	NA	pCi/l	Th_{230}	NA	pCi/l
Pu_{240}	NA	pCi/l	$Th_{232+10d}$	NA	pCi/l
Pa_{231}	NA	pCi/l	U_{234}	2.5E+01	pCi/l
Ra_{226+8d}	3.2E–03	pCi/l	U_{235+1d}	6.7E–01	pCi/l
Ra_{228+1d}	NA	pCi/l	U_{236}	2.8E–01	pCi/l
Ru_{106}	NA	pCi/l	U_{238+2d}	1.5E+01	pCi/l

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	ILCR (unitless)
Cs_{137+1d}	NA	2.8E–11	NA
Pb_{210+2d}	NA	6.6E–10	NA
Np_{237+1d}	3.9E+03	2.2E–10	8.7E–07
Pu_{238}	NA	2.2E–10	NA
Pu_{239}	NA	2.3E–10	NA
Pu_{240}	NA	2.3E–10	NA
Pa_{231}	NA	9.2E–11	NA
Ra_{226+8d}	1.5E+02	7.8E–10	1.2E–07
Ra_{228+1d}	NA	1.0E–10	NA
Ru_{106}	NA	9.5E–12	NA
Rn_{222+4d}	NA	1.7E–12	NA
Sr_{90+1d}	NA	3.6E–11	NA
Tc_{99}	6.0E+07	1.3E–12	7.8E–05
Th_{228+7d}	NA	5.5E–11	NA
Th_{230}	NA	1.3E–11	NA
$Th_{232+10d}$	NA	1.7E–10	NA
U_{234}	1.2E+06	1.6E–11	2.0E–05
U_{235+1d}	3.3E+04	1.6E–11	5.2E–07
U_{236}	1.3E+04	1.5E–11	2.0E–07
U_{238+2d}	7.4E+05	2.0E–11	1.5E–05
		ILCR Summation =	1.1E–04

Table I.IV–60
Summary of Intake Quantitation (chemicals)
Future Land Use with Federal Ownership: Off–Property Farmer (Adult)
Via Dermal Contact while Bathing

Intake Equation = $\frac{DA \times EF \times ED \times SA}{BW \times AT}$

DA	Dermal absorbed dose	csv	mg/cm^2–day
EF	Exposure frequency	350	days/year
EDn	Exposure duration for non–carcinogens	70	Year
EDc	Exposure duration for carcinogens	70	Year
BW	Body weight	70	kg
ATc	Average time for carcinogens (lifetime)	25550	days
ATn	Average time for non–carcinogens (EDn x 365)	25550	days
SA	Skin surface area available for contact	23000	cm^2

Chemical Concentrations

Compound	DA	Units	Compound	DA	Units
antimony	1.73E–13	mg/cm^2–day	silver	NA	mg/cm^2–day
arsenic	4.48E–12	mg/cm^2–day	thallium	NA	mg/cm^2–day
barium	NA	mg/cm^2–day	thorium–total	NA	mg/cm^2–day
beryllium	2.22E–14	mg/cm^2–day	uranium–total	1.13E–07	mg/cm^2–day
boron	NA	mg/cm^2–day	vanadium	NA	mg/cm^2–day
cadmium	4.28E–30	mg/cm^2–day	zinc	NA	mg/cm^2–day
chromium vi	NA	mg/cm^2–day	2–methylnaphthalene	NA	mg/cm^2–day
cobalt	NA	mg/cm^2–day	4,4–dde	NA	mg/cm^2–day
copper	NA	mg/cm^2–day	aroclor–1221	8.37E–31	mg/cm^2–day
cyanide	NA	mg/cm^2–day	aroclor–1248	NA	mg/cm^2–day
lead	NA	mg/cm^2–day	aroclor–1254	NA	mg/cm^2–day
manganese	NA	mg/cm^2–day	aroclor–1260	NA	mg/cm^2–day
mercury	NA	mg/cm^2–day	carbazole	NA	mg/cm^2–day
molybdenum	NA	mg/cm^2–day	endrin	NA	mg/cm^2–day
nickel	NA	mg/cm^2–day	2,3,7,8–tcdd	NA	mg/cm^2–day
selenium	NA	mg/cm^2–day			

References

000604

Table I.IV–60 (continued)
Summary of Risk Characterization (chemicals)
Future Land Use with Federal Ownership: Off–Property Farmer (Adult)
Via Dermal Contact while Bathing

Compound	HQ Calculation CDI (mg/kg–day)	RfD (mg/kg–day)	HQ (unitless)
antimony	5.43E–11	6.00E–05	9.06E–07
arsenic	1.41E–09	2.85E–04	4.95E–06
barium	NA	6.37E–02	NA
beryllium	6.98E–12	5.00E–03	1.40E–09
boron	NA	4.50E–03	NA
cadmium	1.35E–27	5.00E–05	2.69E–23
chromium vi	NA	2.25E–03	NA
cobalt	NA	2.70E–02	NA
copper	NA	NA	NA
cyanide	NA	NA	NA
lead	NA	NA	NA
manganese	NA	4.20E–03	NA
mercury	NA	4.50E–05	NA
molybdenum	NA	1.90E–03	NA
nickel	NA	2.00E–03	NA
selenium	NA	4.00E–03	NA
silver	NA	NA	NA
thallium	NA	8.00E–05	NA
thorium–total	NA	NA	NA
uranium–total	3.55E–05	1.50E–04	2.36E–01
vanadium	NA	3.50E–04	NA
zinc	NA	7.50E–02	NA
2–methylnaphthalene	NA	NA	NA
4,4–dde	NA	NA	NA
aroclor–1221	2.64E–28	NA	NA
aroclor–1248	NA	NA	NA
aroclor–1254	NA	NA	NA
aroclor–1260	NA	NA	NA
carbazole	NA	NA	NA
endrin	NA	2.70E–04	NA
2,3,7,8–tcdd	NA	NA	NA
	HQ Summation =		2.36E–01

Compound	ILCR Calculation CDI (mg/kg–day)	CSF (mg/kg–day)$^{-1}$	ILCR (unitless)
antimony	5.43E–11	NA	NA
arsenic	1.41E–09	1.90E+00	2.68E–09
barium	NA	NA	NA
beryllium	6.98E–12	4.30E+00	3.00E–11
boron	NA	NA	NA
cadmium	1.35E–27	NA	NA
chromium vi	NA	NA	NA
cobalt	NA	NA	NA
copper	NA	NA	NA
cyanide	NA	NA	NA
lead	NA	NA	NA
manganese	NA	NA	NA
mercury	NA	NA	NA
molybdenum	NA	NA	NA
nickel	NA	NA	NA
selenium	NA	NA	NA
silver	NA	NA	NA
thallium	NA	NA	NA
thorium–total	NA	NA	NA
uranium–total	3.55E–05	NA	NA
vanadium	NA	NA	NA
zinc	NA	NA	NA
2–methylnaphthalene	NA	NA	NA
4,4–dde	NA	3.40E–01	NA
aroclor–1221	2.64E–28	1.03E+01	2.71E–27
aroclor–1248	NA	1.03E+01	NA
aroclor–1254	NA	1.03E+01	NA
aroclor–1260	NA	1.03E+01	NA
carbazole	NA	2.22E–02	NA
endrin	NA	NA	NA
2,3,7,8–tcdd	NA	3.00E+05	NA
	ILCR Summation =		2.71E–09

000608

Table I.IV-61
Summary of Intake Quantitation (chemicals)
Future Land Use with Federal Ownership: Off-Property Farmer (Adult)
Via Ingestion of Meat Products

Intake Equation = $\frac{CS \times EF \times ED \times FI \times IR}{BW \times AT}$

IR	Ingestion rate of meat	0.101	kg/day
FI	Fraction ingested from contaminated source	0.75	(Unitless)
EF	Exposure frequency	350	days/year
EDn	Exposure duration for non-carcinogens	70	Year
EDc	Exposure duration for carcinogens	70	Year
BW	Body weight	70	kg
ATc	Average time for carcinogens (lifetime)	25550	days
ATn	Average time for non-carcinogens (EDn x 365)	25550	days
CS	Concentration of chemicals in meat		

Chemical Concentrations

Compound	Concentration	Units	Compound	Concentration	Units
antimony	9.6E-07	mg/kg	silver	1.2E-05	mg/kg
arsenic	3.9E-06	mg/kg	thallium	1.8E-06	mg/kg
barium	2.3E-06	mg/kg	thorium-total	4.1E-08	mg/kg
beryllium	1.2E-07	mg/kg	uranium-total	4.7E-04	mg/kg
boron	6.3E-07	mg/kg	vanadium	5.6E-06	mg/kg
cadmium	2.3E-07	mg/kg	zinc	5.4E-02	mg/kg
chromium vi	6.5E-06	mg/kg	2-methylnaphthalene	6.5E-09	mg/kg
cobalt	1.5E-05	mg/kg	4,4-dde	4.1E-09	mg/kg
copper	2.3E-04	mg/kg	aroclor-1221	1.6E-29	mg/kg
cyanide	5.1E-12	mg/kg	aroclor-1248	NA	mg/kg
lead	5.4E-05	mg/kg	aroclor-1254	1.5E-06	mg/kg
manganese	5.3E-08	mg/kg	aroclor-1260	6.3E-06	mg/kg
mercury	2.5E-05	mg/kg	carbazole	1.0E-10	mg/kg
molybdenum	2.4E-06	mg/kg	endrin	NA	mg/kg
nickel	6.6E-05	mg/kg	2,3,7,8-tcdd	9.2E-13	mg/kg
selenium	1.1E-06	mg/kg			

References

Table I.IV-61 (continued)
Summary of Risk Characterization (chemicals)
Future Land Use with Federal Ownership: Off-Property Farmer (Adult)
Via Ingestion of Meat Products

	HQ Calculation		
Compound	CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
antimony	9.9E-10	4.0E-04	2.5E-06
arsenic	4.1E-09	3.0E-04	1.4E-05
barium	2.4E-09	7.0E-02	3.4E-08
beryllium	1.3E-10	5.0E-03	2.6E-08
boron	6.5E-10	9.0E-02	7.2E-09
cadmium	2.4E-10	1.0E-03	2.4E-07
chromium vi	6.7E-09	5.0E-03	1.3E-06
cobalt	1.6E-08	6.0E-02	2.6E-07
copper	2.4E-07	NA	NA
cyanide	5.3E-15	2.0E-02	2.7E-13
lead	5.6E-08	NA	NA
manganese	5.5E-11	1.4E-01	4.0E-10
mercury	2.6E-08	3.0E-04	8.8E-05
molybdenum	2.5E-09	5.0E-03	5.0E-07
nickel	6.9E-08	2.0E-02	3.4E-06
selenium	1.1E-09	5.0E-03	2.2E-07
silver	1.2E-08	5.0E-03	2.4E-06
thallium	1.9E-09	8.0E-05	2.4E-05
thorium-total	4.2E-11	NA	NA
uranium-total	4.8E-07	3.0E-03	1.6E-04
vanadium	5.8E-09	7.0E-03	8.3E-07
zinc	5.6E-05	3.0E-01	1.9E-04
2-methylnaphthalene	6.7E-12	NA	NA
4,4-dde	4.2E-12	NA	NA
aroclor-1221	1.6E-32	NA	NA
aroclor-1248	NA	NA	NA
aroclor-1254	1.5E-09	NA	NA
aroclor-1260	6.5E-09	NA	NA
carbazole	1.1E-13	NA	NA
endrin	NA	3.0E-04	NA
2,3,7,8-tcdd	9.6E-16	NA	NA
	HQ Summation =		4.9E-04

	ILCR Calculation		
Compound	CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	ILCR (unitless)
antimony	9.9E-10	NA	NA
arsenic	4.1E-09	1.8E+00	7.2E-09
barium	2.4E-09	NA	NA
beryllium	1.3E-10	4.3E+00	5.5E-10
boron	6.5E-10	NA	NA
cadmium	2.4E-10	NA	NA
chromium vi	6.7E-09	NA	NA
cobalt	1.6E-08	NA	NA
copper	2.4E-07	NA	NA
cyanide	5.3E-15	NA	NA
lead	5.6E-08	NA	NA
manganese	5.5E-11	NA	NA
mercury	2.6E-08	NA	NA
molybdenum	2.5E-09	NA	NA
nickel	6.9E-08	NA	NA
selenium	1.1E-09	NA	NA
silver	1.2E-08	NA	NA
thallium	1.9E-09	NA	NA
thorium-total	4.2E-11	NA	NA
uranium-total	4.8E-07	NA	NA
vanadium	5.8E-09	NA	NA
zinc	5.6E-05	NA	NA
2-methylnaphthalene	6.7E-12	NA	NA
4,4-dde	4.2E-12	3.4E-01	1.4E-12
aroclor-1221	1.6E-32	7.7E+00	1.3E-31
aroclor-1248	NA	7.7E+00	NA
aroclor-1254	1.5E-09	7.7E+00	1.2E-08
aroclor-1260	6.5E-09	7.7E+00	5.0E-08
carbazole	1.1E-13	2.0E-02	2.2E-15
endrin	NA	NA	NA
2,3,7,8-tcdd	9.6E-16	1.5E+05	1.4E-10
	ILCR Summation =		7.0E-08

000607

Table I.IV–62
Summary of Intake and Risk Quantitation (radionuclides)
Future Land Use with Federal Ownership: Off–Property Farmer (Adult)
Via Ingestion of Meat Products

Intake Equation = Cf X EF X EDn X FI X IR

IR	Ingestion rate of meat	0.101 kg/day
FI	Fraction ingested from contaminated source	0.75 (Unitless)
EF	Exposure frequency	350 days/year
EDn	Exposure duration	70 Year
Cf	Concentration of radionuclides in meat	

Cs_{137+1d}	1.2E–03	pCi/kg	Rn_{222+4d}	ERR	pCi/kg
Pb_{210+2d}	3.2E–04	pCi/kg	Sr_{90+1d}	1.8E+01	pCi/kg
Np_{237+1d}	2.2E–04	pCi/kg	Tc_{99}	2.8E–02	pCi/kg
Pu_{238}	4.5E–07	pCi/kg	Th_{228+7d}	4.2E–07	pCi/kg
Pu_{239}	1.5E–08	pCi/kg	Th_{230}	1.5E–06	pCi/kg
Pu_{240}	NA	pCi/kg	$Th_{232+10d}$	1.2E–06	pCi/kg
Pa_{231}	3.2E–07	pCi/kg	U_{234}	7.0E–04	pCi/kg
Ra_{226+8d}	6.9E–05	pCi/kg	U_{235+1d}	1.9E–05	pCi/kg
Ra_{228+1d}	2.2E–05	pCi/kg	U_{236}	7.7E–06	pCi/kg
Ru_{106}	1.1E–05	pCi/kg	U_{238+2d}	4.2E–04	pCi/kg

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	ILCR (unitless)
Cs_{137+1d}	2.3E+00	2.8E–11	6.3E–11
Pb_{210+2d}	6.0E–01	6.6E–10	3.9E–10
Np_{237+1d}	4.1E–01	2.2E–10	9.1E–11
Pu_{238}	8.4E–04	2.2E–10	1.8E–13
Pu_{239}	2.8E–05	2.3E–10	6.5E–15
Pu_{240}	NA	2.3E–10	NA
Pa_{231}	6.0E–04	9.2E–11	5.5E–14
Ra_{226+8d}	1.3E–01	7.8E–10	1.0E–10
Ra_{228+1d}	4.1E–02	1.0E–10	4.1E–12
Ru_{106}	2.1E–02	9.5E–12	2.0E–13
Rn_{222+4d}	NA	1.7E–12	NA
Sr_{90+1d}	3.4E+04	3.6E–11	1.2E–06
Tc_{99}	5.1E+01	1.3E–12	6.7E–11
Th_{228+7d}	7.8E–04	5.5E–11	4.3E–14
Th_{230}	2.7E–03	1.3E–11	3.6E–14
$Th_{232+10d}$	2.3E–03	1.7E–10	3.8E–13
U_{234}	1.3E+00	1.6E–11	2.1E–11
U_{235+1d}	3.4E–02	1.6E–11	5.5E–13
U_{236}	1.4E–02	1.5E–11	2.1E–13
U_{238+2d}	7.8E–01	2.0E–11	1.6E–11
		ILCR Summation =	1.2E–06

Table I.IV–63
Summary of Intake Quantitation (chemicals)
Future Land Use with Federal Ownership: Off–Property Farmer (Adult)
Via Ingestion of Dairy Products

Intake Equation = $\frac{CS \times EF \times ED \times FI \times IR}{BW \times AT}$

IR	Ingestion rate of dairy products	0.4 l/day
FI	Fraction ingested from contaminated source	0.75 (Unitless)
EF	Exposure frequency	350 days/year
EDn	Exposure duration for non–carcinogens	70 Year
EDc	Exposure duration for carcinogens	70 Year
BW	Body weight	70 kg
ATc	Average time for carcinogens (lifetime)	25550 days
ATn	Average time for non–carcinogens (EDn x 365)	25550 days
CS	Concentration of chemicals in animal products	

Chemical Concentrations

Compound	Concentration	Units	Compound	Concentration	Units
antimony	9.6E–08	mg/kg	silver	7.7E–05	mg/kg
arsenic	1.2E–07	mg/kg	thallium	9.2E–08	mg/kg
barium	5.4E–06	mg/kg	thorium–total	3.4E–08	mg/kg
beryllium	1.1E–10	mg/kg	uranium–total	1.7E–03	mg/kg
boron	1.2E–06	mg/kg	vanadium	4.5E–08	mg/kg
cadmium	4.3E–07	mg/kg	zinc	5.4E–03	mg/kg
chromium vi	1.8E–06	mg/kg	2–methylnaphthalene	2.1E–09	mg/kg
cobalt	1.5E–06	mg/kg	4,4–dde	1.3E–09	mg/kg
copper	3.4E–05	mg/kg	aroclor–1221	6.0E–30	mg/kg
cyanide	1.6E–12	mg/kg	aroclor–1248	NA	mg/kg
lead	4.5E–05	mg/kg	aroclor–1254	4.6E–07	mg/kg
manganese	4.7E–08	mg/kg	aroclor–1260	NA	mg/kg
mercury	NA	mg/kg	carbazole	3.3E–11	mg/kg
molybdenum	6.0E–07	mg/kg	endrin	NA	mg/kg
nickel	1.1E–05	mg/kg	2,3,7,8–tcdd	3.3E–13	mg/kg
selenium	2.9E–07	mg/kg			

References

Table I.IV-63 (continued)
Summary of Risk Characterization (chemicals)
Future Land Use with Federal Ownership: Off-Property Farmer (Adult)
Via Ingestion of Dairy Products

	HQ Calculation		
Compound	CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
antimony	3.9E-10	4.0E-04	9.8E-07
arsenic	4.9E-10	3.0E-04	1.6E-06
barium	2.2E-08	7.0E-02	3.2E-07
beryllium	4.6E-13	5.0E-03	9.1E-11
boron	4.8E-09	9.0E-02	5.4E-08
cadmium	1.8E-09	1.0E-03	1.8E-06
chromium vi	7.3E-09	5.0E-03	1.5E-06
cobalt	6.3E-09	6.0E-02	1.0E-07
copper	1.4E-07	NA	NA
cyanide	6.6E-15	2.0E-02	3.3E-13
lead	1.8E-07	NA	NA
manganese	1.9E-10	1.4E-01	1.4E-09
mercury	NA	3.0E-04	NA
molybdenum	2.5E-09	5.0E-03	4.9E-07
nickel	4.5E-08	2.0E-02	2.3E-06
selenium	1.2E-09	5.0E-03	2.4E-07
silver	3.2E-07	5.0E-03	6.3E-05
thallium	3.8E-10	8.0E-05	4.7E-06
thorium-total	1.4E-10	NA	NA
uranium-total	6.8E-06	3.0E-03	2.3E-03
vanadium	1.8E-10	7.0E-03	2.6E-08
zinc	2.2E-05	3.0E-01	7.4E-05
2-methylnaphthalene	8.4E-12	NA	NA
4,4-dde	5.3E-12	NA	NA
aroclor-1221	2.5E-32	NA	NA
aroclor-1248	NA	NA	NA
aroclor-1254	1.9E-09	NA	NA
aroclor-1260	NA	NA	NA
carbazole	1.3E-13	NA	NA
endrin	NA	3.0E-04	NA
2,3,7,8-tcdd	1.3E-15	NA	NA
	HQ Summation =		2.4E-03

	ILCR Calculation		
Compound	CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	ILCR (unitless)
antimony	3.9E-10	NA	NA
arsenic	4.9E-10	1.8E+00	8.6E-10
barium	2.2E-08	NA	NA
beryllium	4.6E-13	4.3E+00	2.0E-12
boron	4.8E-09	NA	NA
cadmium	1.8E-09	NA	NA
chromium vi	7.3E-09	NA	NA
cobalt	6.3E-09	NA	NA
copper	1.4E-07	NA	NA
cyanide	6.6E-15	NA	NA
lead	1.8E-07	NA	NA
manganese	1.9E-10	NA	NA
mercury	NA	NA	NA
molybdenum	2.5E-09	NA	NA
nickel	4.5E-08	NA	NA
selenium	1.2E-09	NA	NA
silver	3.2E-07	NA	NA
thallium	3.8E-10	NA	NA
thorium-total	1.4E-10	NA	NA
uranium-total	6.8E-06	NA	NA
vanadium	1.8E-10	NA	NA
zinc	2.2E-05	NA	NA
2-methylnaphthalene	8.4E-12	NA	NA
4,4-dde	5.3E-12	3.4E-01	1.8E-12
aroclor-1221	2.5E-32	7.7E+00	1.9E-31
aroclor-1248	NA	7.7E+00	NA
aroclor-1254	1.9E-09	7.7E+00	1.5E-08
aroclor-1260	NA	7.7E+00	NA
carbazole	1.3E-13	2.0E-02	2.7E-15
endrin	NA	NA	NA
2,3,7,8-tcdd	1.3E-15	1.5E+05	2.0E-10
	ILCR Summation =		1.6E-08

Table I.IV–64
Summary of Intake and Risk Quantitation (radionuclides)
Future Land Use with Federal Ownership: Off–Property Farmer (Adult)
Via Ingestion of Dairy Products

Intake Equation = Cp X EF X EDn X FI X IR

IR	Ingestion rate of dairy products	0.4 l/day
FI	Fraction ingested from contaminated source	0.75 (Unitless)
EF	Exposure frequency	350 days/year
EDn	Exposure duration	70 Year
Cp	Concentration of radionuclides in animal products	

Cs_{137+1d}	4.3E–04	pCi/kg	Rn_{222+4d}	ERR	pCi/kg
Pb_{210+2d}	2.7E–04	pCi/kg	Sr_{90+1d}	6.2E–04	pCi/kg
Np_{237+1d}	2.4E–05	pCi/kg	Tc_{99}	7.3E+02	pCi/kg
Pu_{238}	9.0E–08	pCi/kg	Th_{228+7d}	3.5E–07	pCi/kg
Pu_{239}	3.0E–09	pCi/kg	Th_{230}	1.2E–06	pCi/kg
Pu_{240}	NA	pCi/kg	$Th_{232+10d}$	1.0E–06	pCi/kg
Pa_{231}	1.6E–05	pCi/kg	U_{234}	2.1E–03	pCi/kg
Ra_{226+8d}	1.4E–04	pCi/kg	U_{235+1d}	5.6E–05	pCi/kg
Ra_{228+1d}	4.0E–05	pCi/kg	U_{236}	2.3E–05	pCi/kg
Ru_{106}	3.5E–09	pCi/kg	U_{238+2d}	1.3E–03	pCi/kg

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	ILCR (unitless)
Cs_{137+1d}	3.1E+00	2.8E–11	8.8E–11
Pb_{210+2d}	2.0E+00	6.6E–10	1.3E–09
Np_{237+1d}	1.8E–01	2.2E–10	3.9E–11
Pu_{238}	6.6E–04	2.2E–10	1.5E–13
Pu_{239}	2.2E–05	2.3E–10	5.1E–15
Pu_{240}	NA	2.3E–10	NA
Pa_{231}	1.2E–01	9.2E–11	1.1E–11
Ra_{226+8d}	1.0E+00	7.8E–10	8.0E–10
Ra_{228+1d}	2.9E–01	1.0E–10	2.9E–11
Ru_{106}	2.6E–05	9.5E–12	2.5E–16
Rn_{222+4d}	NA	1.7E–12	NA
Sr_{90+1d}	4.6E+00	3.6E–11	1.6E–10
Tc_{99}	5.4E+06	1.3E–12	7.0E–06
Th_{228+7d}	2.6E–03	5.5E–11	1.4E–13
Th_{230}	9.0E–03	1.3E–11	1.2E–13
$Th_{232+10d}$	7.5E–03	1.7E–10	1.3E–12
U_{234}	1.5E+01	1.6E–11	2.5E–10
U_{235+1d}	4.1E–01	1.6E–11	6.5E–12
U_{236}	1.7E–01	1.5E–11	2.5E–12
U_{238+2d}	9.2E+00	2.0E–11	1.8E–10
		ILCR Summation =	7.0E–06

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Table I.IV–65
Future Land Use with Federal Ownership: Off–Property Farmer (Adult) Via Ingestion of Vegetables and Fruits

Intake Equation = $\frac{CS \times EF \times ED \times FI \times IR}{BW \times AT}$

IR	Ingestion rate of fruits or vegetables	0.122	kg/day
FI	Fraction ingested from contaminated source	1	(Unitless)
EF	Exposure frequency	350	days/year
EDn	Exposure duration for non–carcinogens	70	Year
EDc	Exposure duration for carcinogens	70	Year
BW	Body weight	70	kg
ATc	Average time for carcinogens (lifetime)	25550	days
ATn	Average time for non–carcinogens (EDn x 365)	25550	days
CS	Concentration of chemicals in vegetables		

Chemical Concentrations

Compound	Concentration	Units	Compound	Concentration	Units
antimony	1.1E–05	mg/kg	silver	3.4E–05	mg/kg
arsenic	2.7E–05	mg/kg	thallium	5.0E–07	mg/kg
barium	1.6E–04	mg/kg	thorium–total	8.3E–05	mg/kg
beryllium	1.4E–06	mg/kg	uranium–total	2.2E–01	mg/kg
boron	9.5E–06	mg/kg	vanadium	2.6E–05	mg/kg
cadmium	4.1E–06	mg/kg	zinc	4.6E–03	mg/kg
chromium vi	1.4E–05	mg/kg	2–methylnaphthalene	3.3E–07	mg/kg
cobalt	8.7E–06	mg/kg	4,4–dde	4.2E–09	mg/kg
copper	2.1E–04	mg/kg	aroclor–1221	5.1E–27	mg/kg
cyanide	9.3E–07	mg/kg	aroclor–1248	NA	mg/kg
lead	2.0E–03	mg/kg	aroclor–1254	5.6E–07	mg/kg
manganese	1.2E–06	mg/kg	aroclor–1260	1.7E–07	mg/kg
mercury	9.5E–07	mg/kg	carbazole	1.6E–08	mg/kg
molybdenum	4.8E–06	mg/kg	endrin	NA	mg/kg
nickel	9.9E–05	mg/kg	2,3,7,8–tcdd	8.5E–14	mg/kg
selenium	7.3E–07	mg/kg			

References

Table I.IV-65 (continued)
Summary of Risk Characterization (chemicals)
Future Land Use with Federal Ownership: Off-Property Farmer (Adult)
Via Ingestion of Vegetables and Fruits

	HQ Calculation		
Compound	CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
antimony	1.8E-08	4.0E-04	4.6E-05
arsenic	4.5E-08	3.0E-04	1.5E-04
barium	2.7E-07	7.0E-02	3.8E-06
beryllium	2.3E-09	5.0E-03	4.5E-07
boron	1.6E-08	9.0E-02	1.8E-07
cadmium	6.8E-09	1.0E-03	6.8E-06
chromium vi	2.4E-08	5.0E-03	4.8E-06
cobalt	1.5E-08	6.0E-02	2.4E-07
copper	3.5E-07	NA	NA
cyanide	1.6E-09	2.0E-02	7.8E-08
lead	3.3E-06	NA	NA
manganese	2.0E-09	1.4E-01	1.5E-08
mercury	1.6E-09	3.0E-04	5.3E-06
molybdenum	8.0E-09	5.0E-03	1.6E-06
nickel	1.7E-07	2.0E-02	8.3E-06
selenium	1.2E-09	5.0E-03	2.4E-07
silver	5.6E-08	5.0E-03	1.1E-05
thallium	8.4E-10	8.0E-05	1.1E-05
thorium-total	1.4E-07	NA	NA
uranium-total	3.7E-04	3.0E-03	1.2E-01
vanadium	4.3E-08	7.0E-03	6.2E-06
zinc	7.8E-06	3.0E-01	2.6E-05
2-methylnaphthalene	5.4E-10	NA	NA
4,4-dde	7.0E-12	NA	NA
aroclor-1221	8.5E-30	NA	NA
aroclor-1248	NA	NA	NA
aroclor-1254	9.3E-10	NA	NA
aroclor-1260	2.9E-10	NA	NA
carbazole	2.8E-11	NA	NA
endrin	NA	3.0E-04	NA
2,3,7,8-tcdd	1.4E-16	NA	NA
	HQ Summation =		1.2E-01

	ILCR Calculation		
Compound	CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	ILCR (unitless)
antimony	1.8E-08	NA	NA
arsenic	4.5E-08	1.8E+00	7.8E-08
barium	2.7E-07	NA	NA
beryllium	2.3E-09	4.3E+00	9.8E-09
boron	1.6E-08	NA	NA
cadmium	6.8E-09	NA	NA
chromium vi	2.4E-08	NA	NA
cobalt	1.5E-08	NA	NA
copper	3.5E-07	NA	NA
cyanide	1.6E-09	NA	NA
lead	3.3E-06	NA	NA
manganese	2.0E-09	NA	NA
mercury	1.6E-09	NA	NA
molybdenum	8.0E-09	NA	NA
nickel	1.7E-07	NA	NA
selenium	1.2E-09	NA	NA
silver	5.6E-08	NA	NA
thallium	8.4E-10	NA	NA
thorium-total	1.4E-07	NA	NA
uranium-total	3.7E-04	NA	NA
vanadium	4.3E-08	NA	NA
zinc	7.8E-06	NA	NA
2-methylnaphthalene	5.4E-10	NA	NA
4,4-dde	7.0E-12	3.4E-01	2.4E-12
aroclor-1221	8.5E-30	7.7E+00	6.6E-29
aroclor-1248	NA	7.7E+00	NA
aroclor-1254	9.3E-10	7.7E+00	7.2E-09
aroclor-1260	2.9E-10	7.7E+00	2.2E-09
carbazole	2.8E-11	2.0E-02	5.5E-13
endrin	NA	NA	NA
2,3,7,8-tcdd	1.4E-16	1.5E+05	2.1E-11
	ILCR Summation =		9.7E-08

Table I.IV–66
Summary of Intake and Risk Quantitation (radionuclides)
Future Land Use with Federal Ownership: Off–Property Farmer (Adult)
Via Ingestion of Vegetables and Fruits

Intake Equation = Cv X EF X EDn X FI X IR

IR	Ingestion rate of fruits or vegetables	0.122 kg/day
FI	Fraction ingested from contaminated source	1 (Unitless)
EF	Exposure frequency	350 days/year
EDn	Exposure duration	70 Year
Cv	Concentration of radionuclides in vegetables	

Cs_{137+1d}	6.7E–04	pCi/kg	Rn_{222+4d}	ERR	pCi/kg
Pb_{210+2d}	1.3E–02	pCi/kg	Sr_{90+1d}	4.0E–03	pCi/kg
Np_{237+1d}	3.9E–01	pCi/kg	Tc_{99}	6.7E+03	pCi/kg
Pu_{238}	1.2E–02	pCi/kg	Th_{228+7d}	9.2E–04	pCi/kg
Pu_{239}	3.9E–04	pCi/kg	Th_{230}	3.6E–03	pCi/kg
Pu_{240}	1.4E–03	pCi/kg	$Th_{232+10d}$	3.0E–03	pCi/kg
Pa_{231}	4.1E–04	pCi/kg	U_{234}	4.6E–02	pCi/kg
Ra_{226+8d}	1.7E–02	pCi/kg	U_{235+1d}	1.2E–03	pCi/kg
Ra_{228+1d}	1.1E–03	pCi/kg	U_{236}	5.0E–04	pCi/kg
Ru_{106}	7.6E–05	pCi/kg	U_{238+2d}	2.7E–02	pCi/kg

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	ILCR (unitless)
Cs_{137+1d}	2.0E+00	2.8E–11	5.6E–11
Pb_{210+2d}	3.9E+01	6.6E–10	2.6E–08
Np_{237+1d}	1.2E+03	2.2E–10	2.6E–07
Pu_{238}	3.5E+01	2.2E–10	7.7E–09
Pu_{239}	1.2E+00	2.3E–10	2.7E–10
Pu_{240}	4.2E+00	2.3E–10	9.8E–10
Pa_{231}	1.2E+00	9.2E–11	1.1E–10
Ra_{226+8d}	5.0E+01	7.8E–10	3.9E–08
Ra_{228+1d}	3.4E+00	1.0E–10	3.4E–10
Ru_{106}	2.3E–01	9.5E–12	2.2E–12
Rn_{222+4d}	NA	1.7E–12	NA
Sr_{90+1d}	1.2E+01	3.6E–11	4.3E–10
Tc_{99}	2.0E+07	1.3E–12	2.6E–05
Th_{228+7d}	2.8E+00	5.5E–11	1.5E–10
Th_{230}	1.1E+01	1.3E–11	1.4E–10
$Th_{232+10d}$	8.9E+00	1.7E–10	1.5E–09
U_{234}	1.4E+02	1.6E–11	2.2E–09
U_{235+1d}	3.6E+00	1.6E–11	5.8E–11
U_{236}	1.5E+00	1.5E–11	2.2E–11
U_{238+2d}	8.2E+01	2.0E–11	1.6E–09
		ILCR Summation =	2.7E–05

Table I.IV-67
Summary of Intake Quantitation (chemicals)
Future Land Use with Federal Ownership: Off-Property Farmer (Child)
Via Inhalation of Particulates

Intake Equation = $\frac{CS \times EF \times ED \times IR}{BW \times AT}$

IR	Inhalation rate of gases (RAGS, 1989)	12 m^3/day
EF	Exposure frequency	350 days/year
EDn	Exposure duration for non-carcinogens	6 Year
EDc	Exposure duration for carcinogens	6 Year
BW	Body weight	15 kg
ATc	Average time for carcinogens (lifetime)	25550 days
ATn	Average time for non-carcinogens (EDn x 365)	2190 days
CS	Concentration of chemicals in soil	(see table below)

Chemical Concentrations

Compound	Concentration	Units	Compound	Concentration	Units
antimony	7.5E-09	mg/m^3	silver	2.7E-09	mg/m^3
arsenic	5.3E-09	mg/m^3	thallium	3.3E-10	mg/m^3
barium	8.2E-08	mg/m^3	thorium-total	7.5E-08	mg/m^3
beryllium	7.8E-10	mg/m^3	uranium-total	1.0E-06	mg/m^3
boron	8.5E-09	mg/m^3	vanadium	2.0E-08	mg/m^3
cadmium	1.3E-09	mg/m^3	zinc	5.1E-08	mg/m^3
chromium vi	1.2E-08	mg/m^3	2-methylnaphthalene	6.0E-11	mg/m^3
cobalt	6.3E-09	mg/m^3	4,4-dde	4.3E-12	mg/m^3
copper	3.8E-08	mg/m^3	aroclor-1221	NANA	mg/m^3
cyanide	4.6E-10	mg/m^3	aroclor-1248	NANA	mg/m^3
lead	1.3E-06	mg/m^3	aroclor-1254	2.7E-10	mg/m^3
manganese	2.4E-10	mg/m^3	aroclor-1260	6.4E-11	mg/m^3
mercury	2.4E-10	mg/m^3	carbazole	1.7E-11	mg/m^3
molybdenum	4.1E-09	mg/m^3	endrin	NANA	mg/m^3
nickel	1.5E-08	mg/m^3	2,3,7,8-tcdd	8.8E-17	mg/m^3
selenium	3.4E-10	mg/m^3			

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Table I.IV-67 (continued)
Summary of Risk Characterization (chemicals)
Future Land Use with Federal Ownership: Off-Property Farmer (Child)
Via Inhalation of Particulates

Compound	HQ Calculation CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
antimony	5.8E-09	NA	NA
arsenic	4.1E-09	NA	NA
barium	6.3E-08	1.4E-04	4.4E-04
beryllium	6.0E-10	NA	NA
boron	6.5E-09	5.7E-03	1.1E-06
cadmium	1.0E-09	NA	NA
chromium vi	9.5E-09	NA	NA
cobalt	4.9E-09	3.0E-07	1.6E-02
copper	2.9E-08	NA	NA
cyanide	3.5E-10	NA	NA
lead	9.8E-07	NA	NA
manganese	1.9E-10	1.4E-05	1.3E-05
mercury	1.9E-10	8.6E-05	2.2E-06
molybdenum	3.1E-09	NA	NA
nickel	1.2E-08	NA	NA
selenium	2.6E-10	NA	NA
silver	2.0E-09	NA	NA
thallium	2.5E-10	NA	NA
thorium-total	5.8E-08	NA	NA
uranium-total	7.7E-07	NA	NA
vanadium	1.5E-08	NA	NA
zinc	3.9E-08	NA	NA
2-methylnaphthalene	4.6E-11	NA	NA
4,4-dde	3.3E-12	NA	NA
aroclor-1221	NA	NA	NA
aroclor-1248	NA	NA	NA
aroclor-1254	2.0E-10	NA	NA
aroclor-1260	4.9E-11	NA	NA
carbazole	1.3E-11	NA	NA
endrin	NA	NA	NA
2,3,7,8-tcdd	6.7E-17	NA	NA
	Hazard Quotient Sum =		1.7E-02

Compound	ILCR Calculation CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	ILCR (unitless)
antimony	5.0E-10	NA	NA
arsenic	3.5E-10	1.5E+01	5.2E-09
barium	5.4E-09	NA	NA
beryllium	5.1E-11	8.4E+00	4.3E-10
boron	5.6E-10	NA	NA
cadmium	8.5E-11	6.3E+00	5.4E-10
chromium vi	8.2E-10	4.1E+01	3.3E-08
cobalt	4.2E-10	NA	NA
copper	2.5E-09	NA	NA
cyanide	3.0E-11	NA	NA
lead	8.4E-08	NA	NA
manganese	1.6E-11	NA	NA
mercury	1.6E-11	NA	NA
molybdenum	2.7E-10	NA	NA
nickel	1.0E-09	8.4E-01	8.4E-10
selenium	2.2E-11	NA	NA
silver	1.8E-10	NA	NA
thallium	2.2E-11	NA	NA
thorium-total	4.9E-09	NA	NA
uranium-total	6.6E-08	NA	NA
vanadium	1.3E-09	NA	NA
zinc	3.4E-09	NA	NA
2-methylnaphthalene	4.0E-12	NA	NA
4,4-dde	2.8E-13	NA	NA
aroclor-1221	NA	NA	NA
aroclor-1248	NA	NA	NA
aroclor-1254	1.7E-11	NA	NA
aroclor-1260	4.2E-12	NA	NA
carbazole	1.1E-12	NA	NA
endrin	NA	NA	NA
2,3,7,8-tcdd	5.8E-18	1.5E+05	8.7E-13
	ILCR Summation =		4.0E-08

Table I.IV–68
Summary of Intake and Risk Quantitation (radionuclides)
Future Land Use with Federal Ownership: Off–Property Farmer (Child)
Via Inhalation of Gases and Particulates

Intake Equation = Ca X EF X EDn X IR

IR	Inhalation rate of gases (RAGS, 1989)	12 m^3/day
EF	Exposure frequency	350 days/year
EDn	Exposure duration	6 Year
Ca	Concentration of radionuclides in air	(see table below)

Cs_{137+1d}	4.3E–07	pCi/m^3	Rn_{222+4d}	1.3E+01	pCi/m^3
Pb_{210+2d}	1.1E–05	pCi/m^3	Sr_{90+1d}	1.4E–06	pCi/m^3
Np_{237+1d}	2.0E–07	pCi/m^3	Tc_{99}	2.3E–05	pCi/m^3
Pu_{238}	1.2E–05	pCi/m^3	Th_{228+7d}	9.5E–07	pCi/m^3
Pu_{239}	3.9E–07	pCi/m^3	Th_{230}	3.3E–06	pCi/m^3
Pu_{240}	1.4E–06	pCi/m^3	$Th_{232+10d}$	2.7E–06	pCi/m^3
Pa_{231}	4.1E–07	pCi/m^3	U_{234}	4.6E–05	pCi/m^3
Ra_{226+8d}	9.1E–07	pCi/m^3	U_{235+1d}	1.2E–06	pCi/m^3
Ra_{228+1d}	1.1E–06	pCi/m^3	U_{236}	5.1E–07	pCi/m^3
Ru_{106}	7.8E–08	pCi/m^3	U_{238+2d}	2.8E–05	pCi/m^3

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	ILCR (unitless)
Cs_{137+1d}	1.1E–02	1.9E–11	2.1E–13
Pb_{210+2d}	2.9E–01	4.0E–09	1.1E–09
Np_{237+1d}	5.0E–03	2.9E–08	1.4E–10
Pu_{238}	3.0E–01	3.9E–08	1.2E–08
Pu_{239}	9.9E–03	3.8E–08	3.8E–10
Pu_{240}	3.6E–02	3.8E–08	1.4E–09
Pa_{231}	1.0E–02	3.6E–08	3.7E–10
Ra_{226+8d}	2.3E–02	7.0E–09	1.6E–10
Ra_{228+1d}	2.9E–02	6.9E–10	2.0E–11
Ru_{106}	2.0E–03	4.4E–10	8.6E–13
Rn_{222+4d}	3.2E+05	7.7E–12	2.4E–06
Sr_{90+1d}	3.5E–02	6.2E–11	2.2E–12
Tc_{99}	5.8E–01	8.3E–12	4.8E–12
Th_{228+7d}	2.4E–02	7.8E–08	1.9E–09
Th_{230}	8.2E–02	2.9E–08	2.4E–09
$Th_{232+10d}$	6.8E–02	1.1E–07	7.5E–09
U_{234}	1.2E+00	2.6E–08	3.0E–08
U_{235+1d}	3.1E–02	2.5E–08	7.7E–10
U_{236}	1.3E–02	2.5E–08	3.2E–10
U_{238+2d}	7.0E–01	2.4E–08	1.7E–08
		ILCR Summation =	2.5E–06

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Table I.IV–69
Summary of Intake Quantitation (chemicals)
Future Land Use with Federal Ownership: Off–Property Farmer (Child)
Via Drinking Water Ingestion

Intake Equation = $\frac{CS \times EF \times ED \times IR}{BW \times AT}$

IR	Ingestion rate of groundwater (RAGS, 1989)	1 l/day
EF	Exposure frequency	350 days/year
EDn	Exposure duration for non–carcinogens	6 Year
EDc	Exposure duration for carcinogens	6 Year
BW	Body weight	15 kg
ATc	Average time for carcinogens (lifetime)	25550 days
ATn	Average time for non–carcinogens (EDn x 365)	2190 days
CS	Concentration of chemicals in groundwater	

Chemical Concentrations

Compound	Concentration	Units	Compound	Concentration	Units
antimony	6.90E–08	mg/l	silver	NA	mg/l
arsenic	1.79E–06	mg/l	thallium	NA	mg/l
barium	NA	mg/l	thorium–total	NA	mg/l
beryllium	8.86E–09	mg/l	uranium–total	4.50E–02	mg/l
boron	NA	mg/l	vanadium	NA	mg/l
cadmium	1.71E–24	mg/l	zinc	NA	mg/l
chromium vi	NA	mg/l	2–methylnaphthalene	NA	mg/l
cobalt	NA	mg/l	4,4–dde	NA	mg/l
copper	NA	mg/l	aroclor–1221	1.03E–27	mg/l
cyanide	NA	mg/l	aroclor–1248	NA	mg/l
lead	NA	mg/l	aroclor–1254	NA	mg/l
manganese	NA	mg/l	aroclor–1260	NA	mg/l
mercury	NA	mg/l	carbazole	NA	mg/l
molybdenum	NA	mg/l	endrin	NA	mg/l
nickel	NA	mg/l	2,3,7,8–tcdd	NA	mg/l
selenium	NA	mg/l			

References

Table I.IV-69 (continued)
Summary of Risk Characterization (chemicals)
Future Land Use with Federal Ownership: Off-Property Farmer (Child)
Via Drinking Water Ingestion

	HQ Calculation		
Compound	CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
antimony	4.41E-09	4.00E-04	1.10E-05
arsenic	1.14E-07	3.00E-04	3.81E-04
barium	NA	7.00E-02	NA
beryllium	5.66E-10	5.00E-03	1.13E-07
boron	NA	9.00E-02	NA
cadmium	1.09E-25	1.00E-03	1.09E-22
chromium vi	NA	5.00E-03	NA
cobalt	NA	6.00E-02	NA
copper	NA	NA	NA
cyanide	NA	2.00E-02	NA
lead	NA	NA	NA
manganese	NA	1.40E-01	NA
mercury	NA	3.00E-04	NA
molybdenum	NA	5.00E-03	NA
nickel	NA	2.00E-02	NA
selenium	NA	5.00E-03	NA
silver	NA	5.00E-03	NA
thallium	NA	8.00E-05	NA
thorium-total	NA	NA	NA
uranium-total	2.88E-03	3.00E-03	9.59E-01
vanadium	NA	7.00E-03	NA
zinc	NA	3.00E-01	NA
2-methylnaphthalene	NA	NA	NA
4,4-dde	NA	NA	NA
aroclor-1221	6.58E-29	NA	NA
aroclor-1248	NA	NA	NA
aroclor-1254	NA	NA	NA
aroclor-1260	NA	NA	NA
carbazole	NA	NA	NA
endrin	NA	3.00E-04	NA
2,3,7,8-tcdd	NA	NA	NA
	HQ Summation =		9.60E-01

	ILCR Calculation		
Compound	CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	ILCR (unitless)
antimony	3.78E-10	NA	NA
arsenic	9.81E-09	1.75E+00	1.72E-08
barium	NA	NA	NA
beryllium	4.85E-11	4.30E+00	2.09E-10
boron	NA	NA	NA
cadmium	9.37E-27	NA	NA
chromium vi	NA	NA	NA
cobalt	NA	NA	NA
copper	NA	NA	NA
cyanide	NA	NA	NA
lead	NA	NA	NA
manganese	NA	NA	NA
mercury	NA	NA	NA
molybdenum	NA	NA	NA
nickel	NA	NA	NA
selenium	NA	NA	NA
silver	NA	NA	NA
thallium	NA	NA	NA
thorium-total	NA	NA	NA
uranium-total	2.47E-04	NA	NA
vanadium	NA	NA	NA
zinc	NA	NA	NA
2-methylnaphthalene	NA	NA	NA
4,4-dde	NA	3.40E-01	NA
aroclor-1221	5.64E-30	7.70E+00	4.35E-29
aroclor-1248	NA	7.70E+00	NA
aroclor-1254	NA	7.70E+00	NA
aroclor-1260	NA	7.70E+00	NA
carbazole	NA	2.00E-02	NA
endrin	NA	NA	NA
2,3,7,8-tcdd	NA	1.50E+05	NA
	ILCR Summation =		1.74E-08

Table I.IV–70
Summary of Intake and Risk Quantitation (radionuclides)
Future Land Use with Federal Ownership: Off–Property Farmer (Child)
Via Ingestion of Drinking Water

Intake Equation = Cw X EF X EDn X FI X IR

IR	Ingestion rate of groundwater (RAGS, 1989)	1 l/day
EF	Exposure frequency	350 days/year
EDn	Exposure duration	6 Year
FI	Fractional intake for radionuclides	1 (Unitless)
Cw	Concentration of radionuclides in groundwater	(see table below)

Cs_{137+1d}	NA	pCi/l	Rn_{222+4d}	NA	pCi/l
Pb_{210+2d}	NA	pCi/l	Sr_{90+1d}	NA	pCi/l
Np_{237+1d}	8.0E−02	pCi/l	Tc_{99}	1.2E+03	pCi/l
Pu_{238}	NA	pCi/l	Th_{228+7d}	NA	pCi/l
Pu_{239}	NA	pCi/l	Th_{230}	NA	pCi/l
Pu_{240}	NA	pCi/l	$Th_{232+10d}$	NA	pCi/l
Pa_{231}	NA	pCi/l	U_{234}	2.5E+01	pCi/l
Ra_{226+8d}	3.2E−03	pCi/l	U_{235+1d}	6.7E−01	pCi/l
Ra_{228+1d}	NA	pCi/l	U_{236}	2.8E−01	pCi/l
Ru_{106}	NA	pCi/l	U_{238+2d}	1.5E+01	pCi/l

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	ILCR (unitless)
Cs_{137+1d}	NA	2.8E−11	NA
Pb_{210+2d}	NA	6.6E−10	NA
Np_{237+1d}	1.7E+02	2.2E−10	3.7E−08
Pu_{238}	NA	2.2E−10	NA
Pu_{239}	NA	2.3E−10	NA
Pu_{240}	NA	2.3E−10	NA
Pa_{231}	NA	9.2E−11	NA
Ra_{226+8d}	6.6E+00	7.8E−10	5.2E−09
Ra_{228+1d}	NA	1.0E−10	NA
Ru_{106}	NA	9.5E−12	NA
Rn_{222+4d}	NA	1.7E−12	NA
Sr_{90+1d}	NA	3.6E−11	NA
Tc_{99}	2.6E+06	1.3E−12	3.3E−06
Th_{228+7d}	NA	5.5E−11	NA
Th_{230}	NA	1.3E−11	NA
$Th_{232+10d}$	NA	1.7E−10	NA
U_{234}	5.3E+04	1.6E−11	8.4E−07
U_{235+1d}	1.4E+03	1.6E−11	2.2E−08
U_{236}	5.8E+02	1.5E−11	8.7E−09
U_{238+2d}	3.2E+04	2.0E−11	6.3E−07
		ILCR Summation =	4.9E−06

Table I.IV–71
Summary of Intake Quantitation (chemicals)
Future Land Use with Federal Ownership: Off–Property Farmer (Child)
Via Dermal Contact while Bathing

Intake Equation = $\frac{DA \times EF \times ED \times SA}{BW \times AT}$

DA	Dermal absorbed dose	csv	mg/cm^2–day
EF	Exposure frequency	350	days/year
EDn	Exposure duration for non–carcinogens	6	Year
EDc	Exposure duration for carcinogens	6	Year
BW	Body weight	15	kg
ATc	Average time for carcinogens (lifetime)	25550	days
ATn	Average time for non–carcinogens (EDn x 365)	2190	days
SA	Skin surface area available for contact	8000	cm^2

Chemical Concentrations

Compound	DA	Units	Compound	DA	Units
antimony	1.73E–13	mg/cm^2–day	silver	NA	mg/cm^2–day
arsenic	4.48E–12	mg/cm^2–day	thallium	NA	mg/cm^2–day
barium	NA	mg/cm^2–day	thorium–total	NA	mg/cm^2–day
beryllium	2.22E–14	mg/cm^2–day	uranium–total	1.13E–07	mg/cm^2–day
boron	NA	mg/cm^2–day	vanadium	NA	mg/cm^2–day
cadmium	4.28E–30	mg/cm^2–day	zinc	NA	mg/cm^2–day
chromium vi	NA	mg/cm^2–day	2–methylnaphthalene	NA	mg/cm^2–day
cobalt	NA	mg/cm^2–day	4,4–dde	NA	mg/cm^2–day
copper	NA	mg/cm^2–day	aroclor–1221	8.37E–31	mg/cm^2–day
cyanide	NA	mg/cm^2–day	aroclor–1248	NA	mg/cm^2–day
lead	NA	mg/cm^2–day	aroclor–1254	NA	mg/cm^2–day
manganese	NA	mg/cm^2–day	aroclor–1260	NA	mg/cm^2–day
mercury	NA	mg/cm^2–day	carbazole	NA	mg/cm^2–day
molybdenum	NA	mg/cm^2–day	endrin	NA	mg/cm^2–day
nickel	NA	mg/cm^2–day	2,3,7,8–tcdd	NA	mg/cm^2–day
selenium	NA	mg/cm^2–day			

References

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Table I.IV-71 (continued)
Summary of Risk Characterization (chemicals)
Future Land Use with Federal Ownership: Off-Property Farmer (Child)
Via Dermal Contact while Bathing

Compound	HQ Calculation		
	CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
antimony	8.82E-11	6.00E-05	1.47E-06
arsenic	2.29E-09	2.85E-04	8.03E-06
barium	NA	6.37E-02	NA
beryllium	1.13E-11	5.00E-03	2.27E-09
boron	NA	4.50E-03	NA
cadmium	2.19E-27	5.00E-05	4.37E-23
chromium vi	NA	2.25E-03	NA
cobalt	NA	2.70E-02	NA
copper	NA	NA	NA
cyanide	NA	NA	NA
lead	NA	NA	NA
manganese	NA	4.20E-03	NA
mercury	NA	4.50E-05	NA
molybdenum	NA	1.90E-03	NA
nickel	NA	2.00E-03	NA
selenium	NA	4.00E-03	NA
silver	NA	NA	NA
thallium	NA	8.00E-05	NA
thorium-total	NA	NA	NA
uranium-total	5.75E-05	1.50E-04	3.84E-01
vanadium	NA	3.50E-04	NA
zinc	NA	7.50E-02	NA
2-methylnaphthalene	NA	NA	NA
4,4-dde	NA	NA	NA
aroclor-1221	4.28E-28	NA	NA
aroclor-1248	NA	NA	NA
aroclor-1254	NA	NA	NA
aroclor-1260	NA	NA	NA
carbazole	NA	NA	NA
endrin	NA	2.70E-04	NA
2,3,7,8-tcdd	NA	NA	NA
	HQ Summation =		3.84E-01

Compound	ILCR Calculation		
	CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	ILCR (unitless)
antimony	7.56E-12	NA	NA
arsenic	1.96E-10	1.90E+00	3.73E-10
barium	NA	NA	NA
beryllium	9.71E-13	4.30E+00	4.18E-12
boron	NA	NA	NA
cadmium	1.87E-28	NA	NA
chromium vi	NA	NA	NA
cobalt	NA	NA	NA
copper	NA	NA	NA
cyanide	NA	NA	NA
lead	NA	NA	NA
manganese	NA	NA	NA
mercury	NA	NA	NA
molybdenum	NA	NA	NA
nickel	NA	NA	NA
selenium	NA	NA	NA
silver	NA	NA	NA
thallium	NA	NA	NA
thorium-total	NA	NA	NA
uranium-total	4.93E-06	NA	NA
vanadium	NA	NA	NA
zinc	NA	NA	NA
2-methylnaphthalene	NA	NA	NA
4,4-dde	NA	3.40E-01	NA
aroclor-1221	3.67E-29	1.03E+01	3.77E-28
aroclor-1248	NA	1.03E+01	NA
aroclor-1254	NA	1.03E+01	NA
aroclor-1260	NA	1.03E+01	NA
carbazole	NA	2.22E-02	NA
endrin	NA	NA	NA
2,3,7,8-tcdd	NA	3.00E+05	NA
	ILCR Summation =		3.77E-10

Table I.IV–72
Summary of Intake Quantitation (chemicals)
Future Land Use with Federal Ownership: Off–Property Farmer (Child)
Via Ingestion of Meat Products

Intake Equation = $\frac{CS \times EF \times ED \times FI \times IR}{BW \times AT}$

IR	Ingestion rate of meat	0.039	kg/day
FI	Fraction ingested from contaminated source	0.75	(Unitless)
EF	Exposure frequency	350	days/year
EDn	Exposure duration for non–carcinogens	6	Year
EDc	Exposure duration for carcinogens	6	Year
BW	Body weight	15	kg
ATc	Average time for carcinogens (lifetime)	25550	days
ATn	Average time for non–carcinogens (EDn x 365)	2190	days
CS	Concentration of chemicals in meat		

Chemical Concentrations

Compound	Concentration	Units	Compound	Concentration	Units
antimony	9.6E–07	mg/kg	silver	1.2E–05	mg/kg
arsenic	3.9E–06	mg/kg	thallium	1.8E–06	mg/kg
barium	2.3E–06	mg/kg	thorium–total	4.1E–08	mg/kg
beryllium	1.2E–07	mg/kg	uranium–total	4.7E–04	mg/kg
boron	6.3E–07	mg/kg	vanadium	5.6E–06	mg/kg
cadmium	2.3E–07	mg/kg	zinc	5.4E–02	mg/kg
chromium vi	6.5E–06	mg/kg	2–methylnaphthalene	6.5E–09	mg/kg
cobalt	1.5E–05	mg/kg	4,4–dde	4.1E–09	mg/kg
copper	2.3E–04	mg/kg	aroclor–1221	1.6E–29	mg/kg
cyanide	5.1E–12	mg/kg	aroclor–1248	NA	mg/kg
lead	5.4E–05	mg/kg	aroclor–1254	1.5E–06	mg/kg
manganese	5.3E–08	mg/kg	aroclor–1260	6.3E–06	mg/kg
mercury	2.5E–05	mg/kg	carbazole	1.0E–10	mg/kg
molybdenum	2.4E–06	mg/kg	endrin	NA	mg/kg
nickel	6.6E–05	mg/kg	2,3,7,8–tcdd	9.2E–13	mg/kg
selenium	1.1E–06	mg/kg			

References

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Table I.IV-72 (continued)
Summary of Risk Characterization (chemicals)
Future Land Use with Federal Ownership: Off-Property Farmer (Child)
Via Ingestion of Meat Products

Compound	HQ Calculation CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
antimony	1.8E-09	4.0E-04	4.5E-06
arsenic	7.4E-09	3.0E-04	2.5E-05
barium	4.3E-09	7.0E-02	6.2E-08
beryllium	2.3E-10	5.0E-03	4.6E-08
boron	1.2E-09	9.0E-02	1.3E-08
cadmium	4.4E-10	1.0E-03	4.4E-07
chromium vi	1.2E-08	5.0E-03	2.4E-06
cobalt	2.9E-08	6.0E-02	4.8E-07
copper	4.3E-07	NA	NA
cyanide	9.6E-15	2.0E-02	4.8E-13
lead	1.0E-07	NA	NA
manganese	1.0E-10	1.4E-01	7.1E-10
mercury	4.8E-08	3.0E-04	1.6E-04
molybdenum	4.5E-09	5.0E-03	8.9E-07
nickel	1.2E-07	2.0E-02	6.2E-06
selenium	2.0E-09	5.0E-03	4.0E-07
silver	2.2E-08	5.0E-03	4.3E-06
thallium	3.4E-09	8.0E-05	4.3E-05
thorium-total	7.6E-11	NA	NA
uranium-total	8.7E-07	3.0E-03	2.9E-04
vanadium	1.1E-08	7.0E-03	1.5E-06
zinc	1.0E-04	3.0E-01	3.4E-04
2-methylnaphthalene	1.2E-11	NA	NA
4,4-dde	7.6E-12	NA	NA
aroclor-1221	3.0E-32	NA	NA
aroclor-1248	NA	NA	NA
aroclor-1254	2.7E-09	NA	NA
aroclor-1260	1.2E-08	NA	NA
carbazole	1.9E-13	NA	NA
endrin	NA	3.0E-04	NA
2,3,7,8-tcdd	1.7E-15	NA	NA
	HQ Summation =		8.7E-04

Compound	ILCR Calculation CDI (mg/kg-day)	CSF $(mg/kg\text{-}day)^{-1}$	ILCR (unitless)
antimony	1.5E-10	NA	NA
arsenic	6.3E-10	1.8E+00	1.1E-09
barium	3.7E-10	NA	NA
beryllium	2.0E-11	4.3E+00	8.5E-11
boron	1.0E-10	NA	NA
cadmium	3.8E-11	NA	NA
chromium vi	1.0E-09	NA	NA
cobalt	2.5E-09	NA	NA
copper	3.7E-08	NA	NA
cyanide	8.2E-16	NA	NA
lead	8.6E-09	NA	NA
manganese	8.5E-12	NA	NA
mercury	4.1E-09	NA	NA
molybdenum	3.8E-10	NA	NA
nickel	1.1E-08	NA	NA
selenium	1.7E-10	NA	NA
silver	1.8E-09	NA	NA
thallium	3.0E-10	NA	NA
thorium-total	6.5E-12	NA	NA
uranium-total	7.5E-08	NA	NA
vanadium	9.0E-10	NA	NA
zinc	8.7E-06	NA	NA
2-methylnaphthalene	1.0E-12	NA	NA
4,4-dde	6.5E-13	3.4E-01	2.2E-13
aroclor-1221	2.5E-33	7.7E+00	2.0E-32
aroclor-1248	NA	7.7E+00	NA
aroclor-1254	2.3E-10	7.7E+00	1.8E-09
aroclor-1260	1.0E-09	7.7E+00	7.7E-09
carbazole	1.7E-14	2.0E-02	3.3E-16
endrin	NA	NA	NA
2,3,7,8-tcdd	1.5E-16	1.5E+05	2.2E-11
	ILCR Summation =		1.1E-08

Table I.IV–73
Summary of Intake and Risk Quantitation (radionuclides)
Future Land Use with Federal Ownership: Off–Property Farmer (Child)
Via Ingestion of Meat Products

Intake Equation = Cf X EF X EDn X FI X IR

IR	Ingestion rate of meat	0.039 kg/day
FI	Fraction ingested from contaminated source	0.75 (Unitless)
EF	Exposure frequency	350 days/year
EDn	Exposure duration	6 Year
Cf	Concentration of radionuclides in meat	

Cs_{137+1d}	1.2E–03	pCi/kg	Rn_{222+4d}	ERR	pCi/kg
Pb_{210+2d}	3.2E–04	pCi/kg	Sr_{90+1d}	1.8E+01	pCi/kg
Np_{237+1d}	2.2E–04	pCi/kg	Tc_{99}	2.8E–02	pCi/kg
Pu_{238}	4.5E–07	pCi/kg	Th_{228+7d}	4.2E–07	pCi/kg
Pu_{239}	1.5E–08	pCi/kg	Th_{230}	1.5E–06	pCi/kg
Pu_{240}	NA	pCi/kg	$Th_{232+10d}$	1.2E–06	pCi/kg
Pa_{231}	3.2E–07	pCi/kg	U_{234}	7.0E–04	pCi/kg
Ra_{226+8d}	6.9E–05	pCi/kg	U_{235+1d}	1.9E–05	pCi/kg
Ra_{228+1d}	2.2E–05	pCi/kg	U_{236}	7.7E–06	pCi/kg
Ru_{106}	1.1E–05	pCi/kg	U_{238+2d}	4.2E–04	pCi/kg

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	ILCR (unitless)
Cs_{137+1d}	7.5E–02	2.8E–11	2.1E–12
Pb_{210+2d}	2.0E–02	6.6E–10	1.3E–11
Np_{237+1d}	1.4E–02	2.2E–10	3.0E–12
Pu_{238}	2.8E–05	2.2E–10	6.1E–15
Pu_{239}	9.3E–07	2.3E–10	2.1E–16
Pu_{240}	NA	2.3E–10	NA
Pa_{231}	2.0E–05	9.2E–11	1.8E–15
Ra_{226+8d}	4.3E–03	7.8E–10	3.3E–12
Ra_{228+1d}	1.3E–03	1.0E–10	1.3E–13
Ru_{106}	7.0E–04	9.5E–12	6.6E–15
Rn_{222+4d}	NA	1.7E–12	NA
Sr_{90+1d}	1.1E+03	3.6E–11	4.0E–08
Tc_{99}	1.7E+00	1.3E–12	2.2E–12
Th_{228+7d}	2.6E–05	5.5E–11	1.4E–15
Th_{230}	9.1E–05	1.3E–11	1.2E–15
$Th_{232+10d}$	7.5E–05	1.7E–10	1.3E–14
U_{234}	4.3E–02	1.6E–11	6.9E–13
U_{235+1d}	1.1E–03	1.6E–11	1.8E–14
U_{236}	4.7E–04	1.5E–11	7.1E–15
U_{238+2d}	2.6E–02	2.0E–11	5.1E–13
		ILCR Summation =	4.0E–08

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Table I.IV–74
Summary of Intake Quantitation (chemicals)
Future Land Use with Federal Ownership: Off–Property Farmer (Child)
Via Ingestion of Dairy Products

Intake Equation = $\frac{CS \times EF \times ED \times FI \times IR}{BW \times AT}$

IR	Ingestion rate of dairy products	0.9 l/day
FI	Fraction ingested from contaminated source	0.75 (Unitless)
EF	Exposure frequency	350 days/year
EDn	Exposure duration for non–carcinogens	6 Year
EDc	Exposure duration for carcinogens	6 Year
BW	Body weight	15 kg
ATc	Average time for carcinogens (lifetime)	25550 days
ATn	Average time for non–carcinogens (EDn x 365)	2190 days
CS	Concentration of chemicals in animal products	

Chemical Concentrations

Compound	Concentration	Units	Compound	Concentration	Units
antimony	9.6E–08	mg/kg	silver	7.7E–05	mg/kg
arsenic	1.2E–07	mg/kg	thallium	9.2E–08	mg/kg
barium	5.4E–06	mg/kg	thorium–total	3.4E–08	mg/kg
beryllium	1.1E–10	mg/kg	uranium–total	1.7E–03	mg/kg
boron	1.2E–06	mg/kg	vanadium	4.5E–08	mg/kg
cadmium	4.3E–07	mg/kg	zinc	5.4E–03	mg/kg
chromium vi	1.8E–06	mg/kg	2–methylnaphthalene	2.1E–09	mg/kg
cobalt	1.5E–06	mg/kg	4,4–dde	1.3E–09	mg/kg
copper	3.4E–05	mg/kg	aroclor–1221	6.0E–30	mg/kg
cyanide	1.6E–12	mg/kg	aroclor–1248	NA	mg/kg
lead	4.5E–05	mg/kg	aroclor–1254	4.6E–07	mg/kg
manganese	4.7E–08	mg/kg	aroclor–1260	NA	mg/kg
mercury	NA	mg/kg	carbazole	3.3E–11	mg/kg
molybdenum	6.0E–07	mg/kg	endrin	NA	mg/kg
nickel	1.1E–05	mg/kg	2,3,7,8–tcdd	3.3E–13	mg/kg
selenium	2.9E–07	mg/kg			

References

Table I.IV-74 (continued)
Summary of Risk Characterization (chemicals)
Future Land Use with Federal Ownership: Off-Property Farmer (Child)
Via Ingestion of Dairy Products

	HQ Calculation		
Compound	CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
antimony	4.1E-09	4.0E-04	1.0E-05
arsenic	5.1E-09	3.0E-04	1.7E-05
barium	2.3E-07	7.0E-02	3.3E-06
beryllium	4.8E-12	5.0E-03	9.6E-10
boron	5.1E-08	9.0E-02	5.6E-07
cadmium	1.8E-08	1.0E-03	1.8E-05
chromium vi	7.6E-08	5.0E-03	1.5E-05
cobalt	6.6E-08	6.0E-02	1.1E-06
copper	1.5E-06	NA	NA
cyanide	7.0E-14	2.0E-02	3.5E-12
lead	1.9E-06	NA	NA
manganese	2.0E-09	1.4E-01	1.4E-08
mercury	NA	3.0E-04	NA
molybdenum	2.6E-08	5.0E-03	5.2E-06
nickel	4.8E-07	2.0E-02	2.4E-05
selenium	1.2E-08	5.0E-03	2.5E-06
silver	3.3E-06	5.0E-03	6.6E-04
thallium	4.0E-09	8.0E-05	5.0E-05
thorium-total	1.5E-09	NA	NA
uranium-total	7.2E-05	3.0E-03	2.4E-02
vanadium	1.9E-09	7.0E-03	2.8E-07
zinc	2.3E-04	3.0E-01	7.8E-04
2-methylnaphthalene	8.9E-11	NA	NA
4,4-dde	5.5E-11	NA	NA
aroclor-1221	2.6E-31	NA	NA
aroclor-1248	NA	NA	NA
aroclor-1254	2.0E-08	NA	NA
aroclor-1260	NA	NA	NA
carbazole	1.4E-12	NA	NA
endrin	NA	3.0E-04	NA
2,3,7,8-tcdd	1.4E-14	NA	NA
	HQ Summation =		2.6E-02

	ILCR Calculation		
Compound	CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	ILCR (unitless)
antimony	3.5E-10	NA	NA
arsenic	4.4E-10	1.8E+00	7.7E-10
barium	2.0E-08	NA	NA
beryllium	4.1E-13	4.3E+00	1.8E-12
boron	4.3E-09	NA	NA
cadmium	1.6E-09	NA	NA
chromium vi	6.5E-09	NA	NA
cobalt	5.7E-09	NA	NA
copper	1.3E-07	NA	NA
cyanide	6.0E-15	NA	NA
lead	1.7E-07	NA	NA
manganese	1.7E-10	NA	NA
mercury	NA	NA	NA
molybdenum	2.2E-09	NA	NA
nickel	4.1E-08	NA	NA
selenium	1.1E-09	NA	NA
silver	2.8E-07	NA	NA
thallium	3.4E-10	NA	NA
thorium-total	1.2E-10	NA	NA
uranium-total	6.2E-06	NA	NA
vanadium	1.7E-10	NA	NA
zinc	2.0E-05	NA	NA
2-methylnaphthalene	7.6E-12	NA	NA
4,4-dde	4.7E-12	3.4E-01	1.6E-12
aroclor-1221	2.2E-32	7.7E+00	1.7E-31
aroclor-1248	NA	7.7E+00	NA
aroclor-1254	1.7E-09	7.7E+00	1.3E-08
aroclor-1260	NA	7.7E+00	NA
carbazole	1.2E-13	2.0E-02	2.4E-15
endrin	NA	NA	NA
2,3,7,8-tcdd	1.2E-15	1.5E+05	1.8E-10
	ILCR Summation =		1.4E-08

Table I.IV–75
Summary of Intake and Risk Quantitation (radionuclides)
Future Land Use with Federal Ownership: Off–Property Farmer (Child)
Via Ingestion of Dairy Products

Intake Equation = Cp X EF X EDn X FI X IR

IR	Ingestion rate of dairy products	0.9 l/day
FI	Fraction ingested from contaminated source	0.75 (Unitless)
EF	Exposure frequency	350 days/year
EDn	Exposure duration	6 Year
Cp	Concentration of radionuclides in animal products	

Cs_{137+1d}	4.3E–04	pCi/kg	Rn_{222+4d}	ERR	pCi/kg
Pb_{210+2d}	2.7E–04	pCi/kg	Sr_{90+1d}	6.2E–04	pCi/kg
Np_{237+1d}	2.4E–05	pCi/kg	Tc_{99}	7.3E+02	pCi/kg
Pu_{238}	9.0E–08	pCi/kg	Th_{228+7d}	3.5E–07	pCi/kg
Pu_{239}	3.0E–09	pCi/kg	Th_{230}	1.2E–06	pCi/kg
Pu_{240}	NA	pCi/kg	$Th_{232+10d}$	1.0E–06	pCi/kg
Pa_{231}	1.6E–05	pCi/kg	U_{234}	2.1E–03	pCi/kg
Ra_{226+8d}	1.4E–04	pCi/kg	U_{235+1d}	5.6E–05	pCi/kg
Ra_{228+1d}	4.0E–05	pCi/kg	U_{236}	2.3E–05	pCi/kg
Ru_{106}	3.5E–09	pCi/kg	U_{238+2d}	1.3E–03	pCi/kg

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	ILCR (unitless)
Cs_{137+1d}	6.0E–01	2.8E–11	1.7E–11
Pb_{210+2d}	3.8E–01	6.6E–10	2.5E–10
Np_{237+1d}	3.4E–02	2.2E–10	7.5E–12
Pu_{238}	1.3E–04	2.2E–10	2.8E–14
Pu_{239}	4.3E–06	2.3E–10	9.9E–16
Pu_{240}	NA	2.3E–10	NA
Pa_{231}	2.3E–02	9.2E–11	2.1E–12
Ra_{226+8d}	2.0E–01	7.8E–10	1.5E–10
Ra_{228+1d}	5.6E–02	1.0E–10	5.6E–12
Ru_{106}	5.0E–06	9.5E–12	4.7E–17
Rn_{222+4d}	NA	1.7E–12	NA
Sr_{90+1d}	8.8E–01	3.6E–11	3.2E–11
Tc_{99}	1.0E+06	1.3E–12	1.3E–06
Th_{228+7d}	5.0E–04	5.5E–11	2.8E–14
Th_{230}	1.7E–03	1.3E–11	2.3E–14
$Th_{232+10d}$	1.4E–03	1.7E–10	2.4E–13
U_{234}	3.0E+00	1.6E–11	4.7E–11
U_{235+1d}	7.9E–02	1.6E–11	1.3E–12
U_{236}	3.3E–02	1.5E–11	4.9E–13
U_{238+2d}	1.8E+00	2.0E–11	3.6E–11
		ILCR Summation =	1.3E–06

Table I.IV–76
Summary of Intake Quantitation (chemicals)
Future Land Use with Federal Ownership: Off–Property Farmer (Child)
Via Ingestion of Vegetables and Fruits

Intake Equation = $\frac{CS \times EF \times ED \times FI \times IR}{BW \times AT}$

IR	Ingestion rate of fruits or vegetables	0.1 kg/day
FI	Fraction ingested from contaminated source	1 (Unitless)
EF	Exposure frequency	350 days/year
EDn	Exposure duration for non–carcinogens	6 Year
EDc	Exposure duration for carcinogens	6 Year
BW	Body weight	15 kg
ATc	Average time for carcinogens (lifetime)	25550 days
ATn	Average time for non–carcinogens (EDn x 365)	2190 days
CS	Concentration of chemicals in vegetables	

Chemical Concentrations

Compound	Concentration	Units	Compound	Concentration	Units
antimony	1.1E–05	mg/kg	silver	3.4E–05	mg/kg
arsenic	2.7E–05	mg/kg	thallium	5.0E–07	mg/kg
barium	1.6E–04	mg/kg	thorium–total	8.3E–05	mg/kg
beryllium	1.4E–06	mg/kg	uranium–total	2.2E–01	mg/kg
boron	9.5E–06	mg/kg	vanadium	2.6E–05	mg/kg
cadmium	4.1E–06	mg/kg	zinc	4.6E–03	mg/kg
chromium vi	1.4E–05	mg/kg	2–methylnaphthalene	3.3E–07	mg/kg
cobalt	8.7E–06	mg/kg	4,4–dde	4.2E–09	mg/kg
copper	2.1E–04	mg/kg	aroclor–1221	5.1E–27	mg/kg
cyanide	9.3E–07	mg/kg	aroclor–1248	NA	mg/kg
lead	2.0E–03	mg/kg	aroclor–1254	5.6E–07	mg/kg
manganese	1.2E–06	mg/kg	aroclor–1260	1.7E–07	mg/kg
mercury	9.5E–07	mg/kg	carbazole	1.6E–08	mg/kg
molybdenum	4.8E–06	mg/kg	endrin	NA	mg/kg
nickel	9.9E–05	mg/kg	2,3,7,8–tcdd	8.5E–14	mg/kg
selenium	7.3E–07	mg/kg			

References

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Table I.IV–76 (continued)
Summary of Risk Characterization (chemicals)
Future Land Use with Federal Ownership: Off–Property Farmer (Child)
Via Ingestion of Vegetables and Fruits

	HQ Calculation		
Compound	CDI (mg/kg–day)	RfD (mg/kg–day)	HQ (unitless)
antimony	7.1E–08	4.0E–04	1.8E–04
arsenic	1.7E–07	3.0E–04	5.7E–04
barium	1.0E–06	7.0E–02	1.5E–05
beryllium	8.7E–09	5.0E–03	1.7E–06
boron	6.1E–08	9.0E–02	6.8E–07
cadmium	2.6E–08	1.0E–03	2.6E–05
chromium vi	9.1E–08	5.0E–03	1.8E–05
cobalt	5.5E–08	6.0E–02	9.2E–07
copper	1.3E–06	NA	NA
cyanide	6.0E–09	2.0E–02	3.0E–07
lead	1.3E–05	NA	NA
manganese	7.8E–09	1.4E–01	5.6E–08
mercury	6.1E–09	3.0E–04	2.0E–05
molybdenum	3.1E–08	5.0E–03	6.1E–06
nickel	6.4E–07	2.0E–02	3.2E–05
selenium	4.6E–09	5.0E–03	9.3E–07
silver	2.2E–07	5.0E–03	4.3E–05
thallium	3.2E–09	8.0E–05	4.0E–05
thorium–total	5.3E–07	NA	NA
uranium–total	1.4E–03	3.0E–03	4.7E–01
vanadium	1.7E–07	7.0E–03	2.4E–05
zinc	3.0E–05	3.0E–01	9.9E–05
2–methylnaphthalene	2.1E–09	NA	NA
4,4–dde	2.7E–11	NA	NA
aroclor–1221	3.3E–29	NA	NA
aroclor–1248	NA	NA	NA
aroclor–1254	3.6E–09	NA	NA
aroclor–1260	1.1E–09	NA	NA
carbazole	1.1E–10	NA	NA
endrin	NA	3.0E–04	NA
2,3,7,8–tcdd	5.5E–16	NA	NA
	HQ Summation =		4.7E–01

	ILCR Calculation		
Compound	CDI (mg/kg–day)	CSF $(mg/kg–day)^{-1}$	ILCR (unitless)
antimony	6.0E–09	NA	NA
arsenic	1.5E–08	1.8E+00	2.6E–08
barium	8.8E–08	NA	NA
beryllium	7.4E–10	4.3E+00	3.2E–09
boron	5.2E–09	NA	NA
cadmium	2.2E–09	NA	NA
chromium vi	7.8E–09	NA	NA
cobalt	4.8E–09	NA	NA
copper	1.1E–07	NA	NA
cyanide	5.1E–10	NA	NA
lead	1.1E–06	NA	NA
manganese	6.7E–10	NA	NA
mercury	5.2E–10	NA	NA
molybdenum	2.6E–09	NA	NA
nickel	5.4E–08	NA	NA
selenium	4.0E–10	NA	NA
silver	1.9E–08	NA	NA
thallium	2.8E–10	NA	NA
thorium–total	4.5E–08	NA	NA
uranium–total	1.2E–04	NA	NA
vanadium	1.4E–08	NA	NA
zinc	2.5E–06	NA	NA
2–methylnaphthalene	1.8E–10	NA	NA
4,4–dde	2.3E–12	3.4E–01	7.8E–13
aroclor–1221	2.8E–30	7.7E+00	2.2E–29
aroclor–1248	NA	7.7E+00	NA
aroclor–1254	3.0E–10	7.7E+00	2.3E–09
aroclor–1260	9.5E–11	7.7E+00	7.3E–10
carbazole	9.0E–12	2.0E–02	1.8E–13
endrin	NA	NA	NA
2,3,7,8–tcdd	4.7E–17	1.5E+05	7.0E–12
	ILCR Summation =		3.2E–08

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Table I.IV–77
Summary of Intake and Risk Quantitation (radionuclides)
Future Land Use with Federal Ownership: Off–Property Farmer (Child)
Via Ingestion of Vegetables and Fruits

Intake Equation = Cv X EF X EDn X FI X IR

IR	Ingestion rate of fruits or vegetables	0.1 kg/day
FI	Fraction ingested from contaminated source	1 (Unitless)
EF	Exposure frequency	350 days/year
EDn	Exposure duration	6 Year
Cv	Concentration of radionuclides in vegetables	

Cs_{137+1d}	6.7E–04	pCi/kg	Rn_{222+4d}	ERR	pCi/kg
Pb_{210+2d}	1.3E–02	pCi/kg	Sr_{90+1d}	4.0E–03	pCi/kg
Np_{237+1d}	3.9E–01	pCi/kg	Tc_{99}	6.7E+03	pCi/kg
Pu_{238}	1.2E–02	pCi/kg	Th_{228+7d}	9.2E–04	pCi/kg
Pu_{239}	3.9E–04	pCi/kg	Th_{230}	3.6E–03	pCi/kg
Pu_{240}	1.4E–03	pCi/kg	$Th_{232+10d}$	3.0E–03	pCi/kg
Pa_{231}	4.1E–04	pCi/kg	U_{234}	4.6E–02	pCi/kg
Ra_{226+8d}	1.7E–02	pCi/kg	U_{235+1d}	1.2E–03	pCi/kg
Ra_{228+1d}	1.1E–03	pCi/kg	U_{236}	5.0E–04	pCi/kg
Ru_{106}	7.6E–05	pCi/kg	U_{238+2d}	2.7E–02	pCi/kg

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	ILCR (unitless)
Cs_{137+1d}	1.4E–01	2.8E–11	3.9E–12
Pb_{210+2d}	2.7E+00	6.6E–10	1.8E–09
Np_{237+1d}	8.3E+01	2.2E–10	1.8E–08
Pu_{238}	2.5E+00	2.2E–10	5.4E–10
Pu_{239}	8.2E–02	2.3E–10	1.9E–11
Pu_{240}	3.0E–01	2.3E–10	6.9E–11
Pa_{231}	8.7E–02	9.2E–11	8.0E–12
Ra_{226+8d}	3.5E+00	7.8E–10	2.7E–09
Ra_{228+1d}	2.4E–01	1.0E–10	2.4E–11
Ru_{106}	1.6E–02	9.5E–12	1.5E–13
Rn_{222+4d}	NA	1.7E–12	NA
Sr_{90+1d}	8.4E–01	3.6E–11	3.0E–11
Tc_{99}	1.4E+06	1.3E–12	1.8E–06
Th_{228+7d}	1.9E–01	5.5E–11	1.1E–11
Th_{230}	7.6E–01	1.3E–11	9.9E–12
$Th_{232+10d}$	6.3E–01	1.7E–10	1.1E–10
U_{234}	9.6E+00	1.6E–11	1.5E–10
U_{235+1d}	2.5E–01	1.6E–11	4.1E–12
U_{236}	1.1E–01	1.5E–11	1.6E–12
U_{238+2d}	5.7E+00	2.0E–11	1.1E–10
		ILCR Summation =	1.9E–06

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INTAKE AND RISK CALCULATIONS:
FUTURE LAND USE WITHOUT FEDERAL OWNERSHIP SCENARIO

Table I.IV–78
Summary of Intake Quantitation (chemicals)
Future Land Use with Private Ownership: Off–Property Farmer (Adult)
Via Inhalation of Particulates

Intake Equation = $\frac{CS \times EF \times ED \times IR}{BW \times AT}$

IR	Inhalation rate of gases (RAGS, 1989)	20 m^3/day
EF	Exposure frequency	350 days/year
EDn	Exposure duration for non–carcinogens	70 Year
EDc	Exposure duration for carcinogens	70 Year
BW	Body weight	70 kg
ATc	Average time for carcinogens (lifetime)	25550 days
ATn	Average time for non–carcinogens (EDn x 365)	25550 days
CS	Concentration of chemicals in soil	(see table below)

Chemical Concentrations

Compound	Concentration	Units
antimony	7.5E–09	mg/m^3
arsenic	5.3E–09	mg/m^3
barium	8.2E–08	mg/m^3
beryllium	7.8E–10	mg/m^3
boron	8.5E–09	mg/m^3
cadmium	1.3E–09	mg/m^3
chromium vi	1.2E–08	mg/m^3
cobalt	6.3E–09	mg/m^3
copper	3.8E–08	mg/m^3
cyanide	4.6E–10	mg/m^3
lead	1.3E–06	mg/m^3
manganese	2.4E–10	mg/m^3
mercury	2.4E–10	mg/m^3
molybdenum	4.1E–09	mg/m^3
nickel	1.5E–08	mg/m^3
selenium	3.4E–10	mg/m^3

Compound	Concentration	Units
silver	2.7E–09	mg/m^3
thallium	3.3E–10	mg/m^3
thorium–total	7.5E–08	mg/m^3
uranium–total	1.0E–06	mg/m^3
vanadium	2.0E–08	mg/m^3
zinc	5.1E–08	mg/m^3
2–methylnaphthalene	6.0E–11	mg/m^3
4,4–dde	4.3E–12	mg/m^3
aroclor–1221	NA	mg/m^3
aroclor–1248	NA	mg/m^3
aroclor–1254	2.7E–10	mg/m^3
aroclor–1260	6.4E–11	mg/m^3
carbazole	1.7E–11	mg/m^3
endrin	NA	mg/m^3
2,3,7,8–tcdd	8.8E–17	mg/m^3

References

Table I.IV-78 (continued)
Summary of Risk Characterization (chemicals)
Future Land Use with Private Ownership: Off-Property Farmer (Adult)
Via Inhalation of Particulates

Compound	HQ Calculation CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
antimony	2.1E-09	NA	NA
arsenic	1.5E-09	NA	NA
barium	2.2E-08	1.4E-04	1.6E-04
beryllium	2.1E-10	NA	NA
boron	2.3E-09	5.7E-03	4.1E-07
cadmium	3.6E-10	NA	NA
chromium vi	3.4E-09	NA	NA
cobalt	1.7E-09	3.0E-07	5.8E-03
copper	1.0E-08	NA	NA
cyanide	1.3E-10	NA	NA
lead	3.5E-07	NA	NA
manganese	6.6E-11	1.4E-05	4.7E-06
mercury	6.6E-11	8.6E-05	7.7E-07
molybdenum	1.1E-09	NA	NA
nickel	4.2E-09	NA	NA
selenium	9.2E-11	NA	NA
silver	7.3E-10	NA	NA
thallium	9.0E-11	NA	NA
thorium-total	2.1E-08	NA	NA
uranium-total	2.7E-07	NA	NA
vanadium	5.4E-09	NA	NA
zinc	1.4E-08	NA	NA
2-methylnaphthalene	1.6E-11	NA	NA
4,4-dde	1.2E-12	NA	NA
aroclor-1221	NA	NA	NA
aroclor-1248	NA	NA	NA
aroclor-1254	7.3E-11	NA	NA
aroclor-1260	1.8E-11	NA	NA
carbazole	4.5E-12	NA	NA
endrin	NA	NA	NA
2,3,7,8-tcdd	2.4E-17	NA	NA
	Hazard Quotient Sum =		6.0E-03

Compound	ILCR Calculation CDI (mg/kg-day)	CSF $(mg/kg\text{-}day)^{-1}$	ILCR (unitless)
antimony	2.1E-09	NA	NA
arsenic	1.5E-09	1.5E+01	2.2E-08
barium	2.2E-08	NA	NA
beryllium	2.1E-10	8.4E+00	1.8E-09
boron	2.3E-09	NA	NA
cadmium	3.6E-10	6.3E+00	2.2E-09
chromium vi	3.4E-09	4.1E+01	1.4E-07
cobalt	1.7E-09	NA	NA
copper	1.0E-08	NA	NA
cyanide	1.3E-10	NA	NA
lead	3.5E-07	NA	NA
manganese	6.6E-11	NA	NA
mercury	6.6E-11	NA	NA
molybdenum	1.1E-09	NA	NA
nickel	4.2E-09	8.4E-01	3.5E-09
selenium	9.2E-11	NA	NA
silver	7.3E-10	NA	NA
thallium	9.0E-11	NA	NA
thorium-total	2.1E-08	NA	NA
uranium-total	2.7E-07	NA	NA
vanadium	5.4E-09	NA	NA
zinc	1.4E-08	NA	NA
2-methylnaphthalene	1.6E-11	NA	NA
4,4-dde	1.2E-12	NA	NA
aroclor-1221	NA	NA	NA
aroclor-1248	NA	NA	NA
aroclor-1254	7.3E-11	NA	NA
aroclor-1260	1.8E-11	NA	NA
carbazole	4.5E-12	NA	NA
endrin	NA	NA	NA
2,3,7,8-tcdd	2.4E-17	1.5E+05	3.6E-12
	ILCR Summation =		1.7E-07

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Table I.IV–79
Summary of Intake and Risk Quantitation (radionuclides)
Future Land Use with Private Ownership: Off–Property Farmer (Adult)
Via Inhalation of Gases and Particulates

Intake Equation = Ca X EF X EDn X IR

IR	Inhalation rate of gases (RAGS, 1989)	20 m^3/day
EF	Exposure frequency	350 days/year
EDn	Exposure duration	70 Year
Ca	Concentration of radionuclides in air	(see table below)

Cs_{137+1d}	4.3E–07	pCi/m^3	Rn_{222+4d}	1.3E+01	pCi/m^3
Pb_{210+2d}	1.1E–05	pCi/m^3	Sr_{90+1d}	1.4E–06	pCi/m^3
Np_{237+1d}	2.0E–07	pCi/m^3	Tc_{99}	2.3E–05	pCi/m^3
Pu_{238}	1.2E–05	pCi/m^3	Th_{228+7d}	9.5E–07	pCi/m^3
Pu_{239}	3.9E–07	pCi/m^3	Th_{230}	3.3E–06	pCi/m^3
Pu_{240}	1.4E–06	pCi/m^3	$Th_{232+10d}$	2.7E–06	pCi/m^3
Pa_{231}	4.1E–07	pCi/m^3	U_{234}	4.6E–05	pCi/m^3
Ra_{226+8d}	9.1E–07	pCi/m^3	U_{235+1d}	1.2E–06	pCi/m^3
Ra_{228+1d}	1.1E–06	pCi/m^3	U_{236}	5.1E–07	pCi/m^3
Ru_{106}	7.8E–08	pCi/m^3	U_{238+2d}	2.8E–05	pCi/m^3

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	ILCR (unitless)
Cs_{137+1d}	2.1E–01	1.9E–11	4.0E–12
Pb_{210+2d}	5.6E+00	4.0E–09	2.2E–08
Np_{237+1d}	9.7E–02	2.9E–08	2.8E–09
Pu_{238}	5.8E+00	3.9E–08	2.3E–07
Pu_{239}	1.9E–01	3.8E–08	7.3E–09
Pu_{240}	7.0E–01	3.8E–08	2.7E–08
Pa_{231}	2.0E–01	3.6E–08	7.3E–09
Ra_{226+8d}	4.5E–01	7.0E–09	3.1E–09
Ra_{228+1d}	5.6E–01	6.9E–10	3.9E–10
Ru_{106}	3.8E–02	4.4E–10	1.7E–11
Rn_{222+4d}	6.2E+06	7.7E–12	4.8E–05
Sr_{90+1d}	6.9E–01	6.2E–11	4.3E–11
Tc_{99}	1.1E+01	8.3E–12	9.4E–11
Th_{228+7d}	4.6E–01	7.8E–08	3.6E–08
Th_{230}	1.6E+00	2.9E–08	4.6E–08
$Th_{232+10d}$	1.3E+00	1.1E–07	1.5E–07
U_{234}	2.3E+01	2.6E–08	5.9E–07
U_{235+1d}	6.0E–01	2.5E–08	1.5E–08
U_{236}	2.5E–01	2.5E–08	6.2E–09
U_{238+2d}	1.4E+01	2.4E–08	3.3E–07
		ILCR Summation =	4.9E–05

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Table I.IV–80
Summary of Intake Quantitation (chemicals)
Future Land Use with Private Ownership: Off–Property Farmer (Adult)
Via Drinking Water Ingestion

Intake Equation = $\frac{CS \times EF \times ED \times IR}{BW \times AT}$

IR	Ingestion rate of groundwater (RAGS, 1989)	2 l/day
EF	Exposure frequency	350 days/year
EDn	Exposure duration for non–carcinogens	70 Year
EDc	Exposure duration for carcinogens	70 Year
BW	Body weight	70 kg
ATc	Average time for carcinogens (lifetime)	25550 days
ATn	Average time for non–carcinogens (EDn x 365)	25550 days
CS	Concentration of chemicals in groundwater	

Chemical Concentrations

Compound	Concentration	Units	Compound	Concentration	Units
antimony	6.90E–08	mg/l	silver	NA	mg/l
arsenic	1.79E–06	mg/l	thallium	NA	mg/l
barium	NA	mg/l	thorium–total	NA	mg/l
beryllium	8.86E–09	mg/l	uranium–total	4.50E–02	mg/l
boron	NA	mg/l	vanadium	NA	mg/l
cadmium	1.71E–24	mg/l	zinc	NA	mg/l
chromium vi	NA	mg/l	2–methylnaphthalene	NA	mg/l
cobalt	NA	mg/l	4,4–dde	NA	mg/l
copper	NA	mg/l	aroclor–1221	1.03E–27	mg/l
cyanide	NA	mg/l	aroclor–1248	NA	mg/l
lead	NA	mg/l	aroclor–1254	NA	mg/l
manganese	NA	mg/l	aroclor–1260	NA	mg/l
mercury	NA	mg/l	carbazole	NA	mg/l
molybdenum	NA	mg/l	endrin	NA	mg/l
nickel	NA	mg/l	2,3,7,8–tcdd	NA	mg/l
selenium	NA	mg/l			

References

Table I.IV-80 (continued)
Summary of Risk Characterization (chemicals)
Future Land Use with Private Ownership: Off-Property Farmer (Adult)
Via Drinking Water Ingestion

Compound	HQ Calculation CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
antimony	1.89E-09	4.00E-04	4.73E-06
arsenic	4.90E-08	3.00E-04	1.63E-04
barium	NA	7.00E-02	NA
beryllium	2.43E-10	5.00E-03	4.85E-08
boron	NA	9.00E-02	NA
cadmium	4.68E-26	1.00E-03	4.68E-23
chromium vi	NA	5.00E-03	NA
cobalt	NA	6.00E-02	NA
copper	NA	NA	NA
cyanide	NA	2.00E-02	NA
lead	NA	NA	NA
manganese	NA	1.40E-01	NA
mercury	NA	3.00E-04	NA
molybdenum	NA	5.00E-03	NA
nickel	NA	2.00E-02	NA
selenium	NA	5.00E-03	NA
silver	NA	5.00E-03	NA
thallium	NA	8.00E-05	NA
thorium-total	NA	NA	NA
uranium-total	1.23E-03	3.00E-03	4.11E-01
vanadium	NA	7.00E-03	NA
zinc	NA	3.00E-01	NA
2-methylnaphthalene	NA	NA	NA
4,4-dde	NA	NA	NA
aroclor-1221	2.82E-29	NA	NA
aroclor-1248	NA	NA	NA
aroclor-1254	NA	NA	NA
aroclor-1260	NA	NA	NA
carbazole	NA	NA	NA
endrin	NA	3.00E-04	NA
2,3,7,8-tcdd	NA	NA	NA
	HQ Summation =		4.11E-01

Compound	ILCR Calculation CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	ILCR (unitless)
antimony	1.89E-09	NA	NA
arsenic	4.90E-08	1.75E+00	8.58E-08
barium	NA	NA	NA
beryllium	2.43E-10	4.30E+00	1.04E-09
boron	NA	NA	NA
cadmium	4.68E-26	NA	NA
chromium vi	NA	NA	NA
cobalt	NA	NA	NA
copper	NA	NA	NA
cyanide	NA	NA	NA
lead	NA	NA	NA
manganese	NA	NA	NA
mercury	NA	NA	NA
molybdenum	NA	NA	NA
nickel	NA	NA	NA
selenium	NA	NA	NA
silver	NA	NA	NA
thallium	NA	NA	NA
thorium-total	NA	NA	NA
uranium-total	1.23E-03	NA	NA
vanadium	NA	NA	NA
zinc	NA	NA	NA
2-methylnaphthalene	NA	NA	NA
4,4-dde	NA	3.40E-01	NA
aroclor-1221	2.82E-29	7.70E+00	2.17E-28
aroclor-1248	NA	7.70E+00	NA
aroclor-1254	NA	7.70E+00	NA
aroclor-1260	NA	7.70E+00	NA
carbazole	NA	2.00E-02	NA
endrin	NA	NA	NA
2,3,7,8-tcdd	NA	1.50E+05	NA
	ILCR Summation =		8.69E-08

Table I.IV–81
Summary of Intake and Risk Quantitation (radionuclides)
Future Land Use with Private Ownership: Off–Property Farmer (Adult)
Via Ingestion of Drinking Water

Intake Equation = Cw X EF X EDn X FI X IR

IR	Ingestion rate of groundwater (RAGS, 1989)	2 l/day
EF	Exposure frequency	350 days/year
EDn	Exposure duration	70 Year
FI	Fractional intake for radionuclides	1 (Unitless)
Cw	Concentration of radionuclides in groundwater	(see table below)

Cs_{137+1d}	NA	pCi/l	Rn_{222+4d}	NA	pCi/l
Pb_{210+2d}	NA	pCi/l	Sr_{90+1d}	NA	pCi/l
Np_{237+1d}	8.0E–02	pCi/l	Tc_{99}	1.2E+03	pCi/l
Pu_{238}	NA	pCi/l	Th_{228+7d}	NA	pCi/l
Pu_{239}	NA	pCi/l	Th_{230}	NA	pCi/l
Pu_{240}	NA	pCi/l	$Th_{232+10d}$	NA	pCi/l
Pa_{231}	NA	pCi/l	U_{234}	2.5E+01	pCi/l
Ra_{226+8d}	3.2E–03	pCi/l	U_{235+1d}	6.7E–01	pCi/l
Ra_{228+1d}	NA	pCi/l	U_{236}	2.8E–01	pCi/l
Ru_{106}	NA	pCi/l	U_{238+2d}	1.5E+01	pCi/l

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	ILCR (unitless)
Cs_{137+1d}	NA	2.8E–11	NA
Pb_{210+2d}	NA	6.6E–10	NA
Np_{237+1d}	3.9E+03	2.2E–10	8.7E–07
Pu_{238}	NA	2.2E–10	NA
Pu_{239}	NA	2.3E–10	NA
Pu_{240}	NA	2.3E–10	NA
Pa_{231}	NA	9.2E–11	NA
Ra_{226+8d}	1.5E+02	7.8E–10	1.2E–07
Ra_{228+1d}	NA	1.0E–10	NA
Ru_{106}	NA	9.5E–12	NA
Rn_{222+4d}	NA	1.7E–12	NA
Sr_{90+1d}	NA	3.6E–11	NA
Tc_{99}	6.0E+07	1.3E–12	7.8E–05
Th_{228+7d}	NA	5.5E–11	NA
Th_{230}	NA	1.3E–11	NA
$Th_{232+10d}$	NA	1.7E–10	NA
U_{234}	1.2E+06	1.6E–11	2.0E–05
U_{235+1d}	3.3E+04	1.6E–11	5.2E–07
U_{236}	1.3E+04	1.5E–11	2.0E–07
U_{238+2d}	7.4E+05	2.0E–11	1.5E–05
		ILCR Summation =	1.1E–04

Table I.IV–82
Summary of Intake Quantitation (chemicals)
Future Land Use with Private Ownership: Off–Property Farmer (Adult)
Via Dermal Contact while Bathing

Intake Equation = $\frac{DA \times EF \times ED \times SA}{BW \times AT}$

DA	Dermal absorbed dose	csv	mg/cm^2–day
EF	Exposure frequency	350	days/year
EDn	Exposure duration for non–carcinogens	70	Year
EDc	Exposure duration for carcinogens	70	Year
BW	Body weight	70	kg
ATc	Average time for carcinogens (lifetime)	25550	days
ATn	Average time for non–carcinogens (EDn x 365)	25550	days
SA	Skin surface area available for contact	23000	cm^2

Chemical Concentrations

Compound	DA	Units	Compound	DA	Units
antimony	1.73E–13	mg/cm^2–day	silver	NA	mg/cm^2–day
arsenic	4.48E–12	mg/cm^2–day	thallium	NA	mg/cm^2–day
barium	NA	mg/cm^2–day	thorium–total	NA	mg/cm^2–day
beryllium	2.22E–14	mg/cm^2–day	uranium–total	1.13E–07	mg/cm^2–day
boron	NA	mg/cm^2–day	vanadium	NA	mg/cm^2–day
cadmium	4.28E–30	mg/cm^2–day	zinc	NA	mg/cm^2–day
chromium vi	NA	mg/cm^2–day	2–methylnaphthalene	NA	mg/cm^2–day
cobalt	NA	mg/cm^2–day	4,4–dde	NA	mg/cm^2–day
copper	NA	mg/cm^2–day	aroclor–1221	8.37E–31	mg/cm^2–day
cyanide	NA	mg/cm^2–day	aroclor–1248	NA	mg/cm^2–day
lead	NA	mg/cm^2–day	aroclor–1254	NA	mg/cm^2–day
manganese	NA	mg/cm^2–day	aroclor–1260	NA	mg/cm^2–day
mercury	NA	mg/cm^2–day	carbazole	NA	mg/cm^2–day
molybdenum	NA	mg/cm^2–day	endrin	NA	mg/cm^2–day
nickel	NA	mg/cm^2–day	2,3,7,8–tcdd	NA	mg/cm^2–day
selenium	NA	mg/cm^2–day			

References

Table I.IV–82 (continued)
Summary of Risk Characterization (chemicals)
Future Land Use with Private Ownership: Off–Property Farmer (Adult)
Via Dermal Contact while Showering

Compound	HQ Calculation CDI (mg/kg–day)	RfD (mg/kg–day)	HQ (unitless)
antimony	5.43E–11	6.00E–05	9.06E–07
arsenic	1.41E–09	2.85E–04	4.95E–06
barium	NA	6.37E–02	NA
beryllium	6.98E–12	5.00E–03	1.40E–09
boron	NA	4.50E–03	NA
cadmium	1.35E–27	5.00E–05	2.69E–23
chromium vi	NA	2.25E–03	NA
cobalt	NA	2.70E–02	NA
copper	NA	NA	NA
cyanide	NA	NA	NA
lead	NA	NA	NA
manganese	NA	4.20E–03	NA
mercury	NA	4.50E–05	NA
molybdenum	NA	1.90E–03	NA
nickel	NA	2.00E–03	NA
selenium	NA	4.00E–03	NA
silver	NA	NA	NA
thallium	NA	8.00E–05	NA
thorium–total	NA	NA	NA
uranium–total	3.55E–05	1.50E–04	2.36E–01
vanadium	NA	3.50E–04	NA
zinc	NA	7.50E–02	NA
2–methylnaphthalene	NA	NA	NA
4,4–dde	NA	NA	NA
aroclor–1221	2.64E–28	NA	NA
aroclor–1248	NA	NA	NA
aroclor–1254	NA	NA	NA
aroclor–1260	NA	NA	NA
carbazole	NA	NA	NA
endrin	NA	2.70E–04	NA
2,3,7,8–tcdd	NA	NA	NA
	HQ Summation =		2.36E–01

Compound	ILCR Calculation CDI (mg/kg–day)	CSF $(mg/kg–day)^{-1}$	ILCR (unitless)
antimony	5.43E–11	NA	NA
arsenic	1.41E–09	1.90E+00	2.68E–09
barium	NA	NA	NA
beryllium	6.98E–12	4.30E+00	3.00E–11
boron	NA	NA	NA
cadmium	1.35E–27	NA	NA
chromium vi	NA	NA	NA
cobalt	NA	NA	NA
copper	NA	NA	NA
cyanide	NA	NA	NA
lead	NA	NA	NA
manganese	NA	NA	NA
mercury	NA	NA	NA
molybdenum	NA	NA	NA
nickel	NA	NA	NA
selenium	NA	NA	NA
silver	NA	NA	NA
thallium	NA	NA	NA
thorium–total	NA	NA	NA
uranium–total	3.55E–05	NA	NA
vanadium	NA	NA	NA
zinc	NA	NA	NA
2–methylnaphthalene	NA	NA	NA
4,4–dde	NA	3.40E–01	NA
aroclor–1221	2.64E–28	1.03E+01	2.71E–27
aroclor–1248	NA	1.03E+01	NA
aroclor–1254	NA	1.03E+01	NA
aroclor–1260	NA	1.03E+01	NA
carbazole	NA	2.22E–02	NA
endrin	NA	NA	NA
2,3,7,8–tcdd	NA	3.00E+05	NA
	ILCR Summation =		2.71E–09

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Table I.IV–83
Summary of Intake Quantitation (chemicals)
Future Land Use with Private Ownership: Off–Property Farmer (Adult)
Via Ingestion of Meat Products

Intake Equation = $\frac{CS \times EF \times ED \times FI \times IR}{BW \times AT}$

IR	Ingestion rate of meat	0.101	kg/day
FI	Fraction ingested from contaminated source	0.75	(Unitless)
EF	Exposure frequency	350	days/year
EDn	Exposure duration for non–carcinogens	70	Year
EDc	Exposure duration for carcinogens	70	Year
BW	Body weight	70	kg
ATc	Average time for carcinogens (lifetime)	25550	days
ATn	Average time for non–carcinogens (EDn x 365)	25550	days
CS	Concentration of chemicals in meat		

Chemical Concentrations

Compound	Concentration	Units	Compound	Concentration	Units
antimony	9.6E–07	mg/kg	silver	1.2E–05	mg/kg
arsenic	3.9E–06	mg/kg	thallium	1.8E–06	mg/kg
barium	2.3E–06	mg/kg	thorium–total	4.1E–08	mg/kg
beryllium	1.2E–07	mg/kg	uranium–total	4.7E–04	mg/kg
boron	6.3E–07	mg/kg	vanadium	5.6E–06	mg/kg
cadmium	2.3E–07	mg/kg	zinc	5.4E–02	mg/kg
chromium vi	6.5E–06	mg/kg	2–methylnaphthalene	6.5E–09	mg/kg
cobalt	1.5E–05	mg/kg	4,4–dde	4.1E–09	mg/kg
copper	2.3E–04	mg/kg	aroclor–1221	1.6E–29	mg/kg
cyanide	5.1E–12	mg/kg	aroclor–1248	NA	mg/kg
lead	5.4E–05	mg/kg	aroclor–1254	1.5E–06	mg/kg
manganese	5.3E–08	mg/kg	aroclor–1260	6.3E–06	mg/kg
mercury	2.5E–05	mg/kg	carbazole	1.0E–10	mg/kg
molybdenum	2.4E–06	mg/kg	endrin	NA	mg/kg
nickel	6.6E–05	mg/kg	2,3,7,8–tcdd	9.2E–13	mg/kg
selenium	1.1E–06	mg/kg			

References

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Table I.IV–83 (continued)
Summary of Risk Characterization (chemicals)
Future Land Use with Private Ownership: Off–Property Farmer (Adult)
Via Ingestion of Meat Products

Compound	HQ Calculation CDI (mg/kg–day)	RfD (mg/kg–day)	HQ (unitless)
antimony	9.9E–10	4.0E–04	2.5E–06
arsenic	4.1E–09	3.0E–04	1.4E–05
barium	2.4E–09	7.0E–02	3.4E–08
beryllium	1.3E–10	5.0E–03	2.6E–08
boron	6.5E–10	9.0E–02	7.2E–09
cadmium	2.4E–10	1.0E–03	2.4E–07
chromium vi	6.7E–09	5.0E–03	1.3E–06
cobalt	1.6E–08	6.0E–02	2.6E–07
copper	2.4E–07	NA	NA
cyanide	5.3E–15	2.0E–02	2.7E–13
lead	5.6E–08	NA	NA
manganese	5.5E–11	1.4E–01	4.0E–10
mercury	2.6E–08	3.0E–04	8.8E–05
molybdenum	2.5E–09	5.0E–03	5.0E–07
nickel	6.9E–08	2.0E–02	3.4E–06
selenium	1.1E–09	5.0E–03	2.2E–07
silver	1.2E–08	5.0E–03	2.4E–06
thallium	1.9E–09	8.0E–05	2.4E–05
thorium–total	4.2E–11	NA	NA
uranium–total	4.8E–07	3.0E–03	1.6E–04
vanadium	5.8E–09	7.0E–03	8.3E–07
zinc	5.6E–05	3.0E–01	1.9E–04
2–methylnaphthalene	6.7E–12	NA	NA
4,4–dde	4.2E–12	NA	NA
aroclor–1221	1.6E–32	NA	NA
aroclor–1248	NA	NA	NA
aroclor–1254	1.5E–09	NA	NA
aroclor–1260	6.5E–09	NA	NA
carbazole	1.1E–13	NA	NA
endrin	NA	3.0E–04	NA
2,3,7,8–tcdd	9.6E–16	NA	NA
	HQ Summation =		4.9E–04

Compound	ILCR Calculation CDI (mg/kg–day)	CSF $(mg/kg–day)^{-1}$	ILCR (unitless)
antimony	9.9E–10	NA	NA
arsenic	4.1E–09	1.8E+00	7.2E–09
barium	2.4E–09	NA	NA
beryllium	1.3E–10	4.3E+00	5.5E–10
boron	6.5E–10	NA	NA
cadmium	2.4E–10	NA	NA
chromium vi	6.7E–09	NA	NA
cobalt	1.6E–08	NA	NA
copper	2.4E–07	NA	NA
cyanide	5.3E–15	NA	NA
lead	5.6E–08	NA	NA
manganese	5.5E–11	NA	NA
mercury	2.6E–08	NA	NA
molybdenum	2.5E–09	NA	NA
nickel	6.9E–08	NA	NA
selenium	1.1E–09	NA	NA
silver	1.2E–08	NA	NA
thallium	1.9E–09	NA	NA
thorium–total	4.2E–11	NA	NA
uranium–total	4.8E–07	NA	NA
vanadium	5.8E–09	NA	NA
zinc	5.6E–05	NA	NA
2–methylnaphthalene	6.7E–12	NA	NA
4,4–dde	4.2E–12	3.4E–01	1.4E–12
aroclor–1221	1.6E–32	7.7E+00	1.3E–31
aroclor–1248	NA	7.7E+00	NA
aroclor–1254	1.5E–09	7.7E+00	1.2E–08
aroclor–1260	6.5E–09	7.7E+00	5.0E–08
carbazole	1.1E–13	2.0E–02	2.2E–15
endrin	NA	NA	NA
2,3,7,8–tcdd	9.6E–16	1.5E+05	1.4E–10
	ILCR Summation =		7.0E–08

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Table I.IV–84
Summary of Intake and Risk Quantitation (radionuclides)
Future Land Use with Private Ownership: Off–Property Farmer (Adult)
Via Ingestion of Meat Products

Intake Equation = Cf X EF X EDn X FI X IR

IR	Ingestion rate of meat	0.101 kg/day
FI	Fraction ingested from contaminated source	0.75 (Unitless)
EF	Exposure frequency	350 days/year
EDn	Exposure duration	70 Year
Cf	Concentration of radionuclides in meat	

Cs_{137+1d}	1.2E–03	pCi/kg	Rn_{222+4d}	ERR	pCi/kg
Pb_{210+2d}	3.2E–04	pCi/kg	Sr_{90+1d}	1.8E+01	pCi/kg
Np_{237+1d}	2.2E–04	pCi/kg	Tc_{99}	2.8E–02	pCi/kg
Pu_{238}	4.5E–07	pCi/kg	Th_{228+7d}	4.2E–07	pCi/kg
Pu_{239}	1.5E–08	pCi/kg	Th_{230}	1.5E–06	pCi/kg
Pu_{240}	NA	pCi/kg	$Th_{232+10d}$	1.2E–06	pCi/kg
Pa_{231}	3.2E–07	pCi/kg	U_{234}	7.0E–04	pCi/kg
Ra_{226+8d}	6.9E–05	pCi/kg	U_{235+1d}	1.9E–05	pCi/kg
Ra_{228+1d}	2.2E–05	pCi/kg	U_{236}	7.7E–06	pCi/kg
Ru_{106}	1.1E–05	pCi/kg	U_{238+2d}	4.2E–04	pCi/kg

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	ILCR (unitless)
Cs_{137+1d}	2.3E+00	2.8E–11	6.3E–11
Pb_{210+2d}	6.0E–01	6.6E–10	3.9E–10
Np_{237+1d}	4.1E–01	2.2E–10	9.1E–11
Pu_{238}	8.4E–04	2.2E–10	1.8E–13
Pu_{239}	2.8E–05	2.3E–10	6.5E–15
Pu_{240}	NA	2.3E–10	NA
Pa_{231}	6.0E–04	9.2E–11	5.5E–14
Ra_{226+8d}	1.3E–01	7.8E–10	1.0E–10
Ra_{228+1d}	4.1E–02	1.0E–10	4.1E–12
Ru_{106}	2.1E–02	9.5E–12	2.0E–13
Rn_{222+4d}	NA	1.7E–12	NA
Sr_{90+1d}	3.4E+04	3.6E–11	1.2E–06
Tc_{99}	5.1E+01	1.3E–12	6.7E–11
Th_{228+7d}	7.8E–04	5.5E–11	4.3E–14
Th_{230}	2.7E–03	1.3E–11	3.6E–14
$Th_{232+10d}$	2.3E–03	1.7E–10	3.8E–13
U_{234}	1.3E+00	1.6E–11	2.1E–11
U_{235+1d}	3.4E–02	1.6E–11	5.5E–13
U_{236}	1.4E–02	1.5E–11	2.1E–13
U_{238+2d}	7.8E–01	2.0E–11	1.6E–11
		ILCR Summation =	1.2E–06

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Table I.IV–85
Summary of Intake Quantitation (chemicals)
Future Land Use with Private Ownership: Off–Property Farmer (Adult)
Via Ingestion of Dairy Products

Intake Equation = $\frac{CS \times EF \times ED \times FI \times IR}{BW \times AT}$

IR	Ingestion rate of dairy products	0.4 l/day
FI	Fraction ingested from contaminated source	0.75 (Unitless)
EF	Exposure frequency	350 days/year
EDn	Exposure duration for non–carcinogens	70 Year
EDc	Exposure duration for carcinogens	70 Year
BW	Body weight	70 kg
ATc	Average time for carcinogens (lifetime)	25550 days
ATn	Average time for non–carcinogens (EDn x 365)	25550 days
CS	Concentration of chemicals in animal products	

Chemical Concentrations

Compound	Concentration	Units	Compound	Concentration	Units
antimony	9.6E–08	mg/kg	silver	7.7E–05	mg/kg
arsenic	1.2E–07	mg/kg	thallium	9.2E–08	mg/kg
barium	5.4E–06	mg/kg	thorium–total	3.4E–08	mg/kg
beryllium	1.1E–10	mg/kg	uranium–total	1.7E–03	mg/kg
boron	1.2E–06	mg/kg	vanadium	4.5E–08	mg/kg
cadmium	4.3E–07	mg/kg	zinc	5.4E–03	mg/kg
chromium vi	1.8E–06	mg/kg	2–methylnaphthalene	2.1E–09	mg/kg
cobalt	1.5E–06	mg/kg	4,4–dde	1.3E–09	mg/kg
copper	3.4E–05	mg/kg	aroclor–1221	6.0E–30	mg/kg
cyanide	1.6E–12	mg/kg	aroclor–1248	NA	mg/kg
lead	4.5E–05	mg/kg	aroclor–1254	4.6E–07	mg/kg
manganese	4.7E–08	mg/kg	aroclor–1260	NA	mg/kg
mercury	NA	mg/kg	carbazole	3.3E–11	mg/kg
molybdenum	6.0E–07	mg/kg	endrin	NA	mg/kg
nickel	1.1E–05	mg/kg	2,3,7,8–tcdd	3.3E–13	mg/kg
selenium	2.9E–07	mg/kg			

References

Table I.IV-85 (continued)
Summary of Risk Characterization (chemicals)
Future Land Use with Private Ownership: Off-Property Farmer (Adult)
Via Ingestion of Dairy Products

Compound	HQ Calculation CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
antimony	3.9E-10	4.0E-04	9.8E-07
arsenic	4.9E-10	3.0E-04	1.6E-06
barium	2.2E-08	7.0E-02	3.2E-07
beryllium	4.6E-13	5.0E-03	9.1E-11
boron	4.8E-09	9.0E-02	5.4E-08
cadmium	1.8E-09	1.0E-03	1.8E-06
chromium vi	7.3E-09	5.0E-03	1.5E-06
cobalt	6.3E-09	6.0E-02	1.0E-07
copper	1.4E-07	NA	NA
cyanide	6.6E-15	2.0E-02	3.3E-13
lead	1.8E-07	NA	NA
manganese	1.9E-10	1.4E-01	1.4E-09
mercury	NA	3.0E-04	NA
molybdenum	2.5E-09	5.0E-03	4.9E-07
nickel	4.5E-08	2.0E-02	2.3E-06
selenium	1.2E-09	5.0E-03	2.4E-07
silver	3.2E-07	5.0E-03	6.3E-05
thallium	3.8E-10	8.0E-05	4.7E-06
thorium-total	1.4E-10	NA	NA
uranium-total	6.8E-06	3.0E-03	2.3E-03
vanadium	1.8E-10	7.0E-03	2.6E-08
zinc	2.2E-05	3.0E-01	7.4E-05
2-methylnaphthalene	8.4E-12	NA	NA
4,4-dde	5.3E-12	NA	NA
aroclor-1221	2.5E-32	NA	NA
aroclor-1248	NA	NA	NA
aroclor-1254	1.9E-09	NA	NA
aroclor-1260	NA	NA	NA
carbazole	1.3E-13	NA	NA
endrin	NA	3.0E-04	NA
2,3,7,8-tcdd	1.3E-15	NA	NA
	HQ Summation =		2.4E-03

Compound	ILCR Calculation CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	ILCR (unitless)
antimony	3.9E-10	NA	NA
arsenic	4.9E-10	1.8E+00	8.6E-10
barium	2.2E-08	NA	NA
beryllium	4.6E-13	4.3E+00	2.0E-12
boron	4.8E-09	NA	NA
cadmium	1.8E-09	NA	NA
chromium vi	7.3E-09	NA	NA
cobalt	6.3E-09	NA	NA
copper	1.4E-07	NA	NA
cyanide	6.6E-15	NA	NA
lead	1.8E-07	NA	NA
manganese	1.9E-10	NA	NA
mercury	NA	NA	NA
molybdenum	2.5E-09	NA	NA
nickel	4.5E-08	NA	NA
selenium	1.2E-09	NA	NA
silver	3.2E-07	NA	NA
thallium	3.8E-10	NA	NA
thorium-total	1.4E-10	NA	NA
uranium-total	6.8E-06	NA	NA
vanadium	1.8E-10	NA	NA
zinc	2.2E-05	NA	NA
2-methylnaphthalene	8.4E-12	NA	NA
4,4-dde	5.3E-12	3.4E-01	1.8E-12
aroclor-1221	2.5E-32	7.7E+00	1.9E-31
aroclor-1248	NA	7.7E+00	NA
aroclor-1254	1.9E-09	7.7E+00	1.5E-08
aroclor-1260	NA	7.7E+00	NA
carbazole	1.3E-13	2.0E-02	2.7E-15
endrin	NA	NA	NA
2,3,7,8-tcdd	1.3E-15	1.5E+05	2.0E-10
	ILCR Summation =		1.6E-08

Table I.IV–86
Summary of Intake and Risk Quantitation (radionuclides)
Future Land Use with Private Ownership: Off–Property Farmer (Adult)
Via Ingestion of Dairy Products

Intake Equation = Cp X EF X EDn X FI X IR

IR	Ingestion rate of dairy products	0.4 l/day
FI	Fraction ingested from contaminated source	0.75 (Unitless)
EF	Exposure frequency	350 days/year
EDn	Exposure duration	70 Year
Cp	Concentration of radionuclides in animal products	

Cs_{137+1d}	4.3E–04	pCi/kg	Rn_{222+4d}	ERR	pCi/kg
Pb_{210+2d}	2.7E–04	pCi/kg	Sr_{90+1d}	6.2E–04	pCi/kg
Np_{237+1d}	2.4E–05	pCi/kg	Tc_{99}	7.3E+02	pCi/kg
Pu_{238}	9.0E–08	pCi/kg	Th_{228+7d}	3.5E–07	pCi/kg
Pu_{239}	3.0E–09	pCi/kg	Th_{230}	1.2E–06	pCi/kg
Pu_{240}	NA	pCi/kg	$Th_{232+10d}$	1.0E–06	pCi/kg
Pa_{231}	1.6E–05	pCi/kg	U_{234}	2.1E–03	pCi/kg
Ra_{226+8d}	1.4E–04	pCi/kg	U_{235+1d}	5.6E–05	pCi/kg
Ra_{228+1d}	4.0E–05	pCi/kg	U_{236}	2.3E–05	pCi/kg
Ru_{106}	3.5E–09	pCi/kg	U_{238+2d}	1.3E–03	pCi/kg

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	ILCR (unitless)
Cs_{137+1d}	3.1E+00	2.8E–11	8.8E–11
Pb_{210+2d}	2.0E+00	6.6E–10	1.3E–09
Np_{237+1d}	1.8E–01	2.2E–10	3.9E–11
Pu_{238}	6.6E–04	2.2E–10	1.5E–13
Pu_{239}	2.2E–05	2.3E–10	5.1E–15
Pu_{240}	NA	2.3E–10	NA
Pa_{231}	1.2E–01	9.2E–11	1.1E–11
Ra_{226+8d}	1.0E+00	7.8E–10	8.0E–10
Ra_{228+1d}	2.9E–01	1.0E–10	2.9E–11
Ru_{106}	2.6E–05	9.5E–12	2.5E–16
Rn_{222+4d}	NA	1.7E–12	NA
Sr_{90+1d}	4.6E+00	3.6E–11	1.6E–10
Tc_{99}	5.4E+06	1.3E–12	7.0E–06
Th_{228+7d}	2.6E–03	5.5E–11	1.4E–13
Th_{230}	9.0E–03	1.3E–11	1.2E–13
$Th_{232+10d}$	7.5E–03	1.7E–10	1.3E–12
U_{234}	1.5E+01	1.6E–11	2.5E–10
U_{235+1d}	4.1E–01	1.6E–11	6.5E–12
U_{236}	1.7E–01	1.5E–11	2.5E–12
U_{238+2d}	9.2E+00	2.0E–11	1.8E–10
		ILCR Summation =	7.0E–06

Table I.IV–87
Summary of Intake Quantitation (chemicals)
Future Land Use with Private Ownership: Off–Property Farmer (Adult)
Via Ingestion of Vegetables and Fruits

Intake Equation = $\frac{CS \times EF \times ED \times FI \times IR}{BW \times AT}$

IR	Ingestion rate of fruits or vegetables	0.122 kg/day
FI	Fraction ingested from contaminated source	1 (Unitless)
EF	Exposure frequency	350 days/year
EDn	Exposure duration for non–carcinogens	70 Year
EDc	Exposure duration for carcinogens	70 Year
BW	Body weight	70 kg
ATc	Average time for carcinogens (lifetime)	25550 days
ATn	Average time for non–carcinogens (EDn x 365)	25550 days
CS	Concentration of chemicals in vegetables	

Chemical Concentrations

Compound	Concentration	Units	Compound	Concentration	Units
antimony	1.1E–05	mg/kg	silver	3.4E–05	mg/kg
arsenic	2.7E–05	mg/kg	thallium	5.0E–07	mg/kg
barium	1.6E–04	mg/kg	thorium–total	8.3E–05	mg/kg
beryllium	1.4E–06	mg/kg	uranium–total	2.2E–01	mg/kg
boron	9.5E–06	mg/kg	vanadium	2.6E–05	mg/kg
cadmium	4.1E–06	mg/kg	zinc	4.6E–03	mg/kg
chromium vi	1.4E–05	mg/kg	2–methylnaphthalene	3.3E–07	mg/kg
cobalt	8.7E–06	mg/kg	4,4–dde	4.2E–09	mg/kg
copper	2.1E–04	mg/kg	aroclor–1221	5.1E–27	mg/kg
cyanide	9.3E–07	mg/kg	aroclor–1248	NA	mg/kg
lead	2.0E–03	mg/kg	aroclor–1254	5.6E–07	mg/kg
manganese	1.2E–06	mg/kg	aroclor–1260	1.7E–07	mg/kg
mercury	9.5E–07	mg/kg	carbazole	1.6E–08	mg/kg
molybdenum	4.8E–06	mg/kg	endrin	NA	mg/kg
nickel	9.9E–05	mg/kg	2,3,7,8–tcdd	8.5E–14	mg/kg
selenium	7.3E–07	mg/kg			

References

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Table I.IV-87 (continued)
Summary of Risk Characterization (chemicals)
Future Land Use with Private Ownership: Off-Property Farmer (Adult)
Via Ingestion of Vegetables and Fruits

	HQ Calculation		
Compound	CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
antimony	1.8E-08	4.0E-04	4.6E-05
arsenic	4.5E-08	3.0E-04	1.5E-04
barium	2.7E-07	7.0E-02	3.8E-06
beryllium	2.3E-09	5.0E-03	4.5E-07
boron	1.6E-08	9.0E-02	1.8E-07
cadmium	6.8E-09	1.0E-03	6.8E-06
chromium vi	2.4E-08	5.0E-03	4.8E-06
cobalt	1.5E-08	6.0E-02	2.4E-07
copper	3.5E-07	NA	NA
cyanide	1.6E-09	2.0E-02	7.8E-08
lead	3.3E-06	NA	NA
manganese	2.0E-09	1.4E-01	1.5E-08
mercury	1.6E-09	3.0E-04	5.3E-06
molybdenum	8.0E-09	5.0E-03	1.6E-06
nickel	1.7E-07	2.0E-02	8.3E-06
selenium	1.2E-09	5.0E-03	2.4E-07
silver	5.6E-08	5.0E-03	1.1E-05
thallium	8.4E-10	8.0E-05	1.1E-05
thorium-total	1.4E-07	NA	NA
uranium-total	3.7E-04	3.0E-03	1.2E-01
vanadium	4.3E-08	7.0E-03	6.2E-06
zinc	7.8E-06	3.0E-01	2.6E-05
2-methylnaphthalene	5.4E-10	NA	NA
4,4-dde	7.0E-12	NA	NA
aroclor-1221	8.5E-30	NA	NA
aroclor-1248	NA	NA	NA
aroclor-1254	9.3E-10	NA	NA
aroclor-1260	2.9E-10	NA	NA
carbazole	2.8E-11	NA	NA
endrin	NA	3.0E-04	NA
2,3,7,8-tcdd	1.4E-16	NA	NA
	HQ Summation =		1.2E-01

	ILCR Calculation		
Compound	CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	ILCR (unitless)
antimony	1.8E-08	NA	NA
arsenic	4.5E-08	1.8E+00	7.8E-08
barium	2.7E-07	NA	NA
beryllium	2.3E-09	4.3E+00	9.8E-09
boron	1.6E-08	NA	NA
cadmium	6.8E-09	NA	NA
chromium vi	2.4E-08	NA	NA
cobalt	1.5E-08	NA	NA
copper	3.5E-07	NA	NA
cyanide	1.6E-09	NA	NA
lead	3.3E-06	NA	NA
manganese	2.0E-09	NA	NA
mercury	1.6E-09	NA	NA
molybdenum	8.0E-09	NA	NA
nickel	1.7E-07	NA	NA
selenium	1.2E-09	NA	NA
silver	5.6E-08	NA	NA
thallium	8.4E-10	NA	NA
thorium-total	1.4E-07	NA	NA
uranium-total	3.7E-04	NA	NA
vanadium	4.3E-08	NA	NA
zinc	7.8E-06	NA	NA
2-methylnaphthalene	5.4E-10	NA	NA
4,4-dde	7.0E-12	3.4E-01	2.4E-12
aroclor-1221	8.5E-30	7.7E+00	6.6E-29
aroclor-1248	NA	7.7E+00	NA
aroclor-1254	9.3E-10	7.7E+00	7.2E-09
aroclor-1260	2.9E-10	7.7E+00	2.2E-09
carbazole	2.8E-11	2.0E-02	5.5E-13
endrin	NA	NA	NA
2,3,7,8-tcdd	1.4E-16	1.5E+05	2.1E-11
	ILCR Summation =		9.7E-08

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Table I.IV–88
Summary of Intake and Risk Quantitation (radionuclides)
Future Land Use with Private Ownership: Off–Property Farmer (Adult)
Via Ingestion of Vegetables and Fruits

Intake Equation = Cv X EF X EDn X FI X IR

IR	Ingestion rate of fruits or vegetables	0.122 kg/day
FI	Fraction ingested from contaminated source	1 (Unitless)
EF	Exposure frequency	350 days/year
EDn	Exposure duration	70 Year
Cv	Concentration of radionuclides in vegetables	

Cs_{137+1d}	6.7E–04	pCi/kg	Rn_{222+4d}	ERR	pCi/kg
Pb_{210+2d}	1.3E–02	pCi/kg	Sr_{90+1d}	4.0E–03	pCi/kg
Np_{237+1d}	3.9E–01	pCi/kg	Tc_{99}	6.7E+03	pCi/kg
Pu_{238}	1.2E–02	pCi/kg	Th_{228+7d}	9.2E–04	pCi/kg
Pu_{239}	3.9E–04	pCi/kg	Th_{230}	3.6E–03	pCi/kg
Pu_{240}	1.4E–03	pCi/kg	$Th_{232+10d}$	3.0E–03	pCi/kg
Pa_{231}	4.1E–04	pCi/kg	U_{234}	4.6E–02	pCi/kg
Ra_{226+8d}	1.7E–02	pCi/kg	U_{235+1d}	1.2E–03	pCi/kg
Ra_{228+1d}	1.1E–03	pCi/kg	U_{236}	5.0E–04	pCi/kg
Ru_{106}	7.6E–05	pCi/kg	U_{238+2d}	2.7E–02	pCi/kg

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	ILCR (unitless)
Cs_{137+1d}	2.0E+00	2.8E–11	5.6E–11
Pb_{210+2d}	3.9E+01	6.6E–10	2.6E–08
Np_{237+1d}	1.2E+03	2.2E–10	2.6E–07
Pu_{238}	3.5E+01	2.2E–10	7.7E–09
Pu_{239}	1.2E+00	2.3E–10	2.7E–10
Pu_{240}	4.2E+00	2.3E–10	9.8E–10
Pa_{231}	1.2E+00	9.2E–11	1.1E–10
Ra_{226+8d}	5.0E+01	7.8E–10	3.9E–08
Ra_{228+1d}	3.4E+00	1.0E–10	3.4E–10
Ru_{106}	2.3E–01	9.5E–12	2.2E–12
Rn_{222+4d}	NA	1.7E–12	NA
Sr_{90+1d}	1.2E+01	3.6E–11	4.3E–10
Tc_{99}	2.0E+07	1.3E–12	2.6E–05
Th_{228+7d}	2.8E+00	5.5E–11	1.5E–10
Th_{230}	1.1E+01	1.3E–11	1.4E–10
$Th_{232+10d}$	8.9E+00	1.7E–10	1.5E–09
U_{234}	1.4E+02	1.6E–11	2.2E–09
U_{235+1d}	3.6E+00	1.6E–11	5.8E–11
U_{236}	1.5E+00	1.5E–11	2.2E–11
U_{238+2d}	8.2E+01	2.0E–11	1.6E–09
		ILCR Summation =	2.7E–05

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Table I.IV–89
Summary of Intake Quantitation (chemicals)
Future Land Use with Private Ownership: Off–Property Farmer (Child)
Via Inhalation of Particulates

Intake Equation = $\frac{CS \times EF \times ED \times IR}{BW \times AT}$

IR	Inhalation rate of gases (RAGS, 1989)	12 m^3/day
EF	Exposure frequency	350 days/year
EDn	Exposure duration for non–carcinogens	6 Year
EDc	Exposure duration for carcinogens	6 Year
BW	Body weight	15 kg
ATc	Average time for carcinogens (lifetime)	25550 days
ATn	Average time for non–carcinogens (EDn x 365)	2190 days
CS	Concentration of chemicals in soil	(see table below)

Chemical Concentrations

Compound	Concentration	Units	Compound	Concentration	Units
antimony	7.5E–09	mg/m^3	silver	2.7E–09	mg/m^3
arsenic	5.3E–09	mg/m^3	thallium	3.3E–10	mg/m^3
barium	8.2E–08	mg/m^3	thorium–total	7.5E–08	mg/m^3
beryllium	7.8E–10	mg/m^3	uranium–total	1.0E–06	mg/m^3
boron	8.5E–09	mg/m^3	vanadium	2.0E–08	mg/m^3
cadmium	1.3E–09	mg/m^3	zinc	5.1E–08	mg/m^3
chromium vi	1.2E–08	mg/m^3	2–methylnaphthalene	6.0E–11	mg/m^3
cobalt	6.3E–09	mg/m^3	4,4–dde	4.3E–12	mg/m^3
copper	3.8E–08	mg/m^3	aroclor–1221	NANA	mg/m^3
cyanide	4.6E–10	mg/m^3	aroclor–1248	NANA	mg/m^3
lead	1.3E–06	mg/m^3	aroclor–1254	2.7E–10	mg/m^3
manganese	2.4E–10	mg/m^3	aroclor–1260	6.4E–11	mg/m^3
mercury	2.4E–10	mg/m^3	carbazole	1.7E–11	mg/m^3
molybdenum	4.1E–09	mg/m^3	endrin	NANA	mg/m^3
nickel	1.5E–08	mg/m^3	2,3,7,8–tcdd	8.8E–17	mg/m^3
selenium	3.4E–10	mg/m^3			

References

Table I.IV-89 (continued)
Summary of Risk Characterization (chemicals)
Future Land Use with Private Ownership: Off-Property Farmer (Child)
Via Inhalation of Particulates

	HQ Calculation		
Compound	CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
antimony	5.8E-09	NA	NA
arsenic	4.1E-09	NA	NA
barium	6.3E-08	1.4E-04	4.4E-04
beryllium	6.0E-10	NA	NA
boron	6.5E-09	5.7E-03	1.1E-06
cadmium	1.0E-09	NA	NA
chromium vi	9.5E-09	NA	NA
cobalt	4.9E-09	3.0E-07	1.6E-02
copper	2.9E-08	NA	NA
cyanide	3.5E-10	NA	NA
lead	9.8E-07	NA	NA
manganese	1.9E-10	1.4E-05	1.3E-05
mercury	1.9E-10	8.6E-05	2.2E-06
molybdenum	3.1E-09	NA	NA
nickel	1.2E-08	NA	NA
selenium	2.6E-10	NA	NA
silver	2.0E-09	NA	NA
thallium	2.5E-10	NA	NA
thorium-total	5.8E-08	NA	NA
uranium-total	7.7E-07	NA	NA
vanadium	1.5E-08	NA	NA
zinc	3.9E-08	NA	NA
2-methylnaphthalene	4.6E-11	NA	NA
4,4-dde	3.3E-12	NA	NA
aroclor-1221	NA	NA	NA
aroclor-1248	NA	NA	NA
aroclor-1254	2.0E-10	NA	NA
aroclor-1260	4.9E-11	NA	NA
carbazole	1.3E-11	NA	NA
endrin	NA	NA	NA
2,3,7,8-tcdd	6.7E-17	NA	NA
	Hazard Quotient Sum =		1.7E-02

	ILCR Calculation		
Compound	CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	ILCR (unitless)
antimony	5.0E-10	NA	NA
arsenic	3.5E-10	1.5E+01	5.2E-09
barium	5.4E-09	NA	NA
beryllium	5.1E-11	8.4E+00	4.3E-10
boron	5.6E-10	NA	NA
cadmium	8.5E-11	6.3E+00	5.4E-10
chromium vi	8.2E-10	4.1E+01	3.3E-08
cobalt	4.2E-10	NA	NA
copper	2.5E-09	NA	NA
cyanide	3.0E-11	NA	NA
lead	8.4E-08	NA	NA
manganese	1.6E-11	NA	NA
mercury	1.6E-11	NA	NA
molybdenum	2.7E-10	NA	NA
nickel	1.0E-09	8.4E-01	8.4E-10
selenium	2.2E-11	NA	NA
silver	1.8E-10	NA	NA
thallium	2.2E-11	NA	NA
thorium-total	4.9E-09	NA	NA
uranium-total	6.6E-08	NA	NA
vanadium	1.3E-09	NA	NA
zinc	3.4E-09	NA	NA
2-methylnaphthalene	4.0E-12	NA	NA
4,4-dde	2.8E-13	NA	NA
aroclor-1221	NA	NA	NA
aroclor-1248	NA	NA	NA
aroclor-1254	1.7E-11	NA	NA
aroclor-1260	4.2E-12	NA	NA
carbazole	1.1E-12	NA	NA
endrin	NA	NA	NA
2,3,7,8-tcdd	5.8E-18	1.5E+05	8.7E-13
	ILCR Summation =		4.0E-08

Table I.IV–90
Summary of Intake and Risk Quantitation (radionuclides)
Future Land Use with Private Ownership: Off–Property Farmer (Child)
Via Inhalation of Gases and Particulates

Intake Equation = Ca X EF X EDn X IR

IR	Inhalation rate of gases (RAGS, 1989)	12 m^3/day
EF	Exposure frequency	350 days/year
EDn	Exposure duration	6 Year
Ca	Concentration of radionuclides in air	(see table below)

Cs_{137+1d}	4.3E–07	pCi/m^3	Rn_{222+4d}	1.3E+01	pCi/m^3
Pb_{210+2d}	1.1E–05	pCi/m^3	Sr_{90+1d}	1.4E–06	pCi/m^3
Np_{237+1d}	2.0E–07	pCi/m^3	Tc_{99}	2.3E–05	pCi/m^3
Pu_{238}	1.2E–05	pCi/m^3	Th_{228+7d}	9.5E–07	pCi/m^3
Pu_{239}	3.9E–07	pCi/m^3	Th_{230}	3.3E–06	pCi/m^3
Pu_{240}	1.4E–06	pCi/m^3	$Th_{232+10d}$	2.7E–06	pCi/m^3
Pa_{231}	4.1E–07	pCi/m^3	U_{234}	4.6E–05	pCi/m^3
Ra_{226+8d}	9.1E–07	pCi/m^3	U_{235+1d}	1.2E–06	pCi/m^3
Ra_{228+1d}	1.1E–06	pCi/m^3	U_{236}	5.1E–07	pCi/m^3
Ru_{106}	7.8E–08	pCi/m^3	U_{238+2d}	2.8E–05	pCi/m^3

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	ILCR (unitless)
Cs_{137+1d}	1.1E–02	1.9E–11	2.1E–13
Pb_{210+2d}	2.9E–01	4.0E–09	1.1E–09
Np_{237+1d}	5.0E–03	2.9E–08	1.4E–10
Pu_{238}	3.0E–01	3.9E–08	1.2E–08
Pu_{239}	9.9E–03	3.8E–08	3.8E–10
Pu_{240}	3.6E–02	3.8E–08	1.4E–09
Pa_{231}	1.0E–02	3.6E–08	3.7E–10
Ra_{226+8d}	2.3E–02	7.0E–09	1.6E–10
Ra_{228+1d}	2.9E–02	6.9E–10	2.0E–11
Ru_{106}	2.0E–03	4.4E–10	8.6E–13
Rn_{222+4d}	3.2E+05	7.7E–12	2.4E–06
Sr_{90+1d}	3.5E–02	6.2E–11	2.2E–12
Tc_{99}	5.8E–01	8.3E–12	4.8E–12
Th_{228+7d}	2.4E–02	7.8E–08	1.9E–09
Th_{230}	8.2E–02	2.9E–08	2.4E–09
$Th_{232+10d}$	6.8E–02	1.1E–07	7.5E–09
U_{234}	1.2E+00	2.6E–08	3.0E–08
U_{235+1d}	3.1E–02	2.5E–08	7.7E–10
U_{236}	1.3E–02	2.5E–08	3.2E–10
U_{238+2d}	7.0E–01	2.4E–08	1.7E–08
		ILCR Summation =	2.5E–06

Table I.IV–91
Summary of Intake Quantitation (chemicals)
Future Land Use with Private Ownership: Off–Property Farmer (Child)
Via Drinking Water Ingestion

Intake Equation = $\frac{CS \times EF \times ED \times IR}{BW \times AT}$

IR	Ingestion rate of groundwater (RAGS, 1989)	1 l/day
EF	Exposure frequency	350 days/year
EDn	Exposure duration for non–carcinogens	6 Year
EDc	Exposure duration for carcinogens	6 Year
BW	Body weight	15 kg
ATc	Average time for carcinogens (lifetime)	25550 days
ATn	Average time for non–carcinogens (EDn x 365)	2190 days
CS	Concentration of chemicals in groundwater	

Chemical Concentrations

Compound	Concentration	Units	Compound	Concentration	Units
antimony	6.90E–08	mg/l	silver	NA	mg/l
arsenic	1.79E–06	mg/l	thallium	NA	mg/l
barium	NA	mg/l	thorium–total	NA	mg/l
beryllium	8.86E–09	mg/l	uranium–total	4.50E–02	mg/l
boron	NA	mg/l	vanadium	NA	mg/l
cadmium	1.71E–24	mg/l	zinc	NA	mg/l
chromium vi	NA	mg/l	2–methylnaphthalene	NA	mg/l
cobalt	NA	mg/l	4,4–dde	NA	mg/l
copper	NA	mg/l	aroclor–1221	1.03E–27	mg/l
cyanide	NA	mg/l	aroclor–1248	NA	mg/l
lead	NA	mg/l	aroclor–1254	NA	mg/l
manganese	NA	mg/l	aroclor–1260	NA	mg/l
mercury	NA	mg/l	carbazole	NA	mg/l
molybdenum	NA	mg/l	endrin	NA	mg/l
nickel	NA	mg/l	2,3,7,8–tcdd	NA	mg/l
selenium	NA	mg/l			

References

Table I.IV-91 (continued)
Summary of Risk Characterization (chemicals)
Future Land Use with Private Ownership: Off-Property Farmer (Child)
Via Drinking Water Ingestion

Compound	HQ Calculation CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
antimony	4.41E-09	4.00E-04	1.10E-05
arsenic	1.14E-07	3.00E-04	3.81E-04
barium	NA	7.00E-02	NA
beryllium	5.66E-10	5.00E-03	1.13E-07
boron	NA	9.00E-02	NA
cadmium	1.09E-25	1.00E-03	1.09E-22
chromium vi	NA	5.00E-03	NA
cobalt	NA	6.00E-02	NA
copper	NA	NA	NA
cyanide	NA	2.00E-02	NA
lead	NA	NA	NA
manganese	NA	1.40E-01	NA
mercury	NA	3.00E-04	NA
molybdenum	NA	5.00E-03	NA
nickel	NA	2.00E-02	NA
selenium	NA	5.00E-03	NA
silver	NA	5.00E-03	NA
thallium	NA	8.00E-05	NA
thorium-total	NA	NA	NA
uranium-total	2.88E-03	3.00E-03	9.59E-01
vanadium	NA	7.00E-03	NA
zinc	NA	3.00E-01	NA
2-methylnaphthalene	NA	NA	NA
4,4-dde	NA	NA	NA
aroclor-1221	6.58E-29	NA	NA
aroclor-1248	NA	NA	NA
aroclor-1254	NA	NA	NA
aroclor-1260	NA	NA	NA
carbazole	NA	NA	NA
endrin	NA	3.00E-04	NA
2,3,7,8-tcdd	NA	NA	NA
	HQ Summation =		9.60E-01

Compound	ILCR Calculation CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	ILCR (unitless)
antimony	3.78E-10	NA	NA
arsenic	9.81E-09	1.75E+00	1.72E-08
barium	NA	NA	NA
beryllium	4.85E-11	4.30E+00	2.09E-10
boron	NA	NA	NA
cadmium	9.37E-27	NA	NA
chromium vi	NA	NA	NA
cobalt	NA	NA	NA
copper	NA	NA	NA
cyanide	NA	NA	NA
lead	NA	NA	NA
manganese	NA	NA	NA
mercury	NA	NA	NA
molybdenum	NA	NA	NA
nickel	NA	NA	NA
selenium	NA	NA	NA
silver	NA	NA	NA
thallium	NA	NA	NA
thorium-total	NA	NA	NA
uranium-total	2.47E-04	NA	NA
vanadium	NA	NA	NA
zinc	NA	NA	NA
2-methylnaphthalene	NA	NA	NA
4,4-dde	NA	3.40E-01	NA
aroclor-1221	5.64E-30	7.70E+00	4.35E-29
aroclor-1248	NA	7.70E+00	NA
aroclor-1254	NA	7.70E+00	NA
aroclor-1260	NA	7.70E+00	NA
carbazole	NA	2.00E-02	NA
endrin	NA	NA	NA
2,3,7,8-tcdd	NA	1.50E+05	NA
	ILCR Summation =		1.74E-08

000654

Table I.IV–92
Summary of Intake and Risk Quantitation (radionuclides)
Future Land Use with Private Ownership: Off–Property Farmer (Child)
Via Ingestion of Drinking Water

Intake Equation = Cw X EF X EDn X FI X IR

IR	Ingestion rate of groundwater (RAGS, 1989)	1 l/day
EF	Exposure frequency	350 days/year
EDn	Exposure duration	6 Year
FI	Fractional intake for radionuclides	1 (Unitless)
Cw	Concentration of radionuclides in groundwater	(see table below)

Cs_{137+1d}	NA	pCi/l	Rn_{222+4d}	NA	pCi/l
Pb_{210+2d}	NA	pCi/l	Sr_{90+1d}	NA	pCi/l
Np_{237+1d}	8.0E–02	pCi/l	Tc_{99}	1.2E+03	pCi/l
Pu_{238}	NA	pCi/l	Th_{228+7d}	NA	pCi/l
Pu_{239}	NA	pCi/l	Th_{230}	NA	pCi/l
Pu_{240}	NA	pCi/l	$Th_{232+10d}$	NA	pCi/l
Pa_{231}	NA	pCi/l	U_{234}	2.5E+01	pCi/l
Ra_{226+8d}	3.2E–03	pCi/l	U_{235+1d}	6.7E–01	pCi/l
Ra_{228+1d}	NA	pCi/l	U_{236}	2.8E–01	pCi/l
Ru_{106}	NA	pCi/l	U_{238+2d}	1.5E+01	pCi/l

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	ILCR (unitless)
Cs_{137+1d}	NA	2.8E–11	NA
Pb_{210+2d}	NA	6.6E–10	NA
Np_{237+1d}	1.7E+02	2.2E–10	3.7E–08
Pu_{238}	NA	2.2E–10	NA
Pu_{239}	NA	2.3E–10	NA
Pu_{240}	NA	2.3E–10	NA
Pa_{231}	NA	9.2E–11	NA
Ra_{226+8d}	6.6E+00	7.8E–10	5.2E–09
Ra_{228+1d}	NA	1.0E–10	NA
Ru_{106}	NA	9.5E–12	NA
Rn_{222+4d}	NA	1.7E–12	NA
Sr_{90+1d}	NA	3.6E–11	NA
Tc_{99}	2.6E+06	1.3E–12	3.3E–06
Th_{228+7d}	NA	5.5E–11	NA
Th_{230}	NA	1.3E–11	NA
$Th_{232+10d}$	NA	1.7E–10	NA
U_{234}	5.3E+04	1.6E–11	8.4E–07
U_{235+1d}	1.4E+03	1.6E–11	2.2E–08
U_{236}	5.8E+02	1.5E–11	8.7E–09
U_{238+2d}	3.2E+04	2.0E–11	6.3E–07
		ILCR Summation =	4.9E–06

000659

Table I.IV–93
Summary of Intake Quantitation (chemicals)
Future Land Use with Private Ownership: Off–Property Farmer (Child)
Via Dermal Contact while Bathing

Intake Equation = $\frac{DA \times EF \times ED \times SA}{BW \times AT}$

DA	Dermal absorbed dose	csv mg/cm^2–day
EF	Exposure frequency	350 days/year
EDn	Exposure duration for non–carcinogens	6 Year
EDc	Exposure duration for carcinogens	6 Year
BW	Body weight	15 kg
ATc	Average time for carcinogens (lifetime)	25550 days
ATn	Average time for non–carcinogens (EDn x 365)	2190 days
SA	Skin surface area available for contact	8000 cm^2

Chemical Concentrations

Compound	DA	Units
antimony	1.73E–13	mg/cm^2–day
arsenic	4.48E–12	mg/cm^2–day
barium	NA	mg/cm^2–day
beryllium	2.22E–14	mg/cm^2–day
boron	NA	mg/cm^2–day
cadmium	4.28E–30	mg/cm^2–day
chromium vi	NA	mg/cm^2–day
cobalt	NA	mg/cm^2–day
copper	NA	mg/cm^2–day
cyanide	NA	mg/cm^2–day
lead	NA	mg/cm^2–day
manganese	NA	mg/cm^2–day
mercury	NA	mg/cm^2–day
molybdenum	NA	mg/cm^2–day
nickel	NA	mg/cm^2–day
selenium	NA	mg/cm^2–day

Compound	DA	Units
silver	NA	mg/cm^2–day
thallium	NA	mg/cm^2–day
thorium–total	NA	mg/cm^2–day
uranium–total	1.13E–07	mg/cm^2–day
vanadium	NA	mg/cm^2–day
zinc	NA	mg/cm^2–day
2–methylnaphthalene	NA	mg/cm^2–day
4,4–dde	NA	mg/cm^2–day
aroclor–1221	8.37E–31	mg/cm^2–day
aroclor–1248	NA	mg/cm^2–day
aroclor–1254	NA	mg/cm^2–day
aroclor–1260	NA	mg/cm^2–day
carbazole	NA	mg/cm^2–day
endrin	NA	mg/cm^2–day
2,3,7,8–tcdd	NA	mg/cm^2–day

References

Table I.IV-93 (continued)
Summary of Risk Characterization (chemicals)
Future Land Use with Private Ownership: Off-Property Farmer (Child)
Via Dermal Contact while Bathing

Compound	HQ Calculation CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
antimony	8.82E-11	6.00E-05	1.47E-06
arsenic	2.29E-09	2.85E-04	8.03E-06
barium	NA	6.37E-02	NA
beryllium	1.13E-11	5.00E-03	2.27E-09
boron	NA	4.50E-03	NA
cadmium	2.19E-27	5.00E-05	4.37E-23
chromium vi	NA	2.25E-03	NA
cobalt	NA	2.70E-02	NA
copper	NA	NA	NA
cyanide	NA	NA	NA
lead	NA	NA	NA
manganese	NA	4.20E-03	NA
mercury	NA	4.50E-05	NA
molybdenum	NA	1.90E-03	NA
nickel	NA	2.00E-03	NA
selenium	NA	4.00E-03	NA
silver	NA	NA	NA
thallium	NA	8.00E-05	NA
thorium-total	NA	NA	NA
uranium-total	5.75E-05	1.50E-04	3.84E-01
vanadium	NA	3.50E-04	NA
zinc	NA	7.50E-02	NA
2-methylnaphthalene	NA	NA	NA
4,4-dde	NA	NA	NA
aroclor-1221	4.28E-28	NA	NA
aroclor-1248	NA	NA	NA
aroclor-1254	NA	NA	NA
aroclor-1260	NA	NA	NA
carbazole	NA	NA	NA
endrin	NA	2.70E-04	NA
2,3,7,8-tcdd	NA	NA	NA
	HQ Summation =		3.84E-01

Compound	ILCR Calculation CDI (mg/kg-day)	CSF (mg/kg-day)$^{-1}$	ILCR (unitless)
antimony	7.56E-12	NA	NA
arsenic	1.96E-10	1.90E+00	3.73E-10
barium	NA	NA	NA
beryllium	9.71E-13	4.30E+00	4.18E-12
boron	NA	NA	NA
cadmium	1.87E-28	NA	NA
chromium vi	NA	NA	NA
cobalt	NA	NA	NA
copper	NA	NA	NA
cyanide	NA	NA	NA
lead	NA	NA	NA
manganese	NA	NA	NA
mercury	NA	NA	NA
molybdenum	NA	NA	NA
nickel	NA	NA	NA
selenium	NA	NA	NA
silver	NA	NA	NA
thallium	NA	NA	NA
thorium-total	NA	NA	NA
uranium-total	4.93E-06	NA	NA
vanadium	NA	NA	NA
zinc	NA	NA	NA
2-methylnaphthalene	NA	NA	NA
4,4-dde	NA	3.40E-01	NA
aroclor-1221	3.67E-29	1.03E+01	3.77E-28
aroclor-1248	NA	1.03E+01	NA
aroclor-1254	NA	1.03E+01	NA
aroclor-1260	NA	1.03E+01	NA
carbazole	NA	2.22E-02	NA
endrin	NA	NA	NA
2,3,7,8-tcdd	NA	3.00E+05	NA
	ILCR Summation =		3.77E-10

000658

Table I.IV–94
Summary of Intake Quantitation (chemicals)
Future Land Use with Private Ownership: Off–Property Farmer (Child)
Via Ingestion of Meat Products

Intake Equation = $\frac{CS \times EF \times ED \times FI \times IR}{BW \times AT}$

IR	Ingestion rate of meat	0.039 kg/day
FI	Fraction ingested from contaminated source	0.75 (Unitless)
EF	Exposure frequency	350 days/year
EDn	Exposure duration for non–carcinogens	6 Year
EDc	Exposure duration for carcinogens	6 Year
BW	Body weight	15 kg
ATc	Average time for carcinogens (lifetime)	25550 days
ATn	Average time for non–carcinogens (EDn x 365)	2190 days
CS	Concentration of chemicals in meat	

Chemical Concentrations

Compound	Concentration	Units	Compound	Concentration	Units
antimony	9.6E–07	mg/kg	silver	1.2E–05	mg/kg
arsenic	3.9E–06	mg/kg	thallium	1.8E–06	mg/kg
barium	2.3E–06	mg/kg	thorium–total	4.1E–08	mg/kg
beryllium	1.2E–07	mg/kg	uranium–total	4.7E–04	mg/kg
boron	6.3E–07	mg/kg	vanadium	5.6E–06	mg/kg
cadmium	2.3E–07	mg/kg	zinc	5.4E–02	mg/kg
chromium vi	6.5E–06	mg/kg	2–methylnaphthalene	6.5E–09	mg/kg
cobalt	1.5E–05	mg/kg	4,4–dde	4.1E–09	mg/kg
copper	2.3E–04	mg/kg	aroclor–1221	1.6E–29	mg/kg
cyanide	5.1E–12	mg/kg	aroclor–1248	NA	mg/kg
lead	5.4E–05	mg/kg	aroclor–1254	1.5E–06	mg/kg
manganese	5.3E–08	mg/kg	aroclor–1260	6.3E–06	mg/kg
mercury	2.5E–05	mg/kg	carbazole	1.0E–10	mg/kg
molybdenum	2.4E–06	mg/kg	endrin	NA	mg/kg
nickel	6.6E–05	mg/kg	2,3,7,8–tcdd	9.2E–13	mg/kg
selenium	1.1E–06	mg/kg			

References

Table I.IV-94 (continued)
Summary of Risk Characterization (chemicals)
Future Land Use with Private Ownership: Off-Property Farmer (Child)
Via Ingestion of Meat Products

	HQ Calculation		
Compound	CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
antimony	1.8E-09	4.0E-04	4.5E-06
arsenic	7.4E-09	3.0E-04	2.5E-05
barium	4.3E-09	7.0E-02	6.2E-08
beryllium	2.3E-10	5.0E-03	4.6E-08
boron	1.2E-09	9.0E-02	1.3E-08
cadmium	4.4E-10	1.0E-03	4.4E-07
chromium vi	1.2E-08	5.0E-03	2.4E-06
cobalt	2.9E-08	6.0E-02	4.8E-07
copper	4.3E-07	NA	NA
cyanide	9.6E-15	2.0E-02	4.8E-13
lead	1.0E-07	NA	NA
manganese	1.0E-10	1.4E-01	7.1E-10
mercury	4.8E-08	3.0E-04	1.6E-04
molybdenum	4.5E-09	5.0E-03	8.9E-07
nickel	1.2E-07	2.0E-02	6.2E-06
selenium	2.0E-09	5.0E-03	4.0E-07
silver	2.2E-08	5.0E-03	4.3E-06
thallium	3.4E-09	8.0E-05	4.3E-05
thorium-total	7.6E-11	NA	NA
uranium-total	8.7E-07	3.0E-03	2.9E-04
vanadium	1.1E-08	7.0E-03	1.5E-06
zinc	1.0E-04	3.0E-01	3.4E-04
2-methylnaphthalene	1.2E-11	NA	NA
4,4-dde	7.6E-12	NA	NA
aroclor-1221	3.0E-32	NA	NA
aroclor-1248	NA	NA	NA
aroclor-1254	2.7E-09	NA	NA
aroclor-1260	1.2E-08	NA	NA
carbazole	1.9E-13	NA	NA
endrin	NA	3.0E-04	NA
2,3,7,8-tcdd	1.7E-15	NA	NA
	HQ Summation =		8.7E-04

	ILCR Calculation		
Compound	CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	ILCR (unitless)
antimony	1.5E-10	NA	NA
arsenic	6.3E-10	1.8E+00	1.1E-09
barium	3.7E-10	NA	NA
beryllium	2.0E-11	4.3E+00	8.5E-11
boron	1.0E-10	NA	NA
cadmium	3.8E-11	NA	NA
chromium vi	1.0E-09	NA	NA
cobalt	2.5E-09	NA	NA
copper	3.7E-08	NA	NA
cyanide	8.2E-16	NA	NA
lead	8.6E-09	NA	NA
manganese	8.5E-12	NA	NA
mercury	4.1E-09	NA	NA
molybdenum	3.8E-10	NA	NA
nickel	1.1E-08	NA	NA
selenium	1.7E-10	NA	NA
silver	1.8E-09	NA	NA
thallium	3.0E-10	NA	NA
thorium-total	6.5E-12	NA	NA
uranium-total	7.5E-08	NA	NA
vanadium	9.0E-10	NA	NA
zinc	8.7E-06	NA	NA
2-methylnaphthalene	1.0E-12	NA	NA
4,4-dde	6.5E-13	3.4E-01	2.2E-13
aroclor-1221	2.5E-33	7.7E+00	2.0E-32
aroclor-1248	NA	7.7E+00	NA
aroclor-1254	2.3E-10	7.7E+00	1.8E-09
aroclor-1260	1.0E-09	7.7E+00	7.7E-09
carbazole	1.7E-14	2.0E-02	3.3E-16
endrin	NA	NA	NA
2,3,7,8-tcdd	1.5E-16	1.5E+05	2.2E-11
	ILCR Summation =		1.1E-08

Table I.IV–95
Summary of Intake and Risk Quantitation (radionuclides)
Future Land Use with Private Ownership: Off–Property Farmer (Child)
Via Ingestion of Meat Products

Intake Equation = Cf X EF X EDn X FI X IR

IR	Ingestion rate of meat	0.039 kg/day
FI	Fraction ingested from contaminated source	0.75 (Unitless)
EF	Exposure frequency	350 days/year
EDn	Exposure duration	6 Year
Cf	Concentration of radionuclides in meat	

Cs_{137+1d}	1.2E–03	pCi/kg	Rn_{222+4d}	ERR	pCi/kg
Pb_{210+2d}	3.2E–04	pCi/kg	Sr_{90+1d}	1.8E+01	pCi/kg
Np_{237+1d}	2.2E–04	pCi/kg	Tc_{99}	2.8E–02	pCi/kg
Pu_{238}	4.5E–07	pCi/kg	Th_{228+7d}	4.2E–07	pCi/kg
Pu_{239}	1.5E–08	pCi/kg	Th_{230}	1.5E–06	pCi/kg
Pu_{240}	NA	pCi/kg	$Th_{232+10d}$	1.2E–06	pCi/kg
Pa_{231}	3.2E–07	pCi/kg	U_{234}	7.0E–04	pCi/kg
Ra_{226+8d}	6.9E–05	pCi/kg	U_{235+1d}	1.9E–05	pCi/kg
Ra_{228+1d}	2.2E–05	pCi/kg	U_{236}	7.7E–06	pCi/kg
Ru_{106}	1.1E–05	pCi/kg	U_{238+2d}	4.2E–04	pCi/kg

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	ILCR (unitless)
Cs_{137+1d}	7.5E–02	2.8E–11	2.1E–12
Pb_{210+2d}	2.0E–02	6.6E–10	1.3E–11
Np_{237+1d}	1.4E–02	2.2E–10	3.0E–12
Pu_{238}	2.8E–05	2.2E–10	6.1E–15
Pu_{239}	9.3E–07	2.3E–10	2.1E–16
Pu_{240}	NA	2.3E–10	NA
Pa_{231}	2.0E–05	9.2E–11	1.8E–15
Ra_{226+8d}	4.3E–03	7.8E–10	3.3E–12
Ra_{228+1d}	1.3E–03	1.0E–10	1.3E–13
Ru_{106}	7.0E–04	9.5E–12	6.6E–15
Rn_{222+4d}	NA	1.7E–12	NA
Sr_{90+1d}	1.1E+03	3.6E–11	4.0E–08
Tc_{99}	1.7E+00	1.3E–12	2.2E–12
Th_{228+7d}	2.6E–05	5.5E–11	1.4E–15
Th_{230}	9.1E–05	1.3E–11	1.2E–15
$Th_{232+10d}$	7.5E–05	1.7E–10	1.3E–14
U_{234}	4.3E–02	1.6E–11	6.9E–13
U_{235+1d}	1.1E–03	1.6E–11	1.8E–14
U_{236}	4.7E–04	1.5E–11	7.1E–15
U_{238+2d}	2.6E–02	2.0E–11	5.1E–13
		ILCR Summation =	4.0E–08

Table I.IV–96
Summary of Intake Quantitation (chemicals)
Future Land Use with Private Ownership: Off–Property Farmer (Child)
Via Ingestion of Dairy Products

Intake Equation = $\frac{CS \times EF \times ED \times FI \times IR}{BW \times AT}$

IR	Ingestion rate of dairy products	0.9 l/day
FI	Fraction ingested from contaminated source	0.75 (Unitless)
EF	Exposure frequency	350 days/year
EDn	Exposure duration for non–carcinogens	6 Year
EDc	Exposure duration for carcinogens	6 Year
BW	Body weight	15 kg
ATc	Average time for carcinogens (lifetime)	25550 days
ATn	Average time for non–carcinogens (EDn x 365)	2190 days
CS	Concentration of chemicals in animal products	

Chemical Concentrations

Compound	Concentration	Units	Compound	Concentration	Units
antimony	9.6E–08	mg/kg	silver	7.7E–05	mg/kg
arsenic	1.2E–07	mg/kg	thallium	9.2E–08	mg/kg
barium	5.4E–06	mg/kg	thorium–total	3.4E–08	mg/kg
beryllium	1.1E–10	mg/kg	uranium–total	1.7E–03	mg/kg
boron	1.2E–06	mg/kg	vanadium	4.5E–08	mg/kg
cadmium	4.3E–07	mg/kg	zinc	5.4E–03	mg/kg
chromium vi	1.8E–06	mg/kg	2–methylnaphthalene	2.1E–09	mg/kg
cobalt	1.5E–06	mg/kg	4,4–dde	1.3E–09	mg/kg
copper	3.4E–05	mg/kg	aroclor–1221	6.0E–30	mg/kg
cyanide	1.6E–12	mg/kg	aroclor–1248	NA	mg/kg
lead	4.5E–05	mg/kg	aroclor–1254	4.6E–07	mg/kg
manganese	4.7E–08	mg/kg	aroclor–1260	NA	mg/kg
mercury	NA	mg/kg	carbazole	3.3E–11	mg/kg
molybdenum	6.0E–07	mg/kg	endrin	NA	mg/kg
nickel	1.1E–05	mg/kg	2,3,7,8–tcdd	3.3E–13	mg/kg
selenium	2.9E–07	mg/kg			

References

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Table I.IV–96 (continued)
Summary of Risk Characterization (chemicals)
Future Land Use with Private Ownership: Off–Property Farmer (Child)
Via Ingestion of Dairy Products

	HQ Calculation		
Compound	CDI (mg/kg–day)	RfD (mg/kg–day)	HQ (unitless)
antimony	4.1E–09	4.0E–04	1.0E–05
arsenic	5.1E–09	3.0E–04	1.7E–05
barium	2.3E–07	7.0E–02	3.3E–06
beryllium	4.8E–12	5.0E–03	9.6E–10
boron	5.1E–08	9.0E–02	5.6E–07
cadmium	1.8E–08	1.0E–03	1.8E–05
chromium vi	7.6E–08	5.0E–03	1.5E–05
cobalt	6.6E–08	6.0E–02	1.1E–06
copper	1.5E–06	NA	NA
cyanide	7.0E–14	2.0E–02	3.5E–12
lead	1.9E–06	NA	NA
manganese	2.0E–09	1.4E–01	1.4E–08
mercury	NA	3.0E–04	NA
molybdenum	2.6E–08	5.0E–03	5.2E–06
nickel	4.8E–07	2.0E–02	2.4E–05
selenium	1.2E–08	5.0E–03	2.5E–06
silver	3.3E–06	5.0E–03	6.6E–04
thallium	4.0E–09	8.0E–05	5.0E–05
thorium–total	1.5E–09	NA	NA
uranium–total	7.2E–05	3.0E–03	2.4E–02
vanadium	1.9E–09	7.0E–03	2.8E–07
zinc	2.3E–04	3.0E–01	7.8E–04
2–methylnaphthalene	8.9E–11	NA	NA
4,4–dde	5.5E–11	NA	NA
aroclor–1221	2.6E–31	NA	NA
aroclor–1248	NA	NA	NA
aroclor–1254	2.0E–08	NA	NA
aroclor–1260	NA	NA	NA
carbazole	1.4E–12	NA	NA
endrin	NA	3.0E–04	NA
2,3,7,8–tcdd	1.4E–14	NA	NA
	HQ Summation =		2.6E–02

	ILCR Calculation		
Compound	CDI (mg/kg–day)	CSF $(mg/kg–day)^{-1}$	ILCR (unitless)
antimony	3.5E–10	NA	NA
arsenic	4.4E–10	1.8E+00	7.7E–10
barium	2.0E–08	NA	NA
beryllium	4.1E–13	4.3E+00	1.8E–12
boron	4.3E–09	NA	NA
cadmium	1.6E–09	NA	NA
chromium vi	6.5E–09	NA	NA
cobalt	5.7E–09	NA	NA
copper	1.3E–07	NA	NA
cyanide	6.0E–15	NA	NA
lead	1.7E–07	NA	NA
manganese	1.7E–10	NA	NA
mercury	NA	NA	NA
molybdenum	2.2E–09	NA	NA
nickel	4.1E–08	NA	NA
selenium	1.1E–09	NA	NA
silver	2.8E–07	NA	NA
thallium	3.4E–10	NA	NA
thorium–total	1.2E–10	NA	NA
uranium–total	6.2E–06	NA	NA
vanadium	1.7E–10	NA	NA
zinc	2.0E–05	NA	NA
2–methylnaphthalene	7.6E–12	NA	NA
4,4–dde	4.7E–12	3.4E–01	1.6E–12
aroclor–1221	2.2E–32	7.7E+00	1.7E–31
aroclor–1248	NA	7.7E+00	NA
aroclor–1254	1.7E–09	7.7E+00	1.3E–08
aroclor–1260	NA	7.7E+00	NA
carbazole	1.2E–13	2.0E–02	2.4E–15
endrin	NA	NA	NA
2,3,7,8–tcdd	1.2E–15	1.5E+05	1.8E–10
	ILCR Summation =		1.4E–08

Table I.IV–97
Summary of Intake and Risk Quantitation (radionuclides)
Future Land Use with Private Ownership: Off–Property Farmer (Child)
Via Ingestion of Dairy Products

Intake Equation = Cp X EF X EDn X FI X IR

IR	Ingestion rate of dairy products	0.9 l/day
FI	Fraction ingested from contaminated source	0.75 (Unitless)
EF	Exposure frequency	350 days/year
EDn	Exposure duration	6 Year
Cp	Concentration of radionuclides in animal products	

Cs_{137+1d}	4.3E–04	pCi/kg	Rn_{222+4d}	ERR	pCi/kg
Pb_{210+2d}	2.7E–04	pCi/kg	Sr_{90+1d}	6.2E–04	pCi/kg
Np_{237+1d}	2.4E–05	pCi/kg	Tc_{99}	7.3E+02	pCi/kg
Pu_{238}	9.0E–08	pCi/kg	Th_{228+7d}	3.5E–07	pCi/kg
Pu_{239}	3.0E–09	pCi/kg	Th_{230}	1.2E–06	pCi/kg
Pu_{240}	NA	pCi/kg	$Th_{232+10d}$	1.0E–06	pCi/kg
Pa_{231}	1.6E–05	pCi/kg	U_{234}	2.1E–03	pCi/kg
Ra_{226+8d}	1.4E–04	pCi/kg	U_{235+1d}	5.6E–05	pCi/kg
Ra_{228+1d}	4.0E–05	pCi/kg	U_{236}	2.3E–05	pCi/kg
Ru_{106}	3.5E–09	pCi/kg	U_{238+2d}	1.3E–03	pCi/kg

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	ILCR (unitless)
Cs_{137+1d}	6.0E–01	2.8E–11	1.7E–11
Pb_{210+2d}	3.8E–01	6.6E–10	2.5E–10
Np_{237+1d}	3.4E–02	2.2E–10	7.5E–12
Pu_{238}	1.3E–04	2.2E–10	2.8E–14
Pu_{239}	4.3E–06	2.3E–10	9.9E–16
Pu_{240}	NA	2.3E–10	NA
Pa_{231}	2.3E–02	9.2E–11	2.1E–12
Ra_{226+8d}	2.0E–01	7.8E–10	1.5E–10
Ra_{228+1d}	5.6E–02	1.0E–10	5.6E–12
Ru_{106}	5.0E–06	9.5E–12	4.7E–17
Rn_{222+4d}	NA	1.7E–12	NA
Sr_{90+1d}	8.8E–01	3.6E–11	3.2E–11
Tc_{99}	1.0E+06	1.3E–12	1.3E–06
Th_{228+7d}	5.0E–04	5.5E–11	2.8E–14
Th_{230}	1.7E–03	1.3E–11	2.3E–14
$Th_{232+10d}$	1.4E–03	1.7E–10	2.4E–13
U_{234}	3.0E+00	1.6E–11	4.7E–11
U_{235+1d}	7.9E–02	1.6E–11	1.3E–12
U_{236}	3.3E–02	1.5E–11	4.9E–13
U_{238+2d}	1.8E+00	2.0E–11	3.6E–11
		ILCR Summation =	1.3E–06

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Table I.IV–98
Summary of Intake Quantitation (chemicals)
Future Land Use with Private Ownership: Off–Property Farmer (Child)
Via Ingestion of Vegetables and Fruits

Intake Equation = $\frac{CS \times EF \times ED \times FI \times IR}{BW \times AT}$

IR	Ingestion rate of fruits or vegetables	0.1 kg/day
FI	Fraction ingested from contaminated source	1 (Unitless)
EF	Exposure frequency	350 days/year
EDn	Exposure duration for non–carcinogens	6 Year
EDc	Exposure duration for carcinogens	6 Year
BW	Body weight	15 kg
ATc	Average time for carcinogens (lifetime)	25550 days
ATn	Average time for non–carcinogens (EDn x 365)	2190 days
CS	Concentration of chemicals in vegetables	

Chemical Concentrations

Compound	Concentration	Units	Compound	Concentration	Units
antimony	1.1E–05	mg/kg	silver	3.4E–05	mg/kg
arsenic	2.7E–05	mg/kg	thallium	5.0E–07	mg/kg
barium	1.6E–04	mg/kg	thorium–total	8.3E–05	mg/kg
beryllium	1.4E–06	mg/kg	uranium–total	2.2E–01	mg/kg
boron	9.5E–06	mg/kg	vanadium	2.6E–05	mg/kg
cadmium	4.1E–06	mg/kg	zinc	4.6E–03	mg/kg
chromium vi	1.4E–05	mg/kg	2–methylnaphthalene	3.3E–07	mg/kg
cobalt	8.7E–06	mg/kg	4,4–dde	4.2E–09	mg/kg
copper	2.1E–04	mg/kg	aroclor–1221	5.1E–27	mg/kg
cyanide	9.3E–07	mg/kg	aroclor–1248	NA	mg/kg
lead	2.0E–03	mg/kg	aroclor–1254	5.6E–07	mg/kg
manganese	1.2E–06	mg/kg	aroclor–1260	1.7E–07	mg/kg
mercury	9.5E–07	mg/kg	carbazole	1.6E–08	mg/kg
molybdenum	4.8E–06	mg/kg	endrin	NA	mg/kg
nickel	9.9E–05	mg/kg	2,3,7,8–tcdd	8.5E–14	mg/kg
selenium	7.3E–07	mg/kg			

References

Table I.IV–98 (continued)
Summary of Risk Characterization (chemicals)
Future Land Use with Private Ownership: Off–Property Farmer (Child)
Via Ingestion of Vegetables and Fruits

	HQ Calculation		
Compound	CDI (mg/kg–day)	RfD (mg/kg–day)	HQ (unitless)
antimony	7.1E–08	4.0E–04	1.8E–04
arsenic	1.7E–07	3.0E–04	5.7E–04
barium	1.0E–06	7.0E–02	1.5E–05
beryllium	8.7E–09	5.0E–03	1.7E–06
boron	6.1E–08	9.0E–02	6.8E–07
cadmium	2.6E–08	1.0E–03	2.6E–05
chromium vi	9.1E–08	5.0E–03	1.8E–05
cobalt	5.5E–08	6.0E–02	9.2E–07
copper	1.3E–06	NA	NA
cyanide	6.0E–09	2.0E–02	3.0E–07
lead	1.3E–05	NA	NA
manganese	7.8E–09	1.4E–01	5.6E–08
mercury	6.1E–09	3.0E–04	2.0E–05
molybdenum	3.1E–08	5.0E–03	6.1E–06
nickel	6.4E–07	2.0E–02	3.2E–05
selenium	4.6E–09	5.0E–03	9.3E–07
silver	2.2E–07	5.0E–03	4.3E–05
thallium	3.2E–09	8.0E–05	4.0E–05
thorium–total	5.3E–07	NA	NA
uranium–total	1.4E–03	3.0E–03	4.7E–01
vanadium	1.7E–07	7.0E–03	2.4E–05
zinc	3.0E–05	3.0E–01	9.9E–05
2–methylnaphthalene	2.1E–09	NA	NA
4,4–dde	2.7E–11	NA	NA
aroclor–1221	3.3E–29	NA	NA
aroclor–1248	NA	NA	NA
aroclor–1254	3.6E–09	NA	NA
aroclor–1260	1.1E–09	NA	NA
carbazole	1.1E–10	NA	NA
endrin	NA	3.0E–04	NA
2,3,7,8–tcdd	5.5E–16	NA	NA
	HQ Summation =		4.7E–01

	ILCR Calculation		
Compound	CDI (mg/kg–day)	CSF $(mg/kg–day)^{-1}$	ILCR (unitless)
antimony	6.0E–09	NA	NA
arsenic	1.5E–08	1.8E+00	2.6E–08
barium	8.8E–08	NA	NA
beryllium	7.4E–10	4.3E+00	3.2E–09
boron	5.2E–09	NA	NA
cadmium	2.2E–09	NA	NA
chromium vi	7.8E–09	NA	NA
cobalt	4.8E–09	NA	NA
copper	1.1E–07	NA	NA
cyanide	5.1E–10	NA	NA
lead	1.1E–06	NA	NA
manganese	6.7E–10	NA	NA
mercury	5.2E–10	NA	NA
molybdenum	2.6E–09	NA	NA
nickel	5.4E–08	NA	NA
selenium	4.0E–10	NA	NA
silver	1.9E–08	NA	NA
thallium	2.8E–10	NA	NA
thorium–total	4.5E–08	NA	NA
uranium–total	1.2E–04	NA	NA
vanadium	1.4E–08	NA	NA
zinc	2.5E–06	NA	NA
2–methylnaphthalene	1.8E–10	NA	NA
4,4–dde	2.3E–12	3.4E–01	7.8E–13
aroclor–1221	2.8E–30	7.7E+00	2.2E–29
aroclor–1248	NA	7.7E+00	NA
aroclor–1254	3.0E–10	7.7E+00	2.3E–09
aroclor–1260	9.5E–11	7.7E+00	7.3E–10
carbazole	9.0E–12	2.0E–02	1.8E–13
endrin	NA	NA	NA
2,3,7,8–tcdd	4.7E–17	1.5E+05	7.0E–12
	ILCR Summation =		3.2E–08

Table I.IV–99
Summary of Intake and Risk Quantitation (radionuclides)
Future Land Use with Private Ownership: Off–Property Farmer (Child)
Via Ingestion of Vegetables and Fruits

Intake Equation = Cv X EF X EDn X FI X IR

IR	Ingestion rate of fruits or vegetables	0.1 kg/day
FI	Fraction ingested from contaminated source	1 (Unitless)
EF	Exposure frequency	350 days/year
EDn	Exposure duration	6 Year
Cv	Concentration of radionuclides in vegetables	

Cs_{137+1d}	6.7E–04	pCi/kg	Rn_{222+4d}	ERR	pCi/kg
Pb_{210+2d}	1.3E–02	pCi/kg	Sr_{90+1d}	4.0E–03	pCi/kg
Np_{237+1d}	3.9E–01	pCi/kg	Tc_{99}	6.7E+03	pCi/kg
Pu_{238}	1.2E–02	pCi/kg	Th_{228+7d}	9.2E–04	pCi/kg
Pu_{239}	3.9E–04	pCi/kg	Th_{230}	3.6E–03	pCi/kg
Pu_{240}	1.4E–03	pCi/kg	$Th_{232+10d}$	3.0E–03	pCi/kg
Pa_{231}	4.1E–04	pCi/kg	U_{234}	4.6E–02	pCi/kg
Ra_{226+8d}	1.7E–02	pCi/kg	U_{235+1d}	1.2E–03	pCi/kg
Ra_{228+1d}	1.1E–03	pCi/kg	U_{236}	5.0E–04	pCi/kg
Ru_{106}	7.6E–05	pCi/kg	U_{238+2d}	2.7E–02	pCi/kg

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	ILCR (unitless)
Cs_{137+1d}	1.4E–01	2.8E–11	3.9E–12
Pb_{210+2d}	2.7E+00	6.6E–10	1.8E–09
Np_{237+1d}	8.3E+01	2.2E–10	1.8E–08
Pu_{238}	2.5E+00	2.2E–10	5.4E–10
Pu_{239}	8.2E–02	2.3E–10	1.9E–11
Pu_{240}	3.0E–01	2.3E–10	6.9E–11
Pa_{231}	8.7E–02	9.2E–11	8.0E–12
Ra_{226+8d}	3.5E+00	7.8E–10	2.7E–09
Ra_{228+1d}	2.4E–01	1.0E–10	2.4E–11
Ru_{106}	1.6E–02	9.5E–12	1.5E–13
Rn_{222+4d}	NA	1.7E–12	NA
Sr_{90+1d}	8.4E–01	3.6E–11	3.0E–11
Tc_{99}	1.4E+06	1.3E–12	1.8E–06
Th_{228+7d}	1.9E–01	5.5E–11	1.1E–11
Th_{230}	7.6E–01	1.3E–11	9.9E–12
$Th_{232+10d}$	6.3E–01	1.7E–10	1.1E–10
U_{234}	9.6E+00	1.6E–11	1.5E–10
U_{235+1d}	2.5E–01	1.6E–11	4.1E–12
U_{236}	1.1E–01	1.5E–11	1.6E–12
U_{238+2d}	5.7E+00	2.0E–11	1.1E–10
		ILCR Summation =	1.9E–06

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Table I.IV-100
Summary of Intake Quantitation (chemicals)
Future Land Use with Private Ownership: Perched Groundwater User
Via Inhalation of Particulates

Intake Equation = $\frac{CS \times EF \times ED \times IR}{BW \times AT}$

IR	Inhalation rate of gases (RAGS, 1989)	19.92 m^3/day
EF	Exposure frequency	350 days/year
EDn	Exposure duration for non-carcinogens	70 Year
EDc	Exposure duration for carcinogens	70 Year
BW	Body weight	70 kg
ATc	Average time for carcinogens (lifetime)	25550 days
ATn	Average time for non-carcinogens (EDn x 365)	25550 days
CS	Concentration of chemicals in soil	(see table below)

Chemical Concentrations

Compound	Concentration	Units	Compound	Concentration	Units
antimony	9.2E-09	mg/m^3	silver	4.5E-09	mg/m^3
arsenic	1.0E-08	mg/m^3	thallium	3.4E-10	mg/m^3
barium	1.3E-07	mg/m^3	thorium-total	2.1E-07	mg/m^3
beryllium	1.1E-09	mg/m^3	uranium-total	3.5E-06	mg/m^3
boron	9.0E-09	mg/m^3	vanadium	2.0E-08	mg/m^3
cadmium	2.9E-09	mg/m^3	zinc	6.2E-08	mg/m^3
chromium vi	1.8E-08	mg/m^3	2-methylnaphthalene	2.5E-10	mg/m^3
cobalt	7.7E-09	mg/m^3	4,4-dde	5.3E-12	mg/m^3
copper	4.8E-08	mg/m^3	aroclor-1221	0.0E+00	mg/m^3
cyanide	5.1E-10	mg/m^3	aroclor-1248	0.0E+00	mg/m^3
lead	1.3E-06	mg/m^3	aroclor-1254	1.5E-09	mg/m^3
manganese	4.3E-10	mg/m^3	aroclor-1260	4.1E-10	mg/m^3
mercury	4.3E-10	mg/m^3	carbazole	1.1E-10	mg/m^3
molybdenum	5.8E-09	mg/m^3	endrin	0.0E+00	mg/m^3
nickel	1.9E-08	mg/m^3	2,3,7,8-tcdd	5.4E-16	mg/m^3
selenium	7.6E-10	mg/m^3			

References

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Table I.IV-100 (continued)
Summary of Risk Characterization (chemicals)
Future Land Use with Private Ownership: Perched Groundwater User
Via Inhalation of Particulates

	HQ Calculation		
Compound	CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
antimony	2.5E-09	NA	NA
arsenic	2.7E-09	NA	NA
barium	3.6E-08	1.4E-04	2.5E-04
beryllium	2.9E-10	NA	NA
boron	2.4E-09	5.7E-03	4.3E-07
cadmium	8.0E-10	NA	NA
chromium vi	5.0E-09	NA	NA
cobalt	2.1E-09	3.0E-07	7.0E-03
copper	1.3E-08	NA	NA
cyanide	1.4E-10	NA	NA
lead	3.4E-07	NA	NA
manganese	1.2E-10	1.4E-05	8.4E-06
mercury	1.2E-10	8.6E-05	1.4E-06
molybdenum	1.6E-09	NA	NA
nickel	5.2E-09	NA	NA
selenium	2.1E-10	NA	NA
silver	1.2E-09	NA	NA
thallium	9.1E-11	NA	NA
thorium-total	5.8E-08	NA	NA
uranium-total	9.5E-07	NA	NA
vanadium	5.4E-09	NA	NA
zinc	1.7E-08	NA	NA
2-methylnaphthalene	6.8E-11	NA	NA
4,4-dde	1.4E-12	NA	NA
aroclor-1221	NA	NA	NA
aroclor-1248	NA	NA	NA
aroclor-1254	4.2E-10	NA	NA
aroclor-1260	1.1E-10	NA	NA
carbazole	2.9E-11	NA	NA
endrin	NA	NA	NA
2,3,7,8-tcdd	1.5E-16	NA	NA
	Hazard Quotient Sum =		7.3E-03

	ILCR Calculation		
Compound	CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	ILCR (unitless)
antimony	2.5E-09	NA	NA
arsenic	2.7E-09	1.5E+01	4.1E-08
barium	3.6E-08	NA	NA
beryllium	2.9E-10	8.4E+00	2.4E-09
boron	2.4E-09	NA	NA
cadmium	8.0E-10	6.3E+00	5.0E-09
chromium vi	5.0E-09	4.1E+01	2.0E-07
cobalt	2.1E-09	NA	NA
copper	1.3E-08	NA	NA
cyanide	1.4E-10	NA	NA
lead	3.4E-07	NA	NA
manganese	1.2E-10	NA	NA
mercury	1.2E-10	NA	NA
molybdenum	1.6E-09	NA	NA
nickel	5.2E-09	8.4E-01	4.4E-09
selenium	2.1E-10	NA	NA
silver	1.2E-09	NA	NA
thallium	9.1E-11	NA	NA
thorium-total	5.8E-08	NA	NA
uranium-total	9.5E-07	NA	NA
vanadium	5.4E-09	NA	NA
zinc	1.7E-08	NA	NA
2-methylnaphthalene	6.8E-11	NA	NA
4,4-dde	1.4E-12	NA	NA
aroclor-1221	NA	NA	NA
aroclor-1248	NA	NA	NA
aroclor-1254	4.2E-10	NA	NA
aroclor-1260	1.1E-10	NA	NA
carbazole	2.9E-11	NA	NA
endrin	NA	NA	NA
2,3,7,8-tcdd	1.5E-16	1.5E+05	2.2E-11
	ILCR Summation =		2.6E-07

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Table I.IV–101
Summary of Intake and Risk Quantitation (radionuclides)
Future Land Use with Private Ownership: Perched Groundwater User
Via Inhalation of Gases and Particulates

Intake Equation = Ca X EF X EDn X IR

IR	Inhalation rate of gases (RAGS, 1989)	19.92 m^3/day
EF	Exposure frequency	350 days/year
EDn	Exposure duration	70 Year
Ca	Concentration of radionuclides in air	(see table below)

Cs_{137+1d}	5.7E−07	pCi/m^3	Rn_{222+4d}	1.3E+01	pCi/m^3
Pb_{210+2d}	1.6E−05	pCi/m^3	Sr_{90+1d}	1.8E−06	pCi/m^3
Np_{237+1d}	4.4E−07	pCi/m^3	Tc_{99}	3.3E−05	pCi/m^3
Pu_{238}	1.5E−05	pCi/m^3	Th_{228+7d}	1.0E−06	pCi/m^3
Pu_{239}	1.2E−06	pCi/m^3	Th_{230}	3.7E−06	pCi/m^3
Pu_{240}	4.3E−06	pCi/m^3	$Th_{232+10d}$	2.8E−06	pCi/m^3
Pa_{231}	1.2E−06	pCi/m^3	U_{234}	5.1E−05	pCi/m^3
Ra_{226+8d}	9.3E−07	pCi/m^3	U_{235+1d}	1.3E−06	pCi/m^3
Ra_{228+1d}	1.2E−06	pCi/m^3	U_{236}	5.5E−07	pCi/m^3
Ru_{106}	5.4E−07	pCi/m^3	U_{238+2d}	3.0E−05	pCi/m^3

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	ILCR (unitless)
Cs_{137+1d}	2.8E−01	1.9E−11	5.2E−12
Pb_{210+2d}	7.6E+00	4.0E−09	3.0E−08
Np_{237+1d}	2.1E−01	2.9E−08	6.2E−09
Pu_{238}	7.1E+00	3.9E−08	2.8E−07
Pu_{239}	5.9E−01	3.8E−08	2.2E−08
Pu_{240}	2.1E+00	3.8E−08	8.0E−08
Pa_{231}	5.7E−01	3.6E−08	2.0E−08
Ra_{226+8d}	4.5E−01	7.0E−09	3.2E−09
Ra_{228+1d}	6.1E−01	6.9E−10	4.2E−10
Ru_{106}	2.6E−01	4.4E−10	1.1E−10
Rn_{222+4d}	6.2E+06	7.7E−12	4.8E−05
Sr_{90+1d}	8.9E−01	6.2E−11	5.5E−11
Tc_{99}	1.6E+01	8.3E−12	1.3E−10
Th_{228+7d}	5.0E−01	7.8E−08	3.9E−08
Th_{230}	1.8E+00	2.9E−08	5.2E−08
$Th_{232+10d}$	1.4E+00	1.1E−07	1.5E−07
U_{234}	2.5E+01	2.6E−08	6.4E−07
U_{235+1d}	6.5E−01	2.5E−08	1.6E−08
U_{236}	2.7E−01	2.5E−08	6.7E−09
U_{238+2d}	1.5E+01	2.4E−08	3.5E−07
		ILCR Summation =	5.0E−05

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Table I.IV–102
Summary of Intake Quantitation (chemicals)
Future Land Use with Private Ownership: Perched Groundwater User
Via Incidental Ingestion of Soil

Intake Equation = $\frac{CS \times EF \times ED \times CF \times IR}{BW \times AT}$

IRs	Ingestion rate of soil (RAGS, 1989)	100 mg/day
CF	Conversion factor	1.0E–06 kg/mg
EF	Exposure frequency	350 days/year
EDn	Exposure duration for non–carcinogens	70 Year
EDc	Exposure duration for carcinogens	70 Year
BW	Body weight	70 kg
ATc	Average time for carcinogens (lifetime)	25550 days
ATn	Average time for non–carcinogens (EDn x 365)	25550 days
CS	Concentration of chemicals in soil	(see table below)

Chemical Concentrations

Compound	Concentration	Units	Compound	Concentration	Units
antimony	5.4E+00	mg/kg	silver	6.0E+00	mg/kg
arsenic	5.1E+00	mg/kg	thallium	5.6E–01	mg/kg
barium	9.7E+01	mg/kg	thorium–total	0.0E+00	mg/kg
beryllium	7.6E–01	mg/kg	uranium–total	0.0E+00	mg/kg
boron	1.1E+02	mg/kg	vanadium	2.6E+01	mg/kg
cadmium	3.5E+00	mg/kg	zinc	6.4E+01	mg/kg
chromium vi	1.6E+01	mg/kg	2–methylnaphthalene	0.0E+00	mg/kg
cobalt	1.2E+01	mg/kg	4,4–dde	0.0E+00	mg/kg
copper	2.0E+01	mg/kg	aroclor–1221	0.0E+00	mg/kg
cyanide	2.5E–01	mg/kg	aroclor–1248	0.0E+00	mg/kg
lead	2.4E+01	mg/kg	aroclor–1254	0.0E+00	mg/kg
manganese	9.8E+02	mg/kg	aroclor–1260	0.0E+00	mg/kg
mercury	2.1E–01	mg/kg	carbazole	0.0E+00	mg/kg
molybdenum	6.5E+00	mg/kg	endrin	0.0E+00	mg/kg
nickel	2.3E+01	mg/kg	2,3,7,8–tcdd	0.0E+00	mg/kg
selenium	6.3E–01	mg/kg			

References

Table I.IV–102 (continued)
Summary of Risk Characterization (chemicals)
Future Land Use with Private Ownership: Perched Groundwater User

Via Incidental Ingestion of Soil

Compound	HQ Calculation CDI (mg/kg–day)	RfD (mg/kg–day)	HQ (unitless)
antimony	7.3E–06	4.0E–04	1.8E–02
arsenic	7.0E–06	3.0E–04	2.3E–02
barium	1.3E–04	7.0E–02	1.9E–03
beryllium	1.0E–06	5.0E–03	2.1E–04
boron	1.5E–04	9.0E–02	1.7E–03
cadmium	4.8E–06	1.0E–03	4.8E–03
chromium vi	2.2E–05	5.0E–03	4.5E–03
cobalt	1.7E–05	6.0E–02	2.8E–04
copper	2.8E–05	NA	NA
cyanide	3.4E–07	2.0E–02	1.7E–05
lead	3.2E–05	NA	NA
manganese	1.3E–03	1.4E–01	9.5E–03
mercury	2.9E–07	3.0E–04	9.8E–04
molybdenum	8.9E–06	5.0E–03	1.8E–03
nickel	3.1E–05	2.0E–02	1.5E–03
selenium	8.6E–07	5.0E–03	1.7E–04
silver	8.3E–06	5.0E–03	1.7E–03
thallium	7.6E–07	8.0E–05	9.6E–03
thorium–total	NA	NA	NA
uranium–total	NA	3.0E–03	0.0E+00
vanadium	3.6E–05	7.0E–03	5.1E–03
zinc	8.8E–05	3.0E–01	2.9E–04
2–methylnaphthalene	NA	NA	NA
4,4–dde	NA	NA	NA
aroclor–1221	NA	NA	NA
aroclor–1248	NA	NA	NA
aroclor–1254	NA	NA	NA
aroclor–1260	NA	NA	NA
carbazole	NA	NA	NA
endrin	NA	3.0E–04	0.0E+00
2,3,7,8–tcdd	NA	NA	NA
	HQ Summation =		8.6E–02

Compound	ILCR Calculation CDI (mg/kg–day)	CSF (mg/kg–day)$^{-1}$	ILCR (unitless)
antimony	7.3E–06	NA	NA
arsenic	7.0E–06	1.8E+00	1.2E–05
barium	1.3E–04	NA	NA
beryllium	1.0E–06	4.3E+00	4.4E–06
boron	1.5E–04	NA	NA
cadmium	4.8E–06	NA	NA
chromium vi	2.2E–05	NA	NA
cobalt	1.7E–05	NA	NA
copper	2.8E–05	NA	NA
cyanide	3.4E–07	NA	NA
lead	3.2E–05	NA	NA
manganese	1.3E–03	NA	NA
mercury	2.9E–07	NA	NA
molybdenum	8.9E–06	NA	NA
nickel	3.1E–05	NA	NA
selenium	8.6E–07	NA	NA
silver	8.3E–06	NA	NA
thallium	7.6E–07	NA	NA
thorium–total	NA	NA	NA
uranium–total	NA	NA	NA
vanadium	3.6E–05	NA	NA
zinc	8.8E–05	NA	NA
2–methylnaphthalene	NA	NA	NA
4,4–dde	NA	3.4E–01	0.0E+00
aroclor–1221	NA	7.7E+00	0.0E+00
aroclor–1248	NA	7.7E+00	0.0E+00
aroclor–1254	NA	7.7E+00	0.0E+00
aroclor–1260	NA	7.7E+00	0.0E+00
carbazole	NA	2.0E–02	0.0E+00
endrin	NA	NA	NA
2,3,7,8–tcdd	NA	1.5E+05	0.0E+00
	ILCR Summation =		1.7E–05

Table I.IV−103
Summary of Intake and Risk Quantitation (radionuclides)
Future Land Use with Private Ownership: Perched Groundwater User
Via Incidental Ingestion of Soil

Intake Equation = CS X EF X EDn X FI X IR

IRs	Ingestion rate of soil (RAGS, 1989)	100 mg/day
EF	Exposure frequency	350 days/year
EDn	Exposure Duration	70 Year
FI	Fractional Intake	1 (unitless)
CS	Concentration of radionuclides in soil	

Cs_{137+1d}	5.85E−10	pCi/mg	Rn_{222+4d}	0.00E+00	pCi/mg
Pb_{210+2d}	1.05E−09	pCi/mg	Sr_{90+1d}	8.33E−10	pCi/mg
Np_{237+1d}	8.36E−11	pCi/mg	Tc_{99}	1.87E−09	pCi/mg
Pu_{238}	9.07E−11	pCi/mg	Th_{228+7d}	4.00E−10	pCi/mg
Pu_{239}	1.25E−11	pCi/mg	Th_{230}	5.92E−11	pCi/mg
Pu_{240}	4.55E−11	pCi/mg	$Th_{232+10d}$	5.95E−10	pCi/mg
Pa_{231}	0.00E+00	pCi/mg	U_{234}	2.06E−08	pCi/mg
Ra_{226+8d}	3.99E−10	pCi/mg	U_{235+1d}	9.34E−10	pCi/mg
Ra_{228+1d}	7.00E−10	pCi/mg	U_{236}	6.86E−09	pCi/mg
Ru_{106}	1.33E−10	pCi/mg	U_{238+2d}	1.38E−08	pCi/mg

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	ILCR (unitless)
Cs_{137+1d}	1.43E−03	2.80E−11	4.01E−14
Pb_{210+2d}	2.57E−03	6.60E−10	1.70E−12
Np_{237+1d}	2.05E−04	2.20E−10	4.51E−14
Pu_{238}	2.22E−04	2.20E−10	4.89E−14
Pu_{239}	3.06E−05	2.30E−10	7.04E−15
Pu_{240}	1.11E−04	2.30E−10	2.56E−14
Pa_{231}	NA	9.20E−11	NA
Ra_{226+8d}	9.78E−04	7.80E−10	7.62E−13
Ra_{228+1d}	1.72E−03	1.00E−10	1.72E−13
Ru_{106}	3.26E−04	9.50E−12	3.10E−15
Rn_{222+4d}	NA	1.70E−12	NA
Sr_{90+1d}	2.04E−03	3.60E−11	7.35E−14
Tc_{99}	4.58E−03	1.30E−12	5.96E−15
Th_{228+7d}	9.80E−04	5.50E−11	5.39E−14
Th_{230}	1.45E−04	1.30E−11	1.89E−15
$Th_{232+10d}$	1.46E−03	1.70E−10	2.48E−13
U_{234}	5.05E−02	1.60E−11	8.08E−13
U_{235+1d}	2.29E−03	1.60E−11	3.66E−14
U_{236}	1.68E−02	1.50E−11	2.52E−13
U_{238+2d}	3.38E−02	2.00E−11	6.76E−13
		ILCR Summation =	4.96E−12

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Table I.IV-104
Summary of Intake Quantitation (chemicals)
Future Land Use with Private Ownership: Perched Groundwater User
Via Dermal Contact with Soil

Intake Equation = $\frac{CS \times EF \times ED \times CF \times ABS \times AF \times SA}{BW \times AT}$

SA	Surface area of exposed skin (50th percentile, hands only)	5750 cm^2/day
AF	Soil to skin adherence factor (RAGS, 1989)	1 mg/cm^2
ABS	chemicals specific absorbtion factor (see table below)	csv
CF	Conversion factor	1E-06 kg/mg
EF	Exposure frequency	350 days/year
EDn	Exposure duration for non-carcinogens	70 Year
EDc	Exposure duration for carcinogens	70 Year
BW	Body weight	70 kg
ATc	Average time for carcinogens (lifetime)	25550 days
ATn	Average time for non-carcinogens (EDn x 365)	25550 days
CS	Concentration of chemicals in soil	

Chemical Concentrations

Compound	ABS	Concentrati	Units	Compound		Concentrati	Units
antimony	1.00E-02	5.35E+00	mg/kg	silver	1.00E-02	6.03E+00	mg/kg
arsenic	1.00E-03	5.09E+00	mg/kg	thallium	1.00E-02	5.58E-01	mg/kg
barium	1.00E-02	9.72E+01	mg/kg	thorium-total	1.00E-02	0.00E+00	mg/kg
beryllium	1.00E-02	7.55E-01	mg/kg	uranium-total	1.00E-02	0.00E+00	mg/kg
boron	1.00E-02	1.12E+02	mg/kg	vanadium	1.00E-03	2.60E+01	mg/kg
cadmium	1.00E-02	3.48E+00	mg/kg	zinc	1.00E-02	6.41E+01	mg/kg
chromium vi	1.00E-02	1.64E+01	mg/kg	2-methylnaphthalene	3.00E-01	0.00E+00	mg/kg
cobalt	1.00E-02	1.21E+01	mg/kg	4,4-dde	3.00E-01	0.00E+00	mg/kg
copper	1.00E-03	2.02E+01	mg/kg	aroclor-1221	6.00E-02	0.00E+00	mg/kg
cyanide	1.00E-02	2.50E-01	mg/kg	aroclor-1248	6.00E-02	0.00E+00	mg/kg
lead	1.00E-02	2.35E+01	mg/kg	aroclor-1254	6.00E-02	0.00E+00	mg/kg
manganese	1.00E-02	9.76E+02	mg/kg	aroclor-1260	6.00E-02	0.00E+00	mg/kg
mercury	5.00E-02	2.14E-01	mg/kg	carbazole	3.00E-01	0.00E+00	mg/kg
molybdenum	1.00E-02	6.49E+00	mg/kg	endrin	3.00E-01	0.00E+00	mg/kg
nickel	5.00E-04	2.26E+01	mg/kg	2,3,7,8-tcdd	3.00E-02	0.00E+00	mg/kg
selenium	1.00E-02	6.31E-01	mg/kg				

References

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Table I.IV-104
Summary of Risk Characterization (chemicals)
Future Land Use with Private Ownership: Perched Groundwater User
Via Dermal Contact with Soil

Compound	HQ Calculation		
	CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
antimony	4.21E-06	6.00E-05	7.02E-02
arsenic	4.01E-07	2.85E-04	1.41E-03
barium	7.66E-05	6.37E-02	1.20E-03
beryllium	5.95E-07	5.00E-03	1.19E-04
boron	8.82E-05	4.50E-03	1.96E-02
cadmium	2.74E-06	5.00E-05	5.48E-02
chromium vi	1.29E-05	2.25E-03	5.74E-03
cobalt	9.53E-06	2.70E-02	3.53E-04
copper	1.59E-06	NA	NA
cyanide	1.97E-07	NA	NA
lead	1.85E-05	NA	NA
manganese	7.69E-04	4.20E-03	1.83E-01
mercury	8.43E-07	4.50E-05	1.87E-02
molybdenum	5.11E-06	1.90E-03	2.69E-03
nickel	8.90E-07	2.00E-03	4.45E-04
selenium	4.97E-07	4.00E-03	1.24E-04
silver	4.75E-06	NA	NA
thallium	4.40E-07	8.00E-05	5.49E-03
thorium-total	NA	NA	NA
uranium-total	NA	1.50E-04	0.00E+00
vanadium	2.05E-06	3.50E-04	5.85E-03
zinc	5.05E-05	7.50E-02	6.73E-04
2-methylnaphthalene	NA	NA	NA
4,4-dde	NA	NA	NA
aroclor-1221	NA	NA	NA
aroclor-1248	NA	NA	NA
aroclor-1254	NA	NA	NA
aroclor-1260	NA	NA	NA
carbazole	NA	NA	NA
endrin	NA	2.70E-04	0.00E+00
2,3,7,8-tcdd	NA	NA	NA
	HQ Summation =		3.71E-01

Compound	ILCR Calculation		
	CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	ILCR (unitless)
antimony	4.21E-06	NA	NA
arsenic	4.01E-07	1.90E+00	7.62E-07
barium	7.66E-05	NA	NA
beryllium	5.95E-07	4.30E+00	2.56E-06
boron	8.82E-05	NA	NA
cadmium	2.74E-06	NA	NA
chromium vi	1.29E-05	NA	NA
cobalt	9.53E-06	NA	NA
copper	1.59E-06	NA	NA
cyanide	1.97E-07	NA	NA
lead	1.85E-05	NA	NA
manganese	7.69E-04	NA	NA
mercury	8.43E-07	NA	NA
molybdenum	5.11E-06	NA	NA
nickel	8.90E-07	NA	NA
selenium	4.97E-07	NA	NA
silver	4.75E-06	NA	NA
thallium	4.40E-07	NA	NA
thorium-total	NA	NA	NA
uranium-total	NA	NA	NA
vanadium	2.05E-06	NA	NA
zinc	5.05E-05	NA	NA
2-methylnaphthalene	NA	NA	NA
4,4-dde	NA	3.40E-01	0.00E+00
aroclor-1221	NA	1.03E+01	0.00E+00
aroclor-1248	NA	1.03E+01	0.00E+00
aroclor-1254	NA	1.03E+01	0.00E+00
aroclor-1260	NA	1.03E+01	0.00E+00
carbazole	NA	2.22E-02	0.00E+00
endrin	NA	NA	NA
2,3,7,8-tcdd	NA	3.00E+05	0.00E+00
	ILCR Summation =		3.32E-06

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Table I.IV–105
Summary of Intake Quantitation (chemicals)
Future Land Use with Private Ownership: Perched Groundwater User
Via Drinking Water Ingestion

Intake Equation = $\frac{CS \times EF \times ED \times IR}{BW \times AT}$

IR	Ingestion rate of groundwater (RAGS, 1989)	2 l/day
EF	Exposure frequency	350 days/year
EDn	Exposure duration for non–carcinogens	70 Year
EDc	Exposure duration for carcinogens	70 Year
BW	Body weight	70 kg
ATc	Average time for carcinogens (lifetime)	25550 days
ATn	Average time for non–carcinogens (EDn x 365)	25550 days
CS	Concentration of chemicals in groundwater	

Chemical Concentrations

Compound	Concentration	Units	Compound	Concentration	Units
antimony	2.49E–02	mg/l	silver	0.00E+00	mg/l
arsenic	4.04E–02	mg/l	thallium	0.00E+00	mg/l
barium	0.00E+00	mg/l	thorium–total	0.00E+00	mg/l
beryllium	0.00E+00	mg/l	uranium–total	6.70E+00	mg/l
boron	0.00E+00	mg/l	vanadium	0.00E+00	mg/l
cadmium	7.80E–03	mg/l	zinc	0.00E+00	mg/l
chromium vi	0.00E+00	mg/l	2–methylnaphthalene	0.00E+00	mg/l
cobalt	0.00E+00	mg/l	4,4–dde	0.00E+00	mg/l
copper	0.00E+00	mg/l	aroclor–1221	1.22E–02	mg/l
cyanide	0.00E+00	mg/l	aroclor–1248	0.00E+00	mg/l
lead	0.00E+00	mg/l	aroclor–1254	0.00E+00	mg/l
manganese	0.00E+00	mg/l	aroclor–1260	0.00E+00	mg/l
mercury	0.00E+00	mg/l	carbazole	0.00E+00	mg/l
molybdenum	0.00E+00	mg/l	endrin	0.00E+00	mg/l
nickel	0.00E+00	mg/l	2,3,7,8–tcdd	0.00E+00	mg/l
selenium	0.00E+00	mg/l			

References

Table I.IV-105 (continued)
Summary of Risk Characterization (chemicals)
Future Land Use with Private Ownership: Perched Groundwater User
Via Drinking Water Ingestion

Compound	HQ Calculation CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
antimony	6.82E-04	4.00E-04	1.71E+00
arsenic	1.11E-03	3.00E-04	3.69E+00
barium	NA	7.00E-02	NA
beryllium	NA	5.00E-03	NA
boron	NA	9.00E-02	NA
cadmium	2.14E-04	1.00E-03	2.14E-01
chromium vi	NA	5.00E-03	NA
cobalt	NA	6.00E-02	NA
copper	NA	NA	NA
cyanide	NA	2.00E-02	NA
lead	NA	NA	NA
manganese	NA	1.40E-01	NA
mercury	NA	3.00E-04	NA
molybdenum	NA	5.00E-03	NA
nickel	NA	2.00E-02	NA
selenium	NA	5.00E-03	NA
silver	NA	5.00E-03	NA
thallium	NA	8.00E-05	NA
thorium-total	NA	NA	NA
uranium-total	1.84E-01	3.00E-03	6.12E+01
vanadium	NA	7.00E-03	NA
zinc	NA	3.00E-01	NA
2-methylnaphthalene	NA	NA	NA
4,4-dde	NA	NA	NA
aroclor-1221	3.34E-04	NA	NA
aroclor-1248	NA	NA	NA
aroclor-1254	NA	NA	NA
aroclor-1260	NA	NA	NA
carbazole	NA	NA	NA
endrin	NA	3.00E-04	NA
2,3,7,8-tcdd	NA	NA	NA
	HQ Summation =		6.68E+01

Compound	ILCR Calculation CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	ILCR (unitless)
antimony	6.82E-04	NA	NA
arsenic	1.11E-03	1.75E+00	1.94E-03
barium	NA	NA	NA
beryllium	NA	4.30E+00	NA
boron	NA	NA	NA
cadmium	2.14E-04	NA	NA
chromium vi	NA	NA	NA
cobalt	NA	NA	NA
copper	NA	NA	NA
cyanide	NA	NA	NA
lead	NA	NA	NA
manganese	NA	NA	NA
mercury	NA	NA	NA
molybdenum	NA	NA	NA
nickel	NA	NA	NA
selenium	NA	NA	NA
silver	NA	NA	NA
thallium	NA	NA	NA
thorium-total	NA	NA	NA
uranium-total	1.84E-01	NA	NA
vanadium	NA	NA	NA
zinc	NA	NA	NA
2-methylnaphthalene	NA	NA	NA
4,4-dde	NA	3.40E-01	NA
aroclor-1221	3.34E-04	7.70E+00	2.57E-03
aroclor-1248	NA	7.70E+00	NA
aroclor-1254	NA	7.70E+00	NA
aroclor-1260	NA	7.70E+00	NA
carbazole	NA	2.00E-02	NA
endrin	NA	NA	NA
2,3,7,8-tcdd	NA	1.50E+05	NA
	ILCR Summation =		4.51E-03

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Table I.IV−106
Summary of Intake and Risk Quantitation (radionuclides)
Future Land Use with Private Ownership: Perched Groundwater User
Via Ingestion of Drinking Water

Intake Equation = Cw X EF X EDn X FI X IR

IR	Ingestion rate of groundwater (RAGS, 1989)	2 l/day
EF	Exposure frequency	350 days/year
EDn	Exposure duration	70 Year
FI	Fractional intake for radionuclides	1 (Unitless)
Cw	Concentration of radionuclides in groundwater	(see table below)

Cs_{137+1d}	0.0E+00	pCi/l	Rn_{222+4d}	0.0E+00	pCi/l
Pb_{210+2d}	0.0E+00	pCi/l	Sr_{90+1d}	0.0E+00	pCi/l
Np_{237+1d}	3.3E+02	pCi/l	Tc_{99}	1.8E+04	pCi/l
Pu_{238}	0.0E+00	pCi/l	Th_{228+7d}	0.0E+00	pCi/l
Pu_{239}	0.0E+00	pCi/l	Th_{230}	0.0E+00	pCi/l
Pu_{240}	0.0E+00	pCi/l	$Th_{232+10d}$	0.0E+00	pCi/l
Pa_{231}	0.0E+00	pCi/l	U_{234}	3.7E+03	pCi/l
Ra_{226+8d}	5.7E−01	pCi/l	U_{235+1d}	9.9E+01	pCi/l
Ra_{228+1d}	0.0E+00	pCi/l	U_{236}	4.1E+01	pCi/l
Ru_{106}	0.0E+00	pCi/l	U_{238+2d}	2.2E+03	pCi/l

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	ILCR (unitless)
Cs_{137+1d}	NA	2.8E−11	NA
Pb_{210+2d}	NA	6.6E−10	NA
Np_{237+1d}	1.6E+07	2.2E−10	3.6E−03
Pu_{238}	NA	2.2E−10	NA
Pu_{239}	NA	2.3E−10	NA
Pu_{240}	NA	2.3E−10	NA
Pa_{231}	NA	9.2E−11	NA
Ra_{226+8d}	2.8E+04	7.8E−10	2.2E−05
Ra_{228+1d}	NA	1.0E−10	NA
Ru_{106}	NA	9.5E−12	NA
Rn_{222+4d}	NA	1.7E−12	NA
Sr_{90+1d}	NA	3.6E−11	NA
Tc_{99}	8.8E+08	1.3E−12	1.1E−03
Th_{228+7d}	NA	5.5E−11	NA
Th_{230}	NA	1.3E−11	NA
$Th_{232+10d}$	NA	1.7E−10	NA
U_{234}	1.8E+08	1.6E−11	2.9E−03
U_{235+1d}	4.9E+06	1.6E−11	7.8E−05
U_{236}	2.0E+06	1.5E−11	3.0E−05
U_{238+2d}	1.1E+08	2.0E−11	2.2E−03
		ILCR Summation =	9.9E−03

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Table I.IV–107
Summary of Intake Quantitation (chemicals)
Future Land Use with Private Ownership: Perched Groundwater User
Via Dermal Contact while Bathing

Intake Equation = $\frac{DA \times EF \times ED \times SA}{BW \times AT}$

DA	Dermal absorbed dose	csv mg/cm^2–day
EF	Exposure frequency	350 days/year
EDn	Exposure duration for non–carcinogens	70 Year
EDc	Exposure duration for carcinogens	70 Year
BW	Body weight	70 kg
ATc	Average time for carcinogens (lifetime)	25550 days
ATn	Average time for non–carcinogens (EDn x 365)	25550 days
SA	Skin surface area available for contact	23000 cm^2

Chemical Concentrations

Compound	DA	Units	Compound	DA	Units
antimony	6.23E–08	mg/cm^2–day	silver	NA	mg/cm^2–day
arsenic	1.01E–07	mg/cm^2–day	thallium	NA	mg/cm^2–day
barium	NA	mg/cm^2–day	thorium–total	NA	mg/cm^2–day
beryllium	NA	mg/cm^2–day	uranium–total	1.67E–06	mg/cm^2–day
boron	NA	mg/cm^2–day	vanadium	NA	mg/cm^2–day
cadmium	1.95E–09	mg/cm^2–day	zinc	NA	mg/cm^2–day
chromium vi	NA	mg/cm^2–day	2–methylnaphthalene	NA	mg/cm^2–day
cobalt	NA	mg/cm^2–day	4,4–dde	NA	mg/cm^2–day
copper	NA	mg/cm^2–day	aroclor–1221	9.92E–06	mg/cm^2–day
cyanide	NA	mg/cm^2–day	aroclor–1248	NA	mg/cm^2–day
lead	NA	mg/cm^2–day	aroclor–1254	NA	mg/cm^2–day
manganese	NA	mg/cm^2–day	aroclor–1260	NA	mg/cm^2–day
mercury	NA	mg/cm^2–day	carbazole	NA	mg/cm^2–day
molybdenum	NA	mg/cm^2–day	endrin	NA	mg/cm^2–day
nickel	NA	mg/cm^2–day	2,3,7,8–tcdd	NA	mg/cm^2–day
selenium	NA	mg/cm^2–day			

References

Table I.IV-107 (continued)
Summary of Risk Characterization (chemicals)
Future Land Use with Private Ownership: Perched Groundwater User
Via Dermal Contact while Bathing

Compound	HQ Calculation CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
antimony	1.96E-05	6.00E-05	3.27E-01
arsenic	3.18E-05	2.85E-04	1.12E-01
barium	NA	6.37E-02	NA
beryllium	NA	5.00E-03	NA
boron	NA	4.50E-03	NA
cadmium	6.14E-07	5.00E-05	1.23E-02
chromium vi	NA	2.25E-03	NA
cobalt	NA	2.70E-02	NA
copper	NA	NA	NA
cyanide	NA	NA	NA
lead	NA	NA	NA
manganese	NA	4.20E-03	NA
mercury	NA	4.50E-05	NA
molybdenum	NA	1.90E-03	NA
nickel	NA	2.00E-03	NA
selenium	NA	4.00E-03	NA
silver	NA	NA	NA
thallium	NA	8.00E-05	NA
thorium-total	NA	NA	NA
uranium-total	5.28E-04	1.50E-04	3.52E+00
vanadium	NA	3.50E-04	NA
zinc	NA	7.50E-02	NA
2-methylnaphthalene	NA	NA	NA
4,4-dde	NA	NA	NA
aroclor-1221	3.12E-03	NA	NA
aroclor-1248	NA	NA	NA
aroclor-1254	NA	NA	NA
aroclor-1260	NA	NA	NA
carbazole	NA	NA	NA
endrin	NA	2.70E-04	NA
2,3,7,8-tcdd	NA	NA	NA
	HQ Summation =		3.97E+00

Compound	ILCR Calculation CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	ILCR (unitless)
antimony	1.96E-05	NA	NA
arsenic	3.18E-05	1.90E+00	6.05E-05
barium	NA	NA	NA
beryllium	NA	4.30E+00	NA
boron	NA	NA	NA
cadmium	6.14E-07	NA	NA
chromium vi	NA	NA	NA
cobalt	NA	NA	NA
copper	NA	NA	NA
cyanide	NA	NA	NA
lead	NA	NA	NA
manganese	NA	NA	NA
mercury	NA	NA	NA
molybdenum	NA	NA	NA
nickel	NA	NA	NA
selenium	NA	NA	NA
silver	NA	NA	NA
thallium	NA	NA	NA
thorium-total	NA	NA	NA
uranium-total	5.28E-04	NA	NA
vanadium	NA	NA	NA
zinc	NA	NA	NA
2-methylnaphthalene	NA	NA	NA
4,4-dde	NA	3.40E-01	NA
aroclor-1221	3.12E-03	1.03E+01	3.21E-02
aroclor-1248	NA	1.03E+01	NA
aroclor-1254	NA	1.03E+01	NA
aroclor-1260	NA	1.03E+01	NA
carbazole	NA	2.22E-02	NA
endrin	NA	NA	NA
2,3,7,8-tcdd	NA	3.00E+05	NA
	ILCR Summation =		3.21E-02

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Table I.IV–108
Summary of Intake Quantitation (chemicals)
Future Land Use with Private Ownership: Perched Groundwater User
Via Ingestion of Meat Products

Intake Equation = $\frac{CS \times EF \times ED \times FI \times IR}{BW \times AT}$

IR	Ingestion rate of meat	0.1 kg/day
FI	Fraction ingested from contaminated source	0.75 (Unitless)
EF	Exposure frequency	350 days/year
EDn	Exposure duration for non–carcinogens	70 Year
EDc	Exposure duration for carcinogens	70 Year
BW	Body weight	70 kg
ATc	Average time for carcinogens (lifetime)	25550 days
ATn	Average time for non–carcinogens (EDn x 365)	25550 days
CS	Concentration of chemicals in meat	

Chemical Concentrations

Compound	Concentration	Units
antimony	0.0E+00	mg/kg
arsenic	4.9E–02	mg/kg
barium	1.4E–01	mg/kg
beryllium	1.1E–03	mg/kg
boron	2.2E+00	mg/kg
cadmium	4.0E–02	mg/kg
chromium vi	8.3E–02	mg/kg
cobalt	3.4E–01	mg/kg
copper	8.0E+00	mg/kg
cyanide	4.0E–05	mg/kg
lead	2.6E–01	mg/kg
manganese	6.8E+00	mg/kg
mercury	4.0E+00	mg/kg
molybdenum	1.3E–01	mg/kg
nickel	4.6E–01	mg/kg
selenium	1.8E–02	mg/kg
silver	3.2E–01	mg/kg
thallium	1.5E–02	mg/kg
thorium–total	1.4E–05	mg/kg
uranium–total	9.3E–02	mg/kg
vanadium	5.0E–02	mg/kg
zinc	4.8E+02	mg/kg
2–methylnaphthalene	2.3E–04	mg/kg
4,4–dde	3.8E–05	mg/kg
aroclor–1221	3.5E–26	mg/kg
aroclor–1248	0.0E+00	mg/kg
aroclor–1254	4.7E–03	mg/kg
aroclor–1260	2.5E–02	mg/kg
carbazole	3.9E–05	mg/kg
endrin	0.0E+00	mg/kg
2,3,7,8–tcdd	3.5E–09	mg/kg

References

Table I.IV-108 (continued)
Summary of Risk Characterization (chemicals)
Future Land Use with Private Ownership: Perched Groundwater User
Via Ingestion of Meat Products

Compound	HQ Calculation CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
antimony	NA	4.0E-04	NA
arsenic	5.0E-05	3.0E-04	1.7E-01
barium	1.4E-04	7.0E-02	2.0E-03
beryllium	1.1E-06	5.0E-03	2.2E-04
boron	2.3E-03	9.0E-02	2.5E-02
cadmium	4.1E-05	1.0E-03	4.1E-02
chromium vi	8.5E-05	5.0E-03	1.7E-02
cobalt	3.5E-04	6.0E-02	5.8E-03
copper	8.2E-03	NA	NA
cyanide	4.1E-08	2.0E-02	2.0E-06
lead	2.7E-04	NA	NA
manganese	7.0E-03	1.4E-01	5.0E-02
mercury	4.1E-03	3.0E-04	1.4E+01
molybdenum	1.3E-04	5.0E-03	2.6E-02
nickel	4.7E-04	2.0E-02	2.4E-02
selenium	1.8E-05	5.0E-03	3.6E-03
silver	3.3E-04	5.0E-03	6.5E-02
thallium	1.6E-05	8.0E-05	2.0E-01
thorium-total	1.4E-08	NA	NA
uranium-total	9.5E-05	3.0E-03	3.2E-02
vanadium	5.2E-05	7.0E-03	7.4E-03
zinc	4.9E-01	3.0E-01	1.6E+00
2-methylnaphthalene	2.4E-07	NA	NA
4,4-dde	3.9E-08	NA	NA
aroclor-1221	3.6E-29	NA	NA
aroclor-1248	NA	NA	NA
aroclor-1254	4.8E-06	NA	NA
aroclor-1260	2.5E-05	NA	NA
carbazole	4.0E-08	NA	NA
endrin	NA	3.0E-04	NA
2,3,7,8-tcdd	3.6E-12	NA	NA
	HQ Summation =		1.6E+01

Compound	ILCR Calculation CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	ILCR (unitless)
antimony	NA	NA	NA
arsenic	5.0E-05	1.8E+00	8.8E-05
barium	1.4E-04	NA	NA
beryllium	1.1E-06	4.3E+00	4.7E-06
boron	2.3E-03	NA	NA
cadmium	4.1E-05	NA	NA
chromium vi	8.5E-05	NA	NA
cobalt	3.5E-04	NA	NA
copper	8.2E-03	NA	NA
cyanide	4.1E-08	NA	NA
lead	2.7E-04	NA	NA
manganese	7.0E-03	NA	NA
mercury	4.1E-03	NA	NA
molybdenum	1.3E-04	NA	NA
nickel	4.7E-04	NA	NA
selenium	1.8E-05	NA	NA
silver	3.3E-04	NA	NA
thallium	1.6E-05	NA	NA
thorium-total	1.4E-08	NA	NA
uranium-total	9.5E-05	NA	NA
vanadium	5.2E-05	NA	NA
zinc	4.9E-01	NA	NA
2-methylnaphthalene	2.4E-07	NA	NA
4,4-dde	3.9E-08	3.4E-01	1.3E-08
aroclor-1221	3.6E-29	7.7E+00	2.8E-28
aroclor-1248	NA	7.7E+00	NA
aroclor-1254	4.8E-06	7.7E+00	3.7E-05
aroclor-1260	2.5E-05	7.7E+00	1.9E-04
carbazole	4.0E-08	2.0E-02	8.0E-10
endrin	NA	NA	NA
2,3,7,8-tcdd	3.6E-12	1.5E+05	5.4E-07
	ILCR Summation =		3.2E-04

Table I.IV–109
Summary of Intake and Risk Quantitation (radionuclides)
Future Land Use with Private Ownership: Perched Groundwater User
Via Ingestion of Meat Products

Intake Equation = Cf X EF X EDn X FI X IR

IR	Ingestion rate of meat	0.1 kg/day
FI	Fraction ingested from contaminated source	0.75 (Unitless)
EF	Exposure frequency	350 days/year
EDn	Exposure duration	70 Year
Cf	Concentration of radionuclides in meat	

Cs_{137+1d}	7.1E+01	pCi/kg	Rn_{222+4d}	ERR	pCi/kg
Pb_{210+2d}	8.3E−01	pCi/kg	Sr_{90+1d}	6.3E+01	pCi/kg
Np_{237+1d}	9.1E−03	pCi/kg	Tc_{99}	3.2E+04	pCi/kg
Pu_{238}	2.7E−05	pCi/kg	Th_{228+7d}	3.8E−04	pCi/kg
Pu_{239}	6.4E−06	pCi/kg	Th_{230}	1.0E−03	pCi/kg
Pu_{240}	2.3E−05	pCi/kg	$Th_{232+10d}$	6.1E−04	pCi/kg
Pa_{231}	2.0E−05	pCi/kg	U_{234}	4.7E+00	pCi/kg
Ra_{226+8d}	2.4E−01	pCi/kg	U_{235+1d}	1.3E−01	pCi/kg
Ra_{228+1d}	3.4E−01	pCi/kg	U_{236}	5.2E−02	pCi/kg
Ru_{106}	3.6E−01	pCi/kg	U_{238+2d}	2.8E+00	pCi/kg

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	ILCR (unitless)
Cs_{137+1d}	1.3E+05	2.8E−11	3.7E−06
Pb_{210+2d}	1.5E+03	6.6E−10	1.0E−06
Np_{237+1d}	1.7E+01	2.2E−10	3.7E−09
Pu_{238}	4.9E−02	2.2E−10	1.1E−11
Pu_{239}	1.2E−02	2.3E−10	2.7E−12
Pu_{240}	4.3E−02	2.3E−10	9.8E−12
Pa_{231}	3.7E−02	9.2E−11	3.4E−12
Ra_{226+8d}	4.4E+02	7.8E−10	3.5E−07
Ra_{228+1d}	6.2E+02	1.0E−10	6.2E−08
Ru_{106}	6.6E+02	9.5E−12	6.3E−09
Rn_{222+4d}	NA	1.7E−12	NA
Sr_{90+1d}	1.2E+05	3.6E−11	4.2E−06
Tc_{99}	5.9E+07	1.3E−12	7.7E−05
Th_{228+7d}	6.9E−01	5.5E−11	3.8E−11
Th_{230}	1.9E+00	1.3E−11	2.5E−11
$Th_{232+10d}$	1.1E+00	1.7E−10	1.9E−10
U_{234}	8.7E+03	1.6E−11	1.4E−07
U_{235+1d}	2.3E+02	1.6E−11	3.7E−09
U_{236}	9.5E+01	1.5E−11	1.4E−09
U_{238+2d}	5.2E+03	2.0E−11	1.0E−07
		ILCR Summation =	8.6E−05

Table I.IV–110
Summary of Intake Quantitation (chemicals)
Future Land Use with Private Ownership: Perched Groundwater User
Via Ingestion of Dairy Products

Intake Equation = $\frac{CS \times EF \times ED \times FI \times IR}{BW \times AT}$

IR	Ingestion rate of dairy products	0.4 l/day
FI	Fraction ingested from contaminated source	0.75 (Unitless)
EF	Exposure frequency	350 days/year
EDn	Exposure duration for non–carcinogens	70 Year
EDc	Exposure duration for carcinogens	70 Year
BW	Body weight	70 kg
ATc	Average time for carcinogens (lifetime)	25550 days
ATn	Average time for non–carcinogens (EDn x 365)	25550 days
CS	Concentration of chemicals in animal products	

Chemical Concentrations

Compound	Concentration	Units	Compound	Concentration	Units
antimony	0.0E+00	mg/kg	silver	2.1E+00	mg/kg
arsenic	1.6E–03	mg/kg	thallium	7.2E–04	mg/kg
barium	3.2E–01	mg/kg	thorium–total	1.4E–04	mg/kg
beryllium	1.2E–06	mg/kg	uranium–total	6.0E–01	mg/kg
boron	4.1E+00	mg/kg	vanadium	4.0E–04	mg/kg
cadmium	7.1E–02	mg/kg	zinc	4.8E+01	mg/kg
chromium vi	2.4E–02	mg/kg	2–methylnaphthalene	7.7E–05	mg/kg
cobalt	3.3E–02	mg/kg	4,4–dde	1.9E–05	mg/kg
copper	1.2E+00	mg/kg	aroclor–1221	1.3E–26	mg/kg
cyanide	1.2E–05	mg/kg	aroclor–1248	0.0E+00	mg/kg
lead	2.6E–01	mg/kg	aroclor–1254	3.6E–03	mg/kg
manganese	6.0E+00	mg/kg	aroclor–1260	1.5E–02	mg/kg
mercury	7.2E–03	mg/kg	carbazole	1.3E–05	mg/kg
molybdenum	3.2E–02	mg/kg	endrin	0.0E+00	mg/kg
nickel	7.7E–02	mg/kg	2,3,7,8–tcdd	4.0E–09	mg/kg
selenium	4.9E–03	mg/kg			

References

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Table I.IV−110 (continued)
Summary of Risk Characterization (chemicals)
Future Land Use with Private Ownership: Perched Groundwater User
Via Ingestion of Dairy Products

	HQ Calculation		
Compound	CDI (mg/kg−day)	RfD (mg/kg−day)	HQ (unitless)
antimony	NA	4.0E−04	NA
arsenic	6.7E−06	3.0E−04	2.2E−02
barium	1.3E−03	7.0E−02	1.9E−02
beryllium	5.0E−09	5.0E−03	1.0E−06
boron	1.7E−02	9.0E−02	1.9E−01
cadmium	2.9E−04	1.0E−03	2.9E−01
chromium vi	9.9E−05	5.0E−03	2.0E−02
cobalt	1.4E−04	6.0E−02	2.3E−03
copper	5.0E−03	NA	NA
cyanide	5.1E−08	2.0E−02	2.6E−06
lead	1.1E−03	NA	NA
manganese	2.5E−02	1.4E−01	1.8E−01
mercury	2.9E−05	3.0E−04	9.8E−02
molybdenum	1.3E−04	5.0E−03	2.6E−02
nickel	3.2E−04	2.0E−02	1.6E−02
selenium	2.0E−05	5.0E−03	4.0E−03
silver	8.7E−03	5.0E−03	1.7E+00
thallium	3.0E−06	8.0E−05	3.7E−02
thorium−total	6.0E−07	NA	NA
uranium−total	2.5E−03	3.0E−03	8.2E−01
vanadium	1.6E−06	7.0E−03	2.4E−04
zinc	2.0E−01	3.0E−01	6.5E−01
2−methylnaphthalene	3.1E−07	NA	NA
4,4−dde	7.6E−08	NA	NA
aroclor−1221	5.5E−29	NA	NA
aroclor−1248	NA	NA	NA
aroclor−1254	1.5E−05	NA	NA
aroclor−1260	6.1E−05	NA	NA
carbazole	5.2E−08	NA	NA
endrin	NA	3.0E−04	NA
2,3,7,8−tcdd	1.6E−11	NA	NA
	HQ Summation =		4.1E+00

	ILCR Calculation		
Compound	CDI (mg/kg−day)	CSF $(mg/kg-day)^{-1}$	ILCR (unitless)
antimony	NA	NA	NA
arsenic	6.7E−06	1.8E+00	1.2E−05
barium	1.3E−03	NA	NA
beryllium	5.0E−09	4.3E+00	2.1E−08
boron	1.7E−02	NA	NA
cadmium	2.9E−04	NA	NA
chromium vi	9.9E−05	NA	NA
cobalt	1.4E−04	NA	NA
copper	5.0E−03	NA	NA
cyanide	5.1E−08	NA	NA
lead	1.1E−03	NA	NA
manganese	2.5E−02	NA	NA
mercury	2.9E−05	NA	NA
molybdenum	1.3E−04	NA	NA
nickel	3.2E−04	NA	NA
selenium	2.0E−05	NA	NA
silver	8.7E−03	NA	NA
thallium	3.0E−06	NA	NA
thorium−total	6.0E−07	NA	NA
uranium−total	2.5E−03	NA	NA
vanadium	1.6E−06	NA	NA
zinc	2.0E−01	NA	NA
2−methylnaphthalene	3.1E−07	NA	NA
4,4−dde	7.6E−08	3.4E−01	2.6E−08
aroclor−1221	5.5E−29	7.7E+00	4.2E−28
aroclor−1248	NA	7.7E+00	NA
aroclor−1254	1.5E−05	7.7E+00	1.1E−04
aroclor−1260	6.1E−05	7.7E+00	4.7E−04
carbazole	5.2E−08	2.0E−02	1.0E−09
endrin	NA	NA	NA
2,3,7,8−tcdd	1.6E−11	1.5E+05	2.4E−06
	ILCR Summation =		6.0E−04

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Table I.IV–111
Summary of Intake and Risk Quantitation (radionuclides)
Future Land Use with Private Ownership: Perched Groundwater User
Via Ingestion of Dairy Products

Intake Equation = Cp X EF X EDn X FI X IR

IR	Ingestion rate of dairy products	0.4 l/day
FI	Fraction ingested from contaminated source	0.75 (Unitless)
EF	Exposure frequency	350 days/year
EDn	Exposure duration	70 Year
Cp	Concentration of radionuclides in animal products	

Cs_{137+1d}	2.5E+01	pCi/kg	Rn_{222+4d}	ERR	pCi/kg
Pb_{210+2d}	8.5E−01	pCi/kg	Sr_{90+1d}	3.2E+02	pCi/kg
Np_{237+1d}	1.5E−03	pCi/kg	Tc_{99}	3.8E+04	pCi/kg
Pu_{238}	1.2E−04	pCi/kg	Th_{228+7d}	4.1E−03	pCi/kg
Pu_{239}	3.0E−05	pCi/kg	Th_{230}	1.1E−02	pCi/kg
Pu_{240}	1.1E−04	pCi/kg	$Th_{232+10d}$	6.4E−03	pCi/kg
Pa_{231}	4.0E−02	pCi/kg	U_{234}	2.8E+01	pCi/kg
Ra_{226+8d}	7.2E−01	pCi/kg	U_{235+1d}	7.4E−01	pCi/kg
Ra_{228+1d}	1.0E+00	pCi/kg	U_{236}	3.1E−01	pCi/kg
Ru_{106}	1.7E−04	pCi/kg	U_{238+2d}	1.7E+01	pCi/kg

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	ILCR (unitless)
Cs_{137+1d}	1.8E+05	2.8E−11	5.1E−06
Pb_{210+2d}	6.2E+03	6.6E−10	4.1E−06
Np_{237+1d}	1.1E+01	2.2E−10	2.5E−09
Pu_{238}	8.9E−01	2.2E−10	2.0E−10
Pu_{239}	2.2E−01	2.3E−10	5.0E−11
Pu_{240}	7.9E−01	2.3E−10	1.8E−10
Pa_{231}	2.9E+02	9.2E−11	2.7E−08
Ra_{226+8d}	5.3E+03	7.8E−10	4.1E−06
Ra_{228+1d}	7.5E+03	1.0E−10	7.5E−07
Ru_{106}	1.2E+00	9.5E−12	1.2E−11
Rn_{222+4d}	NA	1.7E−12	NA
Sr_{90+1d}	2.3E+06	3.6E−11	8.4E−05
Tc_{99}	2.8E+08	1.3E−12	3.7E−04
Th_{228+7d}	3.0E+01	5.5E−11	1.7E−09
Th_{230}	8.0E+01	1.3E−11	1.0E−09
$Th_{232+10d}$	4.7E+01	1.7E−10	8.0E−09
U_{234}	2.0E+05	1.6E−11	3.3E−06
U_{235+1d}	5.4E+03	1.6E−11	8.7E−08
U_{236}	2.2E+03	1.5E−11	3.4E−08
U_{238+2d}	1.2E+05	2.0E−11	2.4E−06
		ILCR Summation =	4.7E−04

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Table I.IV–112
Future Land Use with Private Ownership: Perched Groundwater User Via Ingestion of Vegetables and Fruits

Intake Equation = $\frac{CS \times EF \times ED \times FI \times IR}{BW \times AT}$

IR	Ingestion rate of fruits or vegetables	0.122 kg/day
FI	Fraction ingested from contaminated source	0.5 (Unitless)
EF	Exposure frequency	350 days/year
EDn	Exposure duration for non–carcinogens	70 Year
EDc	Exposure duration for carcinogens	70 Year
BW	Body weight	70 kg
ATc	Average time for carcinogens (lifetime)	25550 days
ATn	Average time for non–carcinogens (EDn x 365)	25550 days
CS	Concentration of chemicals in vegetables	

Chemical Concentrations

Compound	Concentration	Units
antimony	0.0E+00	mg/kg
arsenic	2.2E–01	mg/kg
barium	1.5E+01	mg/kg
beryllium	8.1E–03	mg/kg
boron	4.5E+02	mg/kg
cadmium	1.9E+00	mg/kg
chromium vi	1.2E–01	mg/kg
cobalt	2.4E–01	mg/kg
copper	8.1E+00	mg/kg
cyanide	6.1E+00	mg/kg
lead	1.1E+00	mg/kg
manganese	2.4E+02	mg/kg
mercury	1.9E–01	mg/kg
molybdenum	3.9E–01	mg/kg
nickel	1.4E+00	mg/kg
selenium	1.6E–02	mg/kg

Compound	Concentration	Units
silver	2.4E+00	mg/kg
thallium	2.2E–03	mg/kg
thorium–total	2.7E–04	mg/kg
uranium–total	8.9E–01	mg/kg
vanadium	1.4E–01	mg/kg
zinc	9.6E+01	mg/kg
2–methylnaphthalene	2.8E–06	mg/kg
4,4–dde	5.2E–09	mg/kg
aroclor–1221	1.2E–23	mg/kg
aroclor–1248	0.0E+00	mg/kg
aroclor–1254	5.5E–06	mg/kg
aroclor–1260	2.0E–06	mg/kg
carbazole	1.1E–07	mg/kg
endrin	0.0E+00	mg/kg
2,3,7,8–tcdd	5.3E–13	mg/kg

References

Table I.IV-112 (continued)
Summary of Risk Characterization (chemicals)
Future Land Use with Private Ownership: Perched Groundwater User
Via Ingestion of Vegetables and Fruits

	HQ Calculation		
Compound	CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
antimony	NA	4.0E-04	NA
arsenic	1.9E-04	3.0E-04	6.3E-01
barium	1.2E-02	7.0E-02	1.7E-01
beryllium	6.8E-06	5.0E-03	1.4E-03
boron	3.7E-01	9.0E-02	4.2E+00
cadmium	1.6E-03	1.0E-03	1.6E+00
chromium vi	1.0E-04	5.0E-03	2.1E-02
cobalt	2.0E-04	6.0E-02	3.4E-03
copper	6.8E-03	NA	NA
cyanide	5.1E-03	2.0E-02	2.5E-01
lead	8.9E-04	NA	NA
manganese	2.0E-01	1.4E-01	1.5E+00
mercury	1.6E-04	3.0E-04	5.4E-01
molybdenum	3.3E-04	5.0E-03	6.5E-02
nickel	1.1E-03	2.0E-02	5.7E-02
selenium	1.3E-05	5.0E-03	2.6E-03
silver	2.0E-03	5.0E-03	4.0E-01
thallium	1.9E-06	8.0E-05	2.3E-02
thorium-total	2.3E-07	NA	NA
uranium-total	7.5E-04	3.0E-03	2.5E-01
vanadium	1.2E-04	7.0E-03	1.7E-02
zinc	8.0E-02	3.0E-01	2.7E-01
2-methylnaphthalene	2.4E-09	NA	NA
4,4-dde	4.3E-12	NA	NA
aroclor-1221	9.7E-27	NA	NA
aroclor-1248	NA	NA	NA
aroclor-1254	4.6E-09	NA	NA
aroclor-1260	1.7E-09	NA	NA
carbazole	8.9E-11	NA	NA
endrin	NA	3.0E-04	NA
2,3,7,8-tcdd	4.4E-16	NA	NA
	HQ Summation =		9.9E+00

	ILCR Calculation		
Compound	CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	ILCR (unitless)
antimony	NA	NA	NA
arsenic	1.9E-04	1.8E+00	3.3E-04
barium	1.2E-02	NA	NA
beryllium	6.8E-06	4.3E+00	2.9E-05
boron	3.7E-01	NA	NA
cadmium	1.6E-03	NA	NA
chromium vi	1.0E-04	NA	NA
cobalt	2.0E-04	NA	NA
copper	6.8E-03	NA	NA
cyanide	5.1E-03	NA	NA
lead	8.9E-04	NA	NA
manganese	2.0E-01	NA	NA
mercury	1.6E-04	NA	NA
molybdenum	3.3E-04	NA	NA
nickel	1.1E-03	NA	NA
selenium	1.3E-05	NA	NA
silver	2.0E-03	NA	NA
thallium	1.9E-06	NA	NA
thorium-total	2.3E-07	NA	NA
uranium-total	7.5E-04	NA	NA
vanadium	1.2E-04	NA	NA
zinc	8.0E-02	NA	NA
2-methylnaphthalene	2.4E-09	NA	NA
4,4-dde	4.3E-12	3.4E-01	1.5E-12
aroclor-1221	9.7E-27	7.7E+00	7.4E-26
aroclor-1248	NA	7.7E+00	NA
aroclor-1254	4.6E-09	7.7E+00	3.6E-08
aroclor-1260	1.7E-09	7.7E+00	1.3E-08
carbazole	8.9E-11	2.0E-02	1.8E-12
endrin	NA	NA	NA
2,3,7,8-tcdd	4.4E-16	1.5E+05	6.6E-11
	ILCR Summation =		3.6E-04

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Table I.IV–113
Summary of Intake and Risk Quantitation (radionuclides)
Future Land Use with Private Ownership: Perched Groundwater User
Via Ingestion of Vegetables and Fruits

Intake Equation = Cv X EF X EDn X FI X IR

IR	Ingestion rate of fruits or vegetables	0.122 kg/day
FI	Fraction ingested from contaminated source	0.5 (Unitless)
EF	Exposure frequency	350 days/year
EDn	Exposure duration	70 Year
Cv	Concentration of radionuclides in vegetables	

Cs_{137+1d}	6.3E+01	pCi/kg	Rn_{222+4d}	ERR	pCi/kg
Pb_{210+2d}	2.1E−02	pCi/kg	Sr_{90+1d}	1.2E−02	pCi/kg
Np_{237+1d}	2.8E+00	pCi/kg	Tc_{99}	3.3E+04	pCi/kg
Pu_{238}	1.4E−02	pCi/kg	Th_{228+7d}	1.0E−03	pCi/kg
Pu_{239}	1.2E−03	pCi/kg	Th_{230}	4.7E−03	pCi/kg
Pu_{240}	4.4E−03	pCi/kg	$Th_{232+10d}$	3.6E−03	pCi/kg
Pa_{231}	1.2E−03	pCi/kg	U_{234}	5.0E+02	pCi/kg
Ra_{226+8d}	1.2E+00	pCi/kg	U_{235+1d}	1.3E+01	pCi/kg
Ra_{228+1d}	1.3E−03	pCi/kg	U_{236}	5.5E+00	pCi/kg
Ru_{106}	5.3E−04	pCi/kg	U_{238+2d}	3.0E+02	pCi/kg

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	ILCR (unitless)
Cs_{137+1d}	9.5E+04	2.8E−11	2.7E−06
Pb_{210+2d}	3.2E+01	6.6E−10	2.1E−08
Np_{237+1d}	4.2E+03	2.2E−10	9.1E−07
Pu_{238}	2.2E+01	2.2E−10	4.8E−09
Pu_{239}	1.8E+00	2.3E−10	4.2E−10
Pu_{240}	6.6E+00	2.3E−10	1.5E−09
Pa_{231}	1.8E+00	9.2E−11	1.7E−10
Ra_{226+8d}	1.8E+03	7.8E−10	1.4E−06
Ra_{228+1d}	1.9E+00	1.0E−10	1.9E−10
Ru_{106}	7.9E−01	9.5E−12	7.5E−12
Rn_{222+4d}	NA	1.7E−12	NA
Sr_{90+1d}	1.8E+01	3.6E−11	6.4E−10
Tc_{99}	5.0E+07	1.3E−12	6.5E−05
Th_{228+7d}	1.5E+00	5.5E−11	8.2E−11
Th_{230}	7.0E+00	1.3E−11	9.0E−11
$Th_{232+10d}$	5.4E+00	1.7E−10	9.2E−10
U_{234}	7.5E+05	1.6E−11	1.2E−05
U_{235+1d}	2.0E+04	1.6E−11	3.2E−07
U_{236}	8.2E+03	1.5E−11	1.2E−07
U_{238+2d}	4.5E+05	2.0E−11	9.0E−06
		ILCR Summation =	9.1E−05

Table I.IV–114
Summary of Intake and Risk Quantitation (radionuclides)
Future Land Use with Private Ownership: Perched Groundwater User
Via External Radiation

Dose Equivalency Equat = $[DR \times EF \times EDn \times ET_i \times (1-SH_i)] + [DR \times EF \times EDn \times ET_o \times (1-SH_o)]$

EF	Fraction of year spent exposured	0.96 (unitless)
ED	Exposure duration	70 Year
ET_i	Fraction of day spent indoors	0.24 (unitless)
ET_o	Fraction of day spent outdoors	0.76 (unitless)
SH_i	Shield factor indoors	0.5 (unitless)
SH_o	Shield factor outdoors	0 (unitless)
DR	Radionuclide specific dose concentrations	(see table below)

Cs_{137+1d}	5.85E−07	pCi/g	Rn_{222+4d}	NA	pCi/g
Pb_{210+2d}	1.05E−06	pCi/g	Sr_{90+1d}	8.33E−07	pCi/g
Np_{237+1d}	8.36E−08	pCi/g	Tc_{99}	1.87E−06	pCi/g
Pu_{238}	9.07E−08	pCi/g	Th_{228+7d}	4.00E−07	pCi/g
Pu_{239}	1.25E−08	pCi/g	Th_{230}	5.92E−08	pCi/g
Pu_{240}	4.55E−08	pCi/g	$Th_{232+10d}$	5.95E−07	pCi/g
Pa_{231}	NA	pCi/g	U_{234}	2.06E−05	pCi/g
Ra_{226+8d}	3.99E−07	pCi/g	U_{235+1d}	9.34E−07	pCi/g
Ra_{228+1d}	7.00E−07	pCi/g	U_{236}	6.86E−06	pCi/g
Ru_{106}	1.33E−07	pCi/g	U_{238+2d}	1.38E−05	pCi/g

Radionuclides	CDI (year pCi/g)	CSF $(g/pCi-year)^{-1}$	ILCR (unitless)
Cs_{137+1d}	3.5E−05	2.0E−06	6.9E−11
Pb_{210+2d}	6.2E−05	1.6E−10	9.9E−15
Np_{237+1d}	4.9E−06	4.3E−07	2.1E−12
Pu_{238}	5.4E−06	2.8E−11	1.5E−16
Pu_{239}	7.4E−07	1.7E−11	1.3E−17
Pu_{240}	2.7E−06	2.7E−11	7.3E−17
Pa_{231}	NA	2.6E−08	NA
Ra_{226+8d}	2.4E−05	6.0E−06	1.4E−10
Ra_{228+1d}	4.1E−05	2.9E−06	1.2E−10
Ru_{106}	7.9E−06	NA	0.0E+00
Rn_{222+4d}	NA	5.9E−06	NA
Sr_{90+1d}	4.9E−05	NA	0.0E+00
Tc_{99}	1.1E−04	6.0E−13	6.6E−17
Th_{228+7d}	2.4E−05	5.6E−06	1.3E−10
Th_{230}	3.5E−06	5.4E−11	1.9E−16
$Th_{232+10d}$	3.5E−05	8.5E−06	3.0E−10
U_{234}	1.2E−03	3.0E−11	3.7E−14
U_{235+1d}	5.5E−05	2.4E−07	1.3E−11
U_{236}	4.1E−04	2.4E−11	9.7E−15
U_{238+2d}	8.2E−04	5.1E−08	4.2E−11
		ILCR Summation =	8.2E−10

Table H.IV–115
Summary of Intake Quantitation (chemicals)
Future Land Use with Private Ownership: On–Property Farmer (Adult)
Via Inhalation of Particulates

Intake Equation = $\frac{CS \times EF \times ED \times IR}{BW \times AT}$

IR	Inhalation rate of gases (RAGS, 1989)	19.92 m^3/day
EF	Exposure frequency	350 days/year
EDn	Exposure duration for non–carcinogens	70 Year
EDc	Exposure duration for carcinogens	70 Year
BW	Body weight	70 kg
ATc	Average time for carcinogens (lifetime)	25550 days
ATn	Average time for non–carcinogens (EDn x 365)	25550 days
CS	Concentration of chemicals in soil	(see table below)

Chemical Concentrations

Compound	Concentration	Units	Compound	Concentration	Units
antimony	9.2E–09	mg/m^3	silver	4.5E–09	mg/m^3
arsenic	1.0E–08	mg/m^3	thallium	3.4E–10	mg/m^3
barium	1.3E–07	mg/m^3	thorium–total	2.1E–07	mg/m^3
beryllium	1.1E–09	mg/m^3	uranium–total	3.5E–06	mg/m^3
boron	9.0E–09	mg/m^3	vanadium	2.0E–08	mg/m^3
cadmium	2.9E–09	mg/m^3	zinc	6.2E–08	mg/m^3
chromium vi	1.8E–08	mg/m^3	2–methylnaphthalene	2.5E–10	mg/m^3
cobalt	7.7E–09	mg/m^3	4,4–dde	5.3E–12	mg/m^3
copper	4.8E–08	mg/m^3	aroclor–1221	0.0E+00	mg/m^3
cyanide	5.1E–10	mg/m^3	aroclor–1248	0.0E+00	mg/m^3
lead	1.3E–06	mg/m^3	aroclor–1254	1.5E–09	mg/m^3
manganese	4.3E–10	mg/m^3	aroclor–1260	4.1E–10	mg/m^3
mercury	4.3E–10	mg/m^3	carbazole	1.1E–10	mg/m^3
molybdenum	5.8E–09	mg/m^3	endrin	0.0E+00	mg/m^3
nickel	1.9E–08	mg/m^3	2,3,7,8–tcdd	5.4E–16	mg/m^3
selenium	7.6E–10	mg/m^3			

References

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Table H.IV-115 (continued)
Summary of Risk Characterization (chemicals)
Future Land Use with Private Ownership: On-Property Farmer (Adult)
Via Inhalation of Particulates

	HQ Calculation		
Compound	CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
antimony	2.5E-09	NA	NA
arsenic	2.7E-09	NA	NA
barium	3.6E-08	1.4E-04	2.5E-04
beryllium	2.9E-10	NA	NA
boron	2.4E-09	5.7E-03	4.3E-07
cadmium	8.0E-10	NA	NA
chromium vi	5.0E-09	NA	NA
cobalt	2.1E-09	3.0E-07	7.0E-03
copper	1.3E-08	NA	NA
cyanide	1.4E-10	NA	NA
lead	3.4E-07	NA	NA
manganese	1.2E-10	1.4E-05	8.4E-06
mercury	1.2E-10	8.6E-05	1.4E-06
molybdenum	1.6E-09	NA	NA
nickel	5.2E-09	NA	NA
selenium	2.1E-10	NA	NA
silver	1.2E-09	NA	NA
thallium	9.1E-11	NA	NA
thorium-total	5.8E-08	NA	NA
uranium-total	9.5E-07	NA	NA
vanadium	5.4E-09	NA	NA
zinc	1.7E-08	NA	NA
2-methylnaphthalene	6.8E-11	NA	NA
4,4-dde	1.4E-12	NA	NA
aroclor-1221	NA	NA	NA
aroclor-1248	NA	NA	NA
aroclor-1254	4.2E-10	NA	NA
aroclor-1260	1.1E-10	NA	NA
carbazole	2.9E-11	NA	NA
endrin	NA	NA	NA
2,3,7,8-tcdd	1.5E-16	NA	NA
	Hazard Quotient Sum =		7.3E-03

	ILCR Calculation		
Compound	CDI (mg/kg-day)	CSF $(mg/kg\text{-}day)^{-1}$	ILCR (unitless)
antimony	2.5E-09	NA	NA
arsenic	2.7E-09	1.5E+01	4.1E-08
barium	3.6E-08	NA	NA
beryllium	2.9E-10	8.4E+00	2.4E-09
boron	2.4E-09	NA	NA
cadmium	8.0E-10	6.3E+00	5.0E-09
chromium vi	5.0E-09	4.1E+01	2.0E-07
cobalt	2.1E-09	NA	NA
copper	1.3E-08	NA	NA
cyanide	1.4E-10	NA	NA
lead	3.4E-07	NA	NA
manganese	1.2E-10	NA	NA
mercury	1.2E-10	NA	NA
molybdenum	1.6E-09	NA	NA
nickel	5.2E-09	8.4E-01	4.4E-09
selenium	2.1E-10	NA	NA
silver	1.2E-09	NA	NA
thallium	9.1E-11	NA	NA
thorium-total	5.8E-08	NA	NA
uranium-total	9.5E-07	NA	NA
vanadium	5.4E-09	NA	NA
zinc	1.7E-08	NA	NA
2-methylnaphthalene	6.8E-11	NA	NA
4,4-dde	1.4E-12	NA	NA
aroclor-1221	NA	NA	NA
aroclor-1248	NA	NA	NA
aroclor-1254	4.2E-10	NA	NA
aroclor-1260	1.1E-10	NA	NA
carbazole	2.9E-11	NA	NA
endrin	NA	NA	NA
2,3,7,8-tcdd	1.5E-16	1.5E+05	2.2E-11
	ILCR Summation =		2.6E-07

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Table H.IV–116
Summary of Intake and Risk Quantitation (radionuclides)
Future Land Use with Private Ownership: On–Property Farmer (Adult)
Via Inhalation of Gases and Particulates

Intake Equation = Ca X EF X EDn X IR

IR	Inhalation rate of gases (RAGS, 1989)	19.92 m^3/day
EF	Exposure frequency	350 days/year
EDn	Exposure duration	70 Year
Ca	Concentration of radionuclides in air	(see table below)

Cs_{137+1d}	5.7E–07	pCi/m^3	Rn_{222+4d}	1.3E+01	pCi/m^3
Pb_{210+2d}	1.6E–05	pCi/m^3	Sr_{90+1d}	1.8E–06	pCi/m^3
Np_{237+1d}	4.4E–07	pCi/m^3	Tc_{99}	3.3E–05	pCi/m^3
Pu_{238}	1.5E–05	pCi/m^3	Th_{228+7d}	1.0E–06	pCi/m^3
Pu_{239}	1.2E–06	pCi/m^3	Th_{230}	3.7E–06	pCi/m^3
Pu_{240}	4.3E–06	pCi/m^3	$Th_{232+10d}$	2.8E–06	pCi/m^3
Pa_{231}	1.2E–06	pCi/m^3	U_{234}	5.1E–05	pCi/m^3
Ra_{226+8d}	9.3E–07	pCi/m^3	U_{235+1d}	1.3E–06	pCi/m^3
Ra_{228+1d}	1.2E–06	pCi/m^3	U_{236}	5.5E–07	pCi/m^3
Ru_{106}	5.4E–07	pCi/m^3	U_{238+2d}	3.0E–05	pCi/m^3

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	ILCR (unitless)
Cs_{137+1d}	2.8E–01	1.9E–11	5.2E–12
Pb_{210+2d}	7.6E+00	4.0E–09	3.0E–08
Np_{237+1d}	2.1E–01	2.9E–08	6.2E–09
Pu_{238}	7.1E+00	3.9E–08	2.8E–07
Pu_{239}	5.9E–01	3.8E–08	2.2E–08
Pu_{240}	2.1E+00	3.8E–08	8.0E–08
Pa_{231}	5.7E–01	3.6E–08	2.0E–08
Ra_{226+8d}	4.5E–01	7.0E–09	3.2E–09
Ra_{228+1d}	6.1E–01	6.9E–10	4.2E–10
Ru_{106}	2.6E–01	4.4E–10	1.1E–10
Rn_{222+4d}	6.2E+06	7.7E–12	4.8E–05
Sr_{90+1d}	8.9E–01	6.2E–11	5.5E–11
Tc_{99}	1.6E+01	8.3E–12	1.3E–10
Th_{228+7d}	5.0E–01	7.8E–08	3.9E–08
Th_{230}	1.8E+00	2.9E–08	5.2E–08
$Th_{232+10d}$	1.4E+00	1.1E–07	1.5E–07
U_{234}	2.5E+01	2.6E–08	6.4E–07
U_{235+1d}	6.5E–01	2.5E–08	1.6E–08
U_{236}	2.7E–01	2.5E–08	6.7E–09
U_{238+2d}	1.5E+01	2.4E–08	3.5E–07
		ILCR Summation =	5.0E–05

Table H.IV-117
Summary of Intake Quantitation (chemicals)
Future Land Use with Private Ownership: On-Property Farmer (Adult)
Via Incidental Ingestion of Soil

Intake Equation = $\frac{CS \times EF \times ED \times CF \times IR}{BW \times AT}$

IRs	Ingestion rate of soil (RAGS, 1989)	100 mg/day
CF	Conversion factor	1.0E-06 kg/mg
EF	Exposure frequency	350 days/year
EDn	Exposure duration for non-carcinogens	70 Year
EDc	Exposure duration for carcinogens	70 Year
BW	Body weight	70 kg
ATc	Average time for carcinogens (lifetime)	25550 days
ATn	Average time for non-carcinogens (EDn x 365)	25550 days
CS	Concentration of chemicals in soil	(see table below)

Chemical Concentrations

Compound	Concentration	Units	Compound	Concentration	Units
antimony	5.4E+00	mg/kg	silver	6.0E+00	mg/kg
arsenic	5.1E+00	mg/kg	thallium	5.6E-01	mg/kg
barium	9.7E+01	mg/kg	thorium-total	0.0E+00	mg/kg
beryllium	7.6E-01	mg/kg	uranium-total	0.0E+00	mg/kg
boron	1.1E+02	mg/kg	vanadium	2.6E+01	mg/kg
cadmium	3.5E+00	mg/kg	zinc	6.4E+01	mg/kg
chromium vi	1.6E+01	mg/kg	2-methylnaphthalene	0.0E+00	mg/kg
cobalt	1.2E+01	mg/kg	4,4-dde	0.0E+00	mg/kg
copper	2.0E+01	mg/kg	aroclor-1221	0.0E+00	mg/kg
cyanide	2.5E-01	mg/kg	aroclor-1248	0.0E+00	mg/kg
lead	2.4E+01	mg/kg	aroclor-1254	0.0E+00	mg/kg
manganese	9.8E+02	mg/kg	aroclor-1260	0.0E+00	mg/kg
mercury	2.1E-01	mg/kg	carbazole	0.0E+00	mg/kg
molybdenum	6.5E+00	mg/kg	endrin	0.0E+00	mg/kg
nickel	2.3E+01	mg/kg	2,3,7,8-tcdd	0.0E+00	mg/kg
selenium	6.3E-01	mg/kg			

References

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Table H.IV–117 (continued)
Summary of Risk Characterization (chemicals)
Future Land Use with Private Ownership: On–Property Farmer (Adult)
Via Incidental Ingestion of Soil

	HQ Calculation		
Compound	CDI (mg/kg–day)	RfD (mg/kg–day)	HQ (unitless)
antimony	7.3E–06	4.0E–04	1.8E–02
arsenic	7.0E–06	3.0E–04	2.3E–02
barium	1.3E–04	7.0E–02	1.9E–03
beryllium	1.0E–06	5.0E–03	2.1E–04
boron	1.5E–04	9.0E–02	1.7E–03
cadmium	4.8E–06	1.0E–03	4.8E–03
chromium vi	2.2E–05	5.0E–03	4.5E–03
cobalt	1.7E–05	6.0E–02	2.8E–04
copper	2.8E–05	NA	NA
cyanide	3.4E–07	2.0E–02	1.7E–05
lead	3.2E–05	NA	NA
manganese	1.3E–03	1.4E–01	9.5E–03
mercury	2.9E–07	3.0E–04	9.8E–04
molybdenum	8.9E–06	5.0E–03	1.8E–03
nickel	3.1E–05	2.0E–02	1.5E–03
selenium	8.6E–07	5.0E–03	1.7E–04
silver	8.3E–06	5.0E–03	1.7E–03
thallium	7.6E–07	8.0E–05	9.6E–03
thorium–total	NA	NA	NA
uranium–total	NA	3.0E–03	0.0E+00
vanadium	3.6E–05	7.0E–03	5.1E–03
zinc	8.8E–05	3.0E–01	2.9E–04
2–methylnaphthalene	NA	NA	NA
4,4–dde	NA	NA	NA
aroclor–1221	NA	NA	NA
aroclor–1248	NA	NA	NA
aroclor–1254	NA	NA	NA
aroclor–1260	NA	NA	NA
carbazole	NA	NA	NA
endrin	NA	3.0E–04	0.0E+00
2,3,7,8–tcdd	NA	NA	NA
	HQ Summation =		8.6E–02

	ILCR Calculation		
Compound	CDI (mg/kg–day)	CSF $(mg/kg–day)^{-1}$	ILCR (unitless)
antimony	7.3E–06	NA	NA
arsenic	7.0E–06	1.8E+00	1.2E–05
barium	1.3E–04	NA	NA
beryllium	1.0E–06	4.3E+00	4.4E–06
boron	1.5E–04	NA	NA
cadmium	4.8E–06	NA	NA
chromium vi	2.2E–05	NA	NA
cobalt	1.7E–05	NA	NA
copper	2.8E–05	NA	NA
cyanide	3.4E–07	NA	NA
lead	3.2E–05	NA	NA
manganese	1.3E–03	NA	NA
mercury	2.9E–07	NA	NA
molybdenum	8.9E–06	NA	NA
nickel	3.1E–05	NA	NA
selenium	8.6E–07	NA	NA
silver	8.3E–06	NA	NA
thallium	7.6E–07	NA	NA
thorium–total	NA	NA	NA
uranium–total	NA	NA	NA
vanadium	3.6E–05	NA	NA
zinc	8.8E–05	NA	NA
2–methylnaphthalene	NA	NA	NA
4,4–dde	NA	3.4E–01	0.0E+00
aroclor–1221	NA	7.7E+00	0.0E+00
aroclor–1248	NA	7.7E+00	0.0E+00
aroclor–1254	NA	7.7E+00	0.0E+00
aroclor–1260	NA	7.7E+00	0.0E+00
carbazole	NA	2.0E–02	0.0E+00
endrin	NA	NA	NA
2,3,7,8–tcdd	NA	1.5E+05	0.0E+00
	ILCR Summation =		1.7E–05

Table H.IV-118
Summary of Intake and Risk Quantitation (radionuclides)
Future Land Use with Private Ownership: On-Property Farmer (Adult)
Via Incidental Ingestion of Soil

Intake Equation = CS X EF X EDn X FI X IR

IRs	Ingestion rate of soil (RAGS, 1989)	100 mg/day
EF	Exposure frequency	350 days/year
EDn	Exposure Duration	70 Year
FI	Fractional Intake	1 (unitless)
CS	Concentration of radionuclides in soil	

Cs_{137+1d}	7.93E-04	pCi/mg	Rn_{222+4d}	0.00E+00	pCi/mg
Pb_{210+2d}	1.05E-09	pCi/mg	Sr_{90+1d}	8.33E-10	pCi/mg
Np_{237+1d}	8.36E-11	pCi/mg	Tc_{99}	1.87E-09	pCi/mg
Pu_{238}	9.07E-11	pCi/mg	Th_{228+7d}	4.00E-10	pCi/mg
Pu_{239}	1.25E-11	pCi/mg	Th_{230}	5.92E-11	pCi/mg
Pu_{240}	4.55E-11	pCi/mg	$Th_{232+10d}$	5.95E-10	pCi/mg
Pa_{231}	0.00E+00	pCi/mg	U_{234}	2.06E-08	pCi/mg
Ra_{226+8d}	3.99E-10	pCi/mg	U_{235+1d}	9.34E-10	pCi/mg
Ra_{228+1d}	7.00E-10	pCi/mg	U_{236}	6.86E-09	pCi/mg
Ru_{106}	1.33E-10	pCi/mg	U_{238+2d}	1.38E-08	pCi/mg

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	ILCR (unitless)
Cs_{137+1d}	1.94E+03	2.80E-11	5.44E-08
Pb_{210+2d}	2.57E-03	6.60E-10	1.70E-12
Np_{237+1d}	2.05E-04	2.20E-10	4.51E-14
Pu_{238}	2.22E-04	2.20E-10	4.89E-14
Pu_{239}	3.06E-05	2.30E-10	7.04E-15
Pu_{240}	1.11E-04	2.30E-10	2.56E-14
Pa_{231}	NA	9.20E-11	NA
Ra_{226+8d}	9.78E-04	7.80E-10	7.62E-13
Ra_{228+1d}	1.72E-03	1.00E-10	1.72E-13
Ru_{106}	3.26E-04	9.50E-12	3.10E-15
Rn_{222+4d}	NA	1.70E-12	NA
Sr_{90+1d}	2.04E-03	3.60E-11	7.35E-14
Tc_{99}	4.58E-03	1.30E-12	5.96E-15
Th_{228+7d}	9.80E-04	5.50E-11	5.39E-14
Th_{230}	1.45E-04	1.30E-11	1.89E-15
$Th_{232+10d}$	1.46E-03	1.70E-10	2.48E-13
U_{234}	5.05E-02	1.60E-11	8.08E-13
U_{235+1d}	2.29E-03	1.60E-11	3.66E-14
U_{236}	1.68E-02	1.50E-11	2.52E-13
U_{238+2d}	3.38E-02	2.00E-11	6.76E-13
		ILCR Summation =	5.44E-08

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Table H.IV–119
Summary of Intake Quantitation (chemicals)
Future Land Use with Private Ownership: On–Property Farmer (Adult)
Via Dermal Contact with Soil

Intake Equation = $\frac{CS \times EF \times ED \times CF \times ABS \times AF \times SA}{BW \times AT}$

SA	Surface area of exposed skin (50th percentile, hands only)	5750	cm^2/day
AF	Soil to skin adherence factor (RAGS, 1989)	1	mg/cm^2
ABS	chemicals specific absorbtion factor (see table below)	csv	
CF	Conversion factor	1E–06	kg/mg
EF	Exposure frequency	350	days/year
EDn	Exposure duration for non–carcinogens	70	Year
EDc	Exposure duration for carcinogens	70	Year
BW	Body weight	70	kg
ATc	Average time for carcinogens (lifetime)	25550	days
ATn	Average time for non–carcinogens (EDn x 365)	25550	days
CS	Concentration of chemicals in soil		

Chemical Concentrations

Compound	ABS	Concentrati	Units
antimony	1.00E–02	5.35E+00	mg/kg
arsenic	1.00E–03	5.09E+00	mg/kg
barium	1.00E–02	9.72E+01	mg/kg
beryllium	1.00E–02	7.55E–01	mg/kg
boron	1.00E–02	1.12E+02	mg/kg
cadmium	1.00E–02	3.48E+00	mg/kg
chromium vi	1.00E–02	1.64E+01	mg/kg
cobalt	1.00E–02	1.21E+01	mg/kg
copper	1.00E–03	2.02E+01	mg/kg
cyanide	1.00E–02	2.50E–01	mg/kg
lead	1.00E–02	2.35E+01	mg/kg
manganese	1.00E–02	9.76E+02	mg/kg
mercury	5.00E–02	2.14E–01	mg/kg
molybdenum	1.00E–02	6.49E+00	mg/kg
nickel	5.00E–04	2.26E+01	mg/kg
selenium	1.00E–02	6.31E–01	mg/kg

Compound		Concentrati	Units
silver	1.00E–02	6.03E+00	mg/kg
thallium	1.00E–02	5.58E–01	mg/kg
thorium–total	1.00E–02	0.00E+00	mg/kg
uranium–total	1.00E–02	0.00E+00	mg/kg
vanadium	1.00E–03	2.60E+01	mg/kg
zinc	1.00E–02	6.41E+01	mg/kg
2–methylnaphthalene	3.00E–01	0.00E+00	mg/kg
4,4–dde	3.00E–01	0.00E+00	mg/kg
aroclor–1221	6.00E–02	0.00E+00	mg/kg
aroclor–1248	6.00E–02	0.00E+00	mg/kg
aroclor–1254	6.00E–02	0.00E+00	mg/kg
aroclor–1260	6.00E–02	0.00E+00	mg/kg
carbazole	3.00E–01	0.00E+00	mg/kg
endrin	3.00E–01	0.00E+00	mg/kg
2,3,7,8–tcdd	3.00E–02	0.00E+00	mg/kg

References

Table H.IV–119 (continued)
Summary of Risk Characterization (chemicals)
Future Land Use with Private Ownership: On–Property Farmer (Adult)
Via Dermal Contact with Soil

	HQ Calculation		
Compound	CDI (mg/kg–day)	RfD (mg/kg–day)	HQ (unitless)
antimony	4.21E–06	6.00E–05	7.02E–02
arsenic	4.01E–07	2.85E–04	1.41E–03
barium	7.66E–05	6.37E–02	1.20E–03
beryllium	5.95E–07	5.00E–03	1.19E–04
boron	8.82E–05	4.50E–03	1.96E–02
cadmium	2.74E–06	5.00E–05	5.48E–02
chromium vi	1.29E–05	2.25E–03	5.74E–03
cobalt	9.53E–06	2.70E–02	3.53E–04
copper	1.59E–06	NA	NA
cyanide	1.97E–07	NA	NA
lead	1.85E–05	NA	NA
manganese	7.69E–04	4.20E–03	1.83E–01
mercury	8.43E–07	4.50E–05	1.87E–02
molybdenum	5.11E–06	1.90E–03	2.69E–03
nickel	8.90E–07	2.00E–03	4.45E–04
selenium	4.97E–07	4.00E–03	1.24E–04
silver	4.75E–06	NA	NA
thallium	4.40E–07	8.00E–05	5.49E–03
thorium–total	NA	NA	NA
uranium–total	NA	1.50E–04	0.00E+00
vanadium	2.05E–06	3.50E–04	5.85E–03
zinc	5.05E–05	7.50E–02	6.73E–04
2–methylnaphthalene	NA	NA	NA
4,4–dde	NA	NA	NA
aroclor–1221	NA	NA	NA
aroclor–1248	NA	NA	NA
aroclor–1254	NA	NA	NA
aroclor–1260	NA	NA	NA
carbazole	NA	NA	NA
endrin	NA	2.70E–04	0.00E+00
2,3,7,8–tcdd	NA	NA	NA
	HQ Summation =		3.71E–01

	ILCR Calculation		
Compound	CDI (mg/kg–day)	CSF $(mg/kg–day)^{-1}$	ILCR (unitless)
antimony	4.21E–06	NA	NA
arsenic	4.01E–07	1.90E+00	7.62E–07
barium	7.66E–05	NA	NA
beryllium	5.95E–07	4.30E+00	2.56E–06
boron	8.82E–05	NA	NA
cadmium	2.74E–06	NA	NA
chromium vi	1.29E–05	NA	NA
cobalt	9.53E–06	NA	NA
copper	1.59E–06	NA	NA
cyanide	1.97E–07	NA	NA
lead	1.85E–05	NA	NA
manganese	7.69E–04	NA	NA
mercury	8.43E–07	NA	NA
molybdenum	5.11E–06	NA	NA
nickel	8.90E–07	NA	NA
selenium	4.97E–07	NA	NA
silver	4.75E–06	NA	NA
thallium	4.40E–07	NA	NA
thorium–total	NA	NA	NA
uranium–total	NA	NA	NA
vanadium	2.05E–06	NA	NA
zinc	5.05E–05	NA	NA
2–methylnaphthalene	NA	NA	NA
4,4–dde	NA	3.40E–01	0.00E+00
aroclor–1221	NA	1.03E+01	0.00E+00
aroclor–1248	NA	1.03E+01	0.00E+00
aroclor–1254	NA	1.03E+01	0.00E+00
aroclor–1260	NA	1.03E+01	0.00E+00
carbazole	NA	2.22E–02	0.00E+00
endrin	NA	NA	NA
2,3,7,8–tcdd	NA	3.00E+05	0.00E+00
	ILCR Summation =		3.32E–06

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Table H.IV-120
Summary of Intake Quantitation (chemicals)
Future Land Use with Private Ownership: On-Property Farmer (Adult)
Via Drinking Water Ingestion

Intake Equation = $\frac{CS \times EF \times ED \times IR}{BW \times AT}$

IR	Ingestion rate of groundwater (RAGS, 1989)	2 l/day
EF	Exposure frequency	350 days/year
EDn	Exposure duration for non-carcinogens	70 Year
EDc	Exposure duration for carcinogens	70 Year
BW	Body weight	70 kg
ATc	Average time for carcinogens (lifetime)	25550 days
ATn	Average time for non-carcinogens (EDn x 365)	25550 days
CS	Concentration of chemicals in groundwater	

Chemical Concentrations

Compound	Concentration	Units	Compound	Concentration	Units
antimony	1.24E-03	mg/l	silver	0.00E+00	mg/l
arsenic	4.26E-03	mg/l	thallium	0.00E+00	mg/l
barium	0.00E+00	mg/l	thorium-total	0.00E+00	mg/l
beryllium	1.15E-04	mg/l	uranium-total	1.82E-01	mg/l
boron	0.00E+00	mg/l	vanadium	0.00E+00	mg/l
cadmium	2.88E-20	mg/l	zinc	0.00E+00	mg/l
chromium vi	0.00E+00	mg/l	2-methylnaphthalene	0.00E+00	mg/l
cobalt	0.00E+00	mg/l	4,4-dde	0.00E+00	mg/l
copper	0.00E+00	mg/l	aroclor-1221	2.29E-24	mg/l
cyanide	0.00E+00	mg/l	aroclor-1248	0.00E+00	mg/l
lead	0.00E+00	mg/l	aroclor-1254	0.00E+00	mg/l
manganese	0.00E+00	mg/l	aroclor-1260	0.00E+00	mg/l
mercury	0.00E+00	mg/l	carbazole	0.00E+00	mg/l
molybdenum	0.00E+00	mg/l	endrin	0.00E+00	mg/l
nickel	0.00E+00	mg/l	2,3,7,8-tcdd	0.00E+00	mg/l
selenium	0.00E+00	mg/l			

References

Table H.IV-120 (continued)
Summary of Risk Characterization (chemicals)
Future Land Use with Private Ownership: On-Property Farmer (Adult)
Via Drinking Water Ingestion

Compound	HQ Calculation CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
antimony	3.40E-05	4.00E-04	8.49E-02
arsenic	1.17E-04	3.00E-04	3.89E-01
barium	NA	7.00E-02	NA
beryllium	3.15E-06	5.00E-03	6.30E-04
boron	NA	9.00E-02	NA
cadmium	7.89E-22	1.00E-03	7.89E-19
chromium vi	NA	5.00E-03	NA
cobalt	NA	6.00E-02	NA
copper	NA	NA	NA
cyanide	NA	2.00E-02	NA
lead	NA	NA	NA
manganese	NA	1.40E-01	NA
mercury	NA	3.00E-04	NA
molybdenum	NA	5.00E-03	NA
nickel	NA	2.00E-02	NA
selenium	NA	5.00E-03	NA
silver	NA	5.00E-03	NA
thallium	NA	8.00E-05	NA
thorium-total	NA	NA	NA
uranium-total	4.99E-03	3.00E-03	1.66E+00
vanadium	NA	7.00E-03	NA
zinc	NA	3.00E-01	NA
2-methylnaphthalene	NA	NA	NA
4,4-dde	NA	NA	NA
aroclor-1221	6.27E-26	NA	NA
aroclor-1248	NA	NA	NA
aroclor-1254	NA	NA	NA
aroclor-1260	NA	NA	NA
carbazole	NA	NA	NA
endrin	NA	3.00E-04	NA
2,3,7,8-tcdd	NA	NA	NA
	HQ Summation =		2.14E+00

Compound	ILCR Calculation CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	ILCR (unitless)
antimony	3.40E-05	NA	NA
arsenic	1.17E-04	1.75E+00	2.04E-04
barium	NA	NA	NA
beryllium	3.15E-06	4.30E+00	1.35E-05
boron	NA	NA	NA
cadmium	7.89E-22	NA	NA
chromium vi	NA	NA	NA
cobalt	NA	NA	NA
copper	NA	NA	NA
cyanide	NA	NA	NA
lead	NA	NA	NA
manganese	NA	NA	NA
mercury	NA	NA	NA
molybdenum	NA	NA	NA
nickel	NA	NA	NA
selenium	NA	NA	NA
silver	NA	NA	NA
thallium	NA	NA	NA
thorium-total	NA	NA	NA
uranium-total	4.99E-03	NA	NA
vanadium	NA	NA	NA
zinc	NA	NA	NA
2-methylnaphthalene	NA	NA	NA
4,4-dde	NA	3.40E-01	NA
aroclor-1221	6.27E-26	7.70E+00	4.83E-25
aroclor-1248	NA	7.70E+00	NA
aroclor-1254	NA	7.70E+00	NA
aroclor-1260	NA	7.70E+00	NA
carbazole	NA	2.00E-02	NA
endrin	NA	NA	NA
2,3,7,8-tcdd	NA	1.50E+05	NA
	ILCR Summation =		2.18E-04

Table H.IV–121
Summary of Intake and Risk Quantitation (radionuclides)
Future Land Use with Private Ownership: On–Property Farmer (Adult)
Via Ingestion of Drinking Water

Intake Equation = Cw X EF X EDn X FI X IR

IR	Ingestion rate of groundwater (RAGS, 1989)	2 l/day
EF	Exposure frequency	350 days/year
EDn	Exposure duration	70 Year
FI	Fractional intake for radionuclides	1 (Unitless)
Cw	Concentration of radionuclides in groundwater	(see table below)

Cs_{137+1d}	0.0E+00	pCi/l	Rn_{222+4d}	0.0E+00	pCi/l
Pb_{210+2d}	0.0E+00	pCi/l	Sr_{90+1d}	0.0E+00	pCi/l
Np_{237+1d}	5.7E−01	pCi/l	Tc_{99}	5.2E+03	pCi/l
Pu_{238}	0.0E+00	pCi/l	Th_{228+7d}	0.0E+00	pCi/l
Pu_{239}	0.0E+00	pCi/l	Th_{230}	0.0E+00	pCi/l
Pu_{240}	0.0E+00	pCi/l	$Th_{232+10d}$	0.0E+00	pCi/l
Pa_{231}	0.0E+00	pCi/l	U_{234}	1.0E+02	pCi/l
Ra_{226+8d}	2.5E−01	pCi/l	U_{235+1d}	2.7E+00	pCi/l
Ra_{228+1d}	0.0E+00	pCi/l	U_{236}	1.1E+00	pCi/l
Ru_{106}	0.0E+00	pCi/l	U_{238+2d}	6.1E+01	pCi/l

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	ILCR (unitless)
Cs_{137+1d}	NA	2.8E−11	NA
Pb_{210+2d}	NA	6.6E−10	NA
Np_{237+1d}	2.8E+04	2.2E−10	6.1E−06
Pu_{238}	NA	2.2E−10	NA
Pu_{239}	NA	2.3E−10	NA
Pu_{240}	NA	2.3E−10	NA
Pa_{231}	NA	9.2E−11	NA
Ra_{226+8d}	1.2E+04	7.8E−10	9.6E−06
Ra_{228+1d}	NA	1.0E−10	NA
Ru_{106}	NA	9.5E−12	NA
Rn_{222+4d}	NA	1.7E−12	NA
Sr_{90+1d}	NA	3.6E−11	NA
Tc_{99}	2.6E+08	1.3E−12	3.3E−04
Th_{228+7d}	NA	5.5E−11	NA
Th_{230}	NA	1.3E−11	NA
$Th_{232+10d}$	NA	1.7E−10	NA
U_{234}	5.0E+06	1.6E−11	8.0E−05
U_{235+1d}	1.3E+05	1.6E−11	2.1E−06
U_{236}	5.5E+04	1.5E−11	8.2E−07
U_{238+2d}	3.0E+06	2.0E−11	6.0E−05
		ILCR Summation =	4.9E−04

Table H.IV–122
Summary of Intake Quantitation (chemicals)
Future Land Use with Private Ownership: On–Property Farmer (Adult)
Via Dermal Contact while Bathing

Intake Equation = $\frac{DA \times EF \times ED \times SA}{BW \times AT}$

DA	Dermal absorbed dose	csv	mg/cm^2–day
EF	Exposure frequency	350	days/year
EDn	Exposure duration for non–carcinogens	70	Year
EDc	Exposure duration for carcinogens	70	Year
BW	Body weight	70	kg
ATc	Average time for carcinogens (lifetime)	25550	days
ATn	Average time for non–carcinogens (EDn x 365)	25550	days
SA	Skin surface area available for contact	23000	cm^2

Chemical Concentrations

Compound	DA	Units	Compound	DA	Units
antimony	3.10E–09	mg/cm^2–day	silver	NA	mg/cm^2–day
arsenic	1.06E–08	mg/cm^2–day	thallium	NA	mg/cm^2–day
barium	NA	mg/cm^2–day	thorium–total	NA	mg/cm^2–day
beryllium	2.88E–10	mg/cm^2–day	uranium–total	4.55E–08	mg/cm^2–day
boron	NA	mg/cm^2–day	vanadium	NA	mg/cm^2–day
cadmium	7.20E–27	mg/cm^2–day	zinc	NA	mg/cm^2–day
chromium vi	NA	mg/cm^2–day	2–methylnaphthalene	NA	mg/cm^2–day
cobalt	NA	mg/cm^2–day	4,4–dde	NA	mg/cm^2–day
copper	NA	mg/cm^2–day	aroclor–1221	1.86E–27	mg/cm^2–day
cyanide	NA	mg/cm^2–day	aroclor–1248	NA	mg/cm^2–day
lead	NA	mg/cm^2–day	aroclor–1254	NA	mg/cm^2–day
manganese	NA	mg/cm^2–day	aroclor–1260	NA	mg/cm^2–day
mercury	NA	mg/cm^2–day	carbazole	NA	mg/cm^2–day
molybdenum	NA	mg/cm^2–day	endrin	NA	mg/cm^2–day
nickel	NA	mg/cm^2–day	2,3,7,8–tcdd	NA	mg/cm^2–day
selenium	NA	mg/cm^2–day			

References

Table H.IV-122 (continued)
Summary of Risk Characterization (chemicals)
Future Land Use with Private Ownership: On-Property Farmer (Adult)
Via Dermal Contact while Bathing

Compound	HQ Calculation CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
antimony	9.77E-07	6.00E-05	1.63E-02
arsenic	3.36E-06	2.85E-04	1.18E-02
barium	NA	6.37E-02	NA
beryllium	9.06E-08	5.00E-03	1.81E-05
boron	NA	4.50E-03	NA
cadmium	2.27E-24	5.00E-05	4.54E-20
chromium vi	NA	2.25E-03	NA
cobalt	NA	2.70E-02	NA
copper	NA	NA	NA
cyanide	NA	NA	NA
lead	NA	NA	NA
manganese	NA	4.20E-03	NA
mercury	NA	4.50E-05	NA
molybdenum	NA	1.90E-03	NA
nickel	NA	2.00E-03	NA
selenium	NA	4.00E-03	NA
silver	NA	NA	NA
thallium	NA	8.00E-05	NA
thorium-total	NA	NA	NA
uranium-total	1.43E-05	1.50E-04	9.56E-02
vanadium	NA	3.50E-04	NA
zinc	NA	7.50E-02	NA
2-methylnaphthalene	NA	NA	NA
4,4-dde	NA	NA	NA
aroclor-1221	5.86E-25	NA	NA
aroclor-1248	NA	NA	NA
aroclor-1254	NA	NA	NA
aroclor-1260	NA	NA	NA
carbazole	NA	NA	NA
endrin	NA	2.70E-04	NA
2,3,7,8-tcdd	NA	NA	NA
	HQ Summation =		1.24E-01

Compound	ILCR Calculation CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	ILCR (unitless)
antimony	9.77E-07	NA	NA
arsenic	3.36E-06	1.90E+00	6.38E-06
barium	NA	NA	NA
beryllium	9.06E-08	4.30E+00	3.90E-07
boron	NA	NA	NA
cadmium	2.27E-24	NA	NA
chromium vi	NA	NA	NA
cobalt	NA	NA	NA
copper	NA	NA	NA
cyanide	NA	NA	NA
lead	NA	NA	NA
manganese	NA	NA	NA
mercury	NA	NA	NA
molybdenum	NA	NA	NA
nickel	NA	NA	NA
selenium	NA	NA	NA
silver	NA	NA	NA
thallium	NA	NA	NA
thorium-total	NA	NA	NA
uranium-total	1.43E-05	NA	NA
vanadium	NA	NA	NA
zinc	NA	NA	NA
2-methylnaphthalene	NA	NA	NA
4,4-dde	NA	3.40E-01	NA
aroclor-1221	5.86E-25	1.03E+01	6.02E-24
aroclor-1248	NA	1.03E+01	NA
aroclor-1254	NA	1.03E+01	NA
aroclor-1260	NA	1.03E+01	NA
carbazole	NA	2.22E-02	NA
endrin	NA	NA	NA
2,3,7,8-tcdd	NA	3.00E+05	NA
	ILCR Summation =		6.76E-06

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Table H.IV–123
Summary of Intake Quantitation (chemicals)
Future Land Use with Private Ownership: On–Property Farmer (Adult)
Via Ingestion of Meat Products

Intake Equation = $\frac{CS \times EF \times ED \times FI \times IR}{BW \times AT}$

IR	Ingestion rate of meat	0.1 kg/day
FI	Fraction ingested from contaminated source	0.75 (Unitless)
EF	Exposure frequency	350 days/year
EDn	Exposure duration for non–carcinogens	70 Year
EDc	Exposure duration for carcinogens	70 Year
BW	Body weight	70 kg
ATc	Average time for carcinogens (lifetime)	25550 days
ATn	Average time for non–carcinogens (EDn x 365)	25550 days
CS	Concentration of chemicals in meat	

Chemical Concentrations

Compound	Concentration	Units	Compound	Concentration	Units
antimony	0.0E+00	mg/kg	silver	3.2E–01	mg/kg
arsenic	4.9E–02	mg/kg	thallium	1.5E–02	mg/kg
barium	1.4E–01	mg/kg	thorium–total	1.4E–05	mg/kg
beryllium	1.1E–03	mg/kg	uranium–total	9.3E–02	mg/kg
boron	2.2E+00	mg/kg	vanadium	5.0E–02	mg/kg
cadmium	4.0E–02	mg/kg	zinc	4.8E+02	mg/kg
chromium vi	8.3E–02	mg/kg	2–methylnaphthalene	2.3E–04	mg/kg
cobalt	3.4E–01	mg/kg	4,4–dde	3.8E–05	mg/kg
copper	8.0E+00	mg/kg	aroclor–1221	3.5E–26	mg/kg
cyanide	4.0E–05	mg/kg	aroclor–1248	0.0E+00	mg/kg
lead	2.6E–01	mg/kg	aroclor–1254	4.7E–03	mg/kg
manganese	6.8E+00	mg/kg	aroclor–1260	2.5E–02	mg/kg
mercury	4.0E+00	mg/kg	carbazole	3.9E–05	mg/kg
molybdenum	1.3E–01	mg/kg	endrin	0.0E+00	mg/kg
nickel	4.6E–01	mg/kg	2,3,7,8–tcdd	3.5E–09	mg/kg
selenium	1.8E–02	mg/kg			

References

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Table H.IV-123 (continued)
Summary of Risk Characterization (chemicals)
Future Land Use with Private Ownership: On-Property Farmer (Adult)
Via Ingestion of Meat Products

	HQ Calculation		
Compound	CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
antimony	NA	4.0E-04	NA
arsenic	5.0E-05	3.0E-04	1.7E-01
barium	1.4E-04	7.0E-02	2.0E-03
beryllium	1.1E-06	5.0E-03	2.2E-04
boron	2.3E-03	9.0E-02	2.5E-02
cadmium	4.1E-05	1.0E-03	4.1E-02
chromium vi	8.5E-05	5.0E-03	1.7E-02
cobalt	3.5E-04	6.0E-02	5.8E-03
copper	8.2E-03	NA	NA
cyanide	4.1E-08	2.0E-02	2.0E-06
lead	2.7E-04	NA	NA
manganese	7.0E-03	1.4E-01	5.0E-02
mercury	4.1E-03	3.0E-04	1.4E+01
molybdenum	1.3E-04	5.0E-03	2.6E-02
nickel	4.7E-04	2.0E-02	2.4E-02
selenium	1.8E-05	5.0E-03	3.6E-03
silver	3.3E-04	5.0E-03	6.5E-02
thallium	1.6E-05	8.0E-05	2.0E-01
thorium-total	1.4E-08	NA	NA
uranium-total	9.5E-05	3.0E-03	3.2E-02
vanadium	5.2E-05	7.0E-03	7.4E-03
zinc	4.9E-01	3.0E-01	1.6E+00
2-methylnaphthalene	2.4E-07	NA	NA
4,4-dde	3.9E-08	NA	NA
aroclor-1221	3.6E-29	NA	NA
aroclor-1248	NA	NA	NA
aroclor-1254	4.8E-06	NA	NA
aroclor-1260	2.5E-05	NA	NA
carbazole	4.0E-08	NA	NA
endrin	NA	3.0E-04	NA
2,3,7,8-tcdd	3.6E-12	NA	NA
	HQ Summation =		1.6E+01

	ILCR Calculation		
Compound	CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	ILCR (unitless)
antimony	NA	NA	NA
arsenic	5.0E-05	1.8E+00	8.8E-05
barium	1.4E-04	NA	NA
beryllium	1.1E-06	4.3E+00	4.7E-06
boron	2.3E-03	NA	NA
cadmium	4.1E-05	NA	NA
chromium vi	8.5E-05	NA	NA
cobalt	3.5E-04	NA	NA
copper	8.2E-03	NA	NA
cyanide	4.1E-08	NA	NA
lead	2.7E-04	NA	NA
manganese	7.0E-03	NA	NA
mercury	4.1E-03	NA	NA
molybdenum	1.3E-04	NA	NA
nickel	4.7E-04	NA	NA
selenium	1.8E-05	NA	NA
silver	3.3E-04	NA	NA
thallium	1.6E-05	NA	NA
thorium-total	1.4E-08	NA	NA
uranium-total	9.5E-05	NA	NA
vanadium	5.2E-05	NA	NA
zinc	4.9E-01	NA	NA
2-methylnaphthalene	2.4E-07	NA	NA
4,4-dde	3.9E-08	3.4E-01	1.3E-08
aroclor-1221	3.6E-29	7.7E+00	2.8E-28
aroclor-1248	NA	7.7E+00	NA
aroclor-1254	4.8E-06	7.7E+00	3.7E-05
aroclor-1260	2.5E-05	7.7E+00	1.9E-04
carbazole	4.0E-08	2.0E-02	8.0E-10
endrin	NA	NA	NA
2,3,7,8-tcdd	3.6E-12	1.5E+05	5.4E-07
	ILCR Summation =		3.2E-04

Table H.IV–124
Summary of Intake and Risk Quantitation (radionuclides)
Future Land Use with Private Ownership: On–Property Farmer (Adult)
Via Ingestion of Meat Products

Intake Equation = Cf X EF X EDn X FI X IR

IR	Ingestion rate of meat	0.1 kg/day
FI	Fraction ingested from contaminated source	0.75 (Unitless)
EF	Exposure frequency	350 days/year
EDn	Exposure duration	70 Year
Cf	Concentration of radionuclides in meat	

Cs_{137+1d}	7.1E+01	pCi/kg	Rn_{222+4d}	ERR	pCi/kg
Pb_{210+2d}	8.3E−01	pCi/kg	Sr_{90+1d}	6.3E+01	pCi/kg
Np_{237+1d}	9.1E−03	pCi/kg	Tc_{99}	3.2E+04	pCi/kg
Pu_{238}	2.7E−05	pCi/kg	Th_{228+7d}	3.8E−04	pCi/kg
Pu_{239}	6.4E−06	pCi/kg	Th_{230}	1.0E−03	pCi/kg
Pu_{240}	2.3E−05	pCi/kg	$Th_{232+10d}$	6.1E−04	pCi/kg
Pa_{231}	2.0E−05	pCi/kg	U_{234}	4.7E+00	pCi/kg
Ra_{226+8d}	2.4E−01	pCi/kg	U_{235+1d}	1.3E−01	pCi/kg
Ra_{228+1d}	3.4E−01	pCi/kg	U_{236}	5.2E−02	pCi/kg
Ru_{106}	3.6E−01	pCi/kg	U_{238+2d}	2.8E+00	pCi/kg

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	ILCR (unitless)
Cs_{137+1d}	1.3E+05	2.8E−11	3.7E−06
Pb_{210+2d}	1.5E+03	6.6E−10	1.0E−06
Np_{237+1d}	1.7E+01	2.2E−10	3.7E−09
Pu_{238}	4.9E−02	2.2E−10	1.1E−11
Pu_{239}	1.2E−02	2.3E−10	2.7E−12
Pu_{240}	4.3E−02	2.3E−10	9.8E−12
Pa_{231}	3.7E−02	9.2E−11	3.4E−12
Ra_{226+8d}	4.4E+02	7.8E−10	3.5E−07
Ra_{228+1d}	6.2E+02	1.0E−10	6.2E−08
Ru_{106}	6.6E+02	9.5E−12	6.3E−09
Rn_{222+4d}	NA	1.7E−12	NA
Sr_{90+1d}	1.2E+05	3.6E−11	4.2E−06
Tc_{99}	5.9E+07	1.3E−12	7.7E−05
Th_{228+7d}	6.9E−01	5.5E−11	3.8E−11
Th_{230}	1.9E+00	1.3E−11	2.5E−11
$Th_{232+10d}$	1.1E+00	1.7E−10	1.9E−10
U_{234}	8.7E+03	1.6E−11	1.4E−07
U_{235+1d}	2.3E+02	1.6E−11	3.7E−09
U_{236}	9.5E+01	1.5E−11	1.4E−09
U_{238+2d}	5.2E+03	2.0E−11	1.0E−07
		ILCR Summation =	8.6E−05

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Table H.IV–125
Summary of Intake Quantitation (chemicals)
Future Land Use with Private Ownership: On–Property Farmer (Adult)
Via Ingestion of Dairy Products

Intake Equation = $\frac{CS \times EF \times ED \times FI \times IR}{BW \times AT}$

IR	Ingestion rate of dairy products	0.4 l/day
FI	Fraction ingested from contaminated source	0.75 (Unitless)
EF	Exposure frequency	350 days/year
EDn	Exposure duration for non–carcinogens	70 Year
EDc	Exposure duration for carcinogens	70 Year
BW	Body weight	70 kg
ATc	Average time for carcinogens (lifetime)	25550 days
ATn	Average time for non–carcinogens (EDn x 365)	25550 days
CS	Concentration of chemicals in animal products	

Chemical Concentrations

Compound	Concentration	Units	Compound	Concentration	Units
antimony	0.0E+00	mg/kg	silver	2.1E+00	mg/kg
arsenic	1.6E–03	mg/kg	thallium	7.2E–04	mg/kg
barium	3.2E–01	mg/kg	thorium–total	1.4E–04	mg/kg
beryllium	1.2E–06	mg/kg	uranium–total	6.0E–01	mg/kg
boron	4.1E+00	mg/kg	vanadium	4.0E–04	mg/kg
cadmium	7.1E–02	mg/kg	zinc	4.8E+01	mg/kg
chromium vi	2.4E–02	mg/kg	2–methylnaphthalene	7.7E–05	mg/kg
cobalt	3.3E–02	mg/kg	4,4–dde	1.9E–05	mg/kg
copper	1.2E+00	mg/kg	aroclor–1221	1.3E–26	mg/kg
cyanide	1.2E–05	mg/kg	aroclor–1248	0.0E+00	mg/kg
lead	2.6E–01	mg/kg	aroclor–1254	3.6E–03	mg/kg
manganese	6.0E+00	mg/kg	aroclor–1260	1.5E–02	mg/kg
mercury	7.2E–03	mg/kg	carbazole	1.3E–05	mg/kg
molybdenum	3.2E–02	mg/kg	endrin	0.0E+00	mg/kg
nickel	7.7E–02	mg/kg	2,3,7,8–tcdd	4.0E–09	mg/kg
selenium	4.9E–03	mg/kg			

References

Table H.IV-125 (continued)
Summary of Risk Characterization (chemicals)
Future Land Use with Private Ownership: On-Property Farmer (Adult)
Via Ingestion of Dairy Products

	HQ Calculation		
Compound	CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
antimony	NA	4.0E-04	NA
arsenic	6.7E-06	3.0E-04	2.2E-02
barium	1.3E-03	7.0E-02	1.9E-02
beryllium	5.0E-09	5.0E-03	1.0E-06
boron	1.7E-02	9.0E-02	1.9E-01
cadmium	2.9E-04	1.0E-03	2.9E-01
chromium vi	9.9E-05	5.0E-03	2.0E-02
cobalt	1.4E-04	6.0E-02	2.3E-03
copper	5.0E-03	NA	NA
cyanide	5.1E-08	2.0E-02	2.6E-06
lead	1.1E-03	NA	NA
manganese	2.5E-02	1.4E-01	1.8E-01
mercury	2.9E-05	3.0E-04	9.8E-02
molybdenum	1.3E-04	5.0E-03	2.6E-02
nickel	3.2E-04	2.0E-02	1.6E-02
selenium	2.0E-05	5.0E-03	4.0E-03
silver	8.7E-03	5.0E-03	1.7E+00
thallium	3.0E-06	8.0E-05	3.7E-02
thorium-total	6.0E-07	NA	NA
uranium-total	2.5E-03	3.0E-03	8.2E-01
vanadium	1.6E-06	7.0E-03	2.4E-04
zinc	2.0E-01	3.0E-01	6.5E-01
2-methylnaphthalene	3.1E-07	NA	NA
4,4-dde	7.6E-08	NA	NA
aroclor-1221	5.5E-29	NA	NA
aroclor-1248	NA	NA	NA
aroclor-1254	1.5E-05	NA	NA
aroclor-1260	6.1E-05	NA	NA
carbazole	5.2E-08	NA	NA
endrin	NA	3.0E-04	NA
2,3,7,8-tcdd	1.6E-11	NA	NA
	HQ Summation =		4.1E+00

	ILCR Calculation		
Compound	CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	ILCR (unitless)
antimony	NA	NA	NA
arsenic	6.7E-06	1.8E+00	1.2E-05
barium	1.3E-03	NA	NA
beryllium	5.0E-09	4.3E+00	2.1E-08
boron	1.7E-02	NA	NA
cadmium	2.9E-04	NA	NA
chromium vi	9.9E-05	NA	NA
cobalt	1.4E-04	NA	NA
copper	5.0E-03	NA	NA
cyanide	5.1E-08	NA	NA
lead	1.1E-03	NA	NA
manganese	2.5E-02	NA	NA
mercury	2.9E-05	NA	NA
molybdenum	1.3E-04	NA	NA
nickel	3.2E-04	NA	NA
selenium	2.0E-05	NA	NA
silver	8.7E-03	NA	NA
thallium	3.0E-06	NA	NA
thorium-total	6.0E-07	NA	NA
uranium-total	2.5E-03	NA	NA
vanadium	1.6E-06	NA	NA
zinc	2.0E-01	NA	NA
2-methylnaphthalene	3.1E-07	NA	NA
4,4-dde	7.6E-08	3.4E-01	2.6E-08
aroclor-1221	5.5E-29	7.7E+00	4.2E-28
aroclor-1248	NA	7.7E+00	NA
aroclor-1254	1.5E-05	7.7E+00	1.1E-04
aroclor-1260	6.1E-05	7.7E+00	4.7E-04
carbazole	5.2E-08	2.0E-02	1.0E-09
endrin	NA	NA	NA
2,3,7,8-tcdd	1.6E-11	1.5E+05	2.4E-06
	ILCR Summation =		6.0E-04

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Table H.IV–126
Summary of Intake and Risk Quantitation (radionuclides)
Future Land Use with Private Ownership: On–Property Farmer (Adult)
Via Ingestion of Dairy Products

Intake Equation = Cp X EF X EDn X FI X IR

IR	Ingestion rate of dairy products	0.4 l/day
FI	Fraction ingested from contaminated source	0.75 (Unitless)
EF	Exposure frequency	350 days/year
EDn	Exposure duration	70 Year
Cp	Concentration of radionuclides in animal products	

Cs_{137+1d}	2.5E+01	pCi/kg	Rn_{222+4d}	ERR	pCi/kg
Pb_{210+2d}	8.5E−01	pCi/kg	Sr_{90+1d}	3.2E+02	pCi/kg
Np_{237+1d}	1.5E−03	pCi/kg	Tc_{99}	3.8E+04	pCi/kg
Pu_{238}	1.2E−04	pCi/kg	Th_{228+7d}	4.1E−03	pCi/kg
Pu_{239}	3.0E−05	pCi/kg	Th_{230}	1.1E−02	pCi/kg
Pu_{240}	1.1E−04	pCi/kg	$Th_{232+10d}$	6.4E−03	pCi/kg
Pa_{231}	4.0E−02	pCi/kg	U_{234}	2.8E+01	pCi/kg
Ra_{226+8d}	7.2E−01	pCi/kg	U_{235+1d}	7.4E−01	pCi/kg
Ra_{228+1d}	1.0E+00	pCi/kg	U_{236}	3.1E−01	pCi/kg
Ru_{106}	1.7E−04	pCi/kg	U_{238+2d}	1.7E+01	pCi/kg

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	ILCR (unitless)
Cs_{137+1d}	1.8E+05	2.8E−11	5.1E−06
Pb_{210+2d}	6.2E+03	6.6E−10	4.1E−06
Np_{237+1d}	1.1E+01	2.2E−10	2.5E−09
Pu_{238}	8.9E−01	2.2E−10	2.0E−10
Pu_{239}	2.2E−01	2.3E−10	5.0E−11
Pu_{240}	7.9E−01	2.3E−10	1.8E−10
Pa_{231}	2.9E+02	9.2E−11	2.7E−08
Ra_{226+8d}	5.3E+03	7.8E−10	4.1E−06
Ra_{228+1d}	7.5E+03	1.0E−10	7.5E−07
Ru_{106}	1.2E+00	9.5E−12	1.2E−11
Rn_{222+4d}	NA	1.7E−12	NA
Sr_{90+1d}	2.3E+06	3.6E−11	8.4E−05
Tc_{99}	2.8E+08	1.3E−12	3.7E−04
Th_{228+7d}	3.0E+01	5.5E−11	1.7E−09
Th_{230}	8.0E+01	1.3E−11	1.0E−09
$Th_{232+10d}$	4.7E+01	1.7E−10	8.0E−09
U_{234}	2.0E+05	1.6E−11	3.3E−06
U_{235+1d}	5.4E+03	1.6E−11	8.7E−08
U_{236}	2.2E+03	1.5E−11	3.4E−08
U_{238+2d}	1.2E+05	2.0E−11	2.4E−06
		ILCR Summation =	4.7E−04

Table H.IV-127
Summary of Intake Quantitation (chemicals)
Future Land Use with Private Ownership: On-Property Farmer (Adult)
Via Ingestion of Vegetables and Fruits

Intake Equation = $\frac{CS \times EF \times ED \times FI \times IR}{BW \times AT}$

IR	Ingestion rate of fruits or vegetables	0.122 kg/day
FI	Fraction ingested from contaminated source	0.5 (Unitless)
EF	Exposure frequency	350 days/year
EDn	Exposure duration for non-carcinogens	70 Year
EDc	Exposure duration for carcinogens	70 Year
BW	Body weight	70 kg
ATc	Average time for carcinogens (lifetime)	25550 days
ATn	Average time for non-carcinogens (EDn x 365)	25550 days
CS	Concentration of chemicals in vegetables	

Chemical Concentrations

Compound	Concentration	Units	Compound	Concentration	Units
antimony	0.0E+00	mg/kg	silver	2.4E+00	mg/kg
arsenic	2.2E-01	mg/kg	thallium	2.2E-03	mg/kg
barium	1.5E+01	mg/kg	thorium-total	2.7E-04	mg/kg
beryllium	8.1E-03	mg/kg	uranium-total	8.9E-01	mg/kg
boron	4.5E+02	mg/kg	vanadium	1.4E-01	mg/kg
cadmium	1.9E+00	mg/kg	zinc	9.6E+01	mg/kg
chromium vi	1.2E-01	mg/kg	2-methylnaphthalene	2.8E-06	mg/kg
cobalt	2.4E-01	mg/kg	4,4-dde	5.2E-09	mg/kg
copper	8.1E+00	mg/kg	aroclor-1221	1.2E-23	mg/kg
cyanide	6.1E+00	mg/kg	aroclor-1248	0.0E+00	mg/kg
lead	1.1E+00	mg/kg	aroclor-1254	5.5E-06	mg/kg
manganese	2.4E+02	mg/kg	aroclor-1260	2.0E-06	mg/kg
mercury	1.9E-01	mg/kg	carbazole	1.1E-07	mg/kg
molybdenum	3.9E-01	mg/kg	endrin	0.0E+00	mg/kg
nickel	1.4E+00	mg/kg	2,3,7,8-tcdd	5.3E-13	mg/kg
selenium	1.6E-02	mg/kg			

References

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Table H.IV–127 (continued)
Summary of Risk Characterization (chemicals)
Future Land Use with Private Ownership: On–Property Farmer (Adult)
Via Ingestion of Vegetables and Fruits

	HQ Calculation		
Compound	CDI (mg/kg–day)	RfD (mg/kg–day)	HQ (unitless)
antimony	NA	4.0E–04	NA
arsenic	1.9E–04	3.0E–04	6.3E–01
barium	1.2E–02	7.0E–02	1.7E–01
beryllium	6.8E–06	5.0E–03	1.4E–03
boron	3.7E–01	9.0E–02	4.2E+00
cadmium	1.6E–03	1.0E–03	1.6E+00
chromium vi	1.0E–04	5.0E–03	2.1E–02
cobalt	2.0E–04	6.0E–02	3.4E–03
copper	6.8E–03	NA	NA
cyanide	5.1E–03	2.0E–02	2.5E–01
lead	8.9E–04	NA	NA
manganese	2.0E–01	1.4E–01	1.5E+00
mercury	1.6E–04	3.0E–04	5.4E–01
molybdenum	3.3E–04	5.0E–03	6.5E–02
nickel	1.1E–03	2.0E–02	5.7E–02
selenium	1.3E–05	5.0E–03	2.6E–03
silver	2.0E–03	5.0E–03	4.0E–01
thallium	1.9E–06	8.0E–05	2.3E–02
thorium–total	2.3E–07	NA	NA
uranium–total	7.5E–04	3.0E–03	2.5E–01
vanadium	1.2E–04	7.0E–03	1.7E–02
zinc	8.0E–02	3.0E–01	2.7E–01
2–methylnaphthalene	2.4E–09	NA	NA
4,4–dde	4.3E–12	NA	NA
aroclor–1221	9.7E–27	NA	NA
aroclor–1248	NA	NA	NA
aroclor–1254	4.6E–09	NA	NA
aroclor–1260	1.7E–09	NA	NA
carbazole	8.9E–11	NA	NA
endrin	NA	3.0E–04	NA
2,3,7,8–tcdd	4.4E–16	NA	NA
	HQ Summation =		9.9E+00

	ILCR Calculation		
Compound	CDI (mg/kg–day)	CSF $(mg/kg–day)^{-1}$	ILCR (unitless)
antimony	NA	NA	NA
arsenic	1.9E–04	1.8E+00	3.3E–04
barium	1.2E–02	NA	NA
beryllium	6.8E–06	4.3E+00	2.9E–05
boron	3.7E–01	NA	NA
cadmium	1.6E–03	NA	NA
chromium vi	1.0E–04	NA	NA
cobalt	2.0E–04	NA	NA
copper	6.8E–03	NA	NA
cyanide	5.1E–03	NA	NA
lead	8.9E–04	NA	NA
manganese	2.0E–01	NA	NA
mercury	1.6E–04	NA	NA
molybdenum	3.3E–04	NA	NA
nickel	1.1E–03	NA	NA
selenium	1.3E–05	NA	NA
silver	2.0E–03	NA	NA
thallium	1.9E–06	NA	NA
thorium–total	2.3E–07	NA	NA
uranium–total	7.5E–04	NA	NA
vanadium	1.2E–04	NA	NA
zinc	8.0E–02	NA	NA
2–methylnaphthalene	2.4E–09	NA	NA
4,4–dde	4.3E–12	3.4E–01	1.5E–12
aroclor–1221	9.7E–27	7.7E+00	7.4E–26
aroclor–1248	NA	7.7E+00	NA
aroclor–1254	4.6E–09	7.7E+00	3.6E–08
aroclor–1260	1.7E–09	7.7E+00	1.3E–08
carbazole	8.9E–11	2.0E–02	1.8E–12
endrin	NA	NA	NA
2,3,7,8–tcdd	4.4E–16	1.5E+05	6.6E–11
	ILCR Summation =		3.6E–04

Table H.IV–128
Summary of Intake and Risk Quantitation (radionuclides)
Future Land Use with Private Ownership: On–Property Farmer (Adult)
Via Ingestion of Vegetables and Fruits

Intake Equation = Cv X EF X EDn X FI X IR

IR	Ingestion rate of fruits or vegetables	0.122 kg/day
FI	Fraction ingested from contaminated source	0.5 (Unitless)
EF	Exposure frequency	350 days/year
EDn	Exposure duration	70 Year
Cv	Concentration of radionuclides in vegetables	

Cs_{137+1d}	6.3E+01	pCi/kg	Rn_{222+4d}	ERR	pCi/kg
Pb_{210+2d}	2.1E−02	pCi/kg	Sr_{90+1d}	1.2E−02	pCi/kg
Np_{237+1d}	2.8E+00	pCi/kg	Tc_{99}	3.3E+04	pCi/kg
Pu_{238}	1.4E−02	pCi/kg	Th_{228+7d}	1.0E−03	pCi/kg
Pu_{239}	1.2E−03	pCi/kg	Th_{230}	4.7E−03	pCi/kg
Pu_{240}	4.4E−03	pCi/kg	$Th_{232+10d}$	3.6E−03	pCi/kg
Pa_{231}	1.2E−03	pCi/kg	U_{234}	5.0E+02	pCi/kg
Ra_{226+8d}	1.2E+00	pCi/kg	U_{235+1d}	1.3E+01	pCi/kg
Ra_{228+1d}	1.3E−03	pCi/kg	U_{236}	5.5E+00	pCi/kg
Ru_{106}	5.3E−04	pCi/kg	U_{238+2d}	3.0E+02	pCi/kg

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	ILCR (unitless)
Cs_{137+1d}	9.5E+04	2.8E−11	2.7E−06
Pb_{210+2d}	3.2E+01	6.6E−10	2.1E−08
Np_{237+1d}	4.2E+03	2.2E−10	9.1E−07
Pu_{238}	2.2E+01	2.2E−10	4.8E−09
Pu_{239}	1.8E+00	2.3E−10	4.2E−10
Pu_{240}	6.6E+00	2.3E−10	1.5E−09
Pa_{231}	1.8E+00	9.2E−11	1.7E−10
Ra_{226+8d}	1.8E+03	7.8E−10	1.4E−06
Ra_{228+1d}	1.9E+00	1.0E−10	1.9E−10
Ru_{106}	7.9E−01	9.5E−12	7.5E−12
Rn_{222+4d}	NA	1.7E−12	NA
Sr_{90+1d}	1.8E+01	3.6E−11	6.4E−10
Tc_{99}	5.0E+07	1.3E−12	6.5E−05
Th_{228+7d}	1.5E+00	5.5E−11	8.2E−11
Th_{230}	7.0E+00	1.3E−11	9.0E−11
$Th_{232+10d}$	5.4E+00	1.7E−10	9.2E−10
U_{234}	7.5E+05	1.6E−11	1.2E−05
U_{235+1d}	2.0E+04	1.6E−11	3.2E−07
U_{236}	8.2E+03	1.5E−11	1.2E−07
U_{238+2d}	4.5E+05	2.0E−11	9.0E−06
		ILCR Summation =	9.1E−05

Table H.IV–129
Summary of Intake and Risk Quantitation (radionuclides)
Future Land Use with Private Ownership: On–Property Farmer (Adult)
Via External Radiation

Dose Equivalency Equat = $[DR \times EF \times EDn \times ET_i \times (1-SH_i)] + [DR \times EF \times EDn \times ET_o \times (1-SH_o)]$

EF	Fraction of year spent exposured	0.96 (unitless)
ED	Exposure duration	70 Year
ET_i	Fraction of day spent indoors	0.24 (unitless)
ET_o	Fraction of day spent outdoors	0.76 (unitless)
SH_i	Shield factor indoors	0.5 (unitless)
SH_o	Shield factor outdoors	0 (unitless)
DR	Radionuclide specific dose concentrations	(see table below)

Cs_{137+1d}	7.93E–01	pCi/g	Rn_{222+4d}	NA	pCi/g
Pb_{210+2d}	1.05E–06	pCi/g	Sr_{90+1d}	8.33E–07	pCi/g
Np_{237+1d}	8.36E–08	pCi/g	Tc_{99}	1.87E–06	pCi/g
Pu_{238}	9.07E–08	pCi/g	Th_{228+7d}	4.00E–07	pCi/g
Pu_{239}	1.25E–08	pCi/g	Th_{230}	5.92E–08	pCi/g
Pu_{240}	4.55E–08	pCi/g	$Th_{232+10d}$	5.95E–07	pCi/g
Pa_{231}	NA	pCi/g	U_{234}	2.06E–05	pCi/g
Ra_{226+8d}	3.99E–07	pCi/g	U_{235+1d}	9.34E–07	pCi/g
Ra_{228+1d}	7.00E–07	pCi/g	U_{236}	6.86E–06	pCi/g
Ru_{106}	1.33E–07	pCi/g	U_{238+2d}	1.38E–05	pCi/g

Radionuclides	CDI (year pCi/g)	CSF $(g/pCi-year)^{-1}$	ILCR (unitless)
Cs_{137+1d}	4.7E+01	2.0E–06	9.4E–05
Pb_{210+2d}	6.2E–05	1.6E–10	9.9E–15
Np_{237+1d}	4.9E–06	4.3E–07	2.1E–12
Pu_{238}	5.4E–06	2.8E–11	1.5E–16
Pu_{239}	7.4E–07	1.7E–11	1.3E–17
Pu_{240}	2.7E–06	2.7E–11	7.3E–17
Pa_{231}	NA	2.6E–08	NA
Ra_{226+8d}	2.4E–05	6.0E–06	1.4E–10
Ra_{228+1d}	4.1E–05	2.9E–06	1.2E–10
Ru_{106}	7.9E–06	NA	0.0E+00
Rn_{222+4d}	NA	5.9E–06	NA
Sr_{90+1d}	4.9E–05	NA	0.0E+00
Tc_{99}	1.1E–04	6.0E–13	6.6E–17
Th_{228+7d}	2.4E–05	5.6E–06	1.3E–10
Th_{230}	3.5E–06	5.4E–11	1.9E–16
$Th_{232+10d}$	3.5E–05	8.5E–06	3.0E–10
U_{234}	1.2E–03	3.0E–11	3.7E–14
U_{235+1d}	5.5E–05	2.4E–07	1.3E–11
U_{236}	4.1E–04	2.4E–11	9.7E–15
U_{238+2d}	8.2E–04	5.1E–08	4.2E–11
		ILCR Summation =	9.4E–05

Table H.IV–130
Summary of Intake Quantitation (chemicals)
Future Land Use with Private Ownership: On–Property Farmer (Child)
Via Inhalation of Particulates

Intake Equation = $\frac{CS \times EF \times ED \times IR}{BW \times AT}$

IR	Inhalation rate of gases (RAGS, 1989)	12 m^3/day
EF	Exposure frequency	350 days/year
EDn	Exposure duration for non–carcinogens	6 Year
EDc	Exposure duration for carcinogens	6 Year
BW	Body weight	15 kg
ATc	Average time for carcinogens (lifetime)	25550 days
ATn	Average time for non–carcinogens (EDn x 365)	2190 days
CS	Concentration of chemicals in soil	(see table below)

Chemical Concentrations

Compound	Concentration	Units	Compound	Concentration	Units
antimony	9.2E–09	mg/m^3	silver	4.5E–09	mg/m^3
arsenic	1.0E–08	mg/m^3	thallium	3.4E–10	mg/m^3
barium	1.3E–07	mg/m^3	thorium–total	2.1E–07	mg/m^3
beryllium	1.1E–09	mg/m^3	uranium–total	3.5E–06	mg/m^3
boron	9.0E–09	mg/m^3	vanadium	2.0E–08	mg/m^3
cadmium	2.9E–09	mg/m^3	zinc	6.2E–08	mg/m^3
chromium vi	1.8E–08	mg/m^3	2–methylnaphthalene	2.5E–10	mg/m^3
cobalt	7.7E–09	mg/m^3	4,4–dde	5.3E–12	mg/m^3
copper	4.8E–08	mg/m^3	aroclor–1221	0.0E+00	mg/m^3
cyanide	5.1E–10	mg/m^3	aroclor–1248	0.0E+00	mg/m^3
lead	1.3E–06	mg/m^3	aroclor–1254	1.5E–09	mg/m^3
manganese	4.3E–10	mg/m^3	aroclor–1260	4.1E–10	mg/m^3
mercury	4.3E–10	mg/m^3	carbazole	1.1E–10	mg/m^3
molybdenum	5.8E–09	mg/m^3	endrin	0.0E+00	mg/m^3
nickel	1.9E–08	mg/m^3	2,3,7,8–tcdd	5.4E–16	mg/m^3
selenium	7.6E–10	mg/m^3			

References

Table H.IV-130 (continued)
Summary of Risk Characterization (chemicals)
Future Land Use with Private Ownership: On-Property Farmer (Child)
Via Inhalation of Particulates

	HQ Calculation		
Compound	CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
antimony	7.0E-09	NA	NA
arsenic	7.6E-09	NA	NA
barium	1.0E-07	1.4E-04	7.0E-04
beryllium	8.1E-10	NA	NA
boron	6.9E-09	5.7E-03	1.2E-06
cadmium	2.2E-09	NA	NA
chromium vi	1.4E-08	NA	NA
cobalt	5.9E-09	3.0E-07	2.0E-02
copper	3.7E-08	NA	NA
cyanide	3.9E-10	NA	NA
lead	9.6E-07	NA	NA
manganese	3.3E-10	1.4E-05	2.4E-05
mercury	3.3E-10	8.6E-05	3.9E-06
molybdenum	4.5E-09	NA	NA
nickel	1.5E-08	NA	NA
selenium	5.8E-10	NA	NA
silver	3.4E-09	NA	NA
thallium	2.6E-10	NA	NA
thorium-total	1.6E-07	NA	NA
uranium-total	2.7E-06	NA	NA
vanadium	1.5E-08	NA	NA
zinc	4.7E-08	NA	NA
2-methylnaphthalene	1.9E-10	NA	NA
4,4-dde	4.1E-12	NA	NA
aroclor-1221	NA	NA	NA
aroclor-1248	NA	NA	NA
aroclor-1254	1.2E-09	NA	NA
aroclor-1260	3.1E-10	NA	NA
carbazole	8.1E-11	NA	NA
endrin	NA	NA	NA
2,3,7,8-tcdd	4.1E-16	NA	NA
	Hazard Quotient Sum =		2.0E-02

	ILCR Calculation		
Compound	CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	ILCR (unitless)
antimony	6.0E-10	NA	NA
arsenic	6.5E-10	1.5E+01	9.8E-09
barium	8.6E-09	NA	NA
beryllium	7.0E-11	8.4E+00	5.9E-10
boron	5.9E-10	NA	NA
cadmium	1.9E-10	6.3E+00	1.2E-09
chromium vi	1.2E-09	4.1E+01	4.9E-08
cobalt	5.1E-10	NA	NA
copper	3.2E-09	NA	NA
cyanide	3.3E-11	NA	NA
lead	8.2E-08	NA	NA
manganese	2.8E-11	NA	NA
mercury	2.8E-11	NA	NA
molybdenum	3.8E-10	NA	NA
nickel	1.2E-09	8.4E-01	1.0E-09
selenium	5.0E-11	NA	NA
silver	2.9E-10	NA	NA
thallium	2.2E-11	NA	NA
thorium-total	1.4E-08	NA	NA
uranium-total	2.3E-07	NA	NA
vanadium	1.3E-09	NA	NA
zinc	4.0E-09	NA	NA
2-methylnaphthalene	1.7E-11	NA	NA
4,4-dde	3.5E-13	NA	NA
aroclor-1221	NA	NA	NA
aroclor-1248	NA	NA	NA
aroclor-1254	1.0E-10	NA	NA
aroclor-1260	2.7E-11	NA	NA
carbazole	6.9E-12	NA	NA
endrin	NA	NA	NA
2,3,7,8-tcdd	3.6E-17	1.5E+05	5.3E-12
	ILCR Summation =		6.2E-08

Table H.IV–131
Summary of Intake and Risk Quantitation (radionuclides)
Future Land Use with Private Ownership: On–Property Farmer (Child)
Via Inhalation of Gases and Particulates

Intake Equation = Ca X EF X EDn X IR

IR	Inhalation rate of gases (RAGS, 1989)	12 m^3/day
EF	Exposure frequency	350 days/year
EDn	Exposure duration	6 Year
Ca	Concentration of radionuclides in air	(see table below)

Cs_{137+1d}	5.7E–07	pCi/m^3	Rn_{222+4d}	1.3E+01	pCi/m^3
Pb_{210+2d}	1.6E–05	pCi/m^3	Sr_{90+1d}	1.8E–06	pCi/m^3
Np_{237+1d}	4.4E–07	pCi/m^3	Tc_{99}	3.3E–05	pCi/m^3
Pu_{238}	1.5E–05	pCi/m^3	Th_{228+7d}	1.0E–06	pCi/m^3
Pu_{239}	1.2E–06	pCi/m^3	Th_{230}	3.7E–06	pCi/m^3
Pu_{240}	4.3E–06	pCi/m^3	$Th_{232+10d}$	2.8E–06	pCi/m^3
Pa_{231}	1.2E–06	pCi/m^3	U_{234}	5.1E–05	pCi/m^3
Ra_{226+8d}	9.3E–07	pCi/m^3	U_{235+1d}	1.3E–06	pCi/m^3
Ra_{228+1d}	1.2E–06	pCi/m^3	U_{236}	5.5E–07	pCi/m^3
Ru_{106}	5.4E–07	pCi/m^3	U_{238+2d}	3.0E–05	pCi/m^3

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	ILCR (unitless)
Cs_{137+1d}	1.4E–02	1.9E–11	2.7E–13
Pb_{210+2d}	3.9E–01	4.0E–09	1.6E–09
Np_{237+1d}	1.1E–02	2.9E–08	3.2E–10
Pu_{238}	3.7E–01	3.9E–08	1.4E–08
Pu_{239}	3.0E–02	3.8E–08	1.1E–09
Pu_{240}	1.1E–01	3.8E–08	4.2E–09
Pa_{231}	2.9E–02	3.6E–08	1.1E–09
Ra_{226+8d}	2.3E–02	7.0E–09	1.6E–10
Ra_{228+1d}	3.1E–02	6.9E–10	2.2E–11
Ru_{106}	1.3E–02	4.4E–10	5.9E–12
Rn_{222+4d}	3.2E+05	7.7E–12	2.5E–06
Sr_{90+1d}	4.6E–02	6.2E–11	2.8E–12
Tc_{99}	8.3E–01	8.3E–12	6.9E–12
Th_{228+7d}	2.6E–02	7.8E–08	2.0E–09
Th_{230}	9.2E–02	2.9E–08	2.7E–09
$Th_{232+10d}$	7.1E–02	1.1E–07	7.8E–09
U_{234}	1.3E+00	2.6E–08	3.3E–08
U_{235+1d}	3.4E–02	2.5E–08	8.4E–10
U_{236}	1.4E–02	2.5E–08	3.5E–10
U_{238+2d}	7.6E–01	2.4E–08	1.8E–08
		ILCR Summation =	2.6E–06

Table H.IV–132
Summary of Intake Quantitation (chemicals)
Future Land Use with Private Ownership: On–Property Farmer (Child)
Via Incidental Ingestion of Soil

Intake Equation = $\frac{CS \times EF \times ED \times CF \times IR}{BW \times AT}$

IRs	Ingestion rate of soil (RAGS, 1989)	200 mg/day
CF	Conversion factor	1.0E–06 kg/mg
EF	Exposure frequency	350 days/year
EDn	Exposure duration for non–carcinogens	6 Year
EDc	Exposure duration for carcinogens	6 Year
BW	Body weight	15 kg
ATc	Average time for carcinogens (lifetime)	25550 days
ATn	Average time for non–carcinogens (EDn x 365)	2190 days
CS	Concentration of chemicals in soil	(see table below)

Chemical Concentrations

Compound	Concentration	Units	Compound	Concentration	Units
antimony	5.4E+00	mg/kg	silver	6.0E+00	mg/kg
arsenic	5.1E+00	mg/kg	thallium	5.6E–01	mg/kg
barium	9.7E+01	mg/kg	thorium–total	0.0E+00	mg/kg
beryllium	7.6E–01	mg/kg	uranium–total	0.0E+00	mg/kg
boron	1.1E+02	mg/kg	vanadium	2.6E+01	mg/kg
cadmium	3.5E+00	mg/kg	zinc	6.4E+01	mg/kg
chromium vi	1.6E+01	mg/kg	2–methylnaphthalene	0.0E+00	mg/kg
cobalt	1.2E+01	mg/kg	4,4–dde	0.0E+00	mg/kg
copper	2.0E+01	mg/kg	aroclor–1221	0.0E+00	mg/kg
cyanide	2.5E–01	mg/kg	aroclor–1248	0.0E+00	mg/kg
lead	2.4E+01	mg/kg	aroclor–1254	0.0E+00	mg/kg
manganese	9.8E+02	mg/kg	aroclor–1260	0.0E+00	mg/kg
mercury	2.1E–01	mg/kg	carbazole	0.0E+00	mg/kg
molybdenum	6.5E+00	mg/kg	endrin	0.0E+00	mg/kg
nickel	2.3E+01	mg/kg	2,3,7,8–tcdd	0.0E+00	mg/kg
selenium	6.3E–01	mg/kg			

References

Table H.IV–132 (continued)
Summary of Risk Characterization (chemicals)
Future Land Use with Private Ownership: On–Property Farmer (Child)
Via Incidental Ingestion of Soil

	HQ Calculation		
Compound	CDI (mg/kg–day)	RfD (mg/kg–day)	HQ (unitless)
antimony	6.8E–05	4.0E–04	1.7E–01
arsenic	6.5E–05	3.0E–04	2.2E–01
barium	1.2E–03	7.0E–02	1.8E–02
beryllium	9.7E–06	5.0E–03	1.9E–03
boron	1.4E–03	9.0E–02	1.6E–02
cadmium	4.4E–05	1.0E–03	4.4E–02
chromium vi	2.1E–04	5.0E–03	4.2E–02
cobalt	1.5E–04	6.0E–02	2.6E–03
copper	2.6E–04	NA	NA
cyanide	3.2E–06	2.0E–02	1.6E–04
lead	3.0E–04	NA	NA
manganese	1.2E–02	1.4E–01	8.9E–02
mercury	2.7E–06	3.0E–04	9.1E–03
molybdenum	8.3E–05	5.0E–03	1.7E–02
nickel	2.9E–04	2.0E–02	1.4E–02
selenium	8.1E–06	5.0E–03	1.6E–03
silver	7.7E–05	5.0E–03	1.5E–02
thallium	7.1E–06	8.0E–05	8.9E–02
thorium–total	NA	NA	NA
uranium–total	NA	3.0E–03	0.0E+00
vanadium	3.3E–04	7.0E–03	4.7E–02
zinc	8.2E–04	3.0E–01	2.7E–03
2–methylnaphthalene	NA	NA	NA
4,4–dde	NA	NA	NA
aroclor–1221	NA	NA	NA
aroclor–1248	NA	NA	NA
aroclor–1254	NA	NA	NA
aroclor–1260	NA	NA	NA
carbazole	NA	NA	NA
endrin	NA	3.0E–04	0.0E+00
2,3,7,8–tcdd	NA	NA	NA
	HQ Summation =		8.0E–01

	ILCR Calculation		
Compound	CDI (mg/kg–day)	CSF $(mg/kg–day)^{-1}$	ILCR (unitless)
antimony	5.9E–06	NA	NA
arsenic	5.6E–06	1.8E+00	9.8E–06
barium	1.1E–04	NA	NA
beryllium	8.3E–07	4.3E+00	3.6E–06
boron	1.2E–04	NA	NA
cadmium	3.8E–06	NA	NA
chromium vi	1.8E–05	NA	NA
cobalt	1.3E–05	NA	NA
copper	2.2E–05	NA	NA
cyanide	2.7E–07	NA	NA
lead	2.6E–05	NA	NA
manganese	1.1E–03	NA	NA
mercury	2.3E–07	NA	NA
molybdenum	7.1E–06	NA	NA
nickel	2.5E–05	NA	NA
selenium	6.9E–07	NA	NA
silver	6.6E–06	NA	NA
thallium	6.1E–07	NA	NA
thorium–total	NA	NA	NA
uranium–total	NA	NA	NA
vanadium	2.8E–05	NA	NA
zinc	7.0E–05	NA	NA
2–methylnaphthalene	NA	NA	NA
4,4–dde	NA	3.4E–01	0.0E+00
aroclor–1221	NA	7.7E+00	0.0E+00
aroclor–1248	NA	7.7E+00	0.0E+00
aroclor–1254	NA	7.7E+00	0.0E+00
aroclor–1260	NA	7.7E+00	0.0E+00
carbazole	NA	2.0E–02	0.0E+00
endrin	NA	NA	NA
2,3,7,8–tcdd	NA	1.5E+05	0.0E+00
	ILCR Summation =		1.3E–05

Table H.IV−133
Summary of Intake and Risk Quantitation (radionuclides)
Future Land Use with Private Ownership: On−Property Farmer (Child)
Via Incidental Ingestion of Soil

Intake Equation = CS X EF X EDn X FI X IR

IRs	Ingestion rate of soil (RAGS, 1989)	200 mg/day
EF	Exposure frequency	350 days/year
EDn	Exposure Duration	6 Year
FI	Fractional Intake	1 (unitless)
CS	Concentration of radionuclides in soil	

Cs_{137+1d}	7.93E−04	pCi/mg	Rn_{222+4d}	0.00E+00	pCi/mg
Pb_{210+2d}	1.05E−09	pCi/mg	Sr_{90+1d}	8.33E−10	pCi/mg
Np_{237+1d}	8.36E−11	pCi/mg	Tc_{99}	1.87E−09	pCi/mg
Pu_{238}	9.07E−11	pCi/mg	Th_{228+7d}	4.00E−10	pCi/mg
Pu_{239}	1.25E−11	pCi/mg	Th_{230}	5.92E−11	pCi/mg
Pu_{240}	4.55E−11	pCi/mg	$Th_{232+10d}$	5.95E−10	pCi/mg
Pa_{231}	0.00E+00	pCi/mg	U_{234}	2.06E−08	pCi/mg
Ra_{226+8d}	3.99E−10	pCi/mg	U_{235+1d}	9.34E−10	pCi/mg
Ra_{228+1d}	7.00E−10	pCi/mg	U_{236}	6.86E−09	pCi/mg
Ru_{106}	1.33E−10	pCi/mg	U_{238+2d}	1.38E−08	pCi/mg

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	ILCR (unitless)
Cs_{137+1d}	3.33E+02	2.80E−11	9.33E−09
Pb_{210+2d}	4.41E−04	6.60E−10	2.91E−13
Np_{237+1d}	3.51E−05	2.20E−10	7.72E−15
Pu_{238}	3.81E−05	2.20E−10	8.38E−15
Pu_{239}	5.25E−06	2.30E−10	1.21E−15
Pu_{240}	1.91E−05	2.30E−10	4.40E−15
Pa_{231}	NA	9.20E−11	NA
Ra_{226+8d}	1.68E−04	7.80E−10	1.31E−13
Ra_{228+1d}	2.94E−04	1.00E−10	2.94E−14
Ru_{106}	5.59E−05	9.50E−12	5.31E−16
Rn_{222+4d}	NA	1.70E−12	NA
Sr_{90+1d}	3.50E−04	3.60E−11	1.26E−14
Tc_{99}	7.85E−04	1.30E−12	1.02E−15
Th_{228+7d}	1.68E−04	5.50E−11	9.24E−15
Th_{230}	2.49E−05	1.30E−11	3.23E−16
$Th_{232+10d}$	2.50E−04	1.70E−10	4.25E−14
U_{234}	8.65E−03	1.60E−11	1.38E−13
U_{235+1d}	3.92E−04	1.60E−11	6.28E−15
U_{236}	2.88E−03	1.50E−11	4.32E−14
U_{238+2d}	5.80E−03	2.00E−11	1.16E−13
		ILCR Summation =	9.33E−09

Table H.IV–134
Summary of Intake Quantitation (chemicals)
Future Land Use with Private Ownership: On–Property Farmer (Child)
Via Dermal Contact with Soil

Intake Equation = $\frac{CS \times EF \times ED \times CF \times ABS \times AF \times SA}{BW \times AT}$

SA	Surface area of exposed skin (50th percentile, hands only)	2000 cm^2/day
AF	Soil to skin adherence factor (RAGS, 1989)	1 mg/cm^2
ABS	chemicals specific absorbtion factor (see table below)	csv
CF	Conversion factor	1E–06 kg/mg
EF	Exposure frequency	350 days/year
EDn	Exposure duration for non–carcinogens	6 Year
EDc	Exposure duration for carcinogens	6 Year
BW	Body weight	15 kg
ATc	Average time for carcinogens (lifetime)	25550 days
ATn	Average time for non–carcinogens (EDn x 365)	2190 days
CS	Concentration of chemicals in soil	

Chemical Concentrations

Compound	ABS	Concentrati	Units
antimony	1.00E–02	5.35E+00	mg/kg
arsenic	1.00E–03	5.09E+00	mg/kg
barium	1.00E–02	9.72E+01	mg/kg
beryllium	1.00E–02	7.55E–01	mg/kg
boron	1.00E–02	1.12E+02	mg/kg
cadmium	1.00E–02	3.48E+00	mg/kg
chromium vi	1.00E–02	1.64E+01	mg/kg
cobalt	1.00E–02	1.21E+01	mg/kg
copper	1.00E–03	2.02E+01	mg/kg
cyanide	1.00E–02	2.50E–01	mg/kg
lead	1.00E–02	2.35E+01	mg/kg
manganese	1.00E–02	9.76E+02	mg/kg
mercury	5.00E–02	2.14E–01	mg/kg
molybdenum	1.00E–02	6.49E+00	mg/kg
nickel	5.00E–04	2.26E+01	mg/kg
selenium	1.00E–02	6.31E–01	mg/kg

Compound		Concentrati	Units
silver	1.00E–02	6.03E+00	mg/kg
thallium	1.00E–02	5.58E–01	mg/kg
thorium–total	1.00E–02	0.00E+00	mg/kg
uranium–total	1.00E–02	0.00E+00	mg/kg
vanadium	1.00E–03	2.60E+01	mg/kg
zinc	1.00E–02	6.41E+01	mg/kg
2–methylnaphthalene	3.00E–01	0.00E+00	mg/kg
4,4–dde	3.00E–01	0.00E+00	mg/kg
aroclor–1221	6.00E–02	0.00E+00	mg/kg
aroclor–1248	6.00E–02	0.00E+00	mg/kg
aroclor–1254	6.00E–02	0.00E+00	mg/kg
aroclor–1260	6.00E–02	0.00E+00	mg/kg
carbazole	3.00E–01	0.00E+00	mg/kg
endrin	3.00E–01	0.00E+00	mg/kg
2,3,7,8–tcdd	3.00E–02	0.00E+00	mg/kg

References

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Table H.IV−134 (continued)
Summary of Risk Characterization (chemicals)
Future Land Use with Private Ownership: On−Property Farmer (Child)
Via Dermal Contact with Soil

	HQ Calculation		
Compound	CDI (mg/kg−day)	RfD (mg/kg−day)	HQ (unitless)
antimony	6.84E−06	6.00E−05	1.14E−01
arsenic	6.51E−07	2.85E−04	2.28E−03
barium	1.24E−04	6.37E−02	1.95E−03
beryllium	9.65E−07	5.00E−03	1.93E−04
boron	1.43E−04	4.50E−03	3.18E−02
cadmium	4.45E−06	5.00E−05	8.90E−02
chromium vi	2.10E−05	2.25E−03	9.32E−03
cobalt	1.55E−05	2.70E−02	5.73E−04
copper	2.58E−06	NA	NA
cyanide	3.20E−07	NA	NA
lead	3.00E−05	NA	NA
manganese	1.25E−03	4.20E−03	2.97E−01
mercury	1.37E−06	4.50E−05	3.04E−02
molybdenum	8.30E−06	1.90E−03	4.37E−03
nickel	1.44E−06	2.00E−03	7.22E−04
selenium	8.07E−07	4.00E−03	2.02E−04
silver	7.71E−06	NA	NA
thallium	7.13E−07	8.00E−05	8.92E−03
thorium−total	NA	NA	NA
uranium−total	NA	1.50E−04	0.00E+00
vanadium	3.32E−06	3.50E−04	9.50E−03
zinc	8.20E−05	7.50E−02	1.09E−03
2−methylnaphthalene	NA	NA	NA
4,4−dde	NA	NA	NA
aroclor−1221	NA	NA	NA
aroclor−1248	NA	NA	NA
aroclor−1254	NA	NA	NA
aroclor−1260	NA	NA	NA
carbazole	NA	NA	NA
endrin	NA	2.70E−04	0.00E+00
2,3,7,8−tcdd	NA	NA	NA
	HQ Summation =		6.01E−01

	ILCR Calculation		
Compound	CDI (mg/kg−day)	CSF $(mg/kg-day)^{-1}$	ILCR (unitless)
antimony	5.86E−07	NA	NA
arsenic	5.58E−08	1.90E+00	1.06E−07
barium	1.07E−05	NA	NA
beryllium	8.27E−08	4.30E+00	3.56E−07
boron	1.23E−05	NA	NA
cadmium	3.81E−07	NA	NA
chromium vi	1.80E−06	NA	NA
cobalt	1.33E−06	NA	NA
copper	2.21E−07	NA	NA
cyanide	2.74E−08	NA	NA
lead	2.58E−06	NA	NA
manganese	1.07E−04	NA	NA
mercury	1.17E−07	NA	NA
molybdenum	7.11E−07	NA	NA
nickel	1.24E−07	NA	NA
selenium	6.92E−08	NA	NA
silver	6.61E−07	NA	NA
thallium	6.12E−08	NA	NA
thorium−total	NA	NA	NA
uranium−total	NA	NA	NA
vanadium	2.85E−07	NA	NA
zinc	7.02E−06	NA	NA
2−methylnaphthalene	NA	NA	NA
4,4−dde	NA	3.40E−01	0.00E+00
aroclor−1221	NA	1.03E+01	0.00E+00
aroclor−1248	NA	1.03E+01	0.00E+00
aroclor−1254	NA	1.03E+01	0.00E+00
aroclor−1260	NA	1.03E+01	0.00E+00
carbazole	NA	2.22E−02	0.00E+00
endrin	NA	NA	NA
2,3,7,8−tcdd	NA	3.00E+05	0.00E+00
	ILCR Summation =		4.62E−07

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Table H.IV-135
Summary of Intake Quantitation (chemicals)
Future Land Use with Private Ownership: On-Property Farmer (Child)
Via Drinking Water Ingestion

Intake Equation = $\frac{CS \times EF \times ED \times IR}{BW \times AT}$

IR	Ingestion rate of groundwater (RAGS, 1989)	1 l/day
EF	Exposure frequency	350 days/year
EDn	Exposure duration for non-carcinogens	6 Year
EDc	Exposure duration for carcinogens	6 Year
BW	Body weight	15 kg
ATc	Average time for carcinogens (lifetime)	25550 days
ATn	Average time for non-carcinogens (EDn x 365)	2190 days
CS	Concentration of chemicals in groundwater	

Chemical Concentrations

Compound	Concentration	Units	Compound	Concentration	Units
antimony	1.24E-03	mg/l	silver	0.00E+00	mg/l
arsenic	4.26E-03	mg/l	thallium	0.00E+00	mg/l
barium	0.00E+00	mg/l	thorium-total	0.00E+00	mg/l
beryllium	1.15E-04	mg/l	uranium-total	1.82E-01	mg/l
boron	0.00E+00	mg/l	vanadium	0.00E+00	mg/l
cadmium	2.88E-20	mg/l	zinc	0.00E+00	mg/l
chromium vi	0.00E+00	mg/l	2-methylnaphthalene	0.00E+00	mg/l
cobalt	0.00E+00	mg/l	4,4-dde	0.00E+00	mg/l
copper	0.00E+00	mg/l	aroclor-1221	2.29E-24	mg/l
cyanide	0.00E+00	mg/l	aroclor-1248	0.00E+00	mg/l
lead	0.00E+00	mg/l	aroclor-1254	0.00E+00	mg/l
manganese	0.00E+00	mg/l	aroclor-1260	0.00E+00	mg/l
mercury	0.00E+00	mg/l	carbazole	0.00E+00	mg/l
molybdenum	0.00E+00	mg/l	endrin	0.00E+00	mg/l
nickel	0.00E+00	mg/l	2,3,7,8-tcdd	0.00E+00	mg/l
selenium	0.00E+00	mg/l			

References

Table H.IV–135 (continued)
Summary of Risk Characterization (chemicals)
Future Land Use with Private Ownership: On–Property Farmer (Child)
Via Drinking Water Ingestion

	HQ Calculation		
Compound	CDI (mg/kg–day)	RfD (mg/kg–day)	HQ (unitless)
antimony	7.93E–05	4.00E–04	1.98E–01
arsenic	2.72E–04	3.00E–04	9.08E–01
barium	NA	7.00E–02	NA
beryllium	7.35E–06	5.00E–03	1.47E–03
boron	NA	9.00E–02	NA
cadmium	1.84E–21	1.00E–03	1.84E–18
chromium vi	NA	5.00E–03	NA
cobalt	NA	6.00E–02	NA
copper	NA	NA	NA
cyanide	NA	2.00E–02	NA
lead	NA	NA	NA
manganese	NA	1.40E–01	NA
mercury	NA	3.00E–04	NA
molybdenum	NA	5.00E–03	NA
nickel	NA	2.00E–02	NA
selenium	NA	5.00E–03	NA
silver	NA	5.00E–03	NA
thallium	NA	8.00E–05	NA
thorium–total	NA	NA	NA
uranium–total	1.16E–02	3.00E–03	3.88E+00
vanadium	NA	7.00E–03	NA
zinc	NA	3.00E–01	NA
2–methylnaphthalene	NA	NA	NA
4,4–dde	NA	NA	NA
aroclor–1221	1.46E–25	NA	NA
aroclor–1248	NA	NA	NA
aroclor–1254	NA	NA	NA
aroclor–1260	NA	NA	NA
carbazole	NA	NA	NA
endrin	NA	3.00E–04	NA
2,3,7,8–tcdd	NA	NA	NA
	HQ Summation =		4.99E+00

	ILCR Calculation		
Compound	CDI (mg/kg–day)	CSF $(mg/kg–day)^{-1}$	ILCR (unitless)
antimony	6.79E–06	NA	NA
arsenic	2.33E–05	1.75E+00	4.08E–05
barium	NA	NA	NA
beryllium	6.30E–07	4.30E+00	2.71E–06
boron	NA	NA	NA
cadmium	1.58E–22	NA	NA
chromium vi	NA	NA	NA
cobalt	NA	NA	NA
copper	NA	NA	NA
cyanide	NA	NA	NA
lead	NA	NA	NA
manganese	NA	NA	NA
mercury	NA	NA	NA
molybdenum	NA	NA	NA
nickel	NA	NA	NA
selenium	NA	NA	NA
silver	NA	NA	NA
thallium	NA	NA	NA
thorium–total	NA	NA	NA
uranium–total	9.97E–04	NA	NA
vanadium	NA	NA	NA
zinc	NA	NA	NA
2–methylnaphthalene	NA	NA	NA
4,4–dde	NA	3.40E–01	NA
aroclor–1221	1.25E–26	7.70E+00	9.66E–26
aroclor–1248	NA	7.70E+00	NA
aroclor–1254	NA	7.70E+00	NA
aroclor–1260	NA	7.70E+00	NA
carbazole	NA	2.00E–02	NA
endrin	NA	NA	NA
2,3,7,8–tcdd	NA	1.50E+05	NA
	ILCR Summation =		4.36E–05

Table H.IV–136
Summary of Intake and Risk Quantitation (radionuclides)
Future Land Use with Private Ownership: On–Property Farmer (Child)
Via Ingestion of Drinking Water

Intake Equation = Cw X EF X EDn X FI X IR

IR	Ingestion rate of groundwater (RAGS, 1989)	1 l/day
EF	Exposure frequency	350 days/year
EDn	Exposure duration	6 Year
FI	Fractional intake for radionuclides	1 (Unitless)
Cw	Concentration of radionuclides in groundwater	(see table below)

Cs_{137+1d}	0.0E+00	pCi/l	Rn_{222+4d}	0.0E+00	pCi/l
Pb_{210+2d}	0.0E+00	pCi/l	Sr_{90+1d}	0.0E+00	pCi/l
Np_{237+1d}	5.7E–01	pCi/l	Tc_{99}	5.2E+03	pCi/l
Pu_{238}	0.0E+00	pCi/l	Th_{228+7d}	0.0E+00	pCi/l
Pu_{239}	0.0E+00	pCi/l	Th_{230}	0.0E+00	pCi/l
Pu_{240}	0.0E+00	pCi/l	$Th_{232+10d}$	0.0E+00	pCi/l
Pa_{231}	0.0E+00	pCi/l	U_{234}	1.0E+02	pCi/l
Ra_{226+8d}	2.5E–01	pCi/l	U_{235+1d}	2.7E+00	pCi/l
Ra_{228+1d}	0.0E+00	pCi/l	U_{236}	1.1E+00	pCi/l
Ru_{106}	0.0E+00	pCi/l	U_{238+2d}	6.1E+01	pCi/l

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	ILCR (unitless)
Cs_{137+1d}	NA	2.8E–11	NA
Pb_{210+2d}	NA	6.6E–10	NA
Np_{237+1d}	1.2E+03	2.2E–10	2.6E–07
Pu_{238}	NA	2.2E–10	NA
Pu_{239}	NA	2.3E–10	NA
Pu_{240}	NA	2.3E–10	NA
Pa_{231}	NA	9.2E–11	NA
Ra_{226+8d}	5.3E+02	7.8E–10	4.1E–07
Ra_{228+1d}	NA	1.0E–10	NA
Ru_{106}	NA	9.5E–12	NA
Rn_{222+4d}	NA	1.7E–12	NA
Sr_{90+1d}	NA	3.6E–11	NA
Tc_{99}	1.1E+07	1.3E–12	1.4E–05
Th_{228+7d}	NA	5.5E–11	NA
Th_{230}	NA	1.3E–11	NA
$Th_{232+10d}$	NA	1.7E–10	NA
U_{234}	2.1E+05	1.6E–11	3.4E–06
U_{235+1d}	5.7E+03	1.6E–11	9.1E–08
U_{236}	2.4E+03	1.5E–11	3.5E–08
U_{238+2d}	1.3E+05	2.0E–11	2.6E–06
		ILCR Summation =	2.1E–05

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Table H.IV–137
Summary of Intake Quantitation (chemicals)
Future Land Use with Private Ownership: On–Property Farmer (Child)
Via Dermal Contact while Bathing

Intake Equation = $\frac{DA \times EF \times ED \times SA}{BW \times AT}$

DA	Dermal absorbed dose	csv	mg/cm^2–day
EF	Exposure frequency	350	days/year
EDn	Exposure duration for non–carcinogens	6	Year
EDc	Exposure duration for carcinogens	6	Year
BW	Body weight	15	kg
ATc	Average time for carcinogens (lifetime)	25550	days
ATn	Average time for non–carcinogens (EDn x 365)	2190	days
SA	Skin surface area available for contact	8000	cm^2

Chemical Concentrations

Compound	DA	Units	Compound	DA	Units
antimony	3.10E–09	mg/cm^2–day	silver	NA	mg/cm^2–day
arsenic	1.06E–08	mg/cm^2–day	thallium	NA	mg/cm^2–day
barium	NA	mg/cm^2–day	thorium–total	NA	mg/cm^2–day
beryllium	2.88E–10	mg/cm^2–day	uranium–total	4.55E–08	mg/cm^2–day
boron	NA	mg/cm^2–day	vanadium	NA	mg/cm^2–day
cadmium	7.20E–27	mg/cm^2–day	zinc	NA	mg/cm^2–day
chromium vi	NA	mg/cm^2–day	2–methylnaphthalene	NA	mg/cm^2–day
cobalt	NA	mg/cm^2–day	4,4–dde	NA	mg/cm^2–day
copper	NA	mg/cm^2–day	aroclor–1221	1.86E–27	mg/cm^2–day
cyanide	NA	mg/cm^2–day	aroclor–1248	NA	mg/cm^2–day
lead	NA	mg/cm^2–day	aroclor–1254	NA	mg/cm^2–day
manganese	NA	mg/cm^2–day	aroclor–1260	NA	mg/cm^2–day
mercury	NA	mg/cm^2–day	carbazole	NA	mg/cm^2–day
molybdenum	NA	mg/cm^2–day	endrin	NA	mg/cm^2–day
nickel	NA	mg/cm^2–day	2,3,7,8–tcdd	NA	mg/cm^2–day
selenium	NA	mg/cm^2–day			

References

Table H.IV-137 (continued)
Summary of Risk Characterization (chemicals)
Future Land Use with Private Ownership: On-Property Farmer (Child)
Via Dermal Contact while Bathing

Compound	HQ Calculation CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
antimony	1.59E-06	6.00E-05	2.64E-02
arsenic	5.45E-06	2.85E-04	1.91E-02
barium	NA	6.37E-02	NA
beryllium	1.47E-07	5.00E-03	2.94E-05
boron	NA	4.50E-03	NA
cadmium	3.68E-24	5.00E-05	7.36E-20
chromium vi	NA	2.25E-03	NA
cobalt	NA	2.70E-02	NA
copper	NA	NA	NA
cyanide	NA	NA	NA
lead	NA	NA	NA
manganese	NA	4.20E-03	NA
mercury	NA	4.50E-05	NA
molybdenum	NA	1.90E-03	NA
nickel	NA	2.00E-03	NA
selenium	NA	4.00E-03	NA
silver	NA	NA	NA
thallium	NA	8.00E-05	NA
thorium-total	NA	NA	NA
uranium-total	2.33E-05	1.50E-04	1.55E-01
vanadium	NA	3.50E-04	NA
zinc	NA	7.50E-02	NA
2-methylnaphthalene	NA	NA	NA
4,4-dde	NA	NA	NA
aroclor-1221	9.52E-25	NA	NA
aroclor-1248	NA	NA	NA
aroclor-1254	NA	NA	NA
aroclor-1260	NA	NA	NA
carbazole	NA	NA	NA
endrin	NA	2.70E-04	NA
2,3,7,8-tcdd	NA	NA	NA
	HQ Summation =		2.01E-01

Compound	ILCR Calculation CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	ILCR (unitless)
antimony	1.36E-07	NA	NA
arsenic	4.67E-07	1.90E+00	8.87E-07
barium	NA	NA	NA
beryllium	1.26E-08	4.30E+00	5.42E-08
boron	NA	NA	NA
cadmium	3.16E-25	NA	NA
chromium vi	NA	NA	NA
cobalt	NA	NA	NA
copper	NA	NA	NA
cyanide	NA	NA	NA
lead	NA	NA	NA
manganese	NA	NA	NA
mercury	NA	NA	NA
molybdenum	NA	NA	NA
nickel	NA	NA	NA
selenium	NA	NA	NA
silver	NA	NA	NA
thallium	NA	NA	NA
thorium-total	NA	NA	NA
uranium-total	1.99E-06	NA	NA
vanadium	NA	NA	NA
zinc	NA	NA	NA
2-methylnaphthalene	NA	NA	NA
4,4-dde	NA	3.40E-01	NA
aroclor-1221	8.16E-26	1.03E+01	8.38E-25
aroclor-1248	NA	1.03E+01	NA
aroclor-1254	NA	1.03E+01	NA
aroclor-1260	NA	1.03E+01	NA
carbazole	NA	2.22E-02	NA
endrin	NA	NA	NA
2,3,7,8-tcdd	NA	3.00E+05	NA
	ILCR Summation =		9.41E-07

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Table H.IV-138
Summary of Intake Quantitation (chemicals)
Future Land Use with Private Ownership: On-Property Farmer (Child)
Via Ingestion of Meat Products

Intake Equation = $\frac{CS \times EF \times ED \times FI \times IR}{BW \times AT}$

IR	Ingestion rate of meat	0.039	kg/day
FI	Fraction ingested from contaminated source	0.75	(Unitless)
EF	Exposure frequency	350	days/year
EDn	Exposure duration for non-carcinogens	6	Year
EDc	Exposure duration for carcinogens	6	Year
BW	Body weight	15	kg
ATc	Average time for carcinogens (lifetime)	25550	days
ATn	Average time for non-carcinogens (EDn x 365)	2190	days
CS	Concentration of chemicals in meat		

Chemical Concentrations

Compound	Concentration	Units	Compound	Concentration	Units
antimony	0.0E+00	mg/kg	silver	3.2E-01	mg/kg
arsenic	4.9E-02	mg/kg	thallium	1.5E-02	mg/kg
barium	1.4E-01	mg/kg	thorium-total	1.4E-05	mg/kg
beryllium	1.1E-03	mg/kg	uranium-total	9.3E-02	mg/kg
boron	2.2E+00	mg/kg	vanadium	5.0E-02	mg/kg
cadmium	4.0E-02	mg/kg	zinc	4.8E+02	mg/kg
chromium vi	8.3E-02	mg/kg	2-methylnaphthalene	2.3E-04	mg/kg
cobalt	3.4E-01	mg/kg	4,4-dde	3.8E-05	mg/kg
copper	8.0E+00	mg/kg	aroclor-1221	3.5E-26	mg/kg
cyanide	4.0E-05	mg/kg	aroclor-1248	0.0E+00	mg/kg
lead	2.6E-01	mg/kg	aroclor-1254	4.7E-03	mg/kg
manganese	6.8E+00	mg/kg	aroclor-1260	2.5E-02	mg/kg
mercury	4.0E+00	mg/kg	carbazole	3.9E-05	mg/kg
molybdenum	1.3E-01	mg/kg	endrin	0.0E+00	mg/kg
nickel	4.6E-01	mg/kg	2,3,7,8-tcdd	3.5E-09	mg/kg
selenium	1.8E-02	mg/kg			

References

Table H.IV-138 (continued)
Summary of Risk Characterization (chemicals)
Future Land Use with Private Ownership: On-Property Farmer (Child)
Via Ingestion of Meat Products

Compound	HQ Calculation CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
antimony	NA	4.0E-04	NA
arsenic	9.1E-05	3.0E-04	3.0E-01
barium	2.5E-04	7.0E-02	3.6E-03
beryllium	2.0E-06	5.0E-03	3.9E-04
boron	4.1E-03	9.0E-02	4.6E-02
cadmium	7.4E-05	1.0E-03	7.4E-02
chromium vi	1.6E-04	5.0E-03	3.1E-02
cobalt	6.4E-04	6.0E-02	1.1E-02
copper	1.5E-02	NA	NA
cyanide	7.4E-08	2.0E-02	3.7E-06
lead	4.9E-04	NA	NA
manganese	1.3E-02	1.4E-01	9.1E-02
mercury	7.4E-03	3.0E-04	2.5E+01
molybdenum	2.4E-04	5.0E-03	4.8E-02
nickel	8.6E-04	2.0E-02	4.3E-02
selenium	3.3E-05	5.0E-03	6.6E-03
silver	6.0E-04	5.0E-03	1.2E-01
thallium	2.9E-05	8.0E-05	3.6E-01
thorium-total	2.6E-08	NA	NA
uranium-total	1.7E-04	3.0E-03	5.8E-02
vanadium	9.4E-05	7.0E-03	1.3E-02
zinc	8.9E-01	3.0E-01	3.0E+00
2-methylnaphthalene	4.3E-07	NA	NA
4,4-dde	7.1E-08	NA	NA
aroclor-1221	6.6E-29	NA	NA
aroclor-1248	NA	NA	NA
aroclor-1254	8.8E-06	NA	NA
aroclor-1260	4.6E-05	NA	NA
carbazole	7.3E-08	NA	NA
endrin	NA	3.0E-04	NA
2,3,7,8-tcdd	6.6E-12	NA	NA
	HQ Summation =		2.9E+01

Compound	ILCR Calculation CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	ILCR (unitless)
antimony	NA	NA	NA
arsenic	7.8E-06	1.8E+00	1.4E-05
barium	2.2E-05	NA	NA
beryllium	1.7E-07	4.3E+00	7.3E-07
boron	3.5E-04	NA	NA
cadmium	6.3E-06	NA	NA
chromium vi	1.3E-05	NA	NA
cobalt	5.5E-05	NA	NA
copper	1.3E-03	NA	NA
cyanide	6.3E-09	NA	NA
lead	4.2E-05	NA	NA
manganese	1.1E-03	NA	NA
mercury	6.4E-04	NA	NA
molybdenum	2.0E-05	NA	NA
nickel	7.4E-05	NA	NA
selenium	2.8E-06	NA	NA
silver	5.1E-05	NA	NA
thallium	2.4E-06	NA	NA
thorium-total	2.2E-09	NA	NA
uranium-total	1.5E-05	NA	NA
vanadium	8.1E-06	NA	NA
zinc	7.7E-02	NA	NA
2-methylnaphthalene	3.7E-08	NA	NA
4,4-dde	6.0E-09	3.4E-01	2.1E-09
aroclor-1221	5.7E-30	7.7E+00	4.4E-29
aroclor-1248	NA	7.7E+00	NA
aroclor-1254	7.5E-07	7.7E+00	5.8E-06
aroclor-1260	3.9E-06	7.7E+00	3.0E-05
carbazole	6.2E-09	2.0E-02	1.2E-10
endrin	NA	NA	NA
2,3,7,8-tcdd	5.6E-13	1.5E+05	8.4E-08
	ILCR Summation =		5.1E-05

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Table H.IV–139
Summary of Intake and Risk Quantitation (radionuclides)
Future Land Use with Private Ownership: On–Property Farmer (Child)
Via Ingestion of Meat Products

Intake Equation = Cf X EF X EDn X FI X IR

IR	Ingestion rate of meat	0.039 kg/day
FI	Fraction ingested from contaminated source	0.75 (Unitless)
EF	Exposure frequency	350 days/year
EDn	Exposure duration	6 Year
Cf	Concentration of radionuclides in meat	

Cs_{137+1d}	7.1E+01	pCi/kg	Rn_{222+4d}	ERR	pCi/kg
Pb_{210+2d}	8.3E−01	pCi/kg	Sr_{90+1d}	6.3E+01	pCi/kg
Np_{237+1d}	9.1E−03	pCi/kg	Tc_{99}	3.2E+04	pCi/kg
Pu_{238}	2.7E−05	pCi/kg	Th_{228+7d}	3.8E−04	pCi/kg
Pu_{239}	6.4E−06	pCi/kg	Th_{230}	1.0E−03	pCi/kg
Pu_{240}	2.3E−05	pCi/kg	$Th_{232+10d}$	6.1E−04	pCi/kg
Pa_{231}	2.0E−05	pCi/kg	U_{234}	4.7E+00	pCi/kg
Ra_{226+8d}	2.4E−01	pCi/kg	U_{235+1d}	1.3E−01	pCi/kg
Ra_{228+1d}	3.4E−01	pCi/kg	U_{236}	5.2E−02	pCi/kg
Ru_{106}	3.6E−01	pCi/kg	U_{238+2d}	2.8E+00	pCi/kg

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	ILCR (unitless)
Cs_{137+1d}	4.4E+03	2.8E−11	1.2E−07
Pb_{210+2d}	5.1E+01	6.6E−10	3.4E−08
Np_{237+1d}	5.6E−01	2.2E−10	1.2E−10
Pu_{238}	1.6E−03	2.2E−10	3.6E−13
Pu_{239}	4.0E−04	2.3E−10	9.1E−14
Pu_{240}	1.4E−03	2.3E−10	3.3E−13
Pa_{231}	1.2E−03	9.2E−11	1.1E−13
Ra_{226+8d}	1.5E+01	7.8E−10	1.2E−08
Ra_{228+1d}	2.1E+01	1.0E−10	2.1E−09
Ru_{106}	2.2E+01	9.5E−12	2.1E−10
Rn_{222+4d}	NA	1.7E−12	NA
Sr_{90+1d}	3.9E+03	3.6E−11	1.4E−07
Tc_{99}	2.0E+06	1.3E−12	2.6E−06
Th_{228+7d}	2.3E−02	5.5E−11	1.3E−12
Th_{230}	6.3E−02	1.3E−11	8.2E−13
$Th_{232+10d}$	3.7E−02	1.7E−10	6.3E−12
U_{234}	2.9E+02	1.6E−11	4.6E−09
U_{235+1d}	7.7E+00	1.6E−11	1.2E−10
U_{236}	3.2E+00	1.5E−11	4.8E−11
U_{238+2d}	1.7E+02	2.0E−11	3.5E−09
		ILCR Summation =	2.9E−06

Table H.IV-140
Summary of Intake Quantitation (chemicals)
Future Land Use with Private Ownership: On-Property Farmer (Child)
Via Ingestion of Dairy Products

Intake Equation = $\frac{CS \times EF \times ED \times FI \times IR}{BW \times AT}$

IR	Ingestion rate of dairy products	0.9 l/day
FI	Fraction ingested from contaminated source	0.75 (Unitless)
EF	Exposure frequency	350 days/year
EDn	Exposure duration for non-carcinogens	6 Year
EDc	Exposure duration for carcinogens	6 Year
BW	Body weight	15 kg
ATc	Average time for carcinogens (lifetime)	25550 days
ATn	Average time for non-carcinogens (EDn x 365)	2190 days
CS	Concentration of chemicals in animal products	

Chemical Concentrations

Compound	Concentration	Units	Compound	Concentration	Units
antimony	0.0E+00	mg/kg	silver	2.1E+00	mg/kg
arsenic	1.6E-03	mg/kg	thallium	7.2E-04	mg/kg
barium	3.2E-01	mg/kg	thorium-total	1.4E-04	mg/kg
beryllium	1.2E-06	mg/kg	uranium-total	6.0E-01	mg/kg
boron	4.1E+00	mg/kg	vanadium	4.0E-04	mg/kg
cadmium	7.1E-02	mg/kg	zinc	4.8E+01	mg/kg
chromium vi	2.4E-02	mg/kg	2-methylnaphthalene	7.7E-05	mg/kg
cobalt	3.3E-02	mg/kg	4,4-dde	1.9E-05	mg/kg
copper	1.2E+00	mg/kg	aroclor-1221	1.3E-26	mg/kg
cyanide	1.2E-05	mg/kg	aroclor-1248	0.0E+00	mg/kg
lead	2.6E-01	mg/kg	aroclor-1254	3.6E-03	mg/kg
manganese	6.0E+00	mg/kg	aroclor-1260	1.5E-02	mg/kg
mercury	7.2E-03	mg/kg	carbazole	1.3E-05	mg/kg
molybdenum	3.2E-02	mg/kg	endrin	0.0E+00	mg/kg
nickel	7.7E-02	mg/kg	2,3,7,8-tcdd	4.0E-09	mg/kg
selenium	4.9E-03	mg/kg			

References

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Table H.IV-140 (continued)
Summary of Risk Characterization (chemicals)
Future Land Use with Private Ownership: On-Property Farmer (Child)
Via Ingestion of Dairy Products

Compound	HQ Calculation CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
antimony	NA	4.0E-04	NA
arsenic	7.1E-05	3.0E-04	2.4E-01
barium	1.4E-02	7.0E-02	2.0E-01
beryllium	5.2E-08	5.0E-03	1.0E-05
boron	1.8E-01	9.0E-02	1.9E+00
cadmium	3.1E-03	1.0E-03	3.1E+00
chromium vi	1.0E-03	5.0E-03	2.1E-01
cobalt	1.4E-03	6.0E-02	2.4E-02
copper	5.2E-02	NA	NA
cyanide	5.4E-07	2.0E-02	2.7E-05
lead	1.1E-02	NA	NA
manganese	2.6E-01	1.4E-01	1.9E+00
mercury	3.1E-04	3.0E-04	1.0E+00
molybdenum	1.4E-03	5.0E-03	2.7E-01
nickel	3.3E-03	2.0E-02	1.7E-01
selenium	2.1E-04	5.0E-03	4.2E-02
silver	9.1E-02	5.0E-03	1.8E+01
thallium	3.1E-05	8.0E-05	3.9E-01
thorium-total	6.3E-06	NA	NA
uranium-total	2.6E-02	3.0E-03	8.6E+00
vanadium	1.7E-05	7.0E-03	2.5E-03
zinc	2.1E+00	3.0E-01	6.9E+00
2-methylnaphthalene	3.3E-06	NA	NA
4,4-dde	8.0E-07	NA	NA
aroclor-1221	5.8E-28	NA	NA
aroclor-1248	NA	NA	NA
aroclor-1254	1.5E-04	NA	NA
aroclor-1260	6.4E-04	NA	NA
carbazole	5.5E-07	NA	NA
endrin	NA	3.0E-04	NA
2,3,7,8-tcdd	1.7E-10	NA	NA
	HQ Summation =		4.3E+01

Compound	ILCR Calculation CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	ILCR (unitless)
antimony	NA	NA	NA
arsenic	6.0E-06	1.8E+00	1.1E-05
barium	1.2E-03	NA	NA
beryllium	4.5E-09	4.3E+00	1.9E-08
boron	1.5E-02	NA	NA
cadmium	2.6E-04	NA	NA
chromium vi	8.9E-05	NA	NA
cobalt	1.2E-04	NA	NA
copper	4.5E-03	NA	NA
cyanide	4.6E-08	NA	NA
lead	9.7E-04	NA	NA
manganese	2.2E-02	NA	NA
mercury	2.7E-05	NA	NA
molybdenum	1.2E-04	NA	NA
nickel	2.8E-04	NA	NA
selenium	1.8E-05	NA	NA
silver	7.8E-03	NA	NA
thallium	2.7E-06	NA	NA
thorium-total	5.4E-07	NA	NA
uranium-total	2.2E-03	NA	NA
vanadium	1.5E-06	NA	NA
zinc	1.8E-01	NA	NA
2-methylnaphthalene	2.8E-07	NA	NA
4,4-dde	6.9E-08	3.4E-01	2.3E-08
aroclor-1221	5.0E-29	7.7E+00	3.8E-28
aroclor-1248	NA	7.7E+00	NA
aroclor-1254	1.3E-05	7.7E+00	1.0E-04
aroclor-1260	5.5E-05	7.7E+00	4.2E-04
carbazole	4.7E-08	2.0E-02	9.4E-10
endrin	NA	NA	NA
2,3,7,8-tcdd	1.5E-11	1.5E+05	2.2E-06
	ILCR Summation =		5.4E-04

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Table H.IV–141
Summary of Intake and Risk Quantitation (radionuclides)
Future Land Use with Private Ownership: On–Property Farmer (Child)
Via Ingestion of Dairy Products

Intake Equation = Cp X EF X EDn X FI X IR

IR	Ingestion rate of dairy products	0.9 l/day
FI	Fraction ingested from contaminated source	0.75 (Unitless)
EF	Exposure frequency	350 days/year
EDn	Exposure duration	6 Year
Cp	Concentration of radionuclides in animal products	

Cs_{137+1d}	2.5E+01	pCi/kg	Rn_{222+4d}	ERR	pCi/kg
Pb_{210+2d}	8.5E−01	pCi/kg	Sr_{90+1d}	3.2E+02	pCi/kg
Np_{237+1d}	1.5E−03	pCi/kg	Tc_{99}	3.8E+04	pCi/kg
Pu_{238}	1.2E−04	pCi/kg	Th_{228+7d}	4.1E−03	pCi/kg
Pu_{239}	3.0E−05	pCi/kg	Th_{230}	1.1E−02	pCi/kg
Pu_{240}	1.1E−04	pCi/kg	$Th_{232+10d}$	6.4E−03	pCi/kg
Pa_{231}	4.0E−02	pCi/kg	U_{234}	2.8E+01	pCi/kg
Ra_{226+8d}	7.2E−01	pCi/kg	U_{235+1d}	7.4E−01	pCi/kg
Ra_{228+1d}	1.0E+00	pCi/kg	U_{236}	3.1E−01	pCi/kg
Ru_{106}	1.7E−04	pCi/kg	U_{238+2d}	1.7E+01	pCi/kg

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	ILCR (unitless)
Cs_{137+1d}	3.5E+04	2.8E−11	9.9E−07
Pb_{210+2d}	1.2E+03	6.6E−10	7.9E−07
Np_{237+1d}	2.2E+00	2.2E−10	4.8E−10
Pu_{238}	1.7E−01	2.2E−10	3.8E−11
Pu_{239}	4.2E−02	2.3E−10	9.7E−12
Pu_{240}	1.5E−01	2.3E−10	3.5E−11
Pa_{231}	5.6E+01	9.2E−11	5.2E−09
Ra_{226+8d}	1.0E+03	7.8E−10	8.0E−07
Ra_{228+1d}	1.5E+03	1.0E−10	1.5E−07
Ru_{106}	2.4E−01	9.5E−12	2.3E−12
Rn_{222+4d}	NA	1.7E−12	NA
Sr_{90+1d}	4.5E+05	3.6E−11	1.6E−05
Tc_{99}	5.4E+07	1.3E−12	7.1E−05
Th_{228+7d}	5.8E+00	5.5E−11	3.2E−10
Th_{230}	1.5E+01	1.3E−11	2.0E−10
$Th_{232+10d}$	9.1E+00	1.7E−10	1.5E−09
U_{234}	3.9E+04	1.6E−11	6.3E−07
U_{235+1d}	1.1E+03	1.6E−11	1.7E−08
U_{236}	4.3E+02	1.5E−11	6.5E−09
U_{238+2d}	2.4E+04	2.0E−11	4.7E−07
		ILCR Summation =	9.1E−05

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Table H.IV–142
Summary of Intake Quantitation (chemicals)
Future Land Use with Private Ownership: On–Property Farmer (Child)
Via Ingestion of Vegetables and Fruits

Intake Equation = $\frac{CS \times EF \times ED \times FI \times IR}{BW \times AT}$

IR	Ingestion rate of fruits or vegetables	0.1 kg/day
FI	Fraction ingested from contaminated source	0.5 (Unitless)
EF	Exposure frequency	350 days/year
EDn	Exposure duration for non–carcinogens	6 Year
EDc	Exposure duration for carcinogens	6 Year
BW	Body weight	15 kg
ATc	Average time for carcinogens (lifetime)	25550 days
ATn	Average time for non–carcinogens (EDn x 365)	2190 days
CS	Concentration of chemicals in vegetables	

Chemical Concentrations

Compound	Concentration	Units	Compound	Concentration	Units
antimony	0.0E+00	mg/kg	silver	2.4E+00	mg/kg
arsenic	2.2E–01	mg/kg	thallium	2.2E–03	mg/kg
barium	1.5E+01	mg/kg	thorium–total	2.7E–04	mg/kg
beryllium	8.1E–03	mg/kg	uranium–total	8.9E–01	mg/kg
boron	4.5E+02	mg/kg	vanadium	1.4E–01	mg/kg
cadmium	1.9E+00	mg/kg	zinc	9.6E+01	mg/kg
chromium vi	1.2E–01	mg/kg	2–methylnaphthalene	2.8E–06	mg/kg
cobalt	2.4E–01	mg/kg	4,4–dde	5.2E–09	mg/kg
copper	8.1E+00	mg/kg	aroclor–1221	1.2E–23	mg/kg
cyanide	6.1E+00	mg/kg	aroclor–1248	0.0E+00	mg/kg
lead	1.1E+00	mg/kg	aroclor–1254	5.5E–06	mg/kg
manganese	2.4E+02	mg/kg	aroclor–1260	2.0E–06	mg/kg
mercury	1.9E–01	mg/kg	carbazole	1.1E–07	mg/kg
molybdenum	3.9E–01	mg/kg	endrin	0.0E+00	mg/kg
nickel	1.4E+00	mg/kg	2,3,7,8–tcdd	5.3E–13	mg/kg
selenium	1.6E–02	mg/kg			

References

Table H.IV-142 (continued)
Summary of Risk Characterization (chemicals)
Future Land Use with Private Ownership: On-Property Farmer (Child)
Via Ingestion of Vegetables and Fruits

	HQ Calculation		
Compound	CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
antimony	NA	4.0E-04	NA
arsenic	7.2E-04	3.0E-04	2.4E+00
barium	4.7E-02	7.0E-02	6.7E-01
beryllium	2.6E-05	5.0E-03	5.2E-03
boron	1.4E+00	9.0E-02	1.6E+01
cadmium	6.1E-03	1.0E-03	6.1E+00
chromium vi	3.9E-04	5.0E-03	7.9E-02
cobalt	7.7E-04	6.0E-02	1.3E-02
copper	2.6E-02	NA	NA
cyanide	1.9E-02	2.0E-02	9.7E-01
lead	3.4E-03	NA	NA
manganese	7.8E-01	1.4E-01	5.6E+00
mercury	6.2E-04	3.0E-04	2.1E+00
molybdenum	1.2E-03	5.0E-03	2.5E-01
nickel	4.3E-03	2.0E-02	2.2E-01
selenium	5.0E-05	5.0E-03	1.0E-02
silver	7.7E-03	5.0E-03	1.5E+00
thallium	7.1E-06	8.0E-05	8.9E-02
thorium-total	8.7E-07	NA	NA
uranium-total	2.9E-03	3.0E-03	9.5E-01
vanadium	4.6E-04	7.0E-03	6.5E-02
zinc	3.1E-01	3.0E-01	1.0E+00
2-methylnaphthalene	9.1E-09	NA	NA
4,4-dde	1.7E-11	NA	NA
aroclor-1221	3.7E-26	NA	NA
aroclor-1248	NA	NA	NA
aroclor-1254	1.8E-08	NA	NA
aroclor-1260	6.5E-09	NA	NA
carbazole	3.4E-10	NA	NA
endrin	NA	3.0E-04	NA
2,3,7,8-tcdd	1.7E-15	NA	NA
	HQ Summation =		3.8E+01

	ILCR Calculation		
Compound	CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	ILCR (unitless)
antimony	NA	NA	NA
arsenic	6.2E-05	1.8E+00	1.1E-04
barium	4.0E-03	NA	NA
beryllium	2.2E-06	4.3E+00	9.6E-06
boron	1.2E-01	NA	NA
cadmium	5.2E-04	NA	NA
chromium vi	3.4E-05	NA	NA
cobalt	6.6E-05	NA	NA
copper	2.2E-03	NA	NA
cyanide	1.7E-03	NA	NA
lead	2.9E-04	NA	NA
manganese	6.7E-02	NA	NA
mercury	5.3E-05	NA	NA
molybdenum	1.1E-04	NA	NA
nickel	3.7E-04	NA	NA
selenium	4.3E-06	NA	NA
silver	6.6E-04	NA	NA
thallium	6.1E-07	NA	NA
thorium-total	7.5E-08	NA	NA
uranium-total	2.4E-04	NA	NA
vanadium	3.9E-05	NA	NA
zinc	2.6E-02	NA	NA
2-methylnaphthalene	7.8E-10	NA	NA
4,4-dde	1.4E-12	3.4E-01	4.8E-13
aroclor-1221	3.2E-27	7.7E+00	2.4E-26
aroclor-1248	NA	7.7E+00	NA
aroclor-1254	1.5E-09	7.7E+00	1.2E-08
aroclor-1260	5.6E-10	7.7E+00	4.3E-09
carbazole	2.9E-11	2.0E-02	5.8E-13
endrin	NA	NA	NA
2,3,7,8-tcdd	1.4E-16	1.5E+05	2.2E-11
	ILCR Summation =		1.2E-04

Table H.IV–143
Summary of Intake and Risk Quantitation (radionuclides)
Future Land Use with Private Ownership: On–Property Farmer (Child)
Via Ingestion of Vegetables and Fruits

Intake Equation = Cv X EF X EDn X FI X IR

IR	Ingestion rate of fruits or vegetables	0.1 kg/day
FI	Fraction ingested from contaminated source	0.5 (Unitless)
EF	Exposure frequency	350 days/year
EDn	Exposure duration	6 Year
Cv	Concentration of radionuclides in vegetables	

Cs_{137+1d}	6.3E+01	pCi/kg	Rn_{222+4d}	ERR	pCi/kg
Pb_{210+2d}	2.1E–02	pCi/kg	Sr_{90+1d}	1.2E–02	pCi/kg
Np_{237+1d}	2.8E+00	pCi/kg	Tc_{99}	3.3E+04	pCi/kg
Pu_{238}	1.4E–02	pCi/kg	Th_{228+7d}	1.0E–03	pCi/kg
Pu_{239}	1.2E–03	pCi/kg	Th_{230}	4.7E–03	pCi/kg
Pu_{240}	4.4E–03	pCi/kg	$Th_{232+10d}$	3.6E–03	pCi/kg
Pa_{231}	1.2E–03	pCi/kg	U_{234}	5.0E+02	pCi/kg
Ra_{226+8d}	1.2E+00	pCi/kg	U_{235+1d}	1.3E+01	pCi/kg
Ra_{228+1d}	1.3E–03	pCi/kg	U_{236}	5.5E+00	pCi/kg
Ru_{106}	5.3E–04	pCi/kg	U_{238+2d}	3.0E+02	pCi/kg

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	ILCR (unitless)
Cs_{137+1d}	6.7E+03	2.8E–11	1.9E–07
Pb_{210+2d}	2.2E+00	6.6E–10	1.5E–09
Np_{237+1d}	2.9E+02	2.2E–10	6.4E–08
Pu_{238}	1.5E+00	2.2E–10	3.3E–10
Pu_{239}	1.3E–01	2.3E–10	2.9E–11
Pu_{240}	4.6E–01	2.3E–10	1.1E–10
Pa_{231}	1.3E–01	9.2E–11	1.2E–11
Ra_{226+8d}	1.3E+02	7.8E–10	1.0E–07
Ra_{228+1d}	1.3E–01	1.0E–10	1.3E–11
Ru_{106}	5.6E–02	9.5E–12	5.3E–13
Rn_{222+4d}	NA	1.7E–12	NA
Sr_{90+1d}	1.2E+00	3.6E–11	4.5E–11
Tc_{99}	3.5E+06	1.3E–12	4.6E–06
Th_{228+7d}	1.0E–01	5.5E–11	5.8E–12
Th_{230}	4.9E–01	1.3E–11	6.4E–12
$Th_{232+10d}$	3.8E–01	1.7E–10	6.4E–11
U_{234}	5.2E+04	1.6E–11	8.4E–07
U_{235+1d}	1.4E+03	1.6E–11	2.2E–08
U_{236}	5.8E+02	1.5E–11	8.6E–09
U_{238+2d}	3.1E+04	2.0E–11	6.3E–07
		ILCR Summation =	6.4E–06

Table H.IV–144
Summary of Intake and Risk Quantitation (radionuclides)
Future Land Use with Private Ownership: On–Property Farmer (Child)
Via External Radiation

Dose Equivalency Equat = $[DR \times EF \times EDn \times ET_i \times (1-SH_i)] + [DR \times EF \times EDn \times ET_o \times (1-SH_o)]$

EF	Fraction of year spent exposured	0.96 (unitless)
ED	Exposure duration	6 Year
ET_i	Fraction of day spent indoors	0.92 (unitless)
ET_o	Fraction of day spent outdoors	0.08 (unitless)
SH_i	Shield factor indoors	0.5 (unitless)
SH_o	Shield factor outdoors	0 (unitless)
DR	Radionuclide specific dose concentrations	(see table below)

Cs_{137+1d}	7.93E–01	pCi/g	Rn_{222+4d}	NA	pCi/g
Pb_{210+2d}	1.05E–06	pCi/g	Sr_{90+1d}	8.33E–07	pCi/g
Np_{237+1d}	8.36E–08	pCi/g	Tc_{99}	1.87E–06	pCi/g
Pu_{238}	9.07E–08	pCi/g	Th_{228+7d}	4.00E–07	pCi/g
Pu_{239}	1.25E–08	pCi/g	Th_{230}	5.92E–08	pCi/g
Pu_{240}	4.55E–08	pCi/g	$Th_{232+10d}$	5.95E–07	pCi/g
Pa_{231}	NA	pCi/g	U_{234}	2.06E–05	pCi/g
Ra_{226+8d}	3.99E–07	pCi/g	U_{235+1d}	9.34E–07	pCi/g
Ra_{228+1d}	7.00E–07	pCi/g	U_{236}	6.86E–06	pCi/g
Ru_{106}	1.33E–07	pCi/g	U_{238+2d}	1.38E–05	pCi/g

Radionuclides	CDI (year pCi/g)	CSF $(g/pCi-year)^{-1}$	ILCR (unitless)
Cs_{137+1d}	2.5E+00	2.0E–06	4.9E–06
Pb_{210+2d}	3.3E–06	1.6E–10	5.2E–16
Np_{237+1d}	2.6E–07	4.3E–07	1.1E–13
Pu_{238}	2.8E–07	2.8E–11	7.9E–18
Pu_{239}	3.9E–08	1.7E–11	6.6E–19
Pu_{240}	1.4E–07	2.7E–11	3.8E–18
Pa_{231}	NA	2.6E–08	NA
Ra_{226+8d}	1.2E–06	6.0E–06	7.4E–12
Ra_{228+1d}	2.2E–06	2.9E–06	6.3E–12
Ru_{106}	4.1E–07	NA	0.0E+00
Rn_{222+4d}	NA	5.9E–06	NA
Sr_{90+1d}	2.6E–06	NA	0.0E+00
Tc_{99}	5.8E–06	6.0E–13	3.5E–18
Th_{228+7d}	1.2E–06	5.6E–06	7.0E–12
Th_{230}	1.8E–07	5.4E–11	9.9E–18
$Th_{232+10d}$	1.9E–06	8.5E–06	1.6E–11
U_{234}	6.4E–05	3.0E–11	1.9E–15
U_{235+1d}	2.9E–06	2.4E–07	7.0E–13
U_{236}	2.1E–05	2.4E–11	5.1E–16
U_{238+2d}	4.3E–05	5.1E–08	2.2E–12
ILCR Summation		=	4.9E–06

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Table I.IV–145
Summary of Intake Quantitation (chemicals)
Future Land Use with Private Ownership: GMR User (Agricultural)
Via Ingestion of Meat Products

Intake Equation = $\frac{CS \times EF \times ED \times FI \times IR}{BW \times AT}$

IR	Ingestion rate of meat	0.101 kg/day
FI	Fraction ingested from contaminated source	0.75 (Unitless)
EF	Exposure frequency	350 days/year
EDn	Exposure duration for non–carcinogens	70 Year
EDc	Exposure duration for carcinogens	70 Year
BW	Body weight	70 kg
ATc	Average time for carcinogens (lifetime)	25550 days
ATn	Average time for non–carcinogens (EDn x 365)	25550 days
CS	Concentration of chemicals in meat	

Chemical Concentrations

Compound	Concentration	Units	Compound	Concentration	Units
antimony	3.6E–07	mg/kg	silver	NA	mg/kg
arsenic	1.1E–05	mg/kg	thallium	NA	mg/kg
barium	NA	mg/kg	thorium–total	NA	mg/kg
beryllium	1.6E–07	mg/kg	uranium–total	3.3E–05	mg/kg
boron	NA	mg/kg	vanadium	NA	mg/kg
cadmium	NA	mg/kg	zinc	NA	mg/kg
chromium vi	NA	mg/kg	2–methylnaphthalene	NA	mg/kg
cobalt	NA	mg/kg	4,4–dde	NA	mg/kg
copper	NA	mg/kg	aroclor–1221	NA	mg/kg
cyanide	NA	mg/kg	aroclor–1248	NA	mg/kg
lead	NA	mg/kg	aroclor–1254	NA	mg/kg
manganese	NA	mg/kg	aroclor–1260	NA	mg/kg
mercury	NA	mg/kg	carbazole	NA	mg/kg
molybdenum	NA	mg/kg	endrin	NA	mg/kg
nickel	NA	mg/kg	2,3,7,8–tcdd	NA	mg/kg
selenium	NA	mg/kg			

References

Table I.IV-145 (continued)
Summary of Risk Characterization (chemicals)
Future Land Use with Private Ownership: GMR User (Agricultural)
Via Ingestion of Meat Products

	HQ Calculation		
Compound	CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
antimony	3.7E-10	4.0E-04	9.2E-07
arsenic	1.1E-08	3.0E-04	3.7E-05
barium	NA	7.0E-02	NA
beryllium	1.7E-10	5.0E-03	3.4E-08
boron	NA	9.0E-02	NA
cadmium	NA	1.0E-03	NA
chromium vi	NA	5.0E-03	NA
cobalt	NA	6.0E-02	NA
copper	NA	NA	NA
cyanide	NA	2.0E-02	NA
lead	NA	NA	NA
manganese	NA	1.4E-01	NA
mercury	NA	3.0E-04	NA
molybdenum	NA	5.0E-03	NA
nickel	NA	2.0E-02	NA
selenium	NA	5.0E-03	NA
silver	NA	5.0E-03	NA
thallium	NA	8.0E-05	NA
thorium-total	NA	NA	NA
uranium-total	3.4E-08	3.0E-03	1.1E-05
vanadium	NA	7.0E-03	NA
zinc	NA	3.0E-01	NA
2-methylnaphthalene	NA	NA	NA
4,4-dde	NA	NA	NA
aroclor-1221	NA	NA	NA
aroclor-1248	NA	NA	NA
aroclor-1254	NA	NA	NA
aroclor-1260	NA	NA	NA
carbazole	NA	NA	NA
endrin	NA	3.0E-04	NA
2,3,7,8-tcdd	NA	NA	NA
	HQ Summation =		4.9E-05

	ILCR Calculation		
Compound	CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	ILCR (unitless)
antimony	3.7E-10	NA	NA
arsenic	1.1E-08	1.8E+00	1.9E-08
barium	NA	NA	NA
beryllium	1.7E-10	4.3E+00	7.4E-10
boron	NA	NA	NA
cadmium	NA	NA	NA
chromium vi	NA	NA	NA
cobalt	NA	NA	NA
copper	NA	NA	NA
cyanide	NA	NA	NA
lead	NA	NA	NA
manganese	NA	NA	NA
mercury	NA	NA	NA
molybdenum	NA	NA	NA
nickel	NA	NA	NA
selenium	NA	NA	NA
silver	NA	NA	NA
thallium	NA	NA	NA
thorium-total	NA	NA	NA
uranium-total	3.4E-08	NA	NA
vanadium	NA	NA	NA
zinc	NA	NA	NA
2-methylnaphthalene	NA	NA	NA
4,4-dde	NA	3.4E-01	NA
aroclor-1221	NA	7.7E+00	NA
aroclor-1248	NA	7.7E+00	NA
aroclor-1254	NA	7.7E+00	NA
aroclor-1260	NA	7.7E+00	NA
carbazole	NA	2.0E-02	NA
endrin	NA	NA	NA
2,3,7,8-tcdd	NA	1.5E+05	NA
	ILCR Summation =		2.0E-08

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Table I.IV–146
Summary of Intake and Risk Quantitation (radionuclides)
Future Land Use with Private Ownership: GMR User (Agricultural)
Via Ingestion of Meat Products

Intake Equation = Cf X EF X EDn X FI X IR

IR	Ingestion rate of meat	0.101 kg/day
FI	Fraction ingested from contaminated source	0.75 (Unitless)
EF	Exposure frequency	350 days/year
EDn	Exposure duration	70 Year
Cf	Concentration of radionuclides in meat	

Cs_{137+1d}	NA	pCi/kg	Rn_{222+4d}	NA	pCi/kg
Pb_{210+2d}	NA	pCi/kg	Sr_{90+1d}	NA	pCi/kg
Np_{237+1d}	3.2E−05	pCi/kg	Tc_{99}	4.0E+01	pCi/kg
Pu_{238}	NA	pCi/kg	Th_{228+7d}	NA	pCi/kg
Pu_{239}	NA	pCi/kg	Th_{230}	NA	pCi/kg
Pu_{240}	NA	pCi/kg	$Th_{232+10d}$	NA	pCi/kg
Pa_{231}	NA	pCi/kg	U_{234}	NA	pCi/kg
Ra_{226+8d}	1.3E−04	pCi/kg	U_{235+1d}	NA	pCi/kg
Ra_{228+1d}	NA	pCi/kg	U_{236}	NA	pCi/kg
Ru_{106}	NA	pCi/kg	U_{238+2d}	NA	pCi/kg

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	ILCR (unitless)
Cs_{137+1d}	NA	2.8E−11	NA
Pb_{210+2d}	NA	6.6E−10	NA
Np_{237+1d}	5.9E−02	2.2E−10	1.3E−11
Pu_{238}	NA	2.2E−10	NA
Pu_{239}	NA	2.3E−10	NA
Pu_{240}	NA	2.3E−10	NA
Pa_{231}	NA	9.2E−11	NA
Ra_{226+8d}	2.3E−01	7.8E−10	1.8E−10
Ra_{228+1d}	NA	1.0E−10	NA
Ru_{106}	NA	9.5E−12	NA
Rn_{222+4d}	NA	1.7E−12	NA
Sr_{90+1d}	NA	3.6E−11	NA
Tc_{99}	7.5E+04	1.3E−12	9.7E−08
Th_{228+7d}	NA	5.5E−11	NA
Th_{230}	NA	1.3E−11	NA
$Th_{232+10d}$	NA	1.7E−10	NA
U_{234}	NA	1.6E−11	NA
U_{235+1d}	NA	1.6E−11	NA
U_{236}	NA	1.5E−11	NA
U_{238+2d}	NA	2.0E−11	NA
		ILCR Summation =	9.8E−08

Table I.IV–147
Summary of Intake Quantitation (chemicals)
Future Land Use with Private Ownership: GMR User (Agricultural)
Via Ingestion of Dairy Products

Intake Equation = $\frac{CS \times EF \times ED \times FI \times IR}{BW \times AT}$

IR	Ingestion rate of dairy products	0.4	l/day
FI	Fraction ingested from contaminated source	0.75	(Unitless)
EF	Exposure frequency	350	days/year
EDn	Exposure duration for non–carcinogens	70	Year
EDc	Exposure duration for carcinogens	70	Year
BW	Body weight	70	kg
ATc	Average time for carcinogens (lifetime)	25550	days
ATn	Average time for non–carcinogens (EDn x 365)	25550	days
CS	Concentration of chemicals in animal products		

Chemical Concentrations

Compound	Concentration	Units	Compound	Concentration	Units
antimony	4.3E–08	mg/kg	silver	NA	mg/kg
arsenic	3.9E–07	mg/kg	thallium	NA	mg/kg
barium	NA	mg/kg	thorium–total	NA	mg/kg
beryllium	1.8E–10	mg/kg	uranium–total	1.2E–04	mg/kg
boron	NA	mg/kg	vanadium	NA	mg/kg
cadmium	NA	mg/kg	zinc	NA	mg/kg
chromium vi	NA	mg/kg	2–methylnaphthalene	NA	mg/kg
cobalt	NA	mg/kg	4,4–dde	NA	mg/kg
copper	NA	mg/kg	aroclor–1221	NA	mg/kg
cyanide	NA	mg/kg	aroclor–1248	NA	mg/kg
lead	NA	mg/kg	aroclor–1254	NA	mg/kg
manganese	NA	mg/kg	aroclor–1260	NA	mg/kg
mercury	NA	mg/kg	carbazole	NA	mg/kg
molybdenum	NA	mg/kg	endrin	NA	mg/kg
nickel	NA	mg/kg	2,3,7,8–tcdd	NA	mg/kg
selenium	NA	mg/kg			

References

Table I.IV-147 (continued)
Summary of Risk Characterization (chemicals)
Future Land Use with Private Ownership: GMR User (Agricultural)
Via Ingestion of Dairy Products

Compound	HQ Calculation CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
antimony	1.8E-10	4.0E-04	4.4E-07
arsenic	1.6E-09	3.0E-04	5.3E-06
barium	NA	7.0E-02	NA
beryllium	7.3E-13	5.0E-03	1.5E-10
boron	NA	9.0E-02	NA
cadmium	NA	1.0E-03	NA
chromium vi	NA	5.0E-03	NA
cobalt	NA	6.0E-02	NA
copper	NA	NA	NA
cyanide	NA	2.0E-02	NA
lead	NA	NA	NA
manganese	NA	1.4E-01	NA
mercury	NA	3.0E-04	NA
molybdenum	NA	5.0E-03	NA
nickel	NA	2.0E-02	NA
selenium	NA	5.0E-03	NA
silver	NA	5.0E-03	NA
thallium	NA	8.0E-05	NA
thorium-total	NA	NA	NA
uranium-total	4.8E-07	3.0E-03	1.6E-04
vanadium	NA	7.0E-03	NA
zinc	NA	3.0E-01	NA
2-methylnaphthalene	NA	NA	NA
4,4-dde	NA	NA	NA
aroclor-1221	NA	NA	NA
aroclor-1248	NA	NA	NA
aroclor-1254	NA	NA	NA
aroclor-1260	NA	NA	NA
carbazole	NA	NA	NA
endrin	NA	3.0E-04	NA
2,3,7,8-tcdd	NA	NA	NA
	HQ Summation =		1.7E-04

Compound	ILCR Calculation CDI (mg/kg-day)	CSF (mg/kg-day)$^{-1}$	ILCR (unitless)
antimony	1.8E-10	NA	NA
arsenic	1.6E-09	1.8E+00	2.8E-09
barium	NA	NA	NA
beryllium	7.3E-13	4.3E+00	3.1E-12
boron	NA	NA	NA
cadmium	NA	NA	NA
chromium vi	NA	NA	NA
cobalt	NA	NA	NA
copper	NA	NA	NA
cyanide	NA	NA	NA
lead	NA	NA	NA
manganese	NA	NA	NA
mercury	NA	NA	NA
molybdenum	NA	NA	NA
nickel	NA	NA	NA
selenium	NA	NA	NA
silver	NA	NA	NA
thallium	NA	NA	NA
thorium-total	NA	NA	NA
uranium-total	4.8E-07	NA	NA
vanadium	NA	NA	NA
zinc	NA	NA	NA
2-methylnaphthalene	NA	NA	NA
4,4-dde	NA	3.4E-01	NA
aroclor-1221	NA	7.7E+00	NA
aroclor-1248	NA	7.7E+00	NA
aroclor-1254	NA	7.7E+00	NA
aroclor-1260	NA	7.7E+00	NA
carbazole	NA	2.0E-02	NA
endrin	NA	NA	NA
2,3,7,8-tcdd	NA	1.5E+05	NA
	ILCR Summation =		2.8E-09

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Table I.IV–148
Summary of Intake and Risk Quantitation (radionuclides)
Future Land Use with Private Ownership: GMR User (Agricultural)
Via Ingestion of Dairy Products

Intake Equation = Cp X EF X EDn X FI X IR

IR	Ingestion rate of dairy products	0.4 l/day
FI	Fraction ingested from contaminated source	0.75 (Unitless)
EF	Exposure frequency	350 days/year
EDn	Exposure duration	70 Year
Cp	Concentration of radionuclides in animal products	

Cs_{137+1d}	NA	pCi/kg	Rn_{222+4d}	NA	pCi/kg
Pb_{210+2d}	NA	pCi/kg	Sr_{90+1d}	NA	pCi/kg
Np_{237+1d}	3.5E−06	pCi/kg	Tc_{99}	5.7E+01	pCi/kg
Pu_{238}	NA	pCi/kg	Th_{228+7d}	NA	pCi/kg
Pu_{239}	NA	pCi/kg	Th_{230}	NA	pCi/kg
Pu_{240}	NA	pCi/kg	$Th_{232+10d}$	NA	pCi/kg
Pa_{231}	NA	pCi/kg	U_{234}	NA	pCi/kg
Ra_{226+8d}	2.7E−04	pCi/kg	U_{235+1d}	NA	pCi/kg
Ra_{228+1d}	NA	pCi/kg	U_{236}	NA	pCi/kg
Ru_{106}	NA	pCi/kg	U_{238+2d}	NA	pCi/kg

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	ILCR (unitless)
Cs_{137+1d}	NA	2.8E−11	NA
Pb_{210+2d}	NA	6.6E−10	NA
Np_{237+1d}	2.6E−02	2.2E−10	5.6E−12
Pu_{238}	NA	2.2E−10	NA
Pu_{239}	NA	2.3E−10	NA
Pu_{240}	NA	2.3E−10	NA
Pa_{231}	NA	9.2E−11	NA
Ra_{226+8d}	2.0E+00	7.8E−10	1.6E−09
Ra_{228+1d}	NA	1.0E−10	NA
Ru_{106}	NA	9.5E−12	NA
Rn_{222+4d}	NA	1.7E−12	NA
Sr_{90+1d}	NA	3.6E−11	NA
Tc_{99}	4.2E+05	1.3E−12	5.4E−07
Th_{228+7d}	NA	5.5E−11	NA
Th_{230}	NA	1.3E−11	NA
$Th_{232+10d}$	NA	1.7E−10	NA
U_{234}	NA	1.6E−11	NA
U_{235+1d}	NA	1.6E−11	NA
U_{236}	NA	1.5E−11	NA
U_{238+2d}	NA	2.0E−11	NA
		ILCR Summation =	5.5E−07

Table I.IV–149
Summary of Intake Quantitation (chemicals)
Future Land Use with Private Ownership: GMR User
Via Ingestion of Vegetables and Fruits

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Intake Equation = $\frac{CS \times EF \times ED \times FI \times IR}{BW \times AT}$

IR	Ingestion rate of fruits or vegetables	0.122 kg/day
FI	Fraction ingested from contaminated source	1 (Unitless)
EF	Exposure frequency	350 days/year
EDn	Exposure duration for non–carcinogens	70 Year
EDc	Exposure duration for carcinogens	70 Year
BW	Body weight	70 kg
ATc	Average time for carcinogens (lifetime)	25550 days
ATn	Average time for non–carcinogens (EDn x 365)	25550 days
CS	Concentration of chemicals in vegetables	

Chemical Concentrations

Compound	Concentration	Units	Compound	Concentration	Units
antimony	3.5E–05	mg/kg	silver	NA	mg/kg
arsenic	5.2E–04	mg/kg	thallium	NA	mg/kg
barium	NA	mg/kg	thorium–total	NA	mg/kg
beryllium	1.6E–05	mg/kg	uranium–total	1.6E–02	mg/kg
boron	NA	mg/kg	vanadium	NA	mg/kg
cadmium	NA	mg/kg	zinc	NA	mg/kg
chromium vi	NA	mg/kg	2–methylnaphthalene	NA	mg/kg
cobalt	NA	mg/kg	4,4–dde	NA	mg/kg
copper	NA	mg/kg	aroclor–1221	NA	mg/kg
cyanide	NA	mg/kg	aroclor–1248	NA	mg/kg
lead	NA	mg/kg	aroclor–1254	NA	mg/kg
manganese	NA	mg/kg	aroclor–1260	NA	mg/kg
mercury	NA	mg/kg	carbazole	NA	mg/kg
molybdenum	NA	mg/kg	endrin	NA	mg/kg
nickel	NA	mg/kg	2,3,7,8–tcdd	NA	mg/kg
selenium	NA	mg/kg			

References

Table I.IV–149 (continued)
Summary of Risk Characterization (chemicals)
Future Land Use with Private Ownership: GMR User (Agricultural)
Via Ingestion of Vegetables and Fruits

Compound	HQ Calculation CDI (mg/kg–day)	RfD (mg/kg–day)	HQ (unitless)
antimony	5.8E–08	4.0E–04	1.5E–04
arsenic	8.8E–07	3.0E–04	2.9E–03
barium	NA	7.0E–02	NA
beryllium	2.7E–08	5.0E–03	5.4E–06
boron	NA	9.0E–02	NA
cadmium	NA	1.0E–03	NA
chromium vi	NA	5.0E–03	NA
cobalt	NA	6.0E–02	NA
copper	NA	NA	NA
cyanide	NA	2.0E–02	NA
lead	NA	NA	NA
manganese	NA	1.4E–01	NA
mercury	NA	3.0E–04	NA
molybdenum	NA	5.0E–03	NA
nickel	NA	2.0E–02	NA
selenium	NA	5.0E–03	NA
silver	NA	5.0E–03	NA
thallium	NA	8.0E–05	NA
thorium–total	NA	NA	NA
uranium–total	2.7E–05	3.0E–03	8.9E–03
vanadium	NA	7.0E–03	NA
zinc	NA	3.0E–01	NA
2–methylnaphthalene	NA	NA	NA
4,4–dde	NA	NA	NA
aroclor–1221	NA	NA	NA
aroclor–1248	NA	NA	NA
aroclor–1254	NA	NA	NA
aroclor–1260	NA	NA	NA
carbazole	NA	NA	NA
endrin	NA	3.0E–04	NA
2,3,7,8–tcdd	NA	NA	NA
	HQ Summation =		1.2E–02

Compound	ILCR Calculation CDI (mg/kg–day)	CSF $(mg/kg–day)^{-1}$	ILCR (unitless)
antimony	5.8E–08	NA	NA
arsenic	8.8E–07	1.8E+00	1.5E–06
barium	NA	NA	NA
beryllium	2.7E–08	4.3E+00	1.2E–07
boron	NA	NA	NA
cadmium	NA	NA	NA
chromium vi	NA	NA	NA
cobalt	NA	NA	NA
copper	NA	NA	NA
cyanide	NA	NA	NA
lead	NA	NA	NA
manganese	NA	NA	NA
mercury	NA	NA	NA
molybdenum	NA	NA	NA
nickel	NA	NA	NA
selenium	NA	NA	NA
silver	NA	NA	NA
thallium	NA	NA	NA
thorium–total	NA	NA	NA
uranium–total	2.7E–05	NA	NA
vanadium	NA	NA	NA
zinc	NA	NA	NA
2–methylnaphthalene	NA	NA	NA
4,4–dde	NA	3.4E–01	NA
aroclor–1221	NA	7.7E+00	NA
aroclor–1248	NA	7.7E+00	NA
aroclor–1254	NA	7.7E+00	NA
aroclor–1260	NA	7.7E+00	NA
carbazole	NA	2.0E–02	NA
endrin	NA	NA	NA
2,3,7,8–tcdd	NA	1.5E+05	NA
	ILCR Summation =		1.6E–06

Table I.IV–150
Summary of Intake and Risk Quantitation (radionuclides)
Future Land Use with Private Ownership: GMR User (Agricultural)
Via Ingestion of Vegetables and Fruits

Intake Equation = Cv X EF X EDn X FI X IR

IR	Ingestion rate of fruits or vegetables	0.122 kg/day
FI	Fraction ingested from contaminated source	1 (Unitless)
EF	Exposure frequency	350 days/year
EDn	Exposure duration	70 Year
Cv	Concentration of radionuclides in vegetables	

Cs_{137+1d}	NA	pCi/kg	Rn_{222+4d}	ERR	pCi/kg
Pb_{210+2d}	NA	pCi/kg	Sr_{90+1d}	NA	pCi/kg
Np_{237+1d}	5.7E−02	pCi/kg	Tc_{99}	5.2E+02	pCi/kg
Pu_{238}	NA	pCi/kg	Th_{228+7d}	NA	pCi/kg
Pu_{239}	NA	pCi/kg	Th_{230}	NA	pCi/kg
Pu_{240}	NA	pCi/kg	$Th_{232+10d}$	NA	pCi/kg
Pa_{231}	NA	pCi/kg	U_{234}	NA	pCi/kg
Ra_{226+8d}	4.9E−02	pCi/kg	U_{235+1d}	NA	pCi/kg
Ra_{228+1d}	NA	pCi/kg	U_{236}	NA	pCi/kg
Ru_{106}	NA	pCi/kg	U_{238+2d}	NA	pCi/kg

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	ILCR (unitless)
Cs_{137+1d}	NA	2.8E−11	NA
Pb_{210+2d}	NA	6.6E−10	NA
Np_{237+1d}	1.7E+02	2.2E−10	3.7E−08
Pu_{238}	NA	2.2E−10	NA
Pu_{239}	NA	2.3E−10	NA
Pu_{240}	NA	2.3E−10	NA
Pa_{231}	NA	9.2E−11	NA
Ra_{226+8d}	1.5E+02	7.8E−10	1.2E−07
Ra_{228+1d}	NA	1.0E−10	NA
Ru_{106}	NA	9.5E−12	NA
Rn_{222+4d}	NA	1.7E−12	NA
Sr_{90+1d}	NA	3.6E−11	NA
Tc_{99}	1.6E+06	1.3E−12	2.0E−06
Th_{228+7d}	NA	5.5E−11	NA
Th_{230}	NA	1.3E−11	NA
$Th_{232+10d}$	NA	1.7E−10	NA
U_{234}	NA	1.6E−11	NA
U_{235+1d}	NA	1.6E−11	NA
U_{236}	NA	1.5E−11	NA
U_{238+2d}	NA	2.0E−11	NA
		ILCR Summation =	2.2E−06

Table I.IV–151
Summary of Intake Quantitation (chemicals)
Future Land Use with Private Ownership: GMR User (Residential)
Via Drinking Water Ingestion

Intake Equation = $\frac{CS \times EF \times ED \times IR}{BW \times AT}$

IR	Ingestion rate of groundwater (RAGS, 1989)	2 l/day
EF	Exposure frequency	350 days/year
EDn	Exposure duration for non–carcinogens	70 Year
EDc	Exposure duration for carcinogens	70 Year
BW	Body weight	70 kg
ATc	Average time for carcinogens (lifetime)	25550 days
ATn	Average time for non–carcinogens (EDn x 365)	25550 days
CS	Concentration of chemicals in groundwater	

Chemical Concentrations

Compound	Concentration	Units	Compound	Concentration	Units
antimony	7.11E–06	mg/l	silver	NA	mg/l
arsenic	1.07E–04	mg/l	thallium	NA	mg/l
barium	NA	mg/l	thorium–total	NA	mg/l
beryllium	3.30E–06	mg/l	uranium–total	3.26E–03	mg/l
boron	NA	mg/l	vanadium	NA	mg/l
cadmium	NA	mg/l	zinc	NA	mg/l
chromium vi	NA	mg/l	2–methylnaphthalene	NA	mg/l
cobalt	NA	mg/l	4,4–dde	NA	mg/l
copper	NA	mg/l	aroclor–1221	NA	mg/l
cyanide	NA	mg/l	aroclor–1248	NA	mg/l
lead	NA	mg/l	aroclor–1254	NA	mg/l
manganese	NA	mg/l	aroclor–1260	NA	mg/l
mercury	NA	mg/l	carbazole	NA	mg/l
molybdenum	NA	mg/l	endrin	NA	mg/l
nickel	NA	mg/l	2,3,7,8–tcdd	NA	mg/l
selenium	NA	mg/l			

References

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Table I.IV-151
Summary of Risk Characterization (chemicals)
Future Land Use with Private Ownership: GMR User (Residential)
Via Drinking Water Ingestion

Compound	HQ Calculation CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
antimony	1.95E-07	4.00E-04	4.87E-04
arsenic	2.93E-06	3.00E-04	9.77E-03
barium	NA	7.00E-02	NA
beryllium	9.04E-08	5.00E-03	1.81E-05
boron	NA	9.00E-02	NA
cadmium	NA	1.00E-03	NA
chromium vi	NA	5.00E-03	NA
cobalt	NA	6.00E-02	NA
copper	NA	NA	NA
cyanide	NA	2.00E-02	NA
lead	NA	NA	NA
manganese	NA	1.40E-01	NA
mercury	NA	3.00E-04	NA
molybdenum	NA	5.00E-03	NA
nickel	NA	2.00E-02	NA
selenium	NA	5.00E-03	NA
silver	NA	5.00E-03	NA
thallium	NA	8.00E-05	NA
thorium-total	NA	NA	NA
uranium-total	8.93E-05	3.00E-03	2.98E-02
vanadium	NA	7.00E-03	NA
zinc	NA	3.00E-01	NA
2-methylnaphthalene	NA	NA	NA
4,4-dde	NA	NA	NA
aroclor-1221	NA	NA	NA
aroclor-1248	NA	NA	NA
aroclor-1254	NA	NA	NA
aroclor-1260	NA	NA	NA
carbazole	NA	NA	NA
endrin	NA	3.00E-04	NA
2,3,7,8-tcdd	NA	NA	NA
	HQ Summation =		4.00E-02

Compound	ILCR Calculation CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	ILCR (unitless)
antimony	1.95E-07	NA	NA
arsenic	2.93E-06	1.75E+00	5.13E-06
barium	NA	NA	NA
beryllium	9.04E-08	4.30E+00	3.89E-07
boron	NA	NA	NA
cadmium	NA	NA	NA
chromium vi	NA	NA	NA
cobalt	NA	NA	NA
copper	NA	NA	NA
cyanide	NA	NA	NA
lead	NA	NA	NA
manganese	NA	NA	NA
mercury	NA	NA	NA
molybdenum	NA	NA	NA
nickel	NA	NA	NA
selenium	NA	NA	NA
silver	NA	NA	NA
thallium	NA	NA	NA
thorium-total	NA	NA	NA
uranium-total	8.93E-05	NA	NA
vanadium	NA	NA	NA
zinc	NA	NA	NA
2-methylnaphthalene	NA	NA	NA
4,4-dde	NA	3.40E-01	NA
aroclor-1221	NA	7.70E+00	NA
aroclor-1248	NA	7.70E+00	NA
aroclor-1254	NA	7.70E+00	NA
aroclor-1260	NA	7.70E+00	NA
carbazole	NA	2.00E-02	NA
endrin	NA	NA	NA
2,3,7,8-tcdd	NA	1.50E+05	NA
	ILCR Summation =		5.52E-06

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Table I.IV–152
Summary of Intake and Risk Quantitation (radionuclides)
Future Land Use with Private Ownership: GMR User (Residential)
Via Ingestion of Drinking Water

Intake Equation = Cw X EF X EDn X FI X IR

IR	Ingestion rate of groundwater (RAGS, 1989)	2 l/day
EF	Exposure frequency	350 days/year
EDn	Exposure duration	70 Year
FI	Fractional intake for radionuclides	1 (Unitless)
Cw	Concentration of radionuclides in groundwater	(see table below)

Cs_{137+1d}	NA	pCi/l	Rn_{222+4d}	NA	pCi/l
Pb_{210+2d}	NA	pCi/l	Sr_{90+1d}	NA	pCi/l
Np_{237+1d}	1.2E−02	pCi/l	Tc_{99}	9.5E+01	pCi/l
Pu_{238}	NA	pCi/l	Th_{228+7d}	NA	pCi/l
Pu_{239}	NA	pCi/l	Th_{230}	NA	pCi/l
Pu_{240}	NA	pCi/l	$Th_{232+10d}$	NA	pCi/l
Pa_{231}	NA	pCi/l	U_{234}	1.8E+00	pCi/l
Ra_{226+8d}	1.0E−02	pCi/l	U_{235+1d}	4.8E−02	pCi/l
Ra_{228+1d}	NA	pCi/l	U_{236}	2.0E−02	pCi/l
Ru_{106}	NA	pCi/l	U_{238+2d}	1.1E+00	pCi/l

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	ILCR (unitless)
Cs_{137+1d}	NA	2.8E−11	NA
Pb_{210+2d}	NA	6.6E−10	NA
Np_{237+1d}	5.7E+02	2.2E−10	1.3E−07
Pu_{238}	NA	2.2E−10	NA
Pu_{239}	NA	2.3E−10	NA
Pu_{240}	NA	2.3E−10	NA
Pa_{231}	NA	9.2E−11	NA
Ra_{226+8d}	4.9E+02	7.8E−10	3.9E−07
Ra_{228+1d}	NA	1.0E−10	NA
Ru_{106}	NA	9.5E−12	NA
Rn_{222+4d}	NA	1.7E−12	NA
Sr_{90+1d}	NA	3.6E−11	NA
Tc_{99}	4.7E+06	1.3E−12	6.1E−06
Th_{228+7d}	NA	5.5E−11	NA
Th_{230}	NA	1.3E−11	NA
$Th_{232+10d}$	NA	1.7E−10	NA
U_{234}	8.9E+04	1.6E−11	1.4E−06
U_{235+1d}	2.4E+03	1.6E−11	3.8E−08
U_{236}	9.8E+02	1.5E−11	1.5E−08
U_{238+2d}	5.3E+04	2.0E−11	1.1E−06
		ILCR Summation =	9.1E−06

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Table I.IV–153
Summary of Intake Quantitation (chemicals)
Future Land Use with Private Ownership: GMR User (Residential)
Via Dermal Contact while Bathing

Intake Equation = $\frac{DA \times EF \times ED \times SA}{BW \times AT}$

DA	Dermal absorbed dose	csv mg/cm^2–day
EF	Exposure frequency	350 days/year
EDn	Exposure duration for non–carcinogens	70 Year
EDc	Exposure duration for carcinogens	70 Year
BW	Body weight	70 kg
ATc	Average time for carcinogens (lifetime)	25550 days
ATn	Average time for non–carcinogens (EDn x 365)	25550 days
SA	Skin surface area available for contact	23000 cm^2

Chemical Concentrations

Compound	DA	Units
antimony	1.78E–11	mg/cm^2–day
arsenic	2.68E–10	mg/cm^2–day
barium	NA	mg/cm^2–day
beryllium	8.25E–12	mg/cm^2–day
boron	NA	mg/cm^2–day
cadmium	NA	mg/cm^2–day
chromium vi	NA	mg/cm^2–day
cobalt	NA	mg/cm^2–day
copper	NA	mg/cm^2–day
cyanide	NA	mg/cm^2–day
lead	NA	mg/cm^2–day
manganese	NA	mg/cm^2–day
mercury	NA	mg/cm^2–day
molybdenum	NA	mg/cm^2–day
nickel	NA	mg/cm^2–day
selenium	NA	mg/cm^2–day

Compound	DA	Units
silver	NA	mg/cm^2–day
thallium	NA	mg/cm^2–day
thorium–total	NA	mg/cm^2–day
uranium–total	8.15E–10	mg/cm^2–day
vanadium	NA	mg/cm^2–day
zinc	NA	mg/cm^2–day
2–methylnaphthalene	NA	mg/cm^2–day
4,4–dde	NA	mg/cm^2–day
aroclor–1221	NA	mg/cm^2–day
aroclor–1248	NA	mg/cm^2–day
aroclor–1254	NA	mg/cm^2–day
aroclor–1260	NA	mg/cm^2–day
carbazole	NA	mg/cm^2–day
endrin	NA	mg/cm^2–day
2,3,7,8–tcdd	NA	mg/cm^2–day

References

Table I.IV-153 (continued)
Summary of Risk Characterization (chemicals)
Future Land Use with Private Ownership: GMR User
Via Dermal Contact while Bathing

Compound	HQ Calculation CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
antimony	5.60E-09	6.00E-05	9.33E-05
arsenic	8.43E-08	2.85E-04	2.96E-04
barium	NA	6.37E-02	NA
beryllium	2.60E-09	5.00E-03	5.20E-07
boron	NA	4.50E-03	NA
cadmium	NA	5.00E-05	NA
chromium vi	NA	2.25E-03	NA
cobalt	NA	2.70E-02	NA
copper	NA	NA	NA
cyanide	NA	NA	NA
lead	NA	NA	NA
manganese	NA	4.20E-03	NA
mercury	NA	4.50E-05	NA
molybdenum	NA	1.90E-03	NA
nickel	NA	2.00E-03	NA
selenium	NA	4.00E-03	NA
silver	NA	NA	NA
thallium	NA	8.00E-05	NA
thorium-total	NA	NA	NA
uranium-total	2.57E-07	1.50E-04	1.71E-03
vanadium	NA	3.50E-04	NA
zinc	NA	7.50E-02	NA
2-methylnaphthalene	NA	NA	NA
4,4-dde	NA	NA	NA
aroclor-1221	NA	NA	NA
aroclor-1248	NA	NA	NA
aroclor-1254	NA	NA	NA
aroclor-1260	NA	NA	NA
carbazole	NA	NA	NA
endrin	NA	2.70E-04	NA
2,3,7,8-tcdd	NA	NA	NA
	HQ Summation =		2.10E-03

Compound	ILCR Calculation CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	ILCR (unitless)
antimony	5.60E-09	NA	NA
arsenic	8.43E-08	1.90E+00	1.60E-07
barium	NA	NA	NA
beryllium	2.60E-09	4.30E+00	1.12E-08
boron	NA	NA	NA
cadmium	NA	NA	NA
chromium vi	NA	NA	NA
cobalt	NA	NA	NA
copper	NA	NA	NA
cyanide	NA	NA	NA
lead	NA	NA	NA
manganese	NA	NA	NA
mercury	NA	NA	NA
molybdenum	NA	NA	NA
nickel	NA	NA	NA
selenium	NA	NA	NA
silver	NA	NA	NA
thallium	NA	NA	NA
thorium-total	NA	NA	NA
uranium-total	2.57E-07	NA	NA
vanadium	NA	NA	NA
zinc	NA	NA	NA
2-methylnaphthalene	NA	NA	NA
4,4-dde	NA	3.40E-01	NA
aroclor-1221	NA	1.03E+01	NA
aroclor-1248	NA	1.03E+01	NA
aroclor-1254	NA	1.03E+01	NA
aroclor-1260	NA	1.03E+01	NA
carbazole	NA	2.22E-02	NA
endrin	NA	NA	NA
2,3,7,8-tcdd	NA	3.00E+05	NA
	ILCR Summation =		1.71E-07

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Table I.IV–154
Summary of Intake Quantitation (chemicals)
Future Land Use with Private Ownership: GMR User (Recreational)
Via Ingestion of Fish

Intake Equation = $\frac{CS \times EF \times ED \times FI \times IR}{BW \times AT}$

IR	Ingestion rate of fish	0.054	kg/day
FI	Fraction ingested from contaminated source	1	(Unitless)
EF	Exposure frequency	122	days/year
EDn	Exposure duration for non–carcinogens	30	Year
EDc	Exposure duration for carcinogens	30	Year
BW	Body weight	70	kg
ATc	Average time for carcinogens (lifetime)	25550	days
ATn	Average time for non–carcinogens (EDn x 365)	10950	days
CS	Concentration of chemicals in meat	csv	

Chemical Concentrations

Compound	Concentration	Units	Compound	Concentration	Units
antimony	7.1E–06	mg/kg	silver	NA	mg/kg
arsenic	4.7E–03	mg/kg	thallium	NA	mg/kg
barium	NA	mg/kg	thorium–total	NA	mg/kg
beryllium	6.3E–05	mg/kg	uranium–total	6.5E–06	mg/kg
boron	NA	mg/kg	vanadium	NA	mg/kg
cadmium	NA	mg/kg	zinc	NA	mg/kg
chromium vi	NA	mg/kg	2–methylnaphthalene	NA	mg/kg
cobalt	NA	mg/kg	4,4–dde	NA	mg/kg
copper	NA	mg/kg	aroclor–1221	NA	mg/kg
cyanide	NA	mg/kg	aroclor–1248	NA	mg/kg
lead	NA	mg/kg	aroclor–1254	NA	mg/kg
manganese	NA	mg/kg	aroclor–1260	NA	mg/kg
mercury	NA	mg/kg	carbazole	NA	mg/kg
molybdenum	NA	mg/kg	endrin	NA	mg/kg
nickel	NA	mg/kg	2,3,7,8–tcdd	NA	mg/kg
selenium	NA	mg/kg			

References

Table I.IV-154 (continued)
Summary of Risk Characterization (chemicals)
Future Land Use with Private Ownership: GMR User (Recreational)
Via Ingestion of Fish

Compound	HQ Calculation CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
antimony	7.4E-09	4.0E-04	1.8E-05
arsenic	4.9E-06	3.0E-04	1.6E-02
barium	NA	7.0E-02	NA
beryllium	6.5E-08	5.0E-03	1.3E-05
boron	NA	9.0E-02	NA
cadmium	NA	1.0E-03	NA
chromium vi	NA	5.0E-03	NA
cobalt	NA	6.0E-02	NA
copper	NA	NA	NA
cyanide	NA	2.0E-02	NA
lead	NA	NA	NA
manganese	NA	1.4E-01	NA
mercury	NA	3.0E-04	NA
molybdenum	NA	5.0E-03	NA
nickel	NA	2.0E-02	NA
selenium	NA	5.0E-03	NA
silver	NA	5.0E-03	NA
thallium	NA	8.0E-05	NA
thorium-total	NA	NA	NA
uranium-total	6.8E-09	3.0E-03	2.3E-06
vanadium	NA	7.0E-03	NA
zinc	NA	3.0E-01	NA
2-methylnaphthalene	NA	NA	NA
4,4-dde	NA	NA	NA
aroclor-1221	NA	NA	NA
aroclor-1248	NA	NA	NA
aroclor-1254	NA	NA	NA
aroclor-1260	NA	NA	NA
carbazole	NA	NA	NA
endrin	NA	3.0E-04	NA
2,3,7,8-tcdd	NA	NA	NA
	HQ Summation =		1.6E-02

Compound	ILCR Calculation CDI (mg/kg-day)	CSF (mg/kg-day)$^{-1}$	ILCR (unitless)
antimony	7.4E-09	NA	NA
arsenic	4.9E-06	1.8E+00	8.5E-06
barium	NA	NA	NA
beryllium	6.5E-08	4.3E+00	2.8E-07
boron	NA	NA	NA
cadmium	NA	NA	NA
chromium vi	NA	NA	NA
cobalt	NA	NA	NA
copper	NA	NA	NA
cyanide	NA	NA	NA
lead	NA	NA	NA
manganese	NA	NA	NA
mercury	NA	NA	NA
molybdenum	NA	NA	NA
nickel	NA	NA	NA
selenium	NA	NA	NA
silver	NA	NA	NA
thallium	NA	NA	NA
thorium-total	NA	NA	NA
uranium-total	6.8E-09	NA	NA
vanadium	NA	NA	NA
zinc	NA	NA	NA
2-methylnaphthalene	NA	NA	NA
4,4-dde	NA	3.4E-01	NA
aroclor-1221	NA	7.7E+00	NA
aroclor-1248	NA	7.7E+00	NA
aroclor-1254	NA	7.7E+00	NA
aroclor-1260	NA	7.7E+00	NA
carbazole	NA	2.0E-02	NA
endrin	NA	NA	NA
2,3,7,8-tcdd	NA	1.5E+05	NA
	ILCR Summation =		8.8E-06

Table I.IV−155
Summary of Intake and Risk Quantitation (radionuclides)
Future Land Use with Private Ownership: GMR User (Recreational)
Via Ingestion of Fish

Intake Equation = Cf X EF X EDn X FI X IR

IR	Ingestion rate of meat	0.054 kg/day
FI	Fraction ingested from contaminated source	1 (Unitless)
EF	Exposure frequency	122 days/year
EDn	Exposure duration	30 Year
Cf	Concentration of radionuclides in meat	

Cs_{137+1d}	NA	pCi/kg	Rn_{222+4d}	NA	pCi/kg
Pb_{210+2d}	NA	pCi/kg	Sr_{90+1d}	NA	pCi/kg
Np_{237+1d}	1.2E−04	pCi/kg	Tc_{99}	1.4E+00	pCi/kg
Pu_{238}	NA	pCi/kg	Th_{228+7d}	NA	pCi/kg
Pu_{239}	NA	pCi/kg	Th_{230}	NA	pCi/kg
Pu_{240}	NA	pCi/kg	$Th_{232+10d}$	NA	pCi/kg
Pa_{231}	NA	pCi/kg	U_{234}	3.6E−03	pCi/kg
Ra_{226+8d}	5.0E−04	pCi/kg	U_{235+1d}	9.6E−05	pCi/kg
Ra_{228+1d}	NA	pCi/kg	U_{236}	4.0E−05	pCi/kg
Ru_{106}	NA	pCi/kg	U_{238+2d}	2.2E−03	pCi/kg

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	ILCR (unitless)
Cs_{137+1d}	NA	2.8E−11	NA
Pb_{210+2d}	NA	6.6E−10	NA
Np_{237+1d}	5.9E−02	2.2E−10	1.3E−11
Pu_{238}	NA	2.2E−10	NA
Pu_{239}	NA	2.3E−10	NA
Pu_{240}	NA	2.3E−10	NA
Pa_{231}	NA	9.2E−11	NA
Ra_{226+8d}	2.3E−01	7.8E−10	1.8E−10
Ra_{228+1d}	NA	1.0E−10	NA
Ru_{106}	NA	9.5E−12	NA
Rn_{222+4d}	NA	1.7E−12	NA
Sr_{90+1d}	NA	3.6E−11	NA
Tc_{99}	7.5E+04	1.3E−12	9.7E−08
Th_{228+7d}	NA	5.5E−11	NA
Th_{230}	NA	1.3E−11	NA
$Th_{232+10d}$	NA	1.7E−10	NA
U_{234}	NA	1.6E−11	NA
U_{235+1d}	NA	1.6E−11	NA
U_{236}	NA	1.5E−11	NA
U_{238+2d}	NA	2.0E−11	NA
		ILCR Summation =	9.8E−08

Table I.IV–156
Summary of Intake Quantitation (chemicals)
Future Land Use with Private Ownership: GMR User (Recreational)
Via Incidental Ingestion While Wading

Intake Equation = $\frac{CS \times EF \times ED \times IR}{BW \times AT}$

IRsw	Ingestion rate of surface water	0.035	l/day
EF	Exposure frequency	7	days/year
EDn	Exposure duration for non–carcinogens	30	Year
EDc	Exposure duration for carcinogens	30	Year
BW	Body weight	70	kg
ATc	Average time for carcinogens (lifetime)	10950	days
ATn	Average time for non–carcinogens (EDn x 365)	10950	days
CS	Concentration of chemicals in surface water		

Chemical Concentrations

Compound	DA	Units	Compound	DA	Units
antimony	7.11E–06	mg/cm^2–d	silver	NA	mg/cm^2–d
arsenic	1.07E–04	mg/cm^2–d	thallium	NA	mg/cm^2–d
barium	NA	mg/cm^2–d	thorium–total	NA	mg/cm^2–d
beryllium	3.30E–06	mg/cm^2–d	uranium–total	3.26E–03	mg/cm^2–d
boron	NA	mg/cm^2–d	vanadium	NA	mg/cm^2–d
cadmium	NA	mg/cm^2–d	zinc	NA	mg/cm^2–d
chromium vi	NA	mg/cm^2–d	2–methylnaphthalene	NA	mg/cm^2–d
cobalt	NA	mg/cm^2–d	4,4–dde	NA	mg/cm^2–d
copper	NA	mg/cm^2–d	aroclor–1221	NA	mg/cm^2–d
cyanide	NA	mg/cm^2–d	aroclor–1248	NA	mg/cm^2–d
lead	NA	mg/cm^2–d	aroclor–1254	NA	mg/cm^2–d
manganese	NA	mg/cm^2–d	aroclor–1260	NA	mg/cm^2–d
mercury	NA	mg/cm^2–d	carbazole	NA	mg/cm^2–d
molybdenum	NA	mg/cm^2–d	endrin	NA	mg/cm^2–d
nickel	NA	mg/cm^2–d	2,3,7,8–tcdd	NA	mg/cm^2–d
selenium	NA	mg/cm^2–d			

References

Table I.IV-156 (continued)
Summary of Risk Characterization (chemicals)
Future Land Use with Private Ownership: GMR User (Recreational)
Via Incidental Ingestion While Wading

Compound	HQ Calculation CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
antimony	6.82E-11	4.00E-04	1.70E-07
arsenic	1.03E-09	3.00E-04	3.42E-06
barium	NA	7.00E-02	NA
beryllium	3.16E-11	5.00E-03	6.33E-09
boron	NA	9.00E-02	NA
cadmium	NA	1.00E-03	NA
chromium vi	NA	5.00E-03	NA
cobalt	NA	6.00E-02	NA
copper	NA	NA	NA
cyanide	NA	2.00E-02	NA
lead	NA	NA	NA
manganese	NA	1.40E-01	NA
mercury	NA	3.00E-04	NA
molybdenum	NA	5.00E-03	NA
nickel	NA	2.00E-02	NA
selenium	NA	5.00E-03	NA
silver	NA	5.00E-03	NA
thallium	NA	8.00E-05	NA
thorium-total	NA	NA	NA
uranium-total	3.13E-08	3.00E-03	1.04E-05
vanadium	NA	7.00E-03	NA
zinc	NA	3.00E-01	NA
2-methylnaphthalene	NA	NA	NA
4,4-dde	NA	NA	NA
aroclor-1221	NA	NA	NA
aroclor-1248	NA	NA	NA
aroclor-1254	NA	NA	NA
aroclor-1260	NA	NA	NA
carbazole	NA	NA	NA
endrin	NA	3.00E-04	NA
2,3,7,8-tcdd	NA	NA	NA
	HQ Summation =		1.40E-05

Compound	ILCR Calculation CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	ILCR (unitless)
antimony	6.82E-11	NA	NA
arsenic	1.03E-09	1.75E+00	1.80E-09
barium	NA	NA	NA
beryllium	3.16E-11	4.30E+00	1.36E-10
boron	NA	NA	NA
cadmium	NA	NA	NA
chromium vi	NA	NA	NA
cobalt	NA	NA	NA
copper	NA	NA	NA
cyanide	NA	NA	NA
lead	NA	NA	NA
manganese	NA	NA	NA
mercury	NA	NA	NA
molybdenum	NA	NA	NA
nickel	NA	NA	NA
selenium	NA	NA	NA
silver	NA	NA	NA
thallium	NA	NA	NA
thorium-total	NA	NA	NA
uranium-total	3.13E-08	NA	NA
vanadium	NA	NA	NA
zinc	NA	NA	NA
2-methylnaphthalene	NA	NA	NA
4,4-dde	NA	3.40E-01	NA
aroclor-1221	NA	7.70E+00	NA
aroclor-1248	NA	7.70E+00	NA
aroclor-1254	NA	7.70E+00	NA
aroclor-1260	NA	7.70E+00	NA
carbazole	NA	2.00E-02	NA
endrin	NA	NA	NA
2,3,7,8-tcdd	NA	1.50E+05	NA
	ILCR Summation =		1.93E-09

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Table I.IV–157
Summary of Intake and Risk Quantitation (radionuclides)
Future Land Use with Private Ownership: GMR User (Recreational)
Via Incidental Ingestion while Wading

Intake Equation = Cs X EF X ED X FI X IR

IRsw	Ingestion rate of surface water	0.035 l/day
EF	Exposure frequency	7 days/year
EDn	Exposure duration for non–carcinogens	30 Year
FI	Fractional intake for radionuclides	1 (Unitless)
Cs	Concentration of radionuclides in surface water	

Cs_{137+1d}	NA	pCi/l	Rn_{222+4d}	NA	pCi/l
Pb_{210+2d}	NA	pCi/l	Sr_{90+1d}	NA	pCi/l
Np_{237+1d}	1.16E–02	pCi/l	Tc_{99}	9.50E+01	pCi/l
Pu_{238}	NA	pCi/l	Th_{228+7d}	NA	pCi/l
Pu_{239}	NA	pCi/l	Th_{230}	NA	pCi/l
Pu_{240}	NA	pCi/l	$Th_{232+10d}$	NA	pCi/l
Pa_{231}	NA	pCi/l	U_{234}	1.82E+00	pCi/l
Ra_{226+8d}	1.01E–02	pCi/l	U_{235+1d}	4.82E–02	pCi/l
Ra_{228+1d}	NA	pCi/l	U_{236}	1.99E–02	pCi/l
Ru_{106}	NA	pCi/l	U_{238+2d}	1.09E+00	pCi/l

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	ILCR (unitless)
Cs_{137+1d}	NA	2.80E–11	NA
Pb_{210+2d}	NA	6.60E–10	NA
Np_{237+1d}	8.53E–02	2.20E–10	1.88E–11
Pu_{238}	NA	2.20E–10	NA
Pu_{239}	NA	2.30E–10	NA
Pu_{240}	NA	2.30E–10	NA
Pa_{231}	NA	9.20E–11	NA
Ra_{226+8d}	7.42E–02	7.80E–10	5.79E–11
Ra_{228+1d}	NA	1.00E–10	NA
Ru_{106}	NA	9.50E–12	NA
Rn_{222+4d}	NA	1.70E–12	NA
Sr_{90+1d}	NA	3.60E–11	NA
Tc_{99}	6.98E+02	1.30E–12	9.08E–10
Th_{228+7d}	NA	5.50E–11	NA
Th_{230}	NA	1.30E–11	NA
$Th_{232+10d}$	NA	1.70E–10	NA
U_{234}	1.34E+01	1.60E–11	2.14E–10
U_{235+1d}	3.54E–01	1.60E–11	5.67E–12
U_{236}	1.46E–01	1.50E–11	2.19E–12
U_{238+2d}	8.01E+00	2.00E–11	1.60E–10
		ILCR Summation =	1.37E–09

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Table I.IV–158
Summary of Intake Quantitation (chemicals)
Future Land Use with Private Ownership: GMR User (Recreational)
Via Dermal Contact while Wading

Intake Equation = $\frac{DA \times EF \times ED \times SA}{BW \times AT}$

DA	Dermal absorbed dose	csv mg/cm^2–day
EF	Exposure frequency	7 days/year
EDn	Exposure duration for non–carcinogens	30 Year
EDc	Exposure duration for carcinogens	30 Year
BW	Body weight	70 kg
ATc	Average time for carcinogens (lifetime)	25550 days
ATn	Average time for non–carcinogens (EDn x 365)	25550 days
SA	Skin surface area available for contact	23000 cm^2

Chemical Concentrations

Compound	DA	Units	Compound	DA	Units
antimony	1.78E–11	mg/cm^2–day	silver	NA	mg/cm^2–day
arsenic	2.68E–10	mg/cm^2–day	thallium	NA	mg/cm^2–day
barium	NA	mg/cm^2–day	thorium–total	NA	mg/cm^2–day
beryllium	8.25E–12	mg/cm^2–day	uranium–total	8.15E–10	mg/cm^2–day
boron	NA	mg/cm^2–day	vanadium	NA	mg/cm^2–day
cadmium	NA	mg/cm^2–day	zinc	NA	mg/cm^2–day
chromium vi	NA	mg/cm^2–day	2–methylnaphthalene	NA	mg/cm^2–day
cobalt	NA	mg/cm^2–day	4,4–dde	NA	mg/cm^2–day
copper	NA	mg/cm^2–day	aroclor–1221	NA	mg/cm^2–day
cyanide	NA	mg/cm^2–day	aroclor–1248	NA	mg/cm^2–day
lead	NA	mg/cm^2–day	aroclor–1254	NA	mg/cm^2–day
manganese	NA	mg/cm^2–day	aroclor–1260	NA	mg/cm^2–day
mercury	NA	mg/cm^2–day	carbazole	NA	mg/cm^2–day
molybdenum	NA	mg/cm^2–day	endrin	NA	mg/cm^2–day
nickel	NA	mg/cm^2–day	2,3,7,8–tcdd	NA	mg/cm^2–day
selenium	NA	mg/cm^2–day			

References

Table I.IV-158 (continued)
Summary of Risk Characterization (chemicals)
Future Land Use with Private Ownership: GMR User (Recreational)
Via Dermal Contact while Bathing

Compound	HQ Calculation		
	CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
antimony	1.05E-10	6.00E-05	1.74E-06
arsenic	1.57E-09	2.85E-04	5.52E-06
barium	NA	6.37E-02	NA
beryllium	4.85E-11	5.00E-03	9.70E-09
boron	NA	4.50E-03	NA
cadmium	NA	5.00E-05	NA
chromium vi	NA	2.25E-03	NA
cobalt	NA	2.70E-02	NA
copper	NA	NA	NA
cyanide	NA	NA	NA
lead	NA	NA	NA
manganese	NA	4.20E-03	NA
mercury	NA	4.50E-05	NA
molybdenum	NA	1.90E-03	NA
nickel	NA	2.00E-03	NA
selenium	NA	4.00E-03	NA
silver	NA	NA	NA
thallium	NA	8.00E-05	NA
thorium-total	NA	NA	NA
uranium-total	4.79E-08	1.50E-04	3.20E-04
vanadium	NA	3.50E-04	NA
zinc	NA	7.50E-02	NA
2-methylnaphthalene	NA	NA	NA
4,4-dde	NA	NA	NA
aroclor-1221	NA	NA	NA
aroclor-1248	NA	NA	NA
aroclor-1254	NA	NA	NA
aroclor-1260	NA	NA	NA
carbazole	NA	NA	NA
endrin	NA	2.70E-04	NA
2,3,7,8-tcdd	NA	NA	NA
	HQ Summation =		3.27E-04

Compound	ILCR Calculation		
	CDI (mg/kg-day)	CSF (mg/kg-day)$^{-1}$	ILCR (unitless)
antimony	4.48E-11	NA	NA
arsenic	6.74E-10	1.90E+00	1.28E-09
barium	NA	NA	NA
beryllium	2.08E-11	4.30E+00	8.94E-11
boron	NA	NA	NA
cadmium	NA	NA	NA
chromium vi	NA	NA	NA
cobalt	NA	NA	NA
copper	NA	NA	NA
cyanide	NA	NA	NA
lead	NA	NA	NA
manganese	NA	NA	NA
mercury	NA	NA	NA
molybdenum	NA	NA	NA
nickel	NA	NA	NA
selenium	NA	NA	NA
silver	NA	NA	NA
thallium	NA	NA	NA
thorium-total	NA	NA	NA
uranium-total	2.05E-08	NA	NA
vanadium	NA	NA	NA
zinc	NA	NA	NA
2-methylnaphthalene	NA	NA	NA
4,4-dde	NA	3.40E-01	NA
aroclor-1221	NA	1.03E+01	NA
aroclor-1248	NA	1.03E+01	NA
aroclor-1254	NA	1.03E+01	NA
aroclor-1260	NA	1.03E+01	NA
carbazole	NA	2.22E-02	NA
endrin	NA	NA	NA
2,3,7,8-tcdd	NA	3.00E+05	NA
	ILCR Summation =		1.37E-09

ATTACHMENT I.IV-2
TARGET ORGAN IMPACT CALCULATIONS

TABLE I.IV-1
HAZARD QUOTIENTS FOR THE OFF-PROPERTY RESIDENT FARM CHILD: (RME), FUTURE LAND USE WITH FEDERAL OWNERSHIP

Chemical	Target Organs		Media				Total
	Oral	Inhalation	Soil	Air	Water	Food	
antimony	BDY	ND			1.25E-05	1.91E-04	2.04E-04
arsenic	S	ND			3.89E-04	6.09E-04	9.99E-04
barium	CVS	F		4.38E-04		1.80E-05	4.56E-04
beryllium	ND	ND			1.16E-07	1.79E-06	1.90E-06
boron	T	R		1.14E-06		1.25E-06	2.39E-06
cadmium	K	ND			1.53E-22	4.50E-05	4.50E-05
chromium vi	ND	ND				3.59E-05	3.59E-05
cobalt	CVS	L		1.62E-02		2.50E-06	1.62E-02
copper	ND	ND					
cyanide	BDY	ND				2.98E-07	2.98E-07
lead	ND	ND					
manganese	CNS	CNS		1.33E-05		7.09E-08	1.33E-05
mercury	K	CNS		2.17E-06		1.79E-04	1.81E-04
molybdenum	U	ND				1.22E-05	1.22E-05
nickel	BDY	ND				6.17E-05	6.17E-05
selenium	BDY	ND				3.80E-06	3.80E-06
silver	S	ND				7.10E-04	7.10E-04
thallium	ND	ND				1.33E-04	1.33E-04
thorium-total	ND	ND					
uranium-total	K	ND			1.34E+00	4.96E-01	1.84E+00
vanadium	ND	ND				2.54E-05	2.54E-05
zinc	B	ND				1.21E-03	1.21E-03
2-methylnaphthalene	NA	NA					
4,4-dde	ND	ND					
aroclor-1221	NA	NA					
aroclor-1248	ND	ND					
aroclor-1254	ND	ND					
aroclor-1260	ND	ND					
carbazole	NA	NA					
endrin	CNS	ND					
2,3,7,8-tcdd	NA	NA					
Total Hazard Index			NC	1.67E-02	1.34E+00	4.99E-01	1.86E+00

Total - Liver	1.62E-02
Total - Fetus	4.38E-04
Total - CVS	2.05E-05
Total - Kidney	1.84E+00
Total - Respiratory	1.14E-06
Total - CNS	1.55E-05
Total - Blood	1.21E-03
Total - Whole Body	2.69E-04
Total - Skin	1.71E-03
Total - Testis	1.25E-06
Total - Urine	1.22E-05
Total - NO	NA

B - Blood, CNS - Central Nervous System, CVS - Cardiovascular System,
F - Fetus, K - Kidney, L - Liver, R - Respiratory System, S - Skin,
U- Urine, BDY - Whole Body, ND - Not Determined
T - Testis
Note:
NC - Not calculated, incomplete pathway

TABLE I.IV–2
HAZARD QUOTIENTS FOR THE OFF–PROPERTY RESIDENT
FARM CHILD: (RME), FUTURE LAND USE WITH PRIVATE OWNERSHIP

Chemical	Target Organs		Media				Total
	Oral	Inhalation	Soil	Air	Water	Food	
antimony	BDY	ND			1.25E–05	1.91E–04	2.04E–04
arsenic	S	ND			3.89E–04	6.09E–04	9.99E–04
barium	CVS	F		4.38E–04		1.80E–05	4.56E–04
beryllium	ND	ND			1.16E–07	1.79E–06	1.90E–06
boron	T	R		1.14E–06		1.25E–06	2.39E–06
cadmium	K	ND			1.53E–22	4.50E–05	4.50E–05
chromium vi	ND	ND				3.59E–05	3.59E–05
cobalt	CVS	L		1.62E–02		2.50E–06	1.62E–02
copper	ND	ND					
cyanide	BDY	ND				2.98E–07	2.98E–07
lead	ND	ND					
manganese	CNS	CNS		1.33E–05		7.09E–08	1.33E–05
mercury	K	CNS		2.17E–06		1.79E–04	1.81E–04
molybdenum	U	ND				1.22E–05	1.22E–05
nickel	BDY	ND				6.17E–05	6.17E–05
selenium	BDY	ND				3.80E–06	3.80E–06
silver	S	ND				7.10E–04	7.10E–04
thallium	ND	ND				1.33E–04	1.33E–04
thorium–total	ND	ND					
uranium–total	K	ND			1.34E+00	4.96E–01	1.84E+00
vanadium	ND	ND				2.54E–05	2.54E–05
zinc	B	ND				1.21E–03	1.21E–03
2–methylnaphthalene	NA	NA					
4,4–dde	ND	ND					
aroclor–1221	NA	NA					
aroclor–1248	ND	ND					
aroclor–1254	ND	ND					
aroclor–1260	ND	ND					
carbazole	NA	NA					
endrin	CNS	ND					
2,3,7,8–tcdd	NA	NA					
Total Hazard Index			NC	1.67E–02	1.34E+00	4.99E–01	1.86E+00

Total – Liver	1.62E–02
Total – Fetus	4.38E–04
Total – CVS	2.05E–05
Total – Kidney	1.84E+00
Total – Respiratory	1.14E–06
Total – CNS	1.55E–05
Total – Blood	1.21E–03
Total – Whole Body	2.69E–04
Total – Skin	1.71E–03
Total – Testis	1.25E–06
Total – Urine	1.22E–05
Total – NO	NA

B – Blood, CNS – Central Nervous System, CVS – Cardiovascular System,
F – Fetus, K – Kidney, L – Liver, R – Respiratory System, S – Skin,
U– Urine, BDY – Whole Body, ND – Not Determined
T – Testis

Note:
NC – Not calculated, incomplete pathway

TABLE I.IV–3
HAZARD QUOTIENTS FOR THE ON–PROPERTY RESIDENT FARM ADULT (PERCHED), FUTURE LAND USE WITH PRIVATE OWNERSHIP

Chemical	Target Organs		Media				Total
	Oral	Inhalation	Soil	Air	Water	Food	
antimony	BDY	ND	8.86E–02		2.03E+00		2.12E+00
arsenic	S	ND	2.46E–02		3.80E+00	8.15E–01	4.64E+00
barium	CVS	F	3.10E–03	2.50E–04		1.95E–01	1.98E–01
beryllium	ND	ND	3.26E–04			1.57E–03	1.90E–03
boron	T	R	2.13E–02	4.28E–07		4.37E+00	4.39E+00
cadmium	K	ND	5.96E–02		2.26E–01	1.93E+00	2.22E+00
chromium vi	ND	ND	1.02E–02			5.75E–02	6.77E–02
cobalt	CVS	L	6.29E–04	7.00E–03		1.15E–02	1.91E–02
copper	ND	ND					
cyanide	BDY	ND	1.71E–05			2.54E–01	2.54E–01
lead	ND	ND					
manganese	CNS	CNS	1.93E–01	8.42E–06		1.68E+00	1.88E+00
mercury	K	CNS	1.97E–02	1.38E–06		1.42E+01	1.42E+01
molybdenum	U	ND	4.47E–03			1.17E–01	1.22E–01
nickel	BDY	ND	1.99E–03			9.62E–02	9.81E–02
selenium	BDY	ND	2.97E–04			1.03E–02	1.06E–02
silver	S	ND	1.65E–03			2.21E+00	2.21E+00
thallium	ND	ND	1.50E–02			2.56E–01	2.71E–01
thorium–total	ND	ND					
uranium–total	K	ND			6.47E+01	1.10E+00	6.58E+01
vanadium	ND	ND	1.09E–02			2.47E–02	3.56E–02
zinc	B	ND	9.66E–04			2.56E+00	2.56E+00
2–methylnaphthalene	0	0					
4,4–dde	ND	ND					
aroclor–1221	0	0					
aroclor–1248	ND	ND					
aroclor–1254	ND	ND					
aroclor–1260	ND	ND					
carbazole	0	0					
endrin	CNS	ND					
2,3,7,8–tcdd	0	0					
Total Hazard Index			4.56E–01	7.26E–03	7.08E+01	2.99E+01	1.01E+02

Total – Liver	7.00E–03
Total – Fetus	2.50E–04
Total – CVS	2.10E–01
Total – Kidney	8.23E+01
Total – Respiratory	4.28E–07
Total – CNS	1.88E+00
Total – Blood	2.56E+00
Total – Whole Body	2.48E+00
Total – Skin	6.85E+00
Total – Testis	4.39E+00
Total – Urine	1.22E–01
Total – NO	0.00E+00

B – Blood, CNS – Central Nervous System, CVS – Cardiovascular System,
F – Fetus, K – Kidney, L – Liver, R – Respiratory System, S – Skin,
U – Urine, BDY – Whole Body, ND – Not Determined
T – Testis
Note:
NC – Not calculated, incomplete pathway

TABLE I.IV-4
HAZARD QUOTIENTS FOR THE ON-PROPERTY RESIDENT FARM ADULT (RME), FUTURE LAND USE WITH PRIVATE OWNERSHIP

Chemical	Target Organs		Media				Total
	Oral	Inhalation	Soil	Air	Water	Food	
antimony	BDY	ND	8.86E-02		1.01E-01		1.90E-01
arsenic	S	ND	2.46E-02		3.89E-01	8.15E-01	1.23E+00
barium	CVS	F	3.10E-03	2.50E-04		1.95E-01	1.98E-01
beryllium	ND	ND	3.26E-04		6.30E-04	1.57E-03	2.53E-03
boron	T	R	2.13E-02	4.28E-07		4.37E+00	4.39E+00
cadmium	K	ND	5.96E-02		7.89E-19	1.93E+00	1.99E+00
chromium vi	ND	ND	1.02E-02			5.75E-02	6.77E-02
cobalt	CVS	L	6.29E-04	7.00E-03		1.15E-02	1.91E-02
copper	ND	ND					
cyanide	BDY	ND	1.71E-05			2.54E-01	2.54E-01
lead	ND	ND					
manganese	CNS	CNS	1.93E-01	8.42E-06		1.68E+00	1.88E+00
mercury	K	CNS	1.97E-02	1.38E-06		1.42E+01	1.42E+01
molybdenum	U	ND	4.47E-03			1.17E-01	1.22E-01
nickel	BDY	ND	1.99E-03			9.62E-02	9.81E-02
selenium	BDY	ND	2.97E-04			1.03E-02	1.06E-02
silver	S	ND	1.65E-03			2.21E+00	2.21E+00
thallium	ND	ND	1.50E-02			2.56E-01	2.71E-01
thorium-total	ND	ND					
uranium-total	K	ND			1.66E+00	1.10E+00	2.77E+00
vanadium	ND	ND	1.09E-02			2.47E-02	3.56E-02
zinc	B	ND	9.66E-04			2.56E+00	2.56E+00
2-methylnaphthalene	0	0					
4,4-dde	ND	ND					
aroclor-1221	0	0					
aroclor-1248	ND	ND					
aroclor-1254	ND	ND					
aroclor-1260	ND	ND					
carbazole	0	0					
endrin	CNS	ND					
2,3,7,8-tcdd	0	0					
Total Hazard Index			4.56E-01	7.26E-03	2.15E+00	2.99E+01	3.25E+01

B - Blood, CNS - Central Nervous System, CVS - Cardiovascular System,
F - Fetus, K - Kidney, L - Liver, R - Respiratory System, S - Skin,
U - Urine, BDY - Whole Body, ND - Not Determined
T - Testis
Note:
NC - Not calculated, incomplete pathway

Total - Liver	7.00E-03
Total - Fetus	2.50E-04
Total - CVS	2.10E-01
Total - Kidney	1.90E+01
Total - Respiratory	4.28E-07
Total - CNS	1.88E+00
Total - Blood	2.56E+00
Total - Whole Body	5.52E-01
Total - Skin	3.44E+00
Total - Testis	4.39E+00
Total - Urine	1.22E-01
Total - NO	0.00E+00

TABLE I.IV–5
HAZARD QUOTIENTS FOR THE ON–PROPERTY RESIDENT FARM CHILD (RME), FUTURE LAND USE WITH PRIVATE OWNERSHIP

Chemical	Target Organs: Oral	Target Organs: Inhalation	Media: Soil	Media: Air	Media: Water	Media: Food	Total
antimony	BDY	ND	2.85E–01		2.25E–01		5.10E–01
arsenic	S	ND	2.19E–01		9.27E–01	2.93E+00	4.08E+00
barium	CVS	F	1.97E–02	7.03E–04		8.66E–01	8.87E–01
beryllium	ND	ND	2.12E–03		1.50E–03	5.59E–03	9.22E–03
boron	T	R	4.77E–02	1.20E–06		1.79E+01	1.80E+01
cadmium	K	ND	1.33E–01		1.91E–18	9.27E+00	9.41E+00
chromium vi	ND	ND	5.13E–02			3.18E–01	3.69E–01
cobalt	CVS	L	3.15E–03	1.97E–02		4.73E–02	7.01E–02
copper	ND	ND					
cyanide	BDY	ND	1.60E–04			9.71E–01	9.71E–01
lead	ND	ND					
manganese	CNS	CNS	3.86E–01	2.37E–05		7.51E+00	7.90E+00
mercury	K	CNS	3.95E–02	3.87E–06		2.78E+01	2.78E+01
molybdenum	U	ND	2.10E–02			5.68E–01	5.89E–01
nickel	BDY	ND	1.52E–02			4.25E–01	4.41E–01
selenium	BDY	ND	1.82E–03			5.87E–02	6.05E–02
silver	S	ND	1.54E–02			1.99E+01	1.99E+01
thallium	ND	ND	9.81E–02			8.33E–01	9.32E–01
thorium–total	ND	ND					
uranium–total	K	ND			4.03E+00	9.65E+00	1.37E+01
vanadium	ND	ND	5.70E–02			8.12E–02	1.38E–01
zinc	B	ND	3.82E–03			1.09E+01	1.09E+01
2–methylnaphthalene	0	0					
4,4–dde	ND	ND					
aroclor–1221	0	0					
aroclor–1248	ND	ND					
aroclor–1254	ND	ND					
aroclor–1260	ND	ND					
carbazole	0	0					
endrin	CNS	ND					
2,3,7,8–tcdd	0	0					
Total Hazard Index			1.40E+00	2.04E–02	5.19E+00	1.10E+02	1.17E+02

Total – Liver	1.97E–02
Total – Fetus	7.03E–04
Total – CVS	9.36E–01
Total – Kidney	5.09E+01
Total – Respiratory	1.20E–06
Total – CNS	7.90E+00
Total – Blood	1.09E+01
Total – Whole Body	1.98E+00
Total – Skin	2.40E+01
Total – Testis	1.80E+01
Total – Urine	5.89E–01
Total – NO	0.00E+00

B – Blood, CNS – Central Nervous System, CVS – Cardiovascular System,
F – Fetus, K – Kidney, L – Liver, R – Respiratory System, S – Skin,
U – Urine, BDY – Whole Body, ND – Not Determined
T – Testis
Note:
NC – Not calculated, incomplete pathway