AR TARGET SHEET

The following document was too large to scan as one unit, therefore, it has been broken down into sections.

EDMC#:	0059750
SECTION:	1 OF 2
DOCUMENT #:	03-RCA-0247
TITLE:	Transmittal of RI Report for 200-CW-5, 200-CW-2, 200-CW-4, 200-SC-1 OU, DOE/RL-2003-11 Draft A

0059750

Department of Energy
Richland Operations Office
P.O. Box 550
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MAY 3 0 2003

03-RCA-0247

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EDMC

Mr. Nicholas Ceto, Progam Manager
Office of Environmental Cleanup
Hanford Project Office
U.S. Environmental Protection Agency
712 Swift Boulevard, Suite 5
Richland, Washington 99352

Dear Mr. Ceto:

TRANSMITTAL OF THE REMEDIAL INVESTIGATION REPORT FOR THE 200-CW-5 U POND/Z DITCHES COOLING WATER GROUP, THE 200-CW-2 S POND AND DITCHES COOLING WATER GROUP, THE 200-CW-4 T POND AND DITCHES COOLING WATER GROUP, AND THE 200-SC-1 STEAM CONDENSATE GROUP, DOE/RL-2003-11, DRAFT A

The Remedial Investigation Report For the 200-CW-5 U Pond/Z Ditches Cooling Water Group, the 200-CW-2 S Pond and Ditches Cooling Water Group, and 200-CW-4 T Pond and Ditches Cooling Water Group and the 200-SC-1 Steam Condensate Group, DOE/RL-2002-11, Draft A, a primary document under the Hanford Federal Facility Agreement and Consent Order (Tri-Party Agreement) is attached as required by and in fulfillment of interim Tri-Party Agreement Milestone M-015-40B due May 31, 2003.

A 45-day regulatory review of this report is scheduled from June 1, 2003, to July 15, 2003. If you have any questions on either document or if additional time is needed to complete your review, please contact Bryan Foley, Waste Management Division, on (509) 376-7087, or Ellen Mattlin, Regulatory Compliance and Analysis Division, on (509) 376-2385.

Sincerely,

Keith A. Klein
Manager

RCA:EMM

Attachment

cc: See page 2

cc w/o attach:
L. D. Crass, FHI
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Administrative Record

cc w/attach:
C. E. Cameron, EPA
V. C. Crossman, EM-43
T. Stoops, Oregon Energy
Admin. Record, H6-08 (200-CW-5, 200-CW-2, 200-CW-4, and 200-SC-1)

DOE/RL-2003-11
Draft A

Remedial Investigation for the 200-CW-5 U Pond/ Z Ditches Cooling Water Group, the 200-CW-2 S Pond and Ditches Cooling Water Group, the 200-CW-4 T Pond and Ditches Cooling Water Group, and the 200-SC-1 Steam Condensate Group Operable Units

Date Published
May 2003

Prepared for the U.S. Department of Energy
Assistant Secretary for Environmental Management

United States
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P.O. Box 550
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EXECUTIVE SUMMARY

The purpose of this remedial investigation (RI) report is to evaluate the data generated during the RI and other characterization activities at the 200-CW-5 Operable Unit (OU) to (1) determine if sufficient data have been collected to support risk assessment and remedial decision making, (2) estimate risk at the representative sites based on data collected during the RI and other existing data, (3) determine the need to proceed with a feasibility study (FS), and (4) determine which constituents and site-specific considerations need to be addressed in the FS. This RI report also provides data to support the evaluation of alternatives in the FS with regard to meeting potential applicable or relevant and appropriate requirements, risk reduction, and potentially significant data gaps (if any). This RI report includes an evaluation of the baseline risk using characterization data generated during the RI and significant data from other investigations (e.g., historical data from the 216-U-10 Pond and the 216-U-14, 216-Z-1D, and 216-Z-19 Ditches). Data generated during the RI will support the closeout of waste sites in the 200-CW-5 U, as well as the waste sites in the 200-CW-2, 200-CW-4, and 200-SC-1 consolidated OUs.

Data collected during the RI and data collected before the RI are summarized in this report. Data collection activities during the RI included installation of 20 GeoProbe[1] rods and geophysical logging and drilling one borehole for soil sampling. Geophysical logging was performed in the new borehole and in existing boreholes near the 200-CW-5 OU waste sites (i.e., wells 299-W18-15 and 299-W23-17).

The data evaluation methodology used in this RI report considered applicable regulatory requirements, the data quality objective process conducted for the work plan, land-use uncertainties, risk assessment methodology, other OUs, and site-specific conditions. The data evaluation process consisted of the following:

[1] GeoProbe is a registered trademark of Kejr, Inc., Salina, Kansas.

- Data screening for nondetected constituents and for background constituents
- Human health risk assessment determinations for nonradiological constituents
- Qualitative evaluation of ecological risk based on site- and area-wide information
- Dose and risk evaluation for radiological constituents
- Comparison to risk-based concentrations for nonradiological constituents
- Evaluation of impacts to groundwater.

Conceptual contaminant distribution models developed in the 200-CW-5 Work Plan (DOE/RL-99-66, *200-CW-5 U-Pond/Z Ditches Cooling Water Group Operable Unit RI/FS Work Plan*, Rev 0) were refined based on the RI data in this report. The contaminant distribution models depict current contaminant distribution beneath the representative sites. These models will be used in the FS to apply the analogous site approach to the remaining waste sites (analogous sites) (see the 200 Area Implementation Plan [DOE/RL-98-28, *200 Areas Remedial Investigation/Feasibility Study Implementation Plan –Environmental Restoration Program*]).

A baseline risk assessment was performed using the RI data. Assumptions concerning land-use scenarios, cleanup goals, and potential receptors were discussed. Risk assessment guidance from the U.S. Environmental Protection Agency was used in the risk evaluation. The RESidual RADioactivity dose model (ANL/EAD-4, *User's Manual for RESRAD, Version 6*) was used to evaluate potential doses from radionuclides, and the doses were then converted to risk values. Contaminants of concern were identified for each of the waste sites and will be carried forward into the FS for evaluation of remedial alternatives. Constituents that could impact groundwater above acceptable levels are identified for further analysis within the FS using more sophisticated analytical methods (e.g., vadose zone fate and transport modeling).

CONTENTS

APPENDICES

FIGURES

TABLES

TERMS

ARAR	applicable or relevant and appropriate requirement
ASTM	American Society for Testing and Materials
BCG	biota concentration guide
BDAC	Biota Dose Assessment Committee
bgs	below ground surface
CERCLA	*Comprehensive Environmental Response, Compensation and Liability Act of 1980*
CLARC	cleanup levels and risk calculation
CLUP	comprehensive land-use plan
COC	contaminant of concern
COPC	contaminant of potential concern
CPP	CERCLA past practice
CSM	conceptual site model
DOE	U.S. Department of Energy
DQA	data quality assessment
DQO	data quality objective
Ecology	Washington State Department of Ecology
EIS	environmental impact statement
ELCR	excess lifetime cancer risk
EPA	U.S. Environmental Protection Agency
EPC	exposure point concentration
FS	feasibility study
FY	fiscal year
GPR	ground-penetrating radar
HEAST	Health Effects Assessment Summary Tables
HEIS	Hanford Environmental Information System
HHRA	human health risk assessment
HI	hazard index
HQ	hazard quotient
IRIS	Integrated Risk Information System
LFI	limited field investigation
MCL	maximum contaminant level
NEPA	*National Environmental Policy Act of 1969*
OU	operable unit
PCB	polychlorinated biphenyl
PEF	particulate emissions factor
PNNL	Pacific Northwest National Laboratory
PRG	preliminary remediation goal
PUREX	Plutonium-Uranium Extraction (Plant)
QA	quality assurance
QC	quality control
RA	risk assessment
RAGS	Risk Assessment Guidance for Superfund
RAO	remedial action objective

RAWP	remedial action work plan
RBC	risk-based concentration
RCRA	*Resource Conservation and Recovery Act of 1976*
RDR	remedial design report
REDOX	reduction-oxidation (process)
RESRAD	RESidual RADioactivity
Revised Work Plan	*Steam Condensate/Cooling Water Waste Group Operable Units RI/FS Work Plan; Includes: 200-CW-5, 200-CW-2, 200-CW-4, and 200-SC-1 Operable Units* (DOE/RL-99-66, Rev. 1)
RI	remedial investigation
RME	"reasonable maximum" exposure
ROD	record of decision
RPP	RCRA past-practice
Sampling and Analysis Plan	*200-CW-5 U Pond/Z Ditches Cooling Water Group Operable Unit Remedial Investigation Sampling and Analysis Plan* (DOE/RL-2002-24)
SNAP	Space Nuclear Auxiliary Power
STOMP	Surface Transport Over Multiple Phases
SVOC	semivolatile organic compound
TCLP	toxicity characteristic leaching procedure
Technical Standard	*A Graded Approach for Evaluating Radiation Doses to Aquatic and Terrestrial Biota* (DOE-STD-1153-2002)
TNC	The Nature Conservancy
TPH	total petroleum hydrocarbons
Tri-Parties	U.S. Department of Energy, U.S. Environmental Protection Agency, and Washington State Department of Ecology
Tri-Party Agreement	*Hanford Federal Facility Agreement and Consent Order* (Ecology et al. 1989)
TSD	treatment, storage, and/or disposal (unit)
UCL	upper confidence limit
UPR	unplanned release
VF	volatilization factor
VOC	volatile organic compound
WAC	*Washington Administrative Code*
WDOH	Washington State Department of Health
WIDS	Waste Information Data System
Work Plan	*200-CW-5 U-Pond/Z Ditches Cooling Water Group Operable Unit RI/FS Work Plan* (DOE/RL-99-66, Rev. 0)

METRIC CONVERSION CHART

Into Metric Units			Out of Metric Units		
If You Know	*Multiply By*	*To Get*	*If You Know*	*Multiply By*	*To Get*
Length			**Length**		
inches	25.4	Millimeters	millimeters	0.039	inches
inches	2.54	Centimeters	centimeters	0.394	inches
feet	0.305	Meters	meters	3.281	feet
yards	0.914	Meters	meters	1.094	yards
miles	1.609	Kilometers	kilometers	0.621	miles
Area			**Area**		
sq. inches	6.452	sq. centimeters	sq. centimeters	0.155	sq. inches
sq. feet	0.093	sq. meters	sq. meters	10.76	sq. feet
sq. yards	0.0836	sq. meters	sq. meters	1.196	sq. yards
sq. miles	2.6	sq. kilometers	sq. kilometers	0.4	sq. miles
acres	0.405	Hectares	hectares	2.47	acres
Mass (weight)			**Mass (weight)**		
ounces	28.35	Grams	grams	0.035	ounces
pounds	0.454	Kilograms	kilograms	2.205	pounds
ton	0.907	metric ton	metric ton	1.102	ton
Volume			**Volume**		
teaspoons	5	Milliliters	milliliters	0.033	fluid ounces
tablespoons	15	Milliliters	liters	2.1	pints
fluid ounces	30	Milliliters	liters	1.057	quarts
cups	0.24	Liters	liters	0.264	gallons
pints	0.47	Liters	cubic meters	35.315	cubic feet
quarts	0.95	Liters	cubic meters	1.308	cubic yards
gallons	3.8	Liters			
cubic feet	0.028	cubic meters			
cubic yards	0.765	cubic meters			
Temperature			**Temperature**		
Fahrenheit	subtract 32, then multiply by 5/9	Celsius	Celsius	multiply by 9/5, then add 32	Fahrenheit
Radioactivity			**Radioactivity**		
picocuries	37	Millibecquerel	millibecquerel	0.027	picocuries

1.0 INTRODUCTION

This remedial investigation (RI) report for the 200-CW-5 U Pond/Z-Ditches Cooling Water Group (200-CW-5), the 200-CW-2 S Pond and Ditches Cooling Water Group (200-CW-2), the 200-CW-4 T Pond and Ditches Cooling Water Group (200-CW-4), and the 200-SC-1 Steam Condensate Group (200-SC-1) Operable Units (OU) focuses on the characterization of three representative waste sites in the 200-CW-5 OU: 216-U-10 Pond, 216-U-14 Ditch, and 216-Z-11 Ditch. The three representative waste sites were identified in the *Waste Site Grouping for 200 Areas Soil Investigations* (DOE/RL-96-81), the *200 Areas Remedial Investigation/Feasibility Study Implementation Plan–Environmental Restoration Program* (Implementation Plan) (DOE/RL-98-28), the *200-CW-5 U-Pond/Z Ditches Cooling Water Group Operable Unit RI/FS Work Plan* (Work Plan) (DOE/RL-99-66, Rev. 0), and *the 200-CW-5 U Pond/Z Ditches Cooling Water Group Operable Unit Remedial Investigation Sampling and Analysis Plan* (Sampling and Analysis Plan) (DOE/RL-2002-24) for evaluation as part of the RI. The representative sites were evaluated by implementing the data quality objective (DQO) process. The DQO process was used to determine the data that should be collected to assess site conditions and support remedial decision making.

The 200-CW-5 OU representative waste sites were selected for characterization because waste stream inventories, effluent volumes received, and the current level of characterization suggest that high contaminant inventories are present in the subsurface beneath these receiving sites. This RI report is prepared in fulfillment of *Hanford Federal Facility Agreement and Consent Order* (Tri-Party Agreement) (Ecology et al. 1989), milestone M-015-40B.

The RI was conducted from January to October 2002. Efforts consisted largely of drilling a single borehole (C3808) and performing soil sampling and analysis, geophysical logging, and a pipeline investigation at the 216-Z-11 Ditch representative site. In addition, boreholes 299-W18-15 and 299-W23-16 were geophysically logged at the 216-U-10 Pond and 216-U-14 Ditch, respectively. The 216-Z-11 Ditch characterization and associated tasks were performed in accordance with the 200-CW-5 OU Work Plan (DOE/RL-99-66, Rev. 0) and the 200-CW-5 Sampling and Analysis Plan (DOE/RL-2002-24). These efforts are summarized in CP-12134, *Borehole Summary Report for Borehole C3808 in the 216-Z-11 Ditch, 200-CW-5 U-Pond/ Z-Ditches Cooling Water Group Operable Unit.*

Most of the data included in this report from the 216-U-10 Pond and 216-U-14 Ditch were collected as part of the 200-UP-2 limited field investigation (LFI) and other activities at the Hanford Site. No additional data collection activities were conducted at these sites during the RI, with the exception of the geophysical logging. Additional data were not collected because BHI-01294, *Data Quality Objective Summary Report for the 200-CW-5 U Pond/Z Ditches System Waste Sites*, concludes that data collected before the RI was performed were sufficient to make remedial decisions.

Modifications to the M-013 series of the Tri-Party Agreement milestones for past-practice waste site investigations approved in April 2002 (Tri-Party Agreement Change Number M-13-02-01) describe the approach to investigate one or more OUs in a single RI/feasibility study (FS) process. This modification reduces the number of work plans, RI reports, and FSs needed for the

200 Areas waste sites. The revised approach allows collection of data necessary to adequately characterize the waste sites in more than one OU and to evaluate effective remedial alternatives for groups of OUs. Therefore, the 200-CW-2, 200-CW-4, 200-SC-1 cooling water, and steam condensate OUs are incorporated with the 200-CW-5 OU in a single RI report. The OUs are consolidated with the 200-CW-5 OU because they received similar waste streams (that is, cooling water, steam condensate, or both) and because the contaminant distribution beneath these waste sites is expected to be analogous with regard to use, waste site type, inventory, and effluent volume discharged. Figure 1-1 is a logic diagram showing the consolidation process and history for these OUs and waste sites. The diagram also identifies waste sites aligned with and analogous to representative waste site/contaminant distribution models outside of the subject cooling water and steam condensate OUs.

The U.S. Environmental Protection Agency (EPA) approved the 200-CW-5 Work Plan (DOE/RL-99-66, Rev. 0) in August 2000, fulfilling Tri-Party Agreement milestone M-013-22. The Work Plan (DOE/RL-99-66, Rev. 0) has been revised to incorporate the 200-CW-2, 200-CW-4, and 200-SC-1 OUs in fulfillment of the M-013 series modification to the Tri-Party Agreement. The Revised Work Plan is titled *Steam Condensate/Cooling Water Waste Group Operable Units RI/FS Work Plan; Includes: 200-CW-5, 200-CW-2, 200-CW-4, and 200-SC-1 Operable Units* (DOE/RL-99-66, Rev. 1).

The characterization and remediation of waste sites at the Hanford Site are addressed in the Tri-Party Agreement. This agreement addresses the integration of cleanup programs under the *Comprehensive Environmental Response, Compensation and Liability Act of 1980* (CERCLA) and *Resource Conservation and Recovery Act of 1976* (RCRA) to provide a standard approach to directing cleanup activities in a consistent manner and to ensure that applicable regulatory requirements are met. Details of this integration for the 200 Areas are presented in the Implementation Plan (DOE/RL-98-28) and in the revised Work Plan (DOE/RL-99-66, Rev. 1).

The four subject OUs are located near the center of the Hanford Site in south-central Washington State (Figure 1-2). According to DOE-RL, 1998, *Tri-Party Agreement Handbook Management Procedures*, Guideline Number TPA-MP-14, "Maintenance of the Waste Information Data System (WIDS)," for waste site reclassification, the 200-CW-5 OU consists of 10 CERCLA past-practice (CPP) waste sites, 2 RCRA past-practice (RPP) waste sites, and 3 CPP unplanned release (UPR) sites. The 200-CW-2 OU consists of 8 CPP waste sites and 1 CPP UPR site, the 200-CW-4 OU consists of 7 CPP waste sites and 1 RPP waste site, and the 200-SC-1 OU consists of 13 CPP waste sites and 3 CPP UPR sites. Waste sites in these OUs are listed in Table 1-1 and shown in Figures 1-3 and 1-4.

The waste sites in these OUs received predominantly cooling water and steam condensate. Contaminated process liquids normally did not come into direct contact with the waste streams, because the steam and cooling water were contained inside circulating coils. Therefore, the waste streams in these OUs generally are described as containing low-level radionuclides and chemicals from noncontact cooling water and steam condensate. Minor failures (such as pinholes and hairline cracks) of the coils used to cool the process vessels provided a pathway for contaminated liquid to enter these waste streams. Other accidental releases, such as operator error, also led to contamination of the effluent discharged to these OUs.

The 200-CW-5 waste sites received noncontact effluent from the following:

- 242-S Evaporator
- 221-U Building (U Plant)
- 241-U-11 Tank
- 282-W Reservoir
- 283-W Waste Treat Facility
- 277-W Complex
- 284-W Powerhouse
- 2723-W and 2724-W Laundries
- 231-Z Building
- 234-5Z Building
- 291-Z Building
- UO_3 Plant.

The 200-CW-2 OU waste sites received noncontact effluent from the reduction-oxidation (REDOX) process in the 202-S Canyon Building (S Plant) and from overflow of the 216-U-10 Pond. The 200-CW-4 waste sites received noncontact effluent from the bismuth phosphate and plutonium purification process in the 221-T and 224-T Buildings, respectively. The 200-SC-1 waste sites received noncontact steam condensate from REDOX, the bismuth phosphate process, the uranium recovery process, the Plutonium-Uranium Extraction (PUREX) Plant, the 242-A Evaporator, and the B Plant. The process history of these OU's is described in detail in the Revised Work Plan (DOE/RL-99-66, Rev. 1).

1.1 PURPOSE

This RI report evaluates the data generated during the RI and other characterization activities to determine if sufficient data have been collected to support risk assessment and remedial decision making, to estimate risks at the representative sites based on the data collected during the RI and other existing data, to determine the need to proceed with an FS, and to determine those constituents and site-specific considerations that need to be addressed in the FS. This RI report also provides data to support the evaluation of alternatives in the FS with regard to meeting potential applicable or relevant and appropriate requirements (ARAR), applying risk reduction, and identifying significant data gaps, if any. This RI report includes an evaluation of the baseline risk using characterization data generated during the RI and significant data from other investigations. Risk is evaluated for nonradiological constituents using EPA risk assessment guidance. Risk from radiological constituents is evaluated through the RESidual RADioactivity (RESRAD) computer dose model (ANL/EAD-4, *User's Manual for RESRAD, Version 6*). Fate and transport modeling using the Subsurface Transport Over Multiple Phases (STOMP) code are included for an evaluation of the protection of groundwater (PNNL-12034, *Subsurface Transport Over Multiple Phases [STOMP]*).

1.2 SUPPORTING DOCUMENTS AND REMEDIAL INVESTIGATION BASIS

Supporting documents that provided the basis for the RI report are as follows.

- *Waste Site Grouping for 200 Areas Soil Investigations* (DOE/RL-96-81). This document presents the final prioritized waste site groups, identifies representative sites, and provides preliminary conceptual contaminant distribution models for the waste groups.

- *200 Areas Remedial Investigation/Feasibility Study Implementation Plan – Environmental Restoration Program* (DOE/RL-98-28). This plan outlines a strategy to streamline the characterization and remediation of waste sites in the 200 Areas, including CPP sites, RPP sites, and RCRA treatment, storage, and/or disposal (TSD) units; outlines the framework for implementing assessment activities and evaluating remedial alternatives in the 200 Areas to ensure consistency in documentation, level of characterization, and decision making; establishes a regulatory framework to integrate the requirements of RCRA and CERCLA into one standard approach for cleanup activities in the 200 Areas; lists potential ARARs; identifies preliminary remedial action objectives (RAO); and presents a discussion of potentially feasible remedial technologies that may be used in the 200 Areas.

- *Limited Field Investigation for the 200-UP-2 Operable Unit* (DOE/RL-95-13). The nature and extent of contamination at the 216-U-10 Pond is described in this report.

- *200-CW-5 U-Pond/Z Ditches Cooling Water Group Operable Unit RI/FS Work Plan,* (DOE/RL-99-66, Rev. 0). This work plan describes the path forward for the characterization of the 200-CW-5 OU. It describes the planned characterization of three representative waste sites: 216-U-10 Pond, 216-U-14 Ditch, and 216-Z-11 Ditch.

- *Steam Condensate/Cooling Water Waste Group Operable Units RI/FS Work Plan; Includes: 200-CW-5, 200-CW-2, 200-CW-4, and 200-SC-1 Operable Units* (DOE/RL-99-66, Rev. 1). This work plan describes the path forward for characterization of the 200-CW-5 OU and for consolidation of the 200-CW-2, 200-CW-4, and 200-SC-1 OU waste sites in a single RI/FS process. Knowledge gained from understanding the contaminant distribution at the 216-U-10 Pond, 216-U-14 Ditch, and 216-Z-11 Ditch will be applied to the analogous 200-CW-2, 200-CW-4, and 200-SC-1 OU waste sites.

- *Borehole Summary Report for Borehole C3808 in the 216-Z-11 Ditch, 200-CW-5, U-Pond /Z-Ditches Cooling Water Operable Unit* (CP-12134). This report describes the characterization activities performed at the 216-Z-11 Ditch in fiscal year (FY) 2002.

- *200-CW-5 U Pond/Z Ditches Cooling Water Group Operable Unit Remedial Investigation Sampling and Analysis Plan* (DOE/RL-2002-24). This plan provides the sampling design for characterization of the 216-Z-11 Ditch.

- *Borehole Summary Report for the 200-UP-2 Operable Unit, 200 West Area* (BHI-00034, Rev. 1). This summary report describes characterization efforts completed in the

200-UP-2 OU at the 216-U-1/216-U-2 Cribs, 216-U-4 French Drain, 216-U-8 Crib, 216-U-12 Crib, and 216-U-10 Pond.

- *Surface and Near Surface Field Investigation Data Summary Report for the 200-UP-2 Operable Unit* (BHI-00033). This report summarizes 200-UP-2 OU surface and near-surface data.

- *210-U-10 Pond and 216-Z-19 Ditch Characterization Studies* (WHC-EP-0707). This report describes characterization efforts performed at the 216-U-10 Pond and the 216-Z-1D, 216-Z-11, and 216-Z-19 Ditches when the sites were receiving effluent. Soil samples were collected and analyzed from the bottom of these waste sites.

- *Groundwater Impact Assessment Report for the 216-U-14 Ditch* (WHC-EP-0698). This report describes characterization of the vadose zone and groundwater in the vicinity of the 216-U-14 Ditch. This report also contains the available soil radiological and chemistry data used to assess the nature and extent of contamination and risk.

- *Data Quality Objective Summary Report for the 200-CW-5 U Pond/Z Ditches System Waste Sites* (BHI-01294). This report presents existing information and develops a strategy for data collection at the 216-Z-11 Ditch. The existing information from the 216-U-10 Pond and the 216-U-14 Ditch was determined to be sufficient to support the RI/FS process; therefore, no major data collection activities were identified for these sites.

1.3 DATA EVALUATION METHODOLOGY

The data evaluation methodology used in this RI report considers applicable regulatory requirements, the DQO process conducted for the work plan, land-use uncertainties, risk assessment methodology, other OUs, and site-specific conditions. This evaluation process ultimately supports use of the data in the FS. This RI report does not make recommendations based on the data; its purpose is to provide sufficient evaluation of different aspects of the data to support the development and evaluation of remedial alternatives in the FS and the selection of a preferred remedy (or remedies) in the proposed plan and record of decision (ROD).

The data evaluation process was preceded by collection and validation of the data. A data quality assessment (DQA) was performed on the borehole C3808 soil data collected in FY 2002 at the 216-Z-11 Ditch. The data were collected according to the Sampling and Analysis Plan (DOE/RL 2002-24) on the basis of the DQOs established for the OU in BHI-01294. In accordance with the quality assurance/quality control (QA/QC) procedures specified in the Work Plan, at least 10 percent of all data collected during the RI were validated. A summary of the data validation effort is presented in Appendix A.

The data evaluation process consists of the following:

- Data screening for nondetected constituents
- Data screening against background constituents
- Human health risk assessment (HHRA) determinations for nonradiological constituents
- Evaluation of ecological risk using indicator concentrations

- Human health dose and risk evaluation for radiological constituents
- Comparison with human health risk-based concentrations
- Evaluation of impacts to groundwater through fate and transport modeling.

Data collected before the 200-CW-5 OU RI was performed were included in this report and subjected to a similar data evaluation process. In addition to the data evaluation process, corrections were made to reflect radioactive decay, analytical methods, and changes in the investigation approach. These corrections are described in the following two paragraphs.

Radioisotopic data from the 216-U-10 Pond, 216-U-14 Ditch, and 216-Z-11 Ditch (including the 216-Z-1D and 216-Z-19 Ditches) from prior characterization efforts (as documented in WHC-EP-0707; WHC-EP-0679, Groundwater Impact Assessment Report for the 284-WB Powerplant Ponds; and the Hanford Environmental Information System) were decayed to 2002. The 216-Z-1D and 216-Z-19 Ditches were added to this report because the two waste sites are adjacent to the 216-Z-11 Ditch and share common areas along their length. Additionally, the available data from the two ditches show significantly higher contaminant concentrations than the data collected at the 216-Z-11 Ditch. The higher concentrations in the two adjacent ditches indicate that the data collected from the 216-Z-11 Ditch do not represent the high radiological contaminant burden expected. For these reasons, the available 216-Z-1D Ditch and 216-Z-19 Ditch soil data are included in this RI report to bound the radiological conditions in the vicinity of the Z-Ditches.

Soils data from five boreholes (299-W19-91, 299-W19-92, 299-W19-93, 299-W19-21, and 299-W19-27) adjacent to the 216-U-14 Ditch were analyzed using a high-resolution intrinsic germanium detector within a lead shield. The lead shield was used to reduce background activity from sources other than the samples. The background activity in the lead shield was subtracted from the radioisotopic results.

1.3.1 Identification of Contaminants of Potential Concern

Analytical data included in the human health and ecological risk assessments were screened to identify contaminants of potential concern (COPC). COPCs are constituents that should be carried through the human health or ecological risk quantification process. Any constituent that was not detected in any of the soil samples was eliminated from further consideration. Maximum detected concentrations of metals and radiological contaminants were compared to the 90th percentile background concentrations from DOE/RL-92-24, *Hanford Site Background: Part 1, Soil Background for Inorganics*; DOE/RL-96-12, *Hanford Site Background: Part 2, Soil Background for Radionuclides*; and Ecology-94-115, *Natural Background Soil Metals Concentrations in Washington State*. If the maximum detected value was less than the 90th percentile background value, the constituent was eliminated as a COPC. Aluminum, calcium, magnesium, potassium, and sodium are considered essential nutrients, and they were excluded from further consideration as human health COPCs. All constituents identified as COPCs were included in the risk evaluation.

1.3.2 Risk Evaluation

The risk evaluation for the representative sites is based on EPA risk assessment guidance. Radiological constituents are addressed through a dose and risk evaluation. Human health risks are evaluated for an industrial exposure scenario using site-specific data and exposure assumptions obtained from state and Federal guidance documents. The land surrounding the 200 East and 200 West Areas has been designated as industrial-exclusive in DOE/EIS-0222-F, *Final Hanford Comprehensive Land Use Plan Environmental Impact Statement* (CLUP-EIS). The 200-CW-5, 200-CW-2, 200-CW-4, and 200-SC-1 OU waste sites are located within this industrial-exclusive land-use boundary, with the exception of sites 216-S-5, 216-S-6, 216-S-16P, 216-S-17, 216-S-172, and 2904-S-160.

The U.S. Department of Energy (DOE), EPA, and the Washington State Department of Ecology (Ecology) (the Tri-Parties) recently undertook the task of developing a risk framework to support risk assessments in the Central Plateau. This included a series of workshops with representatives from DOE, EPA, Ecology, the Hanford Advisory Board (HAB), the Tribal Nations, the State of Oregon, and other interested stakeholders. The workshops focused on the different programs involved in activities in the Central Plateau and the need for a consistent application of risk assessment assumptions and goals. The results of the risk framework are documented in HAB advice #132 (HAB 132 2002), in the Tri-Parties' response to the HAB advise (Klein et al. 2002), and in the *Report of the Exposure Scenarios Task Force* (HAB 2002). The following items summarize the Risk Framework Description from the Tri-Parties response to the HAB.

1. The Core Zone (200 Areas including B Pond (main pond) and S Ponds) will have an Industrial Scenario for the foreseeable future.

2. The Core Zone will be remediated and closed allowing for "other uses" consistent with an industrial scenario (environmental industries) that will maintain active human presence in this area, which in turn will enhance the ability to maintain the institutional knowledge of waste left in place for future generations. Exposure scenarios used for this zone should include a reasonable maximum exposure to a worker/day user, to possible Native American users, and to intruders.

3. DOE will follow the required regulatory processes for groundwater remediation (including public participation) to establish the points of compliance and remedial action objectives. It is anticipated that groundwater contamination under the Core Zone will preclude beneficial use for the foreseeable future, which is at least the period of waste management and institutional controls (150 years). It is assumed that the tritium and iodine-129 plumes beyond the Core Zone boundary will exceed the drinking water standards for the period of the next 150 to 300 years (less for the tritium plume). It is expected that other groundwater contaminants will remain below, or be restored to, drinking water levels outside the Core Zone.

4. No drilling for water use or otherwise will be allowed in the Core Zone. An intruder scenario will be calculated for in assessing the risk to human health and environment.

5. Waste sites outside the Core Zone but within the Central Plateau (200 North Area, Gable Mountain Pond, B/C Crib Controlled Area) will be remediated and closed based on an

evaluation of multiple land-use scenarios to optimize land use, institutional control cost, and long-term stewardship.

6. An industrial land-use scenario will set cleanup levels on the Central Plateau. Other scenarios (e.g., residential, recreational) may be used for comparison purposes to support decision making, especially for:
   - The post-institutional controls period (>150 years)
   - Sites near the Core Zone perimeter to analyze opportunities to "shrink the site"
   - Early (precedent-setting) closure/remediation decisions.
7. This framework does not deal with the tank retrieval decision.

Because the 200-CW-5, 200-CW-2, 200-CW-4, and 200-SC-1 OU waste sites are located in the 200 Area Core Zone, this description serves as the basis for the risk assessment activities. The risk assessment is presented for an industrial land-use scenario in Section 5.0. Risk evaluations for possible Native American users and intruder scenarios may be considered in the FS for informational purposes.

The risk evaluation for the 200-CW-5, 200-CW-2, 200-CW-4, and 200-SC-1 OUs is based on these guidelines as well as EPA risk assessment guidance. Radiological constituents are addressed through a dose evaluation, as described in Section 1.3.3, which is then converted to a risk value. Hypothetical human health risks are calculated for industrial exposure scenarios using inputs developed from other Hanford Site OUs, site-specific data, and guidance documents.

The DOE worked for several years with cooperating agencies and stakeholders to define land-use goals for the Hanford Site and develop future land-use plans (*The Future for Hanford: Uses and Cleanup, The Final Report of the Hanford Future Site Uses Working Group,* Drummond 1992). The cooperating agencies and stakeholders included the National Park Service, Tribal Nation, states of Washington and Oregon, local county and city governments, economic and business development interests, environmental groups, and agricultural interests. These efforts were initially reported by Drummond (1992) and culminated in the CLUP-EIS (DOE 1999) and associated ROD (64 FR 61615, "Hanford Comprehensive Land-Use Plan Environmental Impact Statement, Hanford Site, Richland, Washington; Record of Decision), which were issued in 1999.

Drummond (1992) identified nine general recommendations as follows:

- Protect the Columbia River
- Deal realistically and forcefully with groundwater contamination
- Use the Central Plateau wisely for waste management
- Do no harm during cleanup or with new development
- Cleanup of areas of high future use value is important
- Cleanup to the level necessary to enable the future use option to occur
- Transport waste safely and be prepared
- Capture economic development opportunities locally
- Involve the public in future decisions about Hanford.

Specific to the Central Plateau, the findings and recommendations from the Future Site Uses Working Group include the following:

- The Central Plateau is unique.
- Some type of government presence or oversight should be assumed for the foreseeable future.
- Waste from other Hanford Site locations should be concentrated in the 200 Area.
- Waste management, storage, and disposal activities should be concentrated within the 200 Area whenever feasible to minimize the amount of land devoted to these activities, and adverse impacts to clean areas should be minimized also.
- Wastes generated in or coming to the 200 Area from the rest of the site will not necessarily be permanently disposed of in the 200 Area. Off-site shipments are occurring and may continue. New technologies may be applied to waste in the future.
- Waste and contaminants within the 200 Area should be treated and managed to prevent migration from the 200 Area to other areas or off the Hanford Site.
- Access to the "exclusive" areas, including "exclusive buffers," would be restricted to properly trained and monitored personnel.

The working group identified a single cleanup scenario for the Central Plateau. This scenario assumes that future uses of the surface, subsurface, and groundwater in and immediately surrounding the 200 East and 200 West Areas would be "exclusive."

Consistent with the Future Site Uses Working Group report (Drummond 1992), the area around the 200 East and 200 West Areas has been designated as industrial-exclusive in the CLUP-EIS. All of the 200-CW-5, 200-CW-2, 200-CW-4, and 200-SC-1 OU waste sites are located within this exclusive-use boundary. The industrial exposure scenario is used to evaluate each representative site.

Nonradiological constituents from the shallow zone soil 0 to 4.6 m (0 to 15 ft) below ground surface (bgs) are screened to industrial soil risk-based concentrations (RBC) and industrial air RBCs for direct contact and inhalation of ambient air, respectively. Nonradiological constituents from the deep zone soil (0 to water table) are compared with the soil RBCs for protection of groundwater. For the purposes of this RI report, contaminant concentrations were compared to RBCs developed under CERCLA guidance (EPA/540/R-92/003, *Risk Assessment Guidance for Superfund: Volume I -- Human Health Evaluation Manual (Part B. Development of Risk-Based Preliminary Remediation Goals), Interim*) using the excess lifetime cancer risk range of 10^{-4} to 10^{-6} and a hazard quotient of 1.0 using an industrial land-use scenario. Because the waste sites in these OUs are within the Core Zone, RBCs used for screening correspond to a 10^{-5} risk level.

1.3.3 Modeling Approach

Risk and dose estimates were modeled for radiological constituents identified as COPCs using RESRAD Version 6 (ANL/EAD-4). Dose and risk estimates were modeled for shallow zone soil 0 to 4.6 m (0 to 15 ft) bgs on the basis of direct exposure to soils for an industrial exposure scenario. Dose estimates then were compared to direct exposure standards for the public and workers. Risk estimates also were provided for comparison to state and EPA target risk ranges. Input parameters were developed on the basis of previous Hanford Site RESRAD modeling activities, 200 Areas-specific geologic and hydrogeologic information sources, and data collected as part of this RI report.

Protection of groundwater was evaluated for nonradiological constituents based on existing standards for protection of groundwater. Fate and transport modeling for nonradiological constituents was conducted for those constituents with no standard or if the standard is exceeded and additional evaluation is warranted. Protection of groundwater was evaluated through fate and transport modeling using the STOMP code developed by the Pacific Northwest National Laboratory. Additional information is provided in Chapters 4.0 and 5.0.

1.3.4 Ecological Risk Evaluation

The Central Plateau Ecological Evaluation Report (DOE/RL-2001-54, *Ecological Evaluation of the Hanford 200 Areas- Phase I: Compilation of Existing 200 Areas Ecological Data*) has been prepared to support ecological evaluations under the RI/FS process for Central Plateau waste sites. DOE/RL-2001-54 completes a screening-level ecological risk assessment for the Central Plateau in accordance with the eight-step EPA ecological risk assessment process presented in *Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments* (EPA/540/R-97/006) (see Figure 1-1 in DOE/RL-2001-54).

The document contains a compilation and evaluation of ecological sampling data that have been collected over many years from undisturbed and disturbed habitats in the Central Plateau. The document presents descriptions of the habitats in the Central Plateau, including sensitive habitats, and the plants and animals that inhabit them. Potential species of concern, including threatened and endangered species and new-to-science species, are identified. A detailed survey of the Central Plateau performed in 2000 and 2001 is incorporated into the ecological evaluation document and provides a current, detailed description of the ecological setting of the Central Plateau and augments the ecological information presented in this work plan.

The ecological evaluation document helps answer questions about the ecological resources in the Central Plateau that are important to preserve and protect. The document also identifies ecological data needs that can be addressed in future ecological sampling activities on the Central Plateau.

The screening-level ecological risk assessment in DOE/RL-2001-54 is meant to be a conservative evaluation of risk to ecological receptors unique to the Central Plateau from stressors — in this case, introduction of contaminants and habitat elimination. The screening-level ecological risk assessment identifies pathways for ecological receptors to be exposed to the contamination and evaluates potential risk from those exposures.

Chapter 2.0 of DOE/RL-2001-54 describes the physical and ecological setting of the Central Plateau and identifies important aspects of the ecology and the condition of the waste sites to consider during the ecological risk assessment. For instance, while most waste sites are in a disturbed habitat with little vegetation to support wildlife, the nearby shrub-steppe offers a more habitable location for wildlife. This region needs protection because of the habitat is being encroached upon and eliminated in other parts of eastern Washington. Individual species whose populations are limited and are designated as sensitive species must also be protected. Recent surveys of the biological diversity on the Hanford Site have identified a number of new-to-science species, and the protection status of these species has not yet been determined. The U.S. Fish and Wildlife Service and state of Washington may gather additional information from the scientific community at the Hanford Site to make a determination on the protection status of the new species. Regarding the waste sites, most of the waste in the waste sites has been stabilized, thereby limiting ecological access. The decisions to stabilize and remediate waste sites must balance the potential disruption to the ecosystem both at and adjacent to the waste sites as well as from a distant locations (e.g., borrow source sites).

The conceptual site model in DOE/RL-2001-54, Chapter 3.0, provides an understanding of the ecological resources and the ways that receptors may be exposed. It shows where chemicals and radionuclides from the waste sites are likely to come into contact with receptors in the environment. The exposure pathways that are expected to be complete at most waste sites include:

- Direct contact with, or ingestion of, soil by invertebrates (e.g., beetles, ants) and burrowing mammals
- Uptake of contaminants in soil by vegetation
- Bioaccumulation through ingestion of food items (e.g., food chain effects) consumed by wildlife that may forage at the waste sites.

Chapter 4.0 or DOE/RL-2001-54 discusses the toxicity values that are available for contaminants believed to be present in the Central Plateau. Contaminants were identified from a preliminary sampling data available from a subset of waste sites. These contaminants were then screened, primarily with respect to the likelihood to be present in the environment (i.e., half-life and persistence). A literature search for bird and mammalian toxicity values was performed. Toxicity values are not available for some contaminants. A risk management decision will be needed to determine how contaminants that do not have toxicity values will be handled during the risk assessment for each OU.

Chapter 5.0 of DOE/RL-2001-54 presents the exposure parameters used for estimating the exposure in a quantitative manner. In a screening-level ecological risk assessment most exposure parameters are set conservatively at 100 percent. The only organism-specific factor necessary will be body weight, and these data are available in the literature. This section further evaluated the exposure pathways and constructed a food chain exposure model for wildlife specific to the Central Plateau. The wildlife are shown in the food chain and habitat model in DOE/RL-2001-54.

DOE/RL-2001-54, Chapter 6.0, is the screening-level risk calculation for the Central Plateau. The state and DOE provide contaminant-specific numerical values (WAC 173-340-900 and biota concentration guides [BCG]) to potential risks. These are conservative numbers designed to address all possibilities without leaving potential risks out of consideration. Data are available for a subset of the Central Plateau waste sites. These maximum concentrations of contaminants detected at the waste sites were compared with the state and DOE screening-level values. For chemicals, 12 metals, pentachlorophenol, and 4-dinitrophenol were detected at a maximum concentration above the screening level. The high number of metals presenting a risk requires closer examination. Site-specific bioavailability data would be helpful for understanding whether this is a reflection of the conservative nature of the screening assessment or an actual risk to the ecosystems at the waste sites. For radionuclides, cesium-137, radium-226, radium-228, and strontium-90 were above acceptable limits in the soil samples. It is important to recognize the limitations and uncertainty associated with risks identified by screening-level assessments. The risk calculations are useful for determining relative risks between waste sites, not site-specific risk. The information should be considered carefully along with actual biological evidence from the waste site area to determine if a hazard exists. There are data available for hundreds of wastes sites in the Central Plateau (see Appendix C of DOE/RL-2001-54). These data include soil from the waste site, vegetation, and soil invertebrates. As each OU quantifies their risk using the exposure models available it will be important to see if these data will be useful in verifying the mathematical estimates.

The screening-level ecological risk assessment in DOE/RL-2001-54 leads to the problem formulation stage of a baseline ecological risk assessment. During problem formulation, the risk managers and others consider the toxicity evaluation, conceptual model exposure pathways, and assessment endpoints to support cleanup decisions. As a result, they are then able to better define the initial risks and determine direction for the DQO process, if it is needed. The DQO will then

- Establish the level of effort needed to assess ecological risk at a particular site or OUs
- Identify relevant and available data
- Design a conceptual model of the ecological threats at a site and measures to assess those threats
- Select methods and models to be used in the various components of the risk assessment
- Develop assumptions to fill data gaps for toxicity and exposure assessments based on logic and scientific principles
- Interpret the ecological significance of observed or predicted effects.

Data collected during the RI directly support the ecological evaluation. Contaminant data from the soil sampling conducted in the RI are compared against WAC 173-340-900, Table 749-3 ecological soil indicator concentrations as the beginning step of the OU-specific screening-level evaluation of ecological risk from nonradiological constituents. For radiological constituents, no promulgated screening or cleanup levels are available. Biota concentration guides from the U.S. Department of Energy's (DOE) *Graded Approach for Evaluating Radiation Doses to Aquatic and Terrestrial Biota* (DOE/STD-1153-2002) are used in this evaluation of radiological constituents. Additional details are provided in Chapter 5.0.

1.3.5 Analogous Site Approach

The representative waste sites evaluated in this RI report were identified as being representative of sites within their respective OUs in DOE/RL-98-28; therefore, data collected from these sites and the resulting contaminant distribution models are anticipated to be representative of the remaining (or analogous) waste sites within the OUs. Confirmatory investigations of limited scope can be performed at the analogous waste sites rather than full characterization efforts, thereby optimizing investigations in support of RI/FS decision making.

This analogous approach was enhanced in June 2002, with Tri-Party Agreement change packages, M-15-02-01 and M-13-02-01 that consolidated the 200-CW-2, 200-CW-4, and 200-SC-1 OUs into the 200-CW-5 Work Plan. This change added 35 analogous waste sites to the 200-CW-5 OU Work Plan. To assure that the analogous waste sites would be aligned with the proper representative waste sites, each of the consolidated OU waste sites was evaluated against the three 200-CW-5 OU representative waste sites based on the waste site type, historical use, contaminant inventory, effluent volume discharged, and available site data. Based on this evaluation, some of the consolidated OU waste sites aligned well with the contaminant distribution models developed for the 200-CW-5 OU representative sites; however, some sites did not align well with these models. The waste sites that did not align with an appropriate representative site in the 200-CW-5 OU were then evaluated against and aligned with contaminant distribution models (for sites that have already been characterized) or conceptual contaminant distribution models (for sites that are at the work plan stage) developed for representative sites in other OUs (see Appendix B of DOE/RL-99-66, Rev. 1). Based on the consolidation of the work plans and other RI/FS activities, the analogous waste site approach has been broadened to use information from representative sites within any of the 200 Area OUs, as appropriate.

The analogous sites will be evaluated through the analogous site approach during the FS. Figure 1-5 shows the process for evaluating the analogous sites against the representative sites for the RI/FS process out through the confirmatory and design sampling processes and for applying risk assessment results from the representative sites to the analogous sites. Important considerations in determining the appropriate representative site for an analogous waste site include the following:

- Waste site configuration and construction (e.g., pond, trench, surface structure)
- Volume of effluent received in relation to the available pore volume for the waste site
- Types and amounts of contaminants received; contaminant inventory
- Method of discharge and purpose of waste site

- Expected distribution of contamination based on method of discharge and purpose of waste site
- Geological setting
- Neighboring waste sites, structures, or utilities
- Potential for hydrologic and contaminant impacts to groundwater.

The available information from each waste site will be evaluated in the FS against information from the representative sites. In cases where characterization data are available from an analogous waste site, the data will be evaluated for sufficiency to support a site-specific evaluation of risk. If the data are sufficient, a risk estimate for the analogous site will be calculated and then used to support the evaluation and selection of the appropriate remedial action for that waste site. If the data from a particular waste site are insufficient to support a risk estimate, the available data and information will be used to support the comparison and assignment to an appropriate representative site. In most cases, little or no characterization data are available from the analogous sites. In these instances, existing information from the WIDS database, discharge information, and general process information will be used to make assignments.

The characterization data from representative sites is intended to provide sufficient information to select remedies for the waste group. However, site-specific data may also be needed to verify that the selected remedial alternative is appropriate. Following the decision in the ROD, additional sampling would be conducted as needed to confirm the selected remedy for the analogous waste sites and to collect data to support remedial design. Following remedial action, an additional data collection activity would be conducted as needed to verify achievement of cleanup goals.

The risk analysis and data from the representative sites are used to support the risk evaluation and remedial decisions for those analogous sites without data to support a site-specific risk estimate. The use of the risk assessment from the representative sites presents some risk management decisions for the decision makers. If an analogous site is well represented by the representative site (i.e., the evaluation criteria of waste stream, size and construction, geology, waste inventory, effluent volume received are similar or equal to the representative site), then the decision to apply the representative site risk and preferred alternative pose minimal risk and minimal consequences of an incorrect decision. Similarly, if the representative site bounds the contamination problem at an analogous site, the application of the representative site risk and remedial action pose minimal consequences from a human health and ecological risk standpoint, but may significantly impact costs through the potential application of an unnecessary remedy. In this situation, no or limited confirmatory sampling may be needed to verify the nature of the contamination, the risk, and the appropriate remedial action. Design data may be needed depending on the preferred alternative.

If an analogous site is not bound by the representative site because contamination may be greater at that analogous site, then application of the representative site risk estimate and preferred alternative poses the greatest decision risk and resulting consequences. In this case, mandatory confirmatory sampling would be conducted to ensure selection of the appropriate alternative based on a better understanding of the nature and risk of the analogous site. This last scenario is unlikely for most sites because the analogous site approach tends to target the worst-case waste sites and the worst contamination locations in those sites in an effort to bound all the contamination circumstances associated with a waste group.

Based on the results of the RI and previous characterization efforts at these OUs, the preliminary conceptual contaminant distribution models and the conceptual exposure model were revised to reflect the current understanding of the representative waste sites (details are provided in Section 3.3). Revised models were developed for cribs and trenches, which are the main two types of waste sites within these three OUs. The models will be used in the FS to support the evaluation of remedial alternatives and selection of a preferred alternative (or alternatives if site conditions warrant different actions).

A proposed plan and ROD will be written, identifying the proposed remedy (or remedies) for all waste sites in the OUs. The ROD will include criteria for any post-ROD confirmation sampling and analysis needed to verify that all remaining (or analogous) sites in the OU meet the conceptual model for the waste group. If a waste site fails to meet the contaminant distribution model and the selected remedy is not appropriate, the site will be removed from the OU and reassigned to another OU; however, this is not expected to be a common occurrence. The analogous site approach focuses on the typical and worst case sites as representative sites; therefore, data from the representative sites should bound the analogous sites. Also, the ability to utilize data and information from representative sites outside the OU helps reduce the potential to reassign waste sites between OUs. A separate DQO process will be conducted to identify data needs and quality requirements to support the confirmatory sampling design. A permit modification also will be prepared to incorporate the corrective action of the RPP sites into the Hanford RCRA Permit.

1.4 WASTE SITE DESCRIPTION AND HISTORY

1.4.1 216-U-10 Pond

The 216-U-10 Pond was constructed in a natural topographic depression to act as a seepage area for infiltration of wastewater from the 216-U-14 and 216-Z Area Ditches. There is a discrepancy in the literature as to when the 216-U-10 Pond first began operations; some sources list the start date as 1943, while others list it as 1944. (For the purposes of this RI report, the 216-U-10 Pond is assumed to have started operations in 1944.) The pond was located in the southwestern corner of the 200 West Area. The pond was later diked on the south and west edges, and three overflow trenches were added on the east side in approximately 1952-53 to increase volume capacity. At its maximum extent, including the overflow trenches, the pond covered an area of roughly 12 hectares (ha) (30 acres [ac]). The location of the 216-U-10 Pond is shown in Figure 1-3.

In 1985, the pond was deactivated and interim stabilized. Stabilization activities included scraping contaminated pond sediments from peripheral areas to a depth of 0.3 m (1 ft) or more and placing the sediments in the center of the pond. The peripheral areas were covered with a minimum of 0.6 m (2 ft) of clean soil, and the central pond area was covered with a minimum of 1.2 m (4 ft) of clean soil and seeded (DOE/RL-95-106, *Focused Feasibility Study for the 200-UP-2 OU*). In 1990, 0.6 ha (1.5 ac) of contaminated soil on the south side of the pond was covered with an additional 0.6 m (2 ft) of clean fill to stabilize surface contamination (DOE/RL-91-58, *Z Plant Source Aggregate Area Management Study Report*). In November 1994, contamination was detected along the south and west perimeters of the pond (about 1 ha [2.5 ac]) and was stabilized with soil from the 216-U-11 Borrow Pit (BHI-00627, *The Hanford Site N Reactor Building Task Identification and Evaluation of Historic Properties*).

The 216-U-10 Pond received an estimated total of $1.65x10^{11}$ L ($4.3x10^{10}$ gal) of low-level liquid waste (DOE/RL-91-58 and DOE/RL-96-81). Through 1982, the total inventory of radionuclides discharged to the system is estimated to include 8.2 kg plutonium, 1,500 kg uranium, 15.3 Ci cesium-137, and 22.6 Ci strontium-90 (DOE/RL-96-81). The discharge volume and inventory of the 216-U-14 Ditch and Z-Ditches are included in these totals.

The following waste streams were directed into the 216-U-10 Pond at various times via the 216-U-14 Ditch and Z-Ditches:

- 284-W Powerhouse cooling water, steam condensate, and wastewater from batch operations
- 282-W Reservoir cooling water, steam condensate, and wastewater from batch operations (WHC-EP-0679)
- 283-W Filter steam condensate, cooling water, and wastewater from batch operations (WHC-EP-0679)
- 277-W Complex cooling water, steam condensate, and wastewater from batch operations (WHC-EP-0679)
- 231-Z Building steam condensate and laboratory waste
- 234-5Z Building cooling water and steam condensate
- 2723-W Mask Cleaning Station solution
- 2724-W Laundry wastewater
- 221-U and 271-U Buildings cooling water, steam condensate, and chemical sewer waste
- 224-U Building cooling water
- 291-Z Building cooling water and vacuum pump seal water
- 241-U-110 Tank condenser water
- 242-S Evaporator steam condensate and vacuum pump seal water.

1.4.2 216-U-14-Ditch

The 216-U-14 Ditch began operating in 1944 and was used mainly to channel effluent to the 216-U-10 Pond. The ditch was an unlined, open excavation approximately 2.7 m (9 ft) deep and 1,731 m (5,680 ft) long. It originated about 500 m (1,600 ft) northwest of U Plant at the 284-WB Powerhouse Pond and terminated at the 216-U-10 Pond (Figure 1-3). The ditch, and largely 216-U-10 Pond, was used to manage low-level radioactive wastewater by infiltration and evaporation. The ditch received effluent from the following:

- 284-W Powerhouse (and associated building) cooling water, steam condensate, and chemical sewer waste
- 273-W Mask Cleaning Station and 2724-W Laundry Facility steam condensate, and contaminated laundry wash and rinse water
- 221-U (U Plant) cooling water, steam condensate, and chemical sewer wastewater
- 224-U (Uranium Trioxide [UO_3] Plant) cooling water
- 241-U-110 Condenser tank condenser water
- 271-U Building cooling water, steam condensate, and chemical wastewater
- 242-S Evaporator steam condensate.

The contaminant inventory and volume of effluent discharged to the ditch are contained in the 216-U-10 Pond inventory.

During the useful life of the ditch, the growth of live plants and the accumulation of dead plant material caused localized damming. Buildup of fly ash, scale, and lint from the powerhouse laundry discharge reduced the infiltration capacity of the ditch. To prevent discharge backups, the ditch was dredged periodically. Sediments removed during dredging activities were piled on a berm on the west bank of the ditch. The berm was removed and buried in a low-level burial ground in 1979 to reduce the spread of contamination (WHC-EP-0707).

In 1985, the 216-U-10 Pond and most of the 216-U-14 Ditch were stabilized with sand and gravel to control surface contamination. After stabilization in 1985, approximately 430 m (1,410 ft) on the west end of the ditch remained. It was used mainly for percolation of effluent. In 1986, an accidental release led to the discharge of approximately 2,365 L (625 gal) of reprocessed nitric acid to the ditch in less than one day. This release occurred during transfer of the acid from a storage tank. The release was diluted with cooling water originating from the 224-U facility. The residual effluent stream had a pH of less than 2.0 and contained approximately 39 kg (86 lb) of uranium (Whiting 1988, "Unusual Occurrence Report, Public Information Release").

In 1992, the lower open end of the ditch (westernmost end of the ditch) was partially stabilized with an engineered barrier to control surface contamination. The slopes were pushed in, approximately half of the ditch was brought to grade, and the ditch was backfilled with large boulders and gravel. The ditch received effluent until April 1995. The open section that remained was stabilized in 1995 by chemically killing all vegetation, consolidating the contaminated soil into the center of the ditch, and backfilling with clean soil.

1.4.3 216-Z-11 Ditch

The 216-Z-11 Ditch was the second of three ditches constructed to transfer wastewaters from the Z-Plant facilities to the 216-U-10 Pond. Beginning in December 1944, the first "Z-Ditch," currently designated the 216-Z-1D Ditch, received effluent from the 231-Z Building. The 216-Z-1D Ditch was constructed as an unlined, open excavation 1,295 m (4,249 ft) long and 0.6 m (2 ft) deep, with a bottom width of 1.2 m (4 ft), side slopes of 2.5:1, and a minimum grade of 0.05 percent (WHC-EP-0707). The original headwall of the 216-Z-1D Ditch was located approximately 60 m (196 ft) east of the 231-Z Building.

In July 1949, as part of 234-5Z Building (Z-Plant) construction, a vitreous clay pipeline 45.7 cm (18 in.) in diameter was installed to replace the upper portion of the 216-Z-1D Ditch, and a new headwall was constructed approximately 457 m (1,500 ft) downstream. The abandoned upper portion of the ditch was backfilled.

In March 1959, construction of the 216-Z-11 Ditch began to replace the 216-Z-1D Ditch after high plutonium contamination was discovered. The 216-Z-11 Ditch was excavated just east of and parallel to the 216-Z-1D Ditch and was of similar design and construction. Material removed during excavation was used to backfill the 216-Z-1D Ditch to existing grade. The 216-Z-11 Ditch merged back into the original 216-Z-1D Ditch at the lower end between the 216-U-10 Pond delta region and 16th Street crossing. The entire ditch was redesignated as the 216-Z-11 Ditch. The resulting ditch was approximately 797 m (2,615 ft) long, with the upper 36.5 m and lower 202.6 m (120 ft and 665 ft, respectively) in common with the original 216-Z-1D Ditch.

In April 1971, the 216-Z-11 Ditch was retired and replaced with a third ditch, 216-Z-19. The 216-Z-19 Ditch was constructed west of and parallel to the 216-Z-1D and 216-Z-11 Ditches. During construction of the 216-Z-19 Ditch, contaminated sediments from the upper portion of the 216-Z-1D Ditch were inadvertently excavated over an estimated length of 130 m (427 ft). After a radiological control technician discovered that the excavated soils were contaminated, they were buried in a trench that was dug parallel to and east of the 216-Z-11 Ditch. The 216-Z-19 Ditch was subsequently shifted further west of the original 216-Z-1D Ditch. A temporary alignment resulted in the 216-Z-19 Ditch reentering the existing 216-Z-11 Ditch to use the culvert beneath 16th Street. In October 1971, a new culvert was installed 15 m (49 ft) to the west, and the 216-Z-19 Ditch was realigned and continued approximately 305 m (1,000 ft) to the 216-U-10 Pond. Material excavated during the installation of the 216-Z-19 Ditch was used to backfill the 216-Z-11 Ditch to grade.

In late March 1976, an accidental release of contamination occurred in the 216-Z-19 Ditch, and efforts were made to contain the contaminants in the ditch. Wastewater discharge from the 234-5Z Building was reduced, and a series of three dams was constructed at intervals along the upper portion of the ditch. These dams were installed to raise the water level in the ditch to submerge the original contaminated water line and to stop wastewater from reaching the 216-U-10 Pond. A water sprinkler system was installed between the lowermost dam and the

216-U-10 Pond to prevent this portion of the ditch from drying out. In March 1978, the sprinklers were shut down and the dams were removed, but the remaining water never reached the pond. All wastewater was diverted to the 216-Z-20 Crib shortly thereafter.

Deactivation and stabilization of the Z-Ditch Complex began in 1981, following construction of the 216-Z-20 Crib as the primary Z-Plant wastewater disposal facility. Live, woody vegetation in the 216-Z-19 Ditch was killed with herbicides (glyphosate and dicamba) before backfill operations were initiated. The 216-Z-19 Ditch was covered with 0.6 to 0.9 m (2 to 3 ft) of clean soil. The concrete headwalls, vegetation, and miscellaneous unsalvageable equipment were incorporated into the ditch bottom. At the same time, the previously buried 216-Z-1D and 216-Z-11 Ditches received an additional 0.15 to 0.30 m (0.5 to 1.0 ft) of clean fill. The entire Z-Ditch Complex was reposted as an Underground Radioactive Area.

The Z-Ditches received the following waste streams during their time of use:

- Process cooling water and steam condensate from 231-Z Building
- Cooling water and steam condensate from 234-5Z Building
- Vacuum pump seal water from 291-Z Building
- Laboratory waste from 231-Z Building.

1.4.4 Previous Contaminant Inventory Estimates for 216-Z Ditches

Based on DOE/RL-96-81, the 216-Z-1D, 216-Z-11, and 216-Z-19 Ditches received an estimated 0.14 kg, 8.07 kg, and 0.14 kg of plutonium, respectively, during their periods of active use. These estimates are based on limited waste-stream discharge sampling collected during more than 35 years of continuous operation. No discharge records exist for the period 1961 through 1966. During this time, the Space Nuclear Auxiliary Power (SNAP) program was operating in Z-Plant and producing purified neptunium-237 and plutonium-238. A cumulative plutonium release quantity of 7.86 kg was reported for the period 1959 through 1967, representing 96 percent of the total estimated inventory for the 216-Z-11 Ditch (WHC-EP-0707).

Significant uncertainty exists in estimates of plutonium inventory on the basis of waste stream chemistry. Waste-effluent sampling likely was performed by alpha count and then converted to plutonium concentrations. This method can significantly overestimate the quantity of plutonium. Conversely, periodic waste stream sampling likely would not reflect intermittent, short-term higher concentration discharge incidents and, thus, would underestimate the total plutonium released to the ditches.

Soil samples collected in 1959 from the 216-Z-1D Ditch indicated very high plutonium levels in the ditch. Based on the 1959 sampling data, the results of their Z-Ditch characterization, and information obtained when the head end of the 216-Z-1D Ditch was mistakenly unearthed during excavation of the 216-Z-19 Ditch, WHC-EP-0707, concluded that the historical plant operations inventory estimates for the Z-Ditches were erroneous. Their conclusion was that the 216-Z-1D Ditch likely contains from 3 kg to 10 kg of plutonium, with both the 216-Z-11 and 216-Z-19 Ditch inventories an order of magnitude lower (WHC-EP-0707).

Figure 1-1. Cooling Water Group Waste Consolidation Process Logic and History.

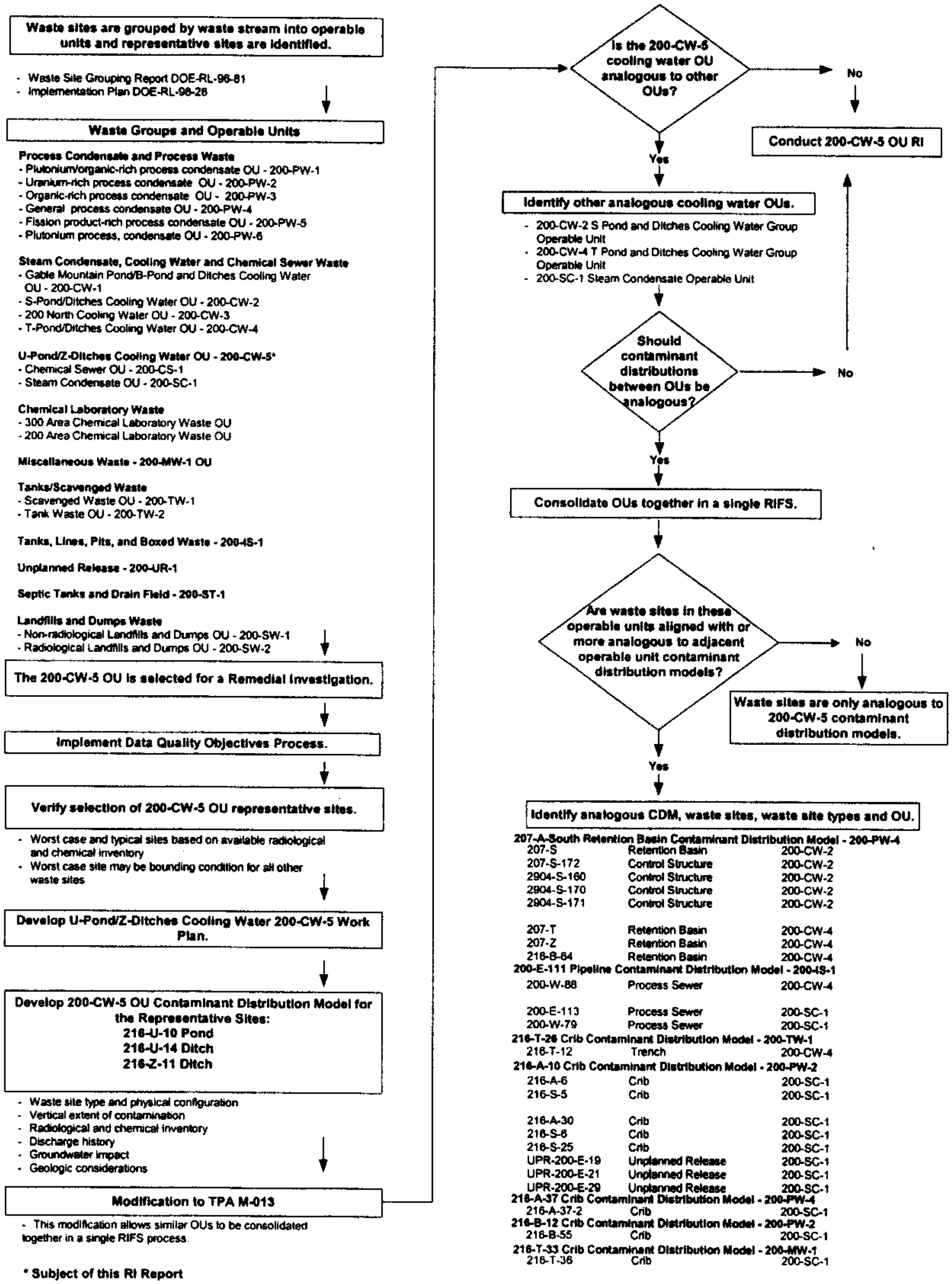


Figure 1-2. Location Map of the Hanford Site and the 200-CW-2, 200-CW-4, 200-CW-5, and 200-SC-1 Operable Units.

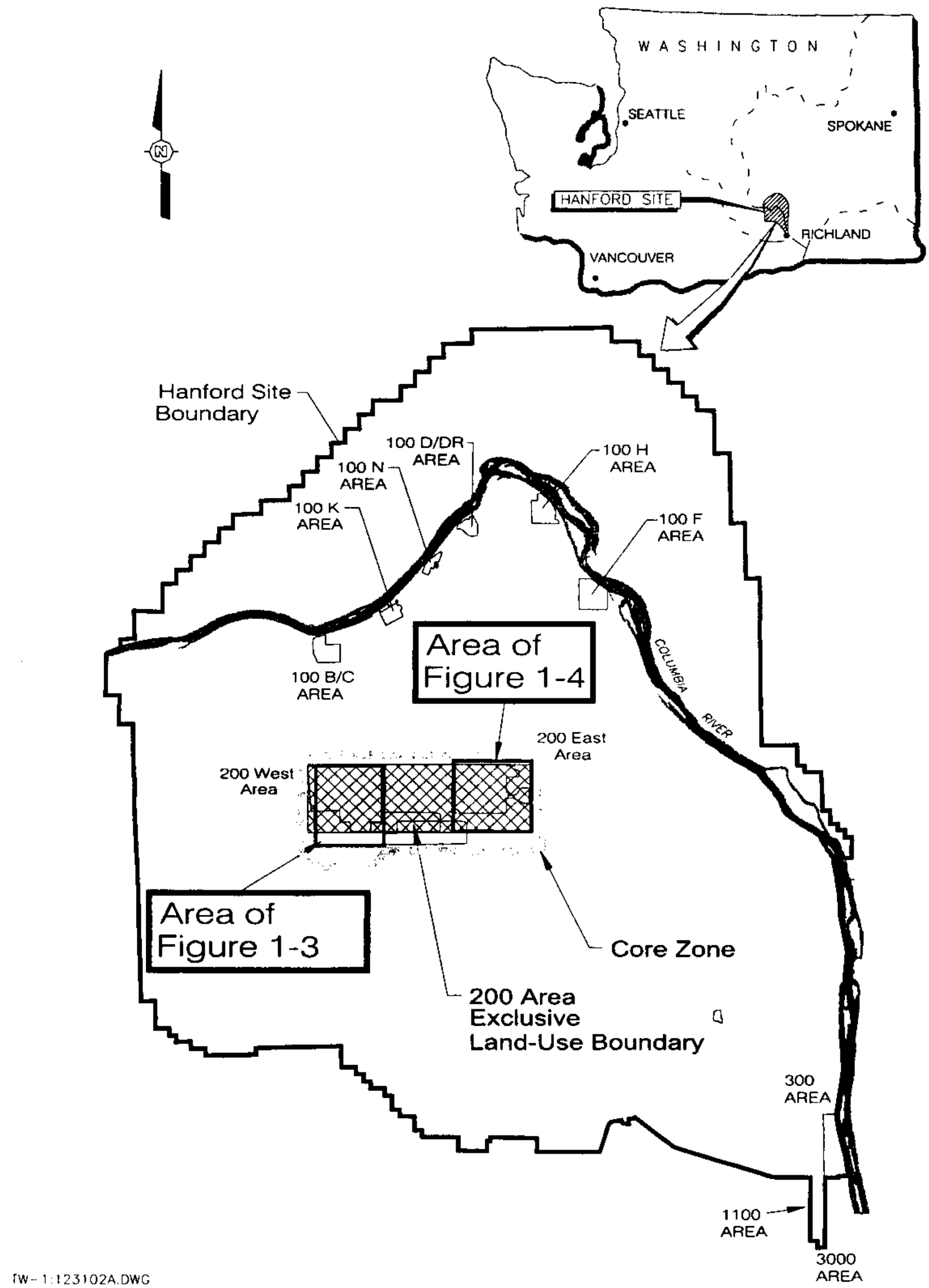


Figure 1-3. Location Map of the 200-CW-2, 200-CW-4, 200-CW-5, and 200-SC-1 Operable Unit Waste Sites in the 200 West Area.

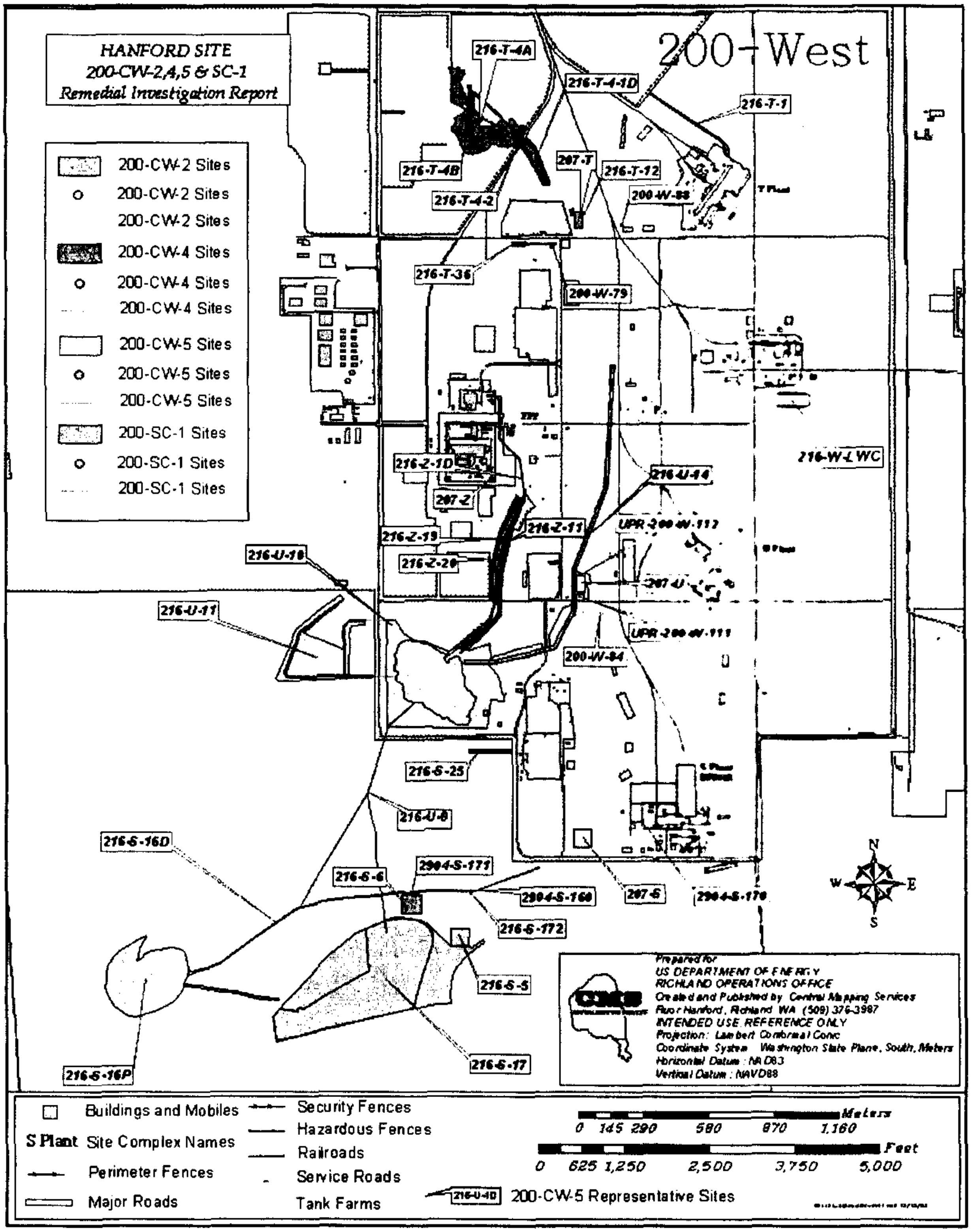
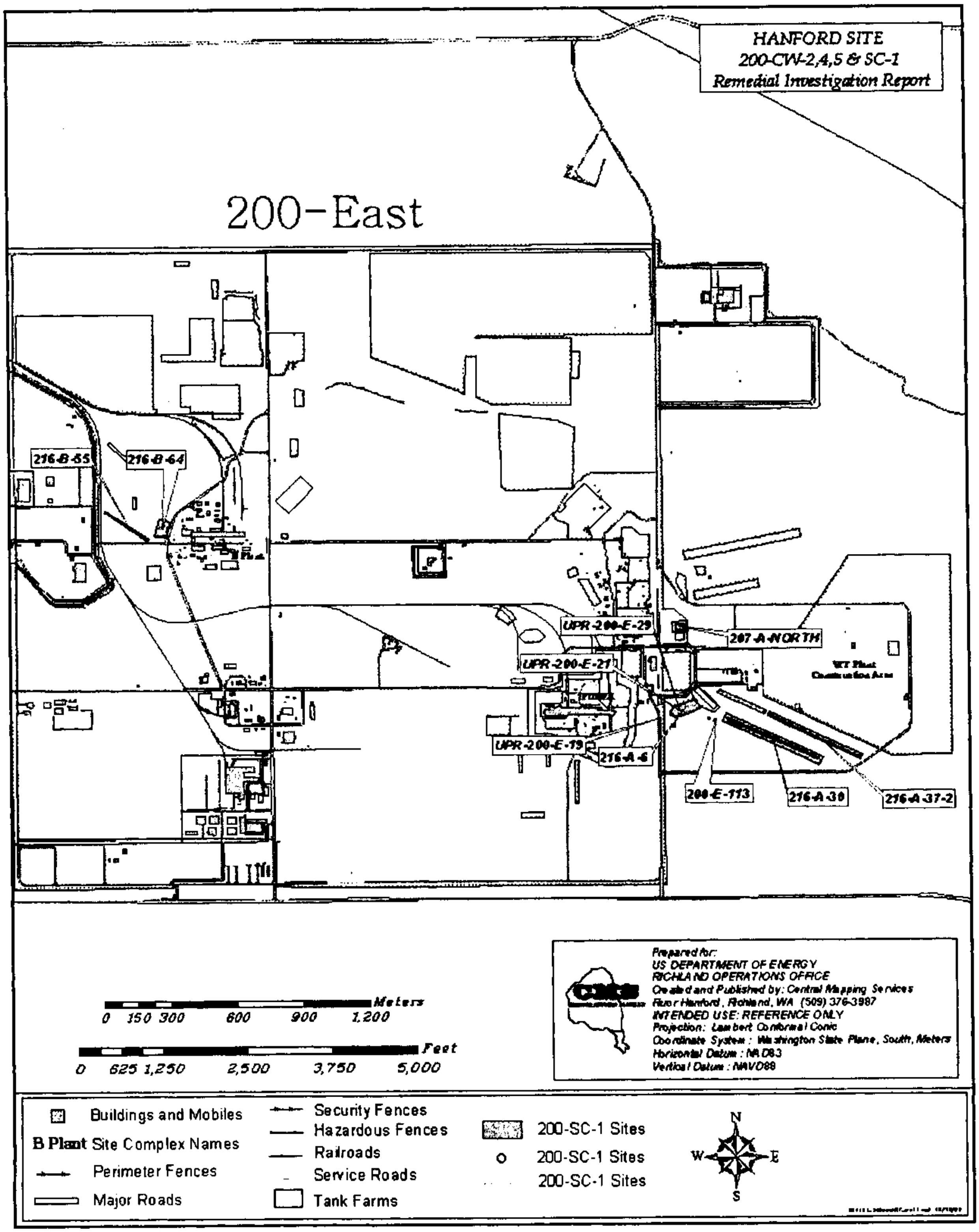


Figure 1-4. Location Map of the 200-SC-1 Operable Unit Waste Sites in the 200 East Area.



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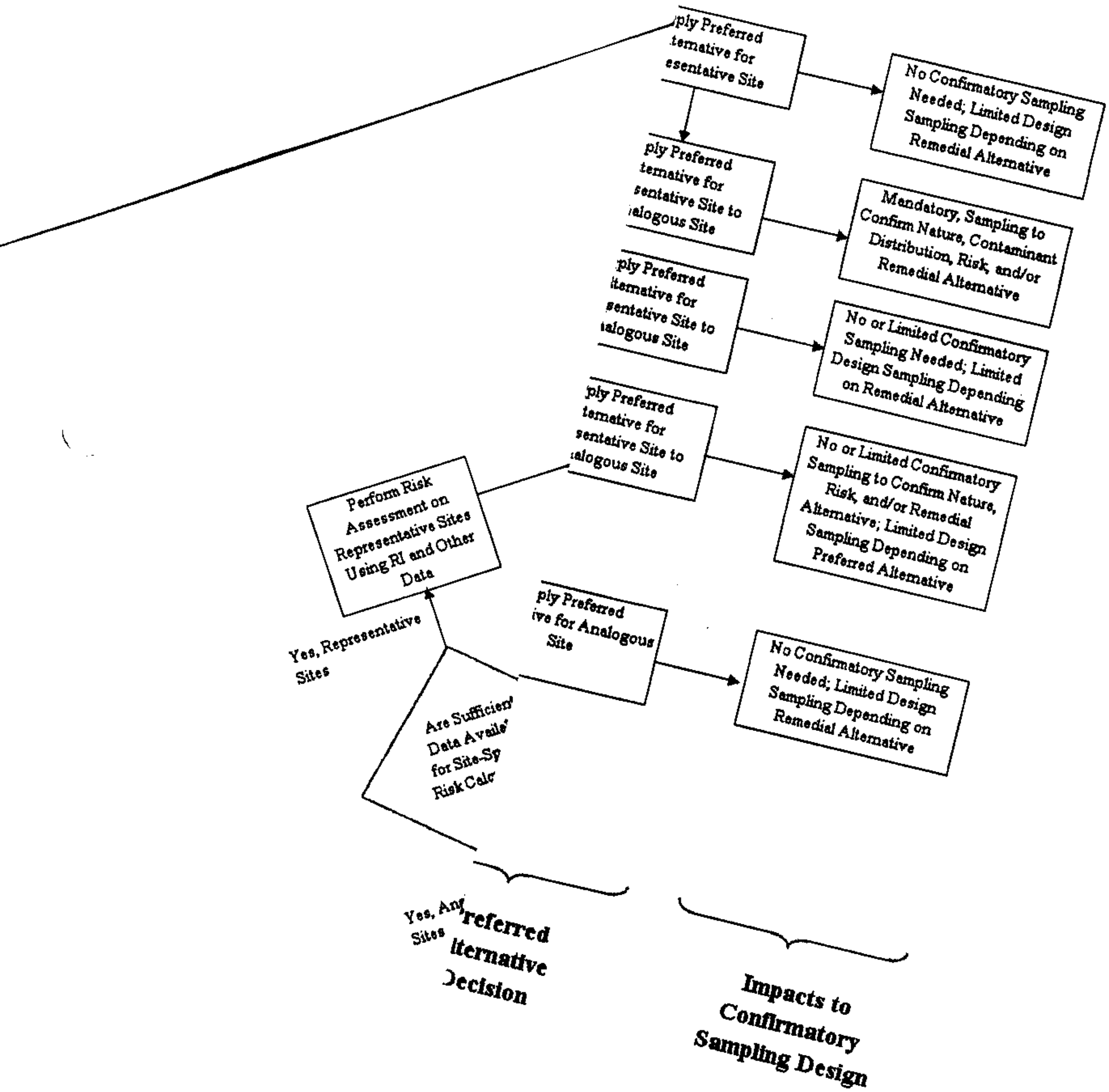

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Table 1-1. List of Operable Unit Waste Sites.

Operable Unit Waste Sites			
200-CW-2	**200-CW-5**	**200-CW-4**	**200-SC-1**
207-S Retention Basin	200-W-84 Process Sewer	200-W-88 Process Sewer	200-E-113 Process Sewer
216-S-16D Ditch	200-W-102 Process Sewer	207-T Retention Basin	200-W-79 Process Sewer
216-S-16P Pond	207-U Retention Basin	216-T-1 Ditch	207-A-NORTH Retention Basin
216-S-17 Pond	216-U-9 Ditch	216-T-4-1D Ditch	207-Z Retention Basin
216-S-172 Control Structure	216-U-10 Pond	216-T-4A Pond	216-A-6 Crib
2904-S-160 Control Structure	216-U-11 Ditch	216-T-4B Pond	216-A-30 Crib
2904-S-170 Control Structure	216-U-14 Ditch	216-T-4-2 Ditch	216-A-37-2 Crib
2904-S-171 Control Structure	216-W-LWC Crib	216-T-12 Trench	216-B-55 Crib
UPR-200-W-124 Unplanned Release	216-Z-1D Ditch		216-B-64 Retention Basin
	216-Z-11 Ditch		216-S-5 Crib
	216-Z-19 Ditch		216-S-6 Crib
	216-Z-20 Crib		216-S-25 Crib
	UPR-200-W-110 Unplanned Release		216-T-36 Crib
	UPR-200-W-111 Unplanned Release		UPR-200-E-19 Unplanned Release
	UPR-200-W-112 Unplanned Release		UPR-200-E-21 Unplanned Release
			UPR-200-E-29 Unplanned Release

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2.0 INVESTIGATION APPROACH AND ACTIVITIES

This section summarizes the data collection activities performed during the 200-CW-5 RI. These activities are described in detail in CP-12134. The RI was conducted in accordance with DOE/RL-99-66, Rev. 0 and DOE/RL-2002-24. Data were collected to characterize the nature and vertical extent of chemical and radiological contamination and the physical conditions in the vadose zone underlying the lower end of the 216-Z-11 Ditch. The scope of the RI included drilling, surface and borehole geophysical surveys, and sampling and analysis of soil.

This RI report also summarizes previous characterization efforts conducted at the 216-U-10 Pond and the 216-U-14 Ditch. The 216-U-10 Pond previously was characterized in support of an LFI (DOE/RL-95-13) in 1993. Characterization of the 216-U-14 Ditch is documented in WHC-EP-0698. The scope of efforts at each site included drilling, test pit excavation, borehole geophysical surveys, and sampling and analysis of soil. With the exception of geophysical logging, no additional soil sampling and analysis were performed at these sites under the 200-CW-5 RI, because the existing data are considered sufficient for making remedial decisions (BHI-01294).

Section 2.1 describes data collection activities applicable to the 200-CW-5 RI at the 216-Z-11 Ditch. Sections 2.2 and 2.3 provide a summary of data collection efforts performed at the 216-U-10 Pond and 216-U-14 Ditch, respectively.

2.1 200-CW-5 REMEDIAL INVESTIGATION AT THE 216-Z-11 DITCH

The primary objective of the 200-CW-5 RI field effort was to characterize the nature and vertical extent of contamination in the vadose zone underlying the 216-Z-11 Ditch. Twenty GeoProbe soil probes were installed at the 216-Z-11 Ditch in five transects. The locations of the five transects were preselected to reflect portions of the ditch where the highest transuranic contamination was expected. Each of the transect locations was subjected to shallow surface geophysical survey (that is, ground-penetrating radar [GPR]) before the soil probes were installed. The results of the GPR survey were interpreted to ensure that the probe locations were free from subsurface debris and utilities and to confirm intersection with the original 216-Z-11 Ditch channel. Each probe was logged with a small-diameter gross gamma/passive neutron logging system to determine the gross concentration and type of gamma-emitting constituent present. The logging results were used to optimize the placement of a borehole (C3808) in the area of the highest contamination in the ditch. Borehole C3808 was located just north of the 16th Street culvert and was drilled through the 216-Z-11 Ditch. Soil samples were collected during drilling for physical property, chemical, and radionuclide analysis. In addition, the borehole was subjected to gross gamma/passive neutron logging and soil vapor sampling. Soil vapor samples were analyzed for carbon tetrachloride contamination in the vadose zone soils as part of a combined effort with the Groundwater/Vadose Zone Integration Project. Field activities (such as drilling, sampling, and decontamination) were performed in accordance with BHI-EE-01, *Environmental Investigations Procedures*.

2.1.1 GeoProbe Investigation

Twenty soil probes were installed at the 216-Z-11 Ditch and logged with a small-diameter gross gamma/passive neutron logging system to determine the gross concentrations and vertical distribution of the transuranic isotopes along the length of the ditch and with depth. A GeoProbe system was used to drive small-diameter carbon steel probe rods 6.35-cm outside diameter, 4.82-cm inside diameter (2.5-in. outside diameter, 1.9-in. inside diameter) to a depth of 4.9 m (16 ft) bgs. The soil borings were decommissioned by extraction of the probe rods and simultaneous cement grouting. A brass survey marker was placed at the surface for each boring.

Fifteen soil probes were installed at five preselected transect locations, with three borings per transect. The locations of the transects are shown in Figure 2-1. The soil probes were spaced approximately 0.5 m (1.5 ft) apart and aligned perpendicular to the length of the ditch. One test probe (C3809) was installed outside the posted underground radioactive area, in a noncontaminated portion of the site, to verify the ability of the GeoProbe to reach the desired depth and to provide background data for interpreting the gross gamma/passive neutron logging results.

During the initial review of the logging data, soil probes C3819 through C3821 at Transect #6 showed higher than anticipated plutonium-239 contamination. The GPR results were reevaluated against historical maps of the Z-Ditches, leading to the conclusion that the probes at Transect #6 were mistakenly placed at the eastern edge of the 216-Z-1D Ditch, not the 216-Z-11 Ditch. The maps showed that all three Z-Ditches (216-Z-1D, 216-Z-11, and 216-Z-19) converged in the area of Transect #6 to allow use of the 16th Street culvert. The soils in the area had been greatly disturbed during ditch construction, which led to erroneous GPR interpretations. Four additional probes (C3825, C3834, C3835, and C3836) subsequently were installed near the original Transect #6 location, based on a better understanding of the ditch configuration. Figure 2-2 shows the placement of the four new probes relative to the original three probes installed at Transect #6.

2.1.2 Borehole Drilling and Geophysical Logging

Borehole C3808 was drilled through the 216-Z-11 Ditch with a cable tool rig to a total depth of 68.6 m (225.2 ft) bgs. Multiple casing strings were used to minimize the potential for downhole cross-contamination. Temporary telescoping casings were set at depths of 6.4 m (21.0 ft), 9.5 m (31.0 ft), and 67.2 m (220.5 ft) bgs. The outside diameters of the three casing strings and sizes of the borehole were 29.8 cm (11.75 in.), 21.9 cm (8.625 in.), and 16.8 cm (6.625 in.), respectively. Casing was not used in the borehole from 67.2 to 68.7 m (220.5 to 225.25 ft) bgs. In this zone, the size of the borehole corresponds to the outside diameter of the split-spoon sampler (11.4 cm [4.5 in.]). The borehole was decommissioned after sample collection activities were complete. Geophysical logging in borehole C3808 was performed using spectral gamma, neutron-moisture, gross gamma, and passive neutron tools. The location of borehole C3808 is shown in Figure 2-3.

2.1.3 Sampling and Analysis

Soil samples were collected from borehole C3808 and submitted to contracted laboratories for chemical and radiological analysis and determination of physical properties. All soil samples were collected in accordance with BHI-EE-01, Procedure 4.0, "Soil and Sediment Sampling." Split-spoon sampling was the primary sampling method used for borehole sample collection. A total of 33 samples, including QA/QC samples, were collected from the borehole. Three samples were collected for physical property analysis, 10 for limited radioisotopic analyses (americium, plutonium, curium), and 12 for full suite chemical and radiological analysis. Eight QA/QC samples were collected. A summary of samples collected is shown in Table 2-1.

2.1.4 Field Screening Measurements

Before being placed in sample jars, soil samples were screened in the field for alpha-gamma and beta-gamma radioactivity to assist in selecting sample points, to support worker health and safety, and for shipping. A radiation control technician performed radiological screening using an E-600 rate meter with an SHP380-A/B[2] scintillation probe and a dose meter. Radiological activity greater than two times background was used as an indication of contamination. Background was determined by measuring the activity at the ground surface adjacent to the borehole. Drill cuttings and samples also were screened for volatile organics using a hand-held vapor analyzer equipped with an 11.7-electron-volt (eV) photoionization detector probe.

2.1.5 Pipeline Investigation

Two pipelines (231-Z and 235-5) were evaluated through manholes 2 and Z-8 during the RI. The locations of the pipelines and manholes are shown in Figure 2-4. The 231-Z pipeline is a 45.7 cm (18 in.) in diameter vitreous clay pipe that was used to discharge effluent to the Z-Ditches from the 231-Z Building. This pipe replaced the upper portion of the original 216-Z-1D Ditch in July 1949 and facilitated relocating the headwall approximately 457 m (1,500 ft) southeast of the 234-5 Building. The 234-5 pipeline is a 38.1-cm- (15-in.) diameter, vitreous clay, process sewer pipe that originated from the 234-5 Building and discharged to the Z-Ditches.

The pipeline investigation consisted of collecting in situ gamma measurements and smear samples. A sodium iodide gamma detector was lowered to within 15 cm (6 in.) of the bottom of the manholes to collect data on the type of contaminants present. Smear samples were collected to assess the type and concentration of contaminants present in the pipeline. Smear samples were collected by affixing two tech smear pads on either side of a foam paintbrush attached to the end of an extendable metal pole. Swipes were made in both directions across the bottom of the pipe and manhole. The condition of each pipe was documented with a video camera. Air sampling and volatile organic compound (VOC) and radiation monitoring were performed for the entire length of the investigation.

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[2] SHP380-A/B is a trademark of Thermo Electron Corporation, Minneapolis, Minnesota.

2.1.6 Other Activities

2.1.6.1 Surface Geophysical Survey

Before the GeoProbe soil probes were installed, the preselected sampling locations were surveyed with GPR to confirm location of the 216-Z-11 Ditch and to locate possible buried debris. For the most part, the GPR survey was successful in delineating the locations of ditches. The ditch bottoms produced weak responses, but the sloped sides of the ditches were clearly identifiable and allowed the bottoms to be interpolated. The 216-Z-11 and 216-Z-19 Ditches were the easiest to distinguish; the 216-Z-1D Ditch more difficult. The original survey of the Z-Ditch area was performed with the antenna pulled behind an all-terrain vehicle to facilitate covering larger areas. To refine the interpretation of the sample locations, the GPR survey was repeated on a smaller scale at each location. The second survey confirmed the results of the first survey, and the locations of the GeoProbe soil probes were selected in the 216-Z-11 Ditch. A complete discussion of the geophysical survey is presented in CP-12134.

2.1.6.2 Soil Vapor Sampling

Vapor samples were collected during drilling for field analysis of carbon tetrachloride, in support of the Groundwater Program. Vapor samples were collected after the lower portion of the borehole was isolated by installing an inflatable packer. The air from the lower region of the borehole then was extracted with a vacuum pump. Vapor samples were collected into clean Tedlar® bags and analyzed at the site with a Brüel and Kjær 1310 multigas analyzer[3].

2.1.6.3 Air Monitoring

Air monitoring was conducted in accordance with *Environmental Program ALARACT Demonstration for Drilling* (WDOH 2001) to verify that contamination did not migrate from the waste site. Existing near-facility stations (numbers N155, N165, and N964) in the 200 West Area were used during the characterization activities. The Washington State Department of Health (WDOH) was notified of and agreed to this plan before drilling activities began, as required by WDOH (2001) for high-risk drilling sites. Data from these stations will be included as part of the annual near-field environmental monitoring report.

2.1.6.4 Geodetic Survey

Survey data for each of the GeoProbe soil probes and for borehole C3808 are reported in CP-12134.

® Tedlar is a registered trademark of E.I. du Pont de Nemours and Company, Wilmington, Delaware.

[3] 1310 multigas analyzer is a trademark of Brüel and Kjær, Nærum, Denmark.

2.1.7 Summary of Data Collection Activities at the 216-Z-1D and 216-Z-19 Ditches

216-Z-1D Ditch Sediment Sampling, 1959

A total of 90 sediment grab samples ("mud samples") were collected from the bottom of the 216-Z-1D Ditch in 1959 to investigate transuranic surface contamination (WHC-EP-0707). Samples were collected on 30 m (100 ft) centers in groups of three for the entire length of the ditch. Nine samples were collected from the 216-Z-1D Ditch. The remaining samples were collected from the 234-235 Ditch.

The 234-235 Ditch has not been confirmed as an alias for the 216-Z-1D Ditch in WIDS; however, the organization of the data in WHC-EP-0707 suggests that the data may be from the 216-Z-1D Ditch. The 234-235 Ditch data are not used in this RI report to describe the nature and extent of contamination, because an association with the 216-Z-1D Ditch has not been confirmed and sample locations cannot be verified. The nine samples collected from the 216-Z-1 Ditch were analyzed for total alpha activity and plutonium-239. Sample locations are shown in WHC-EP-0707.

216-Z-19 Ditch Sediment Sampling, 1976

Eight sediment samples were collected from the bottom of the 216-Z-19 Ditch during March and April 1976 (WHC-EP-0707). The samples were analyzed for potassium-40, strontium-89/90, cesium-137, cerium-139, plutonium-239, americium-241, and radium-226. Samples were collected along the entire ditch. Only descriptive locations are available for these samples (e.g., "west bank head," "U-Pond inlet").

216-Z-19 Ditch Sediment Sampling, 1977–79

As part of the Rockwell Hanford Operations Environmental Surveillance Program, sediment samples were collected from the 216-Z-19 Ditch in 1977, 1978, and 1979 (WHC-EP-0707). One sediment sample was collected in 1977 and four were collected in both 1978 and 1979. Samples were analyzed for a suite of radionuclides including strontium-90, cesium-137, plutonium-239/240, and americium-241. Only descriptive locations are available for these samples.

216-Z-19 Ditch Characterization Sampling, 1979

A characterization study was performed to gather surface and near-surface samples from the 216-Z-19 Ditch in 1979. At the time of the study, the 216-Z-19 Ditch was still in operation and portions of it contained standing water. Two hundred forty-six samples were collected along nine transects with seven sampling points over the length of the 216-Z-19 Ditch. The transect locations are shown in WHC-EP-0707. Sample locations at each transect were labeled A through G, with station C at the bottom of the ditch. Sample intervals were generally 5 to 10 cm (2 to 4 in.) in length, and samples were collected less than 1.0 m (3 ft) below the ditch bottom.

Laboratory analyses were conducted at the Rockwell Laboratory (onsite) and two offsite laboratories (Eberline and Environmental Analysis Laboratory). A portion of the samples was analyzed using a developmental van, (Dev Van IA) with portable gamma energy detectors that were capable of in situ measurements. As discussed in WHC-EP-0707, the results from the Dev Van IA analysis method are believed to be unreliable for low to moderate levels of transuranic contamination. The detector likely was susceptible to recording background "shine" from nearby areas of higher contamination. The effective minimum detection limit reported for plutonium-239/240 was 2,000 pCi/g and was 100 pCi/g for americium-241. For this RI report, only laboratory analyses were used to evaluate the concentrations of the radioactive constituents. After the Dev Van IA data are removed, a total of 201 samples exist for the transect investigation. Samples were analyzed for cesium-137, plutonium 239/240, plutonium-238, strontium-90, and americium-241. Thirteen additional surface grab samples were collected from the bottom of the ditch from 16th Street to the delta region entering the 216-U-10 Pond to better characterize the lower dry end of the ditch.

Nineteen boreholes were drilled in the vicinity of the Z-Ditches. Two deep monitoring wells (299-W18-177 and 299-W18-178) were drilled during March and April 1980 to evaluate the vertical distribution of contaminants. Seventeen shallow exploration wells were drilled between February and April 1981 to locate and sample the 216-Z-1D and 216-Z-11 Ditches, which were backfilled. The locations of the boreholes are shown in Figure 2-3. Seventy samples were collected from these boreholes and analyzed for plutonium-238, plutonium-239/240, and americium-241. As with the transect data described above, results from the Dev Van IA detector are not included in the data set.

2.2 216-U-10 POND CHARACTERIZATION

An LFI was performed between August 1993 and August 1994 at the 216-U-10 Pond. The results are published in following reports: DOE/RL-95-13, BHI-00034, and BHI-00033. The LFI activities consisted of a surface radiation survey, soil and vegetation sampling and analysis, the installation of 10 cone penetrometer pushes and one borehole, a test pit excavation, and geophysical logging. Soil samples were collected and analyzed for chemicals (i.e., indicator parameters, VOCs, semivolatile organic compounds [SVOC], polychlorinated biphenyls [PCB], herbicides, kerosene, and total petroleum hydrocarbon [TPH]), radionuclides, and physical properties (moisture content, porosity, calcium carbonate content, specific gravity, dry density, and soil density). The LFI activities at the 216-U-10 Pond were conducted to determine the nature and vertical extent of the contamination beneath the pond. Borehole and test pit locations are shown in Figure 2-3.

Data generated before the LFI are not used in this RI report for remedial action decision making, because the original sampling points cannot be located and sample results are not representative of conditions after stabilization and dewatering of the pond. The data collected during the LFI are indicative of existing conditions.

2.2.1 216-U-10 Pond Drilling and Cone Penetrometer Pushes

Cone Penetrometer Pushes

Cone penetrometer soil probes were installed to determine the vertical and lateral extent of vadose contamination at the 216-U-10 Pond in the vadose zone. The cone penetrometer probes were logged using a sodium iodide scintillation detector as part of a technology development demonstration. This technology provides a qualitative assessment of gamma-emitting radionuclides present in the vadose zone. The deepest penetration attained was 28.9 m (95 ft) bgs, with an average of 21.7 m (71.4 ft) for all the pushes. Figure 2-3 shows the locations for the cone penetrometer probes placed in the pond bottom.

Cable Tool Drilling

One vadose zone borehole (299-W23-231) was cable-tool drilled to a total depth of 43.1 m (141.4 ft) bgs beneath the 216-U-10 Pond. The location of the borehole was determined based on the results of the cone penetrometer probes and sodium iodide scintillation logging. A total of 12 soil samples, including one split sample and one duplicate sample, were collected for analysis. Four additional samples were collected for physical property testing of the soils. Borehole 299-W23-231 was logged to a depth of 42.7 m (140 ft) bgs with the radionuclide logging system. The borehole was decommissioned after drilling, sampling, and logging.

2.2.2 216-U-10 Pond Test Pit

One test pit (216-U-10-TP2) was excavated in the 216-U-10 Pond as part of the LFI in the expected deepest area of the waste site. The test pit was excavated to a depth of 7.9 m (26 ft) with a track-mounted backhoe to assess contaminant distribution and confirm the location of the pond bottom. Seven samples were collected from the test pit and analyzed. A second test pit was planned in the delta region of the pond but was not excavated because of contamination control concerns.

2.2.3 216-U-10 Pond Shoreline Sampling

Five surface soil samples were collected on the southwest perimeter of the 216-U-10 Pond, because a surface radiation survey indicated that the highest level of detectable contamination was in the southwest section of the pond. Shoreline samples were collected at less than 1 m (3.2 ft) bgs.

2.3 216-U-14 DITCH CHARACTERIZATION

Eleven boreholes (299-W18-33, 299-W18-250, 299-W18-251, 299-W19-1, 299-W19-21, 299-W19-27, 299-W19-91, 299-W19-92, 299-W19-93, 299-W23-16, and 299-W23-17) were drilled adjacent to the 216-U-14 Ditch. None of these boreholes were drilled through the ditch. The boreholes were drilled to evaluate one or more of the following: perched water quality, groundwater quality, soil physical properties, and the extent of contamination in the vadose zone during active operations of the ditch. Soil chemistry data are available from eight boreholes (299-W18-33, 299-W18-250, 299-W18-251, 299-W19-91, 299-W19-92, 299-W19-93, 299-W23-16, and 299-W23-17) and were used to evaluate conditions in the vadose zone. Boreholes 299-W18-33, 299-W18-250, 299-W18-251, 299-W23-16, and 299-W23-17 were drilled and sampled in 1993. Boreholes 299-W19-91, 299-W19-92, and 299-W19-93 were drilled and sampled in 1987. The boreholes also were logged in 1993 with the gross gamma ray, spectral gamma logging tool, or both to assess the presence of manmade radionuclides. Physical property data were collected from five boreholes: 299-W18-33, 299-W18-250, 299-W18-251, 299-W23-16, and 299-W23-17. The physical properties determined were saturated hydraulic conductivity, moisture content, porosity, calcium carbonate content, specific gravity, and soil density. The borehole locations are shown in Figure 2-3.

2.3.1 216-U-14 Ditch Test Pits

Six test pits were excavated and sampled in the ditch to determine the vertical extent of radiological and chemical contamination beneath the 216-U-14 Ditch. The test pits were excavated to depths from 2.1 to 3.0 m (7.0 to 10 ft). Excavated depths have been adjusted in this RI report, because the open ditch was backfilled to grade. Therefore, the excavated depths in the test pits correspond to depths of 4.9 to 5.8 m (16 to 19 ft). Three test pits (216-U-14 WTP-1, WTP-2, and WTP-3) were excavated in conjunction with the backfilling of the ditch in 1992. Three additional test pits were excavated and sampled in 1993 (216-U-14 ETP-1, ETP-2, and ETP-3).

Six samples were collected from test pits 216-U-14 WTP-1, WTP-2, and WTP-3. The samples were analyzed for americium-241, cobalt-60, cesium-137, potassium-40, plutonium-238/239, strontium-90, lead 214, and total uranium. A limited amount of data was available from test pits 216-U-14 ETP-1, ETP-2, and ETP-3; however, the results consist of both radiological and nonradiological data. Three to six samples were collected from each test pit. The location of each test pit is shown in Figure 2-3.

Figure 2-1. Location of Transects Along the 216-Z-11 Ditch for the Remedial Investigation.

Figure 2-2. GeoProbe Location Map Along Transect #6 (see Figure 2-1).

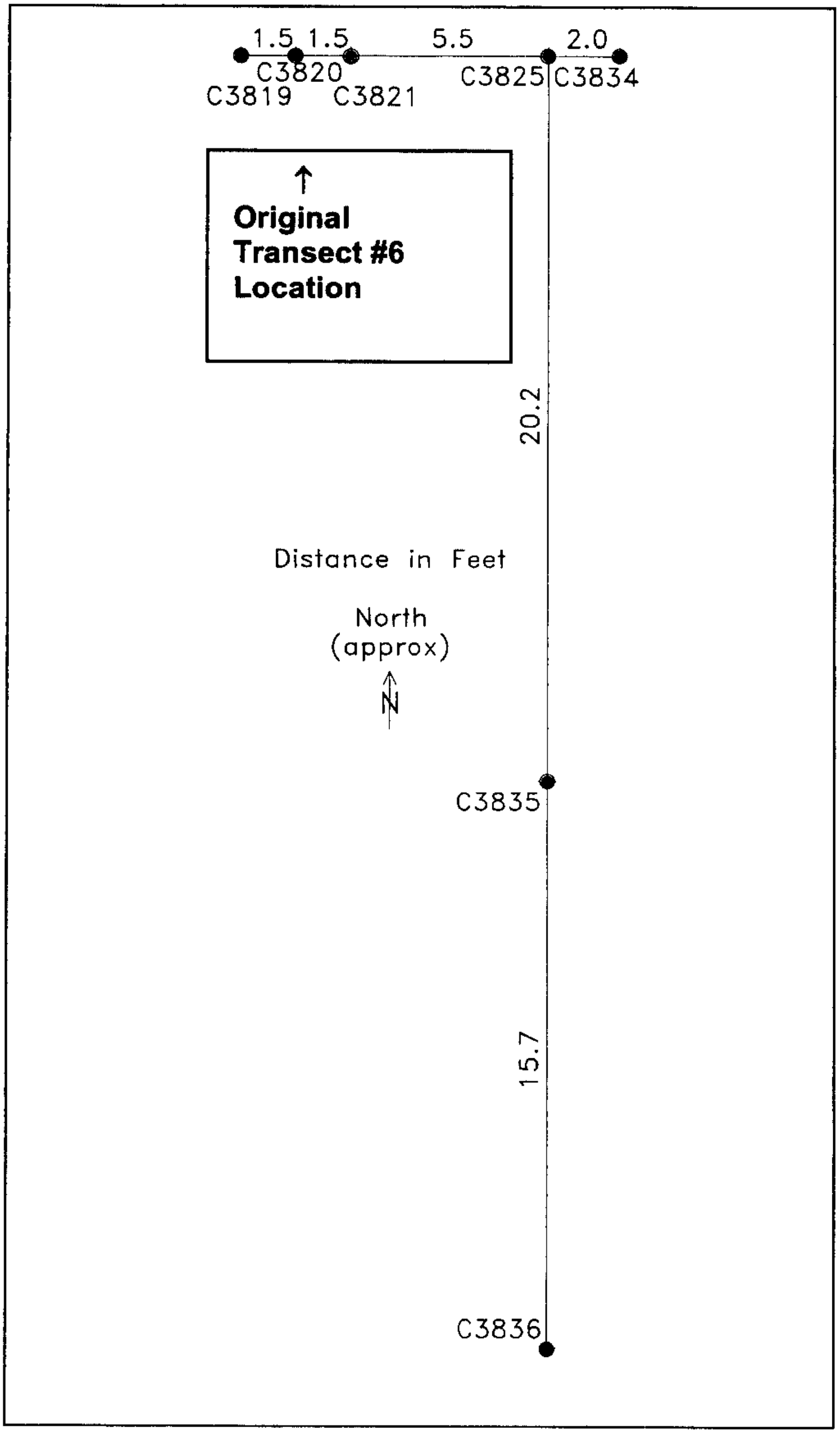

Figure 2-3. Borehole and Test Pit Location Map.

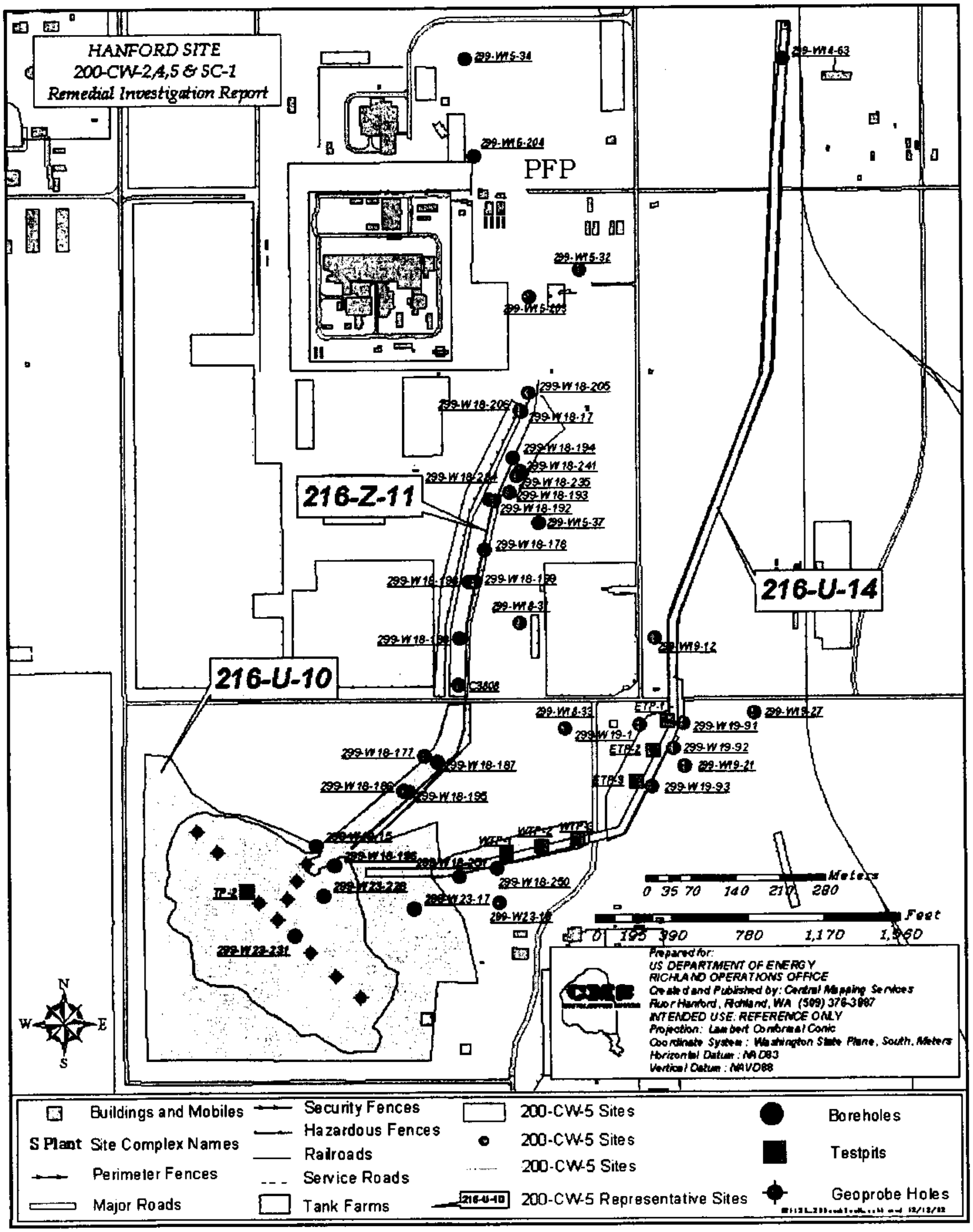

Figure 2-4. Pipeline and Manhole Location Map.

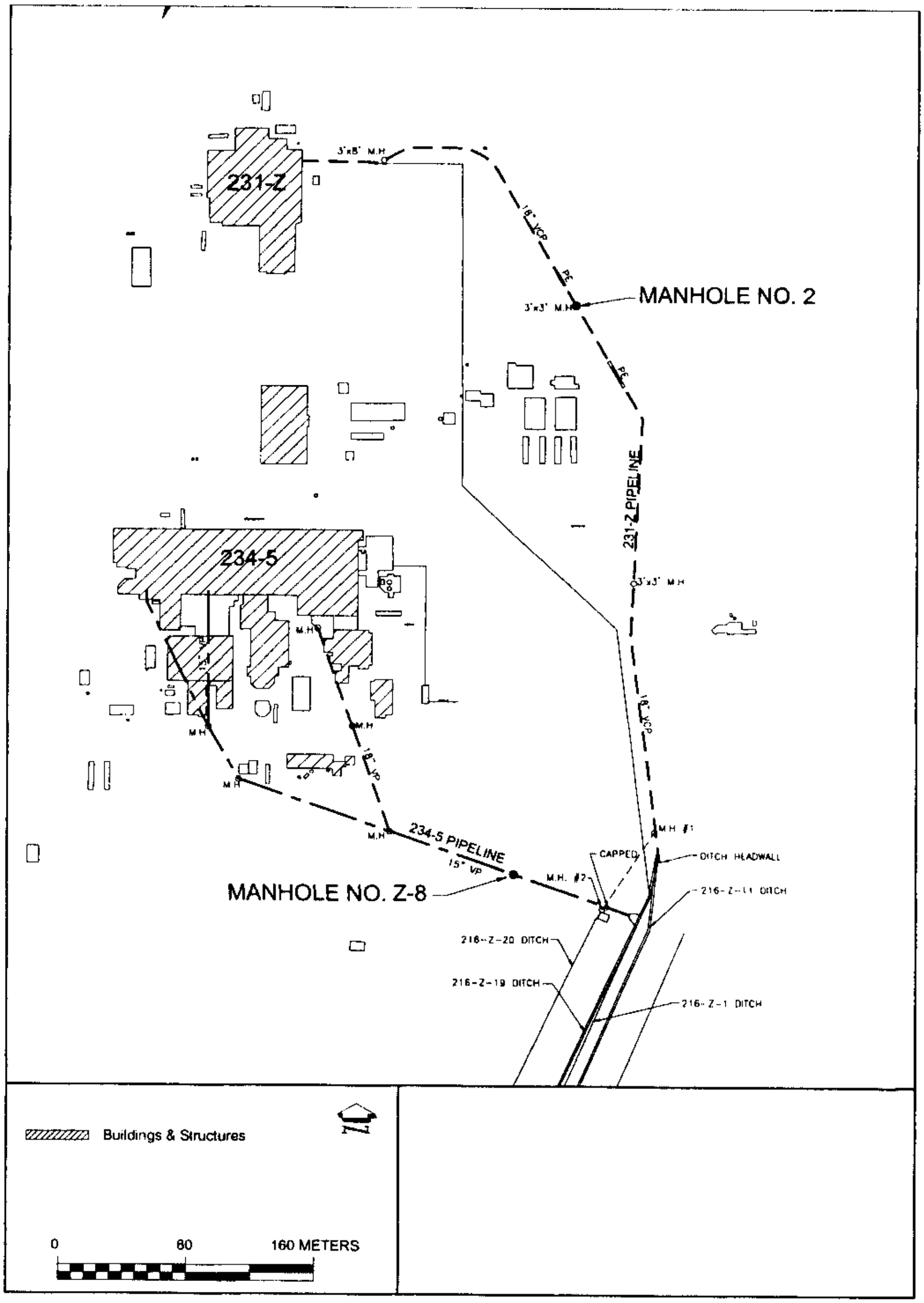

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Table 2-1. Soil and Quality Control Blank Samples Collected During the Remedial Investigation of the 216-Z-11 Ditch. (2 Pages)

Sample Interval		HEIS Number	Date Sampled	Analyses Performed
Top (ft bgs)	Bottom (ft bgs)			
Soil Physical Property Samples				
22.5	25.0	B14DM3	5/1/02	Moisture content, particle size distribution
50.0	52.5	B14DM4	5/3/02	Moisture content, particle size distribution
99.5	102.0	B14DM5	5/7/02	Moisture content, particle size distribution
Radiological Samples (Only)				
7.5	8.0	B14DJ9	4/24/02	Isotopic Americium/Plutonium/Curium
8.0	8.5	B14DK0	4/24/02	Isotopic Americium/Plutonium/Curium
8.5	9.0	B14DK1	4/24/02	Isotopic Americium/Plutonium/Curium
9.0	9.5	B14DK2	4/24/02	Isotopic Americium/Plutonium/Curium
9.5	10.0	B14JC5	4/24/02	Isotopic Americium/Plutonium/Curium
10.0	10.5	B14JC6	4/24/02	Isotopic Americium/Plutonium/Curium
10.5	11.0	B14JC7	4/24/02	Isotopic Americium/Plutonium/Curium
11.0	11.5	B14JC8	4/24/02	Isotopic Americium/Plutonium/Curium
11.5	12.0	B14JC9	4/24/02	Isotopic Americium/Plutonium/Curium
12.0	12.5	B14JD1	4/25/02	Isotopic Americium/Plutonium/Curium
Chemical and Radiological Samples				
2.5	5.0	B14DJ8	4/23/02	RI COCs, TCLP metals, hydrazine, methanol, pesticides/herbicides
7.5	10.0	B14DK3	4/24/02	PCB, total metals, radionuclides
10.0	12.5	B14DK4	4/24/02	RI COCs, TCLP metals, hydrazine, methanol
12.5	15.0	B14DK5	4/25/02	RI COCs
15.0	17.5	B14DK8	4/25/02	RI COCs
22.5	25.0	B14DL1	5/1/02	RI COCs
50.0	52.5	B14DL2	5/3/02	RI COCs
99.5	102.0	B14DL3	5/7/02	RI COCs
112.2	114.7	B14DL4	5/8/02	RI COCs
152.0	154.5	B14DL5	5/10/02	RI COCs
200.0	202.5	B14DL6	5/15/02	RI COCs
220.7	223.2	B14KC7	5/17/02	RI COCs
Duplicate Sample				
10.0	12.5	B14DK6	4/24/02	Tied to B14DK4; radionuclides
12.5	15.0	B14DK9	4/25/02	Tied to B14DK5; VOC, SVOC, PCB, Cr^{+6}, anions, total metals

Table 2-1. Soil and Quality Control Blank Samples Collected During the Remedial Investigation of the 216-Z-11 Ditch. (2 Pages)

Sample Interval		HEIS Number	Date Sampled	Analyses Performed
Top (ft bgs)	Bottom (ft bgs)			
Split Sample				
10.0	12.5	B14DK7	4/24/02	Tied to B14DK4; radionuclides
12.5	15.0	B14DL0	4/25/02	Tied to B14DK5; VOC, SVOC, PCB, Cr^{+6}, anions, total metals
Equipment Blank				
2.5	5.0	B14DP2	4/22/02	Tied to B14DJ8; VOC, SVOC, anions, metals, radionuclides
Trip Blanks				
2.5	5.0	B14DN8	4/23/02	Tied to B14DJ8; VOC
10.0	12.5	B14DN9	4/25/02	Tied to B14JD1; VOC
200.0	202.5	B14DP1	5/15/02	Tied to B14DL6, VOC

Note: The remedial investigation (RI) contaminants of concern (COC) = VOC, SVOC, PCB, Cr^{+6}, anions, total metals, radionuclides.

Cr^{+6} = Hexavalent chromium.
HEIS = Hanford Environmental Information System.
PCB = polychlorinated biphenyl.
SVOC = semivolatile organic compound.
TCLP = toxicity characteristic leaching procedure.
VOC = volatile organic compound.

3.0 REMEDIAL INVESTIGATION RESULTS

This section describes the hydrogeologic framework and nature and extent of contamination at the representative waste sites. The information in this section is based on geologic logs, data collected during the 200-CW-5 RI (for example, depth to water and soil chemistry), and sources identified in Chapter 2.0.

3.1 HYDROGEOLOGIC FRAMEWORK

This section briefly describes the hydrogeologic framework at representative sites and incorporates site-specific data gathered during the RI with historical data. Additional information on the hydrogeologic setting of these areas can be found in the Implementation Plan (DOE/RL-98-28); DOE/RL–91-52, *U-Plant Aggregate Area Management Study Report*; BHI-00032, *Ecological Sampling at Four Waste Sites in the 200 Areas;* and WHC-EP-0698. Figure 3-1 is the generalized stratigraphic column for the 200 West Area. A cross-section location map is shown in Figure 3-2. Stratigraphic relationships in the vicinity of the representative waste sites (216-U-10 Pond, 216-U-14 Ditch, and 216-Z-11 Ditch) are illustrated in Figures 3-3 and 3-4.

3.1.1 Topography

The three representative waste sites are located in the 200 West Area on the 200 Areas Central Plateau. The 200 Areas Central Plateau is the common reference used to describe the broad, flat area forming a local topographic high around the 200 Areas at the Hanford Site (Figure 3-5). The plateau was formed approximately 13,000 years ago during the cataclysmic Missoula floods. The northern boundary of the 200 Areas Central Plateau is defined by an erosional channel that runs east-southeast north of the 200 West Area. A secondary flood channel running southward off the main channel bisects the 200 West Area (Figure 3-5).

Representative waste sites in the 200 West Area are situated in a relatively flat area in the secondary flood channel. Surface elevations are approximately 200 m (673 ft) (NAVD88, *North American Vertical Datum of 1988*).

3.1.2 Geology

The representative waste sites are located in the Pasco Basin on the Columbia Plateau (Figure 3-6). They are underlain by basalt of the Columbia River Basalt Group and a sequence of suprabasalt sediments. From oldest to youngest, major geologic units of interest are the Elephant Mountain Basalt Member, the Ringold Formation, the Cold Creek unit (formally Plio-Pleistocene unit), the Hanford formation, Holocene age deposits, and backfill.

3.1.2.1 Elephant Mountain Basalt Member

The Elephant Mountain Basalt Member is bedrock beneath the OUs. Bedrock consists of a medium- to fine-grained tholeiitic basalt (DOE/RW-0164, *Consultation Draft Site Characterization Plan, Vols. 1-9, Office of Civilian Radioactive Waste Management*). Depth to basalt varies at the representative sites from 166 to 173 m (546 to 569 ft). Depth to basalt increases to the southwest.

3.1.2.2 Ringold Formation

DOE/RL-91-51, *241-T Transuranic Waste Storage and Assay Facility Dangerous Waste Permit Application*, indicates that the basalt is completely overlain by the Ringold Formation in the 200 West Area. The Ringold Formation consists of an interstratified sequence of unconsolidated clay, silt, sand, and granule-to-cobble gravel deposited by the ancestral Columbia River. These alluvial sediments consist of four major units; these are (from oldest to youngest) the fluvial gravel and sand of unit A, the buried soil horizons and lake deposits of the Lower Mud sequence, the fluvial sand and gravel of unit E, and the lacustrine mud of the upper Ringold. Units A and E consist of a silty-sandy gravel with secondary lenses and interbeds of gravely sand, sand, and muddy sands to silt and clay. The Lower Mud unit consists mainly of silt and clay. The upper Ringold consists of silty over-bank deposits and fluvial sand.

3.1.2.3 Cold Creek Unit

Overlying the Ringold Formation in the 200 West Area is a locally derived subunit called the Cold Creek unit (formally Plio-Pleistocene unit). This unit is interpreted to be weathered (WHC-SD-EN-TI-290, *Geologic Setting of the Low-Level Burial Ground*; PNL-7336, *Geohydrology of the 218-W-5 Burial Ground, 200 West Area, Hanford Site*) and an eolian facies (Slate 1996, "Buried Carbonate Paleosols Developed in Pliocene-Pleistocene Deposits of the Pasco Basin, South-Central Washington, U.S.A.,") that consists of poorly sorted, locally derived, interbedded reworked loess, silt, sand, and basaltic gravel. The subunit consists of a lower interbedded carbonate-poor to carbonate-rich paleosol. The upper silty eolian facies previously were interpreted to be early Pleistocene loess and have been referred to as the early Palouse soil (PNL-7336). Generally, they are well-sorted quartz-rich/basalt-poor silty sand to sandy silt (BHI-00270, *Pre-Operational Baseline and Site Characterization Report for the Environmental Restoration Disposal Facility*).

3.1.2.4 Hanford Formation

The Hanford formation overlies the Cold Creek unit in the 200 West Area. The Hanford formation consists of unconsolidated gravel, sand, and silts deposited by cataclysmic floodwaters (DOE/RL-91-52). These deposits consist of gravel-dominated and sand-dominated sequences. The gravel-dominated facies consist of cross-stratified, coarse-grained sands and granule-to-boulder gravel. The gravel is uncemented and matrix poor. The sand facies consist of well-stratified, fine- to coarse-grained sand and granule gravel. Silt in these facies is variable and may be interbedded with the sand. Where the silt content is low, an open-framework texture is common. Upper gravel and lower sand-dominated sequences are present at representative sites.

3.1.2.5 Holocene-Aged Deposits and Backfill

Holocene-aged deposits and material used for backfill overlie the Hanford formation. Holocene-aged deposits are dominated by eolian sheets of sand that form a thin veneer across the site, except in localized areas. The soils consist of very fine to medium-grained sand to occasionally silty sand. Fill material was placed in and over representative waste sites during construction and decommissioning, for the purpose of contamination control. The fill consists of silty sandy gravel, gravel sand, and sandy silt. The thickness of the backfill is up to 3 m (9 ft) at representative sites.

3.1.3 Hydrostratigraphy

Hydrostratigraphic units of concern for the representative sites are separated into five zones: the Ringold Formation, (water-bearing zone and lower part of the vadose zone), Cold Creek unit (vadose zone), Hanford formation sand-dominated sequence (vadose zone), Hanford formation gravel-dominated sequence (vadose zone), and Holocene-aged deposits and backfill (vadose zone).

Vadose Zone. The vadose zone is the area between the ground surface and the water table.

At the representative sites, the vadose zone thickness ranges from 64 to 67 m (211 to 222 ft). Sediments in the vadose zone are the Ringold Formation, the Cold Creek unit, the Hanford formation, and Holocene-aged deposits and backfill.

Moisture content in the 200 Areas vadose zone typically ranges between 2 and 10 percent under ambient conditions (DOE/RL-98-28), but has historically ranged to saturation (perched water) at liquid waste receiving sites. With the reduction of artificial recharge in the 200 Areas in 1995, the downward flux of liquid in the vadose zone beneath waste sites has been decreasing. Before 1995, liquid waste sites provided a significant driving force for contaminant transport. In the absence of artificial recharge, recharge from natural precipitation becomes the dominant driving force for moving contamination remaining in the vadose zone to groundwater.

Data collected with the neutron-moisture logging tool indicate that volumetric moisture content beneath the 216-Z-11 Ditch ranges between 1 and 13 percent. Over most of the log interval, the moisture content was less than 6 percent. Zones of higher moisture are associated with fine-grained textures, formation contacts, and sand and silt associated with the Cold Creek unit.

A limited number of soil samples was collected to determine moisture content using American Society for Testing and Materials (ASTM) Method D2216, *Standard Test Method for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass*, and grain size distribution by ASTM Method D422-63, *Standard Test Method for Particle-Size Analysis of Soils*, at the 216-Z-11 Ditch. Three samples collected indicate that moisture content ranges between 3.2 and 9.2 percent. In contrast, data collected beneath the 214-U-14 Ditch and 216-U-10 Pond indicate that moisture content varies from 2.1 to 31.5 percent and 3.1 to 20.7 percent, respectively. The higher moisture content in samples collected at the 216-U-14 Ditch reflects sample collection when the ditch was actively receiving effluent. The available physical property data collected during the 200-CW-5 RI are summarized in Appendix B.

Unconfined Aquifer. The unconfined aquifer beneath the 200 West Area occurs in the Ringold Formation Unit E. Current sources of recharge to the aquifer in the 200 West Area include rain, snowmelt, septic systems, leaking water lines, and irrigation from private land west of the Hanford Site. Past-practice sources of artificial recharge on the Hanford Site consisted mainly of effluent discharges to the ground from liquid waste receiving sites (that is, ponds, cribs, trenches). Recharge between 1944 and 1995 has resulted in an increase of the water table elevation across the site. Since termination of most of the artificial recharge onsite in 1995, the elevation of the water table is declining.

The elevation of the water table varies across the 200 West Area (Figure 3-7). At OU waste sites, water table elevations are about 138 to 139 m (453 to 456 ft). Groundwater flows from west to east. March/April 2000 and March 2001 depth-to-water measurements in PNNL-13788, *Hanford Site Groundwater Monitoring for Fiscal Year 2001*, indicate that the surface of the water table is declining at a rate of 0.35 m/yr (1.1 ft/yr). The decline is the result of cessation of most discharges to the ground. The saturated thickness of the unconfined aquifer is about 52 to 62.5 m (172 to 205 ft) beneath the representative sites and is bound by the Ringold Formation Lower Mud unit. The upper contact of the Ringold Formation Lower Mud unit is present at an elevation of 76 to 86 m (250 to 282 ft).

3.2 OPERABLE UNIT CONTAMINATION

This section describes the nature and extent of contamination at the 200-CW-5 OU representative sites: 216-U-10 Pond, 216-U-14 Ditch, and 216-Z-11 Ditch area. The types of contamination present in the OU are determined by subjecting constituents to a step-wise screening process. The initial step in the process involves comparing the data with the Hanford Site background threshold concentrations at the 90th percentile in DOE/RL-92-24 and in DOE/RL-96-12. Ecology 94-115 also was used for background concentrations where no site-specific background concentrations were available. To further focus the list of constituents exceeding background concentrations, constituents were screened against existing risk-based concentrations. Nonradiological constituents with concentrations above background were compared to industrial soil RBCs in Ecology Publication No. 94-145, *Cleanup Levels & Risk Calculations under the Model Toxics Control Act Cleanup Regulation (CLARC) Version 3.1*, including soil concentrations considered protective of groundwater. Contaminants passing the screening process are described in this section. Data collected from the RI representative sites are presented in Appendix A.

3.2.1 Nature and Extent of Contamination in the 216-Z-11 Ditch Area

This section describes the nature and extent of contamination in the 216-Z-11 Ditch area, inclusive of the 216-Z-1D and 216-Z-19 Ditches. Initially, the 216-Z-1D and 216-Z-19 Ditches were not included in the scope of the RI because the historic plant operations estimates of waste stream discharges suggest that the 216-Z-11 Ditch contained significantly higher inventories of radionuclides. The ditches are included in this discussion because relatively low levels of contamination were detected during the RI in the 216–Z-11 Ditch, and because the activity of the transuranic isotopes is expected to exceed 100 nCi/g in these two adjacent ditches. The ditches are discussed collectively in this section because of the uncertainty associated with the location of boreholes along the length of these waste sites and because they share common boundaries with the 216-Z-11 Ditch. The contaminant distribution model for the Z Ditches is shown in Figure 3-8.

3.2.1.1 GeoProbe Investigation

Small-diameter soil probes were logged using geophysical methods (gross gamma/passive neutron tool) in and adjacent to the 216-Z-11 Ditch. The investigation was performed to locate the area of highest contamination in the 216-Z-11 Ditch. Americium-241, cesium-137, and plutonium-239 were identified in the ditch. Americium-241 was the dominant contaminant identified during the logging of the 216-Z-11 Ditch. The area of highest contamination in the 216-Z-11 Ditch was located at soil probe C3835. Borehole C3808 was located at the hot spot near soil probe C3835.

Contamination also was detected in the 216-Z-1D Ditch during the GeoProbe investigation. The lower bound estimate for plutonium-239 was 88,000 pCi/g at a depth of 2.7 m (9 ft). This estimate may be significantly lower than the actual concentration because the probe tends to average counts over approximately a 0.3-m (1 ft) depth zone.

3.2.1.2 216-Z-11 Ditch

Contamination was detected in the vadose zone beneath the 216-Z-11 Ditch in borehole C3808 to a depth of 12 m (40 ft) bgs. However, maximum contaminant levels were much lower than expected. Maximum contaminant concentrations are present in the ditch from depths of 2.3 to 5.3 m (7.5 to 17.5 ft). Americium-241 and plutonium-239/240 were the predominant contaminants detected at the ditch bottom, approximately 2.3 to 2.6 m (7.5 to 8.5 ft) bgs. Concentrations were 468 pCi/g and 2,780 pCi/g, respectively. Maximum concentrations of americium-241 (919 pCi/g) and plutonium-239/240 (4,840 pCi/g) were detected about 1.2 m (4 ft) beneath the bottom of the ditch at a depth of 3.7 m (12 ft) bgs. This zone of contamination may represent the bottom of the 216-Z-1D Ditch. The 216-Z-1D 216-Z-11, and 216-Z-19 Ditches were known to converge in this area to use the culvert passing beneath 16th Street.Americium-241 and plutonium-239/240 concentrations decrease with depth to less than 1 pCi/g at depths more than 5.3 m (17.5 ft) bgs.

Other radiological contaminants detected in the upper zone of contamination (2.3 to 5.3 m [7.5 to 17.5 ft] bgs) were plutonium-238, radium-226, strontium-90, and thorium-230. Maximum concentrations were 58.4 pCi/g, 1.07 pCi/g, 2.73 pCi/g, and 8.43 pCi/g, respectively. At more than 5.3 m (17.5 ft) bgs, the contaminant concentrations were less than 1 pCi/g.

Residual concentrations of pesticides/herbicides used to kill vegetation before backfilling the ditch were detected 2.3 to 3 m (7.5 to 10 ft) bgs. Aroclor-1254 and Aroclor-1260[4] were reported in concentrations of 52 and 78 mg/kg, respectively. The distributions of these chemicals are limited to the ditch bottom.

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[4] Aroclor is an expired trademark.

Nitrite, and TPH exceeded screening levels in soil samples collected from borehole C3808. Nitrite was detected 3 to 5.3 m (10 to 17.5 ft) bgs with the maximum concentration of 43 mg/kg at a depth of 3 m (10 ft). Concentrations decrease with depth to 5.3 m (17.5 ft). TPH was detected 3.0 to 3.8 m (10 to 12.5 ft) bgs at a concentration of 27 mg/kg.

Molybdenum is the only inorganic metal that exceeded screening levels in soil samples from borehole C3808. It was detected 46 to 47 m (152 to 154.5 ft) bgs at a concentration of 0.82 mg/kg.

Borehole C3808 was logged with a small-diameter gross gamma/passive neutron tool and the radionuclide logging system to depths of 4.9 and 68.6 m (16 and 225 ft), respectively. The gross gamma and passive neutron detector logging results showed good agreement with the spectral gamma logging data by identifying a major zone of contamination approximately 2.9 m (9.5 ft) bgs.

Plutonium-239 was the primary manmade contaminant identified during logging, at a depth of 2.9 m (9.5 ft) bgs. The concentration of plutonium-239 is estimated to be 21,400 pCi/g. This concentration may be higher because of thin bed effects, because the tool count represents an average response over a depth interval of approximately 0.3 m (1 ft). Contamination was not detected more than 3.4 m (11 ft) bgs with the radionuclide logging system.

3.2.1.3 216-Z-1D Ditch

Samples collected from the bottom of the 216-Z-1D Ditch in 1959 indicate that transuranic levels of contamination are present. Nine surface grab samples were collected along the length of the ditch about 2.7 m (9 ft) bgs. Samples were analyzed for plutonium-239 and alpha activity. Results indicate that plutonium-239 concentrations ranged between 24,000 and 780,000 pCi/g. Alpha activity ranged between 26,000 and 860,000 pCi/g.

Anecdotal data collected from the 234-235 Ditch, which is an unconfirmed alias for the 216-Z-1D Ditch, suggest that concentrations may be even higher. Maximum plutonium-239 concentrations ranged between 1,270,000 and 4,460,000 pCi/g. Alpha activity ranged between 15,000 and 27,100,000 pCi/g. If plutonium is assumed to account for 90 percent of the alpha activity as indicated by previous sampling discussed above, plutonium-239 concentrations may exceed 24,000,000 pCi/g. A summary of this information is included in this RI report for completeness; however, the association with the 216-Z-1D Ditch has not been verified. A maximum concentration of 780,000 pCi/g plutonium-239 is used in this RI report for the 1959 sample event, based on the higher degree of confidence on this data set.

Boreholes 299-W18-188, 299-W18-189, and 299-W18-192 were drilled before the RI was conducted. These boreholes are interpreted to be within or on the edge of the 216-Z-1D Ditch. The major zone of contamination in these boreholes was detected about 0.9 to 4.3 m (3 to 14 ft) bgs. The maximum concentrations of contaminants detected were 380,000 pCi/g for plutonium-239/240, 5,252 pCi/g for plutonium-238, and 34,809 pCi/g for americium-241. Contaminant concentrations decreased to less than 1 pCi/g for all contaminants at 6.0 m (20 ft) bgs.

Boreholes 299-W15-203 and 299-W15-204 are located above the headwall of the 216-Z-1D Ditch. Transuranic contamination (americium-241, plutonium-238, and plutonium 239/240) in these boreholes was less than 100 pCi/g and was detected near the surface.

3.2.1.4 216-Z-19 Ditch

Soil samples collected from the 216-Z-19 Ditch indicate that plutonium-239/240 and americium-241 are present in maximum concentrations of 13,000,000 pCi/g and 7,865,557 pCi/g, respectively. Contaminants such as strontium-90, cesium-137, potassium-40, and radium-226 were also detected; however, concentrations were low by comparison or detections were limited. Cesium-137 was detected in a few samples in concentrations ranging between 1.3 and 66,041 pCi/g. Radium-226 and strontium-90 contamination were detected infrequently. Their maximum concentrations were 5,200 pCi/g, and 216 pCi/g, respectively.

Soil samples were collected to a depth of 4.9 m (16 ft) in the 216-Z-19 Ditch. The available data indicates that contaminants are present to 4.9 m (16 ft). However, it is possible that low levels of contamination extend deeper in the vadose zone based on an sample results from other boreholes in the area.. The highest levels of contamination were associated with the bottom of the ditch, estimated to be 1.6 to 3.4 m (5.2 to 11 ft) bgs. Contamination generally decreases with depth beneath the ditch bottom. The distribution of contamination in the ditch indicates that contaminant levels are generally higher near both ends of the ditch. The maximum contaminant concentrations were detected near the end of the ditch, near the 216-U-10 Pond.

3.2.1.5 Lateral Extent of Contamination in the 216-Z-11 Ditch Area

Boreholes 299-W18-193, 299-W18-194, 299-W18-195, and 299-W18-197 were drilled before the RI was conducted. These boreholes are interpreted to be within or very close to the 216-Z-11 Ditch. Borehole 299-W18-195 also may share boundaries with the 216-Z-1D and 216-Z-19 Ditches. The major zone of contamination in these boreholes was detected from about 0.9 to 3.7 m (3 to 12 ft) bgs. The maximum soil contaminant concentrations were 40,000 pCi/g for plutonium-239/240, 3,389 pCi/g for plutonium-238, and 3,094 pCi/g for americium-241. Contaminant concentrations decreased to less than 1 pCi/g for all contaminants at 6.0 m (20 ft).

Boreholes 299-W18-177, 299-W18-178, 299-W18-186, 299-W18-187, 29-W18-199, and 299-W18-200 appear to be located adjacent to the three ditches. Very little contamination was detected in soil samples from these boreholes. Concentrations were less than 1 pCi/g.

3.2.1.6 Current Impact to Groundwater in the Z Ditch Area

The effluent volume discharged to the Z Ditch area has not been determined. Therefore, impact to groundwater from the volume of effluent discharges is not known. However, use of these ditches suggests that groundwater may not have been impacted. Contaminants associated with Z-Ditch effluents were not detected below 12.2 m (40 ft). Unlike the 216-U-10 Pond and 216-U-14 Ditch, the Z-Ditches were used mainly to channel wastewater to areas of infiltration, rather than to percolate wastewater. RIs at other OU waste sites suggest that infiltration beneath ditches used to channel wastewater is typically very limited (DOE/RL-99-07, *200-CW-1 Operable Unit RI/FS Work Plan and 216-B-3 RCRA TSD Unit Sampling Plan*).

PNNL-13788 reports that nitrate, carbon tetrachloride, and uranium exceed groundwater protection standards in the 216-Z-11 Ditch area. However, these contaminants do not appear to be linked with waste management practices in the Z-Ditch area. The current status of groundwater near the ditch is shown in Figures 3-9 and 3-10. Future impacts to groundwater are evaluated in Chapter 4.0.

3.2.1.7 Summary of Contamination Within the 216-Z-Ditch Complex

Existing soil samples indicate that contamination is present in the three Z-Ditches. Based on historical data (mainly ditch sediment grab samples), the 216-Z-1D Ditch contains the highest concentrations of radiological constituents, primarily plutonium-239/240. Data from shallow soil samples collected in transects across the 216-Z-19 Ditch indicate that most of the contamination is confined to within 0.5 to 1.0 m (1.6 to 3.2 ft) of the ditch bottoms. Boreholes drilled in the vicinity of the Z Ditches suggest that contamination is largely laterally confined to within a few meters of the ditch boundaries.

Surface and near-surface soil data suggest that radioisotopes are distributed over the entire length of the ditches. Significant variability in concentrations reported for closely spaced samples would make it difficult to confidently segregate portions of the ditch as "hot spots" relative to other less contaminated areas.

Although the contamination is largely confined within the individual ditch boundaries, uncertainty in the exact location of the buried ditches, coupled with the close proximity and overlapping construction methods, support treating the three ditches as a single waste unit for the purpose of the feasibility study and proposed plan development. In this regard, it is significant to note that the highly contaminated 216-Z-1D Ditch is closely flanked by the 216-Z-11 Ditch (to the east) and the 216-Z-19 Ditch (to the west).

3.2.2 Pipeline Investigation Results

Investigation of the 231-Z and 234-5 Pipelines indicates that significant contamination is present. Sodium iodide detector measurements collected from within two pipeline manholes indicated the presence of americium-241. No other gamma-emitting radionuclides were discernable from the recorded spectra.

The maximum detected contaminant concentrations were observed in the 231 Z Pipeline, with values of 23.5 pCi/sample for plutonium-238, 1,210 pCi/sample for plutonium-239, and 813 pCi/sample for americium-241. The pipeline data are presented in Appendix C.

3.2.3 Nature and Extent of Contamination at the 216-U-10 Pond

Contaminants were detected throughout the vadose zone beneath the 216-U-10 Pond to a maximum depth of approximately 42.6 m (140 ft), at the base of Cold Creek Interval in borehole 299-W23-231. Maximum contaminant concentrations generally are present near the surface in the upper 2.0 m (6.5 ft) of the soil column. The depth to the bottom of the pond was approximately 2.0 m (6.5 ft) when it was actively receiving effluent. Soils above 2.0 m (6.5 ft) are characterized by material used to fill in the pond during decommissioning efforts, sediment from the bottom of the pond, or both. The following radionuclides were detected in this upper zone.

cesium-137	3,994 pCi/g	europium-154	12 pCi/g
americium-241	44 pCi/g	europium-155	1.7 pCi/g
cobalt –60	16 pCi/g	uranium-233/234	85 pCi/g
sodium-22	8.2 pCi/g	uranium-238	88 pCi/g
technetium-99	8.8 pCi/g	uranium-233	33 pCi/g
strontium-90	157 pCi/g	selenium-79	20 pCi/g
plutonium-238	22 pCi/g	uranium-234	33 pCi/g
plutonium-239/240	75 pCi/g		

Additional radioisotopes such as bismuth-214, europium-152, and neptunium-237 also were detected in this upper zone. However, concentrations were less than 1 pCi/g. Cesium-137, strontium-90, plutonium, uranium-233/234, and uranium-238 are the predominant radionuclides detected from the surface to the bottom of the pond. The concentration of these contaminants generally decreased with depth beneath the pond bottom. With few exceptions, radionuclides either were not detected or were less than about 2.0 pCi/g at depths greater than 2.0 m (6.5 ft). Technetium-99 (maximum 4.6 pCi/g), strontium-90 (maximum 28 pCi/g), uranium-235 (maximum 2.4 pCi/g), selenium-179 (maximum 46 pCi/g), and uranium-234 (maximum 56 pCi/g) are sporadically present in the vadose zone at depths greater than 2.0 m (6.5 ft) bgs.

The radionuclide logging system was used to evaluate the vertical and lateral extent of contamination at the 216-U-10 Pond. Cesium-137 and uranium-235 were the only manmade radionuclides detected above screening levels using this method. In boreholes adjacent to the pond, cesium-137 and uranium-235 were detected above screening levels. Cesium-137 was present at a concentration of 4.3 pCi/g at approximately 0.8 m (2.5 ft) bgs. Uranium-235 was detected 73 m (240 ft) bgs at a concentration of 5 pCi/g. Within the pond, cesium-137 was detected at a maximum concentration of 440 pCi/g decayed to 366 pCi/g (in 2002) 0 to 3 m (0 to 10 ft) bgs in borehole 299-W23-231. In approximately the same interval, the soil samples indicate that the average concentration of cesium-137 is 337 pCi/g. Comparison of the two data sets indicates good correlation between the logging and laboratory data.

Most of the metals and chemistry indicators also were sporadically detected beneath the 216-U-10 Pond above screening levels. Maximum concentrations for the following contaminants also were detected in the upper 2.0 m (6.5 ft) of the soil column.

aluminum	31,500 mg/kg	fluoride	23 mg/kg
antimony	12 mg/kg	sulfate	2,360 mg/kg
cadmium	9.1 mg/kg	kerosene	76 mg/kg
chromium	83 mg/kg	uranium	270 mg/kg
magnesium	8,240 mg/kg	nitrogen in nitrate and nitrite	145 mg/kg

Few metals and chemistry indicators were detected above screening levels more than 2.0 m (6.5 ft) bgs in the vadose zone. The contaminant distribution model for the 216-U-10 Pond is shown in Figure 3-11.

Current Impact to Groundwater at the 216-U-10 Pond. The effluent volume discharged to the 216-U-10 Pond was greater than the soil column pore volume. This information suggests that the volume of effluent released was sufficient to reach the aquifer during operations of the waste site. PNNL-13788 indicates that mobile contaminants (nitrate, carbon tetrachloride, and uranium) exceed groundwater protection standards near the pond. Nitrate and uranium may be associated with waste disposal practices at the pond as well as at other waste sites in the 200 West Area. 200 PW-1 waste sites are the known sources of carbon tetrachloride in the groundwater. Low mobility contaminants such as cesium were not detected in the aquifer. The current status of groundwater near the pond is shown in Figures 3-9 and 3-10. Future impacts to groundwater are evaluated in Chapter 4.0.

3.2.4 Nature and Extent of Contamination at the 216-U-14 Ditch

Soil samples were collected beneath and adjacent to the 216-U-14 Ditch. The combination of the two data sets is used to assess the vertical and lateral extent of contamination.

Samples were collected directly beneath the ditch to a depth of 5.8 m (19 ft). Contamination was detected from 2.7 to 5.8 m (9 to 19 ft) bgs. The major zone of contamination is present from 2.7 to 3 m (9 to 10 ft) bgs, which corresponds to the ditch bottom. Maximum concentrations of cesium-137 (2228 pCi/g), plutonium-239/240 (10 pCi/g), americium-241 (1.6 pCi/g), cobalt-60 (0.62 pCi/g), technetiun-99 (12 pCi/g), antimony-125 (0.10 pCi/g), and total uranium (350 pCi/g) were detected in this interval. From 3.0 to 5.8 m (10 to 19 ft) contaminant concentrations generally decrease with depth. The available data indicate that maximum concentrations at 5.8 m (19 ft) are 8.3 pCi/g for cesium-137, 0.39 pCi/g for plutonium isotopes (0.39), 1.6 pCi/g for americium-241, and 7 pCi/g for total uranium.

Strontium-90 also was detected above screening levels beneath the ditch. Contaminant concentrations ranged between 0.81 and 5.2 pCi/g. The distribution of strontium-90 differs slightly from other radionuclides, because maximum concentrations were not associated with the ditch bottom. Maximum concentrations for strontium-90 typically were detected from 3.6 to 4.5 m (12 to 15 ft) bgs.

The distribution of contaminants in the ditch also varies along its length. In general, contaminants with large contaminant distribution coefficients, such as cesium-137 and plutonium isotopes, were detected in higher concentrations near the head end of the ditch just south of 19th Street. Contaminants with moderate to low contaminant distribution coefficients, such as strontium-90, and uranium, were detected in higher concentrations at the lower end of the ditch.

Antimony was the only metal detected above screening levels. This metal was detected at 3.4 to 5.8 m (11 to 19 ft) bgs in concentrations ranging between 6.1 and 7.0 mg/kg.

3.2.4.1 Lateral Extent of Contamination at the 216-U-14 Ditch

Very little radiological contamination was detected adjacent to the 216-U-14 Ditch. This information suggests that contamination does not extend laterally from the waste site. Contaminants detected include cesium-137, cobalt-60, potassium-40, radium-226, strontium-90, uranium-235, and uranium-238. Cesium-137 (1.2 pCi/g) was detected at a depth of 1.5 m (5 ft) in three samples near background concentration. Cobalt-60 was present infrequently throughout the vadose zone in very low concentrations (0.01 to 0.08 pCi/g). Potassium-40 was detected in most samples just above the background concentration of 16.8 pCi/g; however, much higher concentrations were detected in boreholes 299-W18-33 (179 pCi/g at 50 ft), 299-W23-16 (107 pCi/g at 200 ft) and 299-W23-17 (131 pCi/g at 200 ft). The three boreholes are either up-slope or distant from the ditch. There are no Hanford processes that generate potassium-40. Therefore the elevated concentrations are not attributed to the 216-U-14 Ditch.

Radium-226 was detected more than 23 m (75 ft) bgs and only slightly exceeded background. However, concentrations of 8.36 and 6.96 pCi/g were detected in two samples from borehole 299-W19-93 at depths of 35 and 36.6 m (115 and 120 ft), respectively. Uranium-235 was detected to a maximum depth of 25.9 m (85 ft) and was less than 0.30 pCi/g. Strontium-90 was detected throughout the vadose zone to a depth of 60.1 m (200 ft) bgs. Concentrations were typically less than 0.6 pCi/g. Strontium was detected in borehole 299-W18-251 at a maximum concentration of 4.6 pCi/g at 14 m (46 ft). Plutonium-239/240 was detected in one sample adjacent to the ditch at a maximum concentration of 1.5 pCi/g at a depth of 44 m (145 ft).

Uranium-238 was detected in three samples above the background concentration of 1.06 pCi/g adjacent to the 216-U-14 Ditch. A maximum concentration of 1.1 pCi/g was detected in borehole 299-W18-33 at a depth of 3 m (10 ft). Concentrations of 115,000 pCi/g and 57,000 pCi/g were detected in borehole 299-W23-16 at depths of 15.2 and 60.1 m (50 and 200 ft). The two measurements are deemed erroneous (WHC-EP-0698) and are not used in this RI report because the two samples were screened in the field with the Ludlum[5] beta-gamma and alpha probe for total activity (a measurement of alpha, beta, and gamma), and significant activity was not detected. Borehole geophysical logs also confirmed that significant activity is not present (WHC-EP-0698). The contaminant distribution model for the 216-U-14 Ditch is shown in Figure 3-12.

[5] Ludlum is a trademark of Ludlum Measurements, Inc., Sweetwater, Texas.

3.2.4.2 Geophysical Logging at the 216-U-14 Ditch

Boreholes 299-W18-33, 299-W18-250, 299-W18-251, 299-W19-91, 299-W19-92, 299-W19-93, 299-W19-21, 299-W19-27, 299-W23-16, and 299-W23-17 are adjacent to the 216-U-14 Ditch. These boreholes were logged with the gross gamma ray, the radionuclide logging system, or both in 1993. No manmade radionuclides were identified with the gross gamma ray logging system above the detection threshold. Radionuclides also were not identified with the radionuclide logging system in boreholes 299-W18-33, 299-W18-250, 299-W18-251, 299-W19-21, 299-W19-27, 299-W23-16, and 299-W23-17. In boreholes 299-W19-91, 299-W19-92, and 299-W19-93, cesium-137 was the only contaminant detected. The maximum activity of 1.2 pCi/g was detected at a depth of 3.5 m (11.5 ft) with the radionuclide logging system. All concentrations detected and decayed to 2002 are less than the soil background concentration for cesium-137 of 1.06 pCi/g. This information indicates that contamination does not extend laterally from the ditch. Logs for these wells are documented in WHC-EP-0698.

Borehole 299-W23-17 also was logged with the radionuclide logging system in calendar year 2002 during the RI. Cesium-137 was the only contaminant detected in the borehole with the system. The maximum concentration of 0.2 pCi/g was detected at depths of 21 and 44 m (68 and 143 ft) and is below the background concentration.

3.2.4.3 Current Impact to Groundwater at the 216-U- 14 Ditch

The effluent volume discharged to the 216-U-14 Ditch is greater than the soil column pore volume. This information suggests that the volume of effluent released was sufficient to reach the aquifer during operation of the waste site. Impact to groundwater also was confirmed in WHC-EP-0698 by comparing discharge data, changes in water table elevation, and groundwater chemistry over time.

PNNL-13788 indicate that mobile contaminants (carbon tetrachloride and uranium) exceed groundwater protection standards near the ditch. Uranium from the 216-U-14 Ditch is known to be a source of groundwater contamination. The current status of groundwater near the ditch is shown in Figures 3-9 and 3-10. Future impacts to groundwater are evaluated in Chapter 4.0.

Figure 3-1. Stratigraphic Column for the 200 Areas.

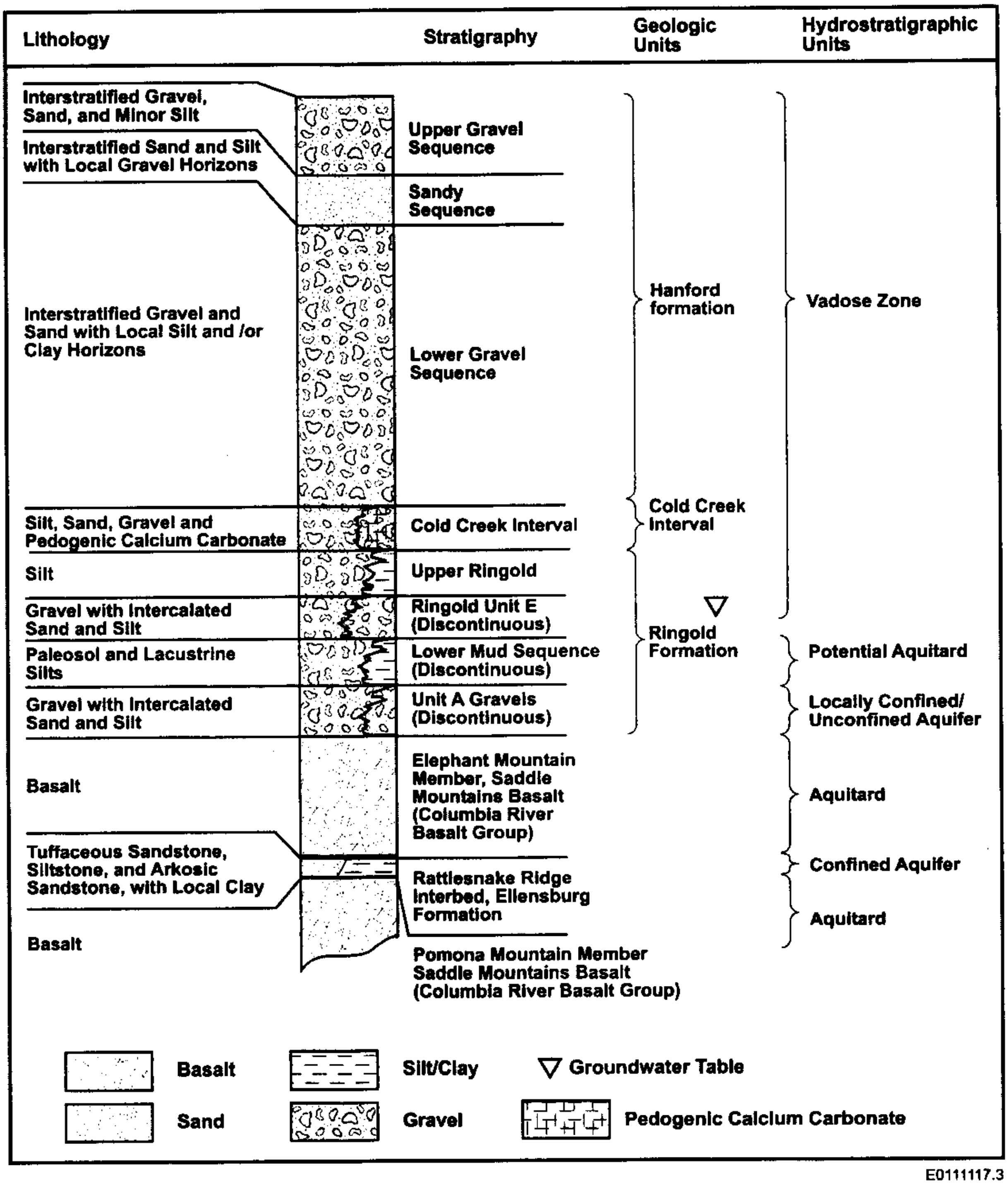


Figure 3-2. Cross-Section Location Map for 200-CW-5 Operable Unit.

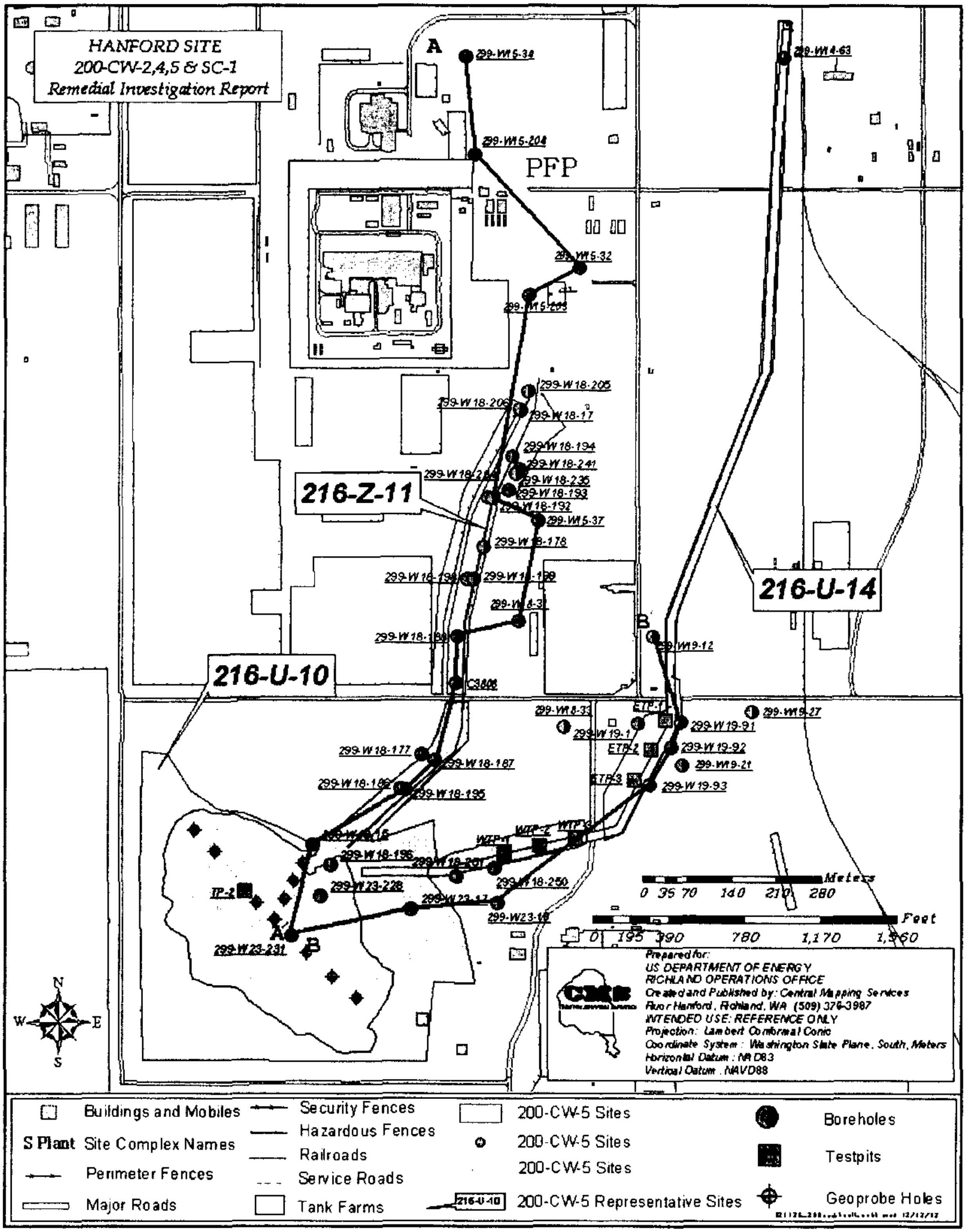


Figure 3-3. Geologic Cross Section A to A'.

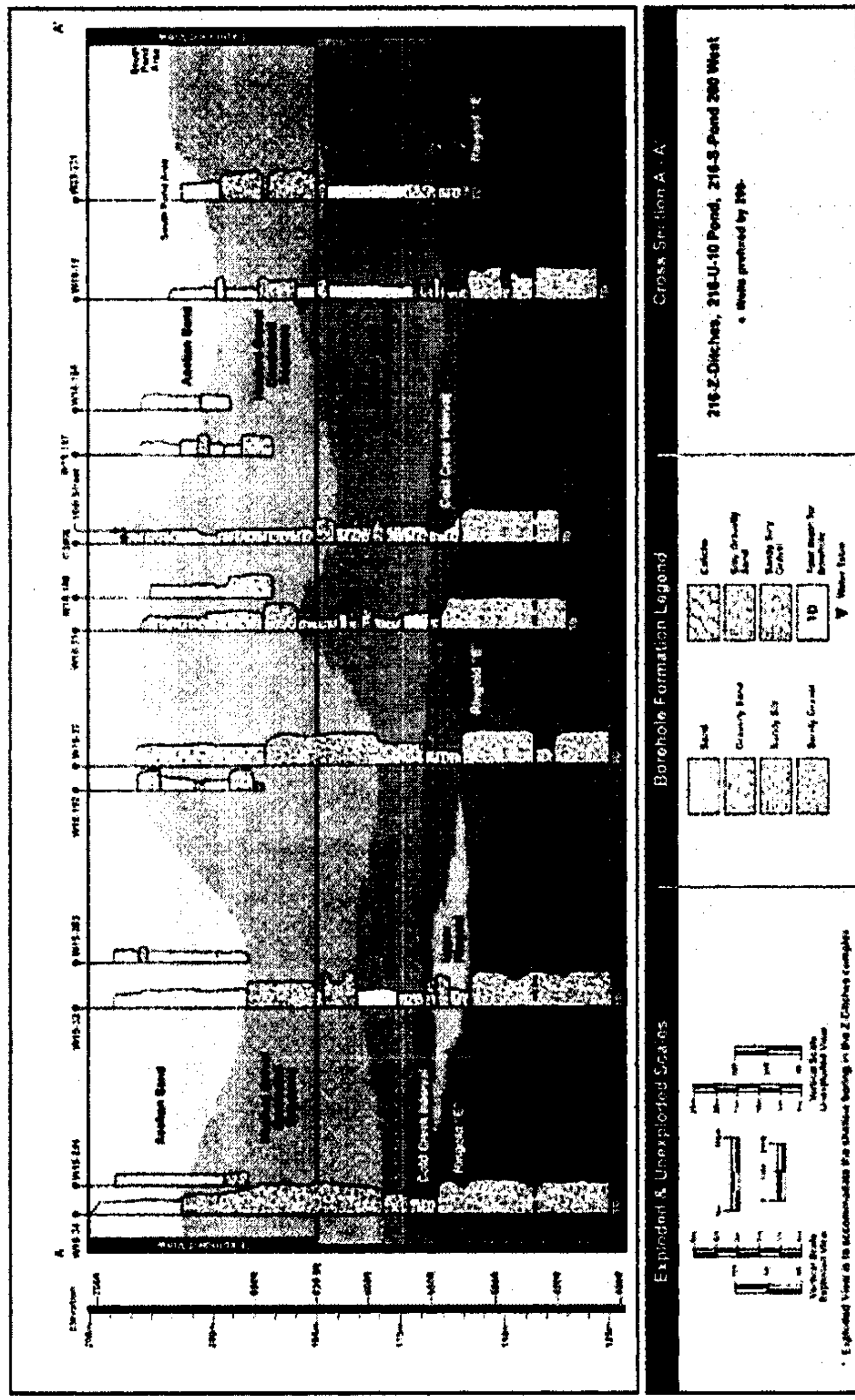


Figure 3-4. Geologic Cross Section B to B'.

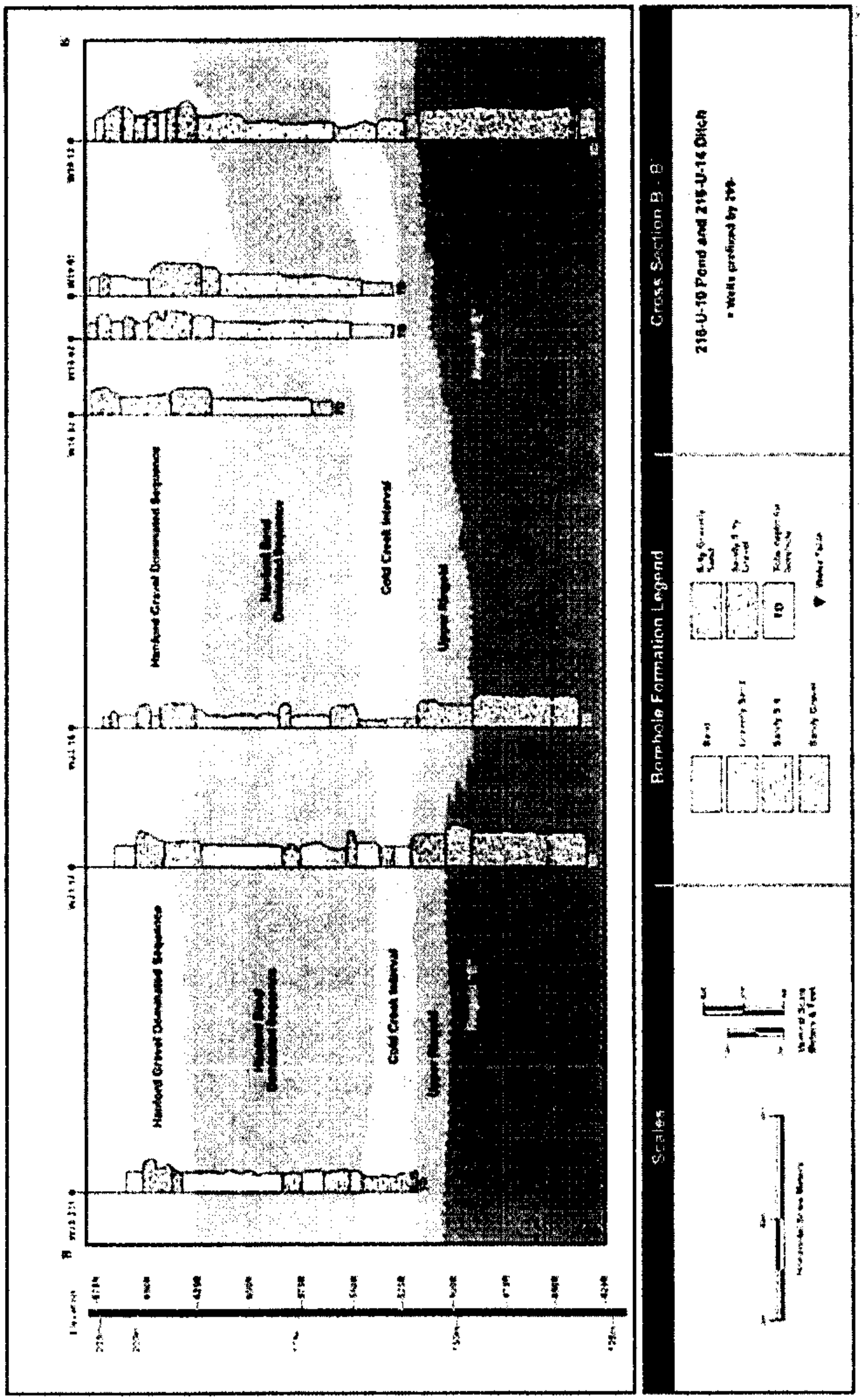


Figure 3 5. Topographic Map of the Hanford Site.

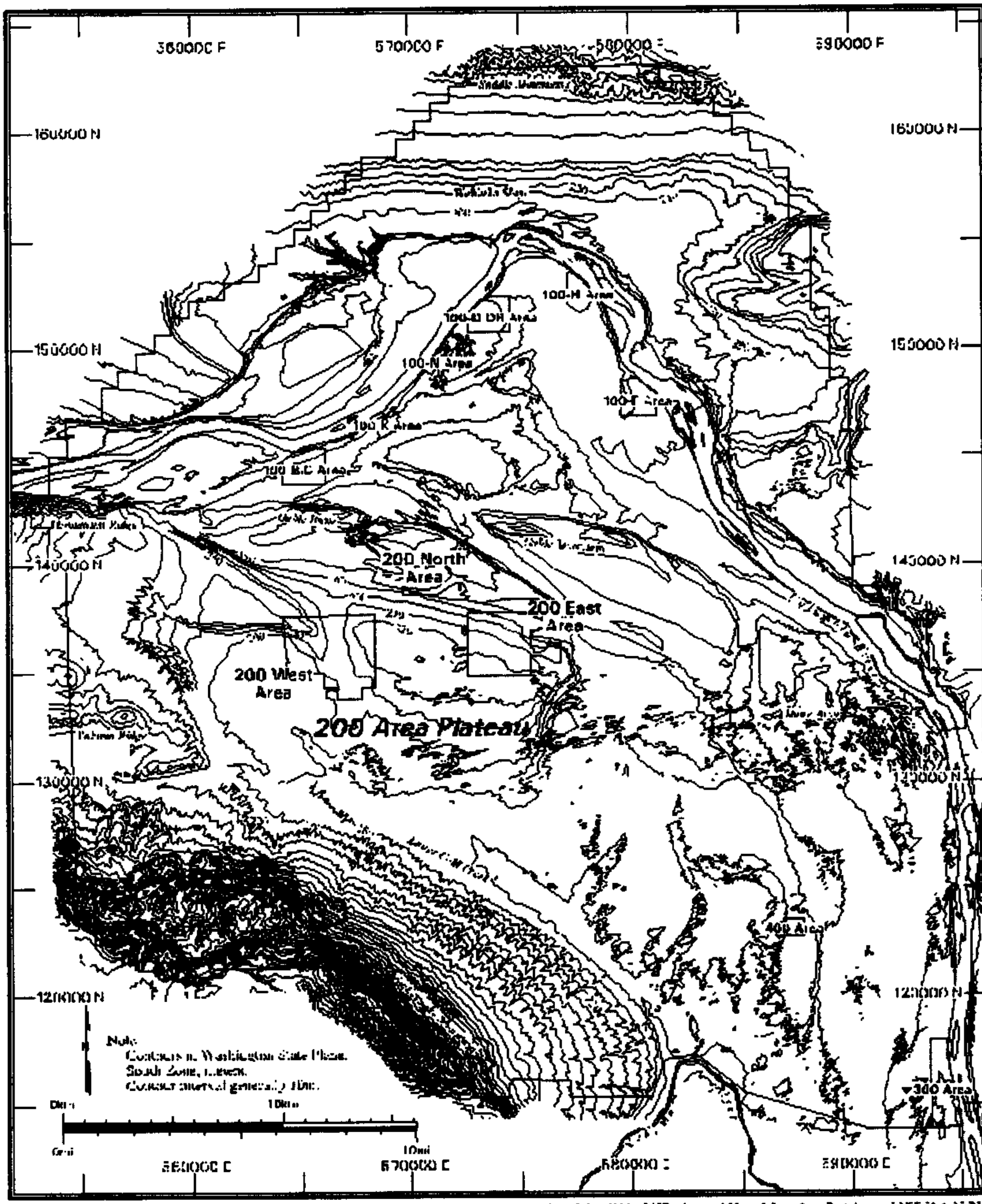


Figure 3-6. Pasco Basin Location Map.

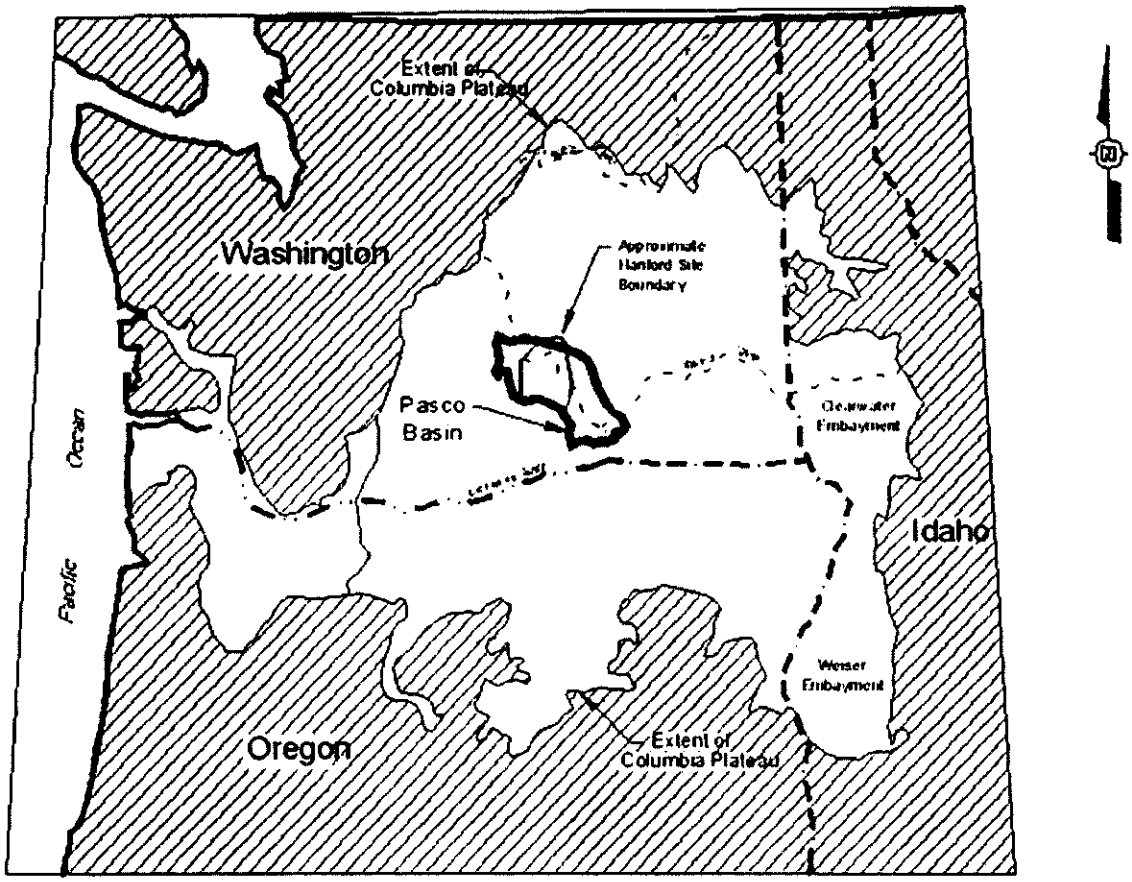


Figure 3-7. Water Table Map Encompassing the 200-CW-5 Operable Unit.

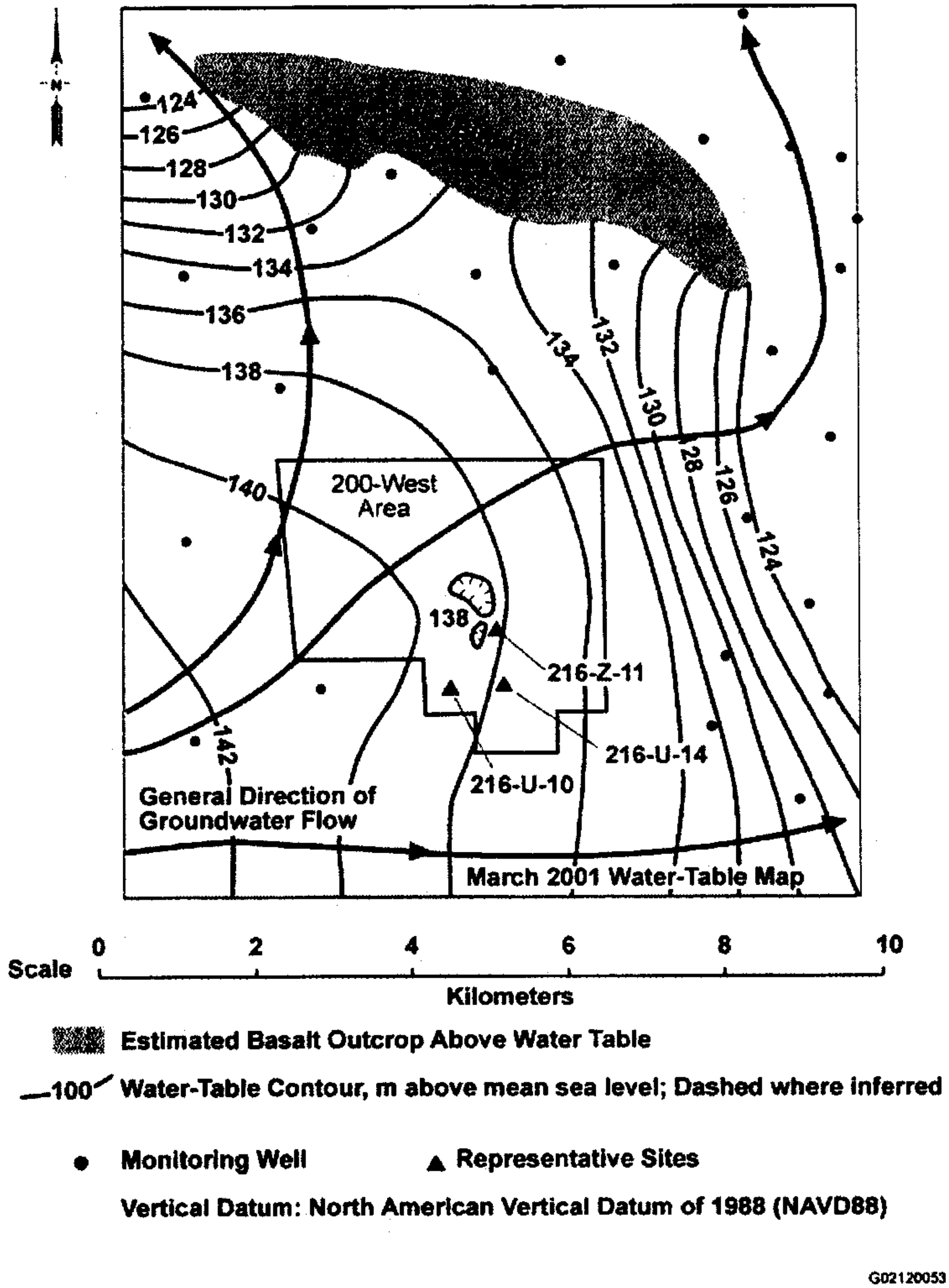


Figure 3-8. Z Ditches Contaminant Distribution Model.

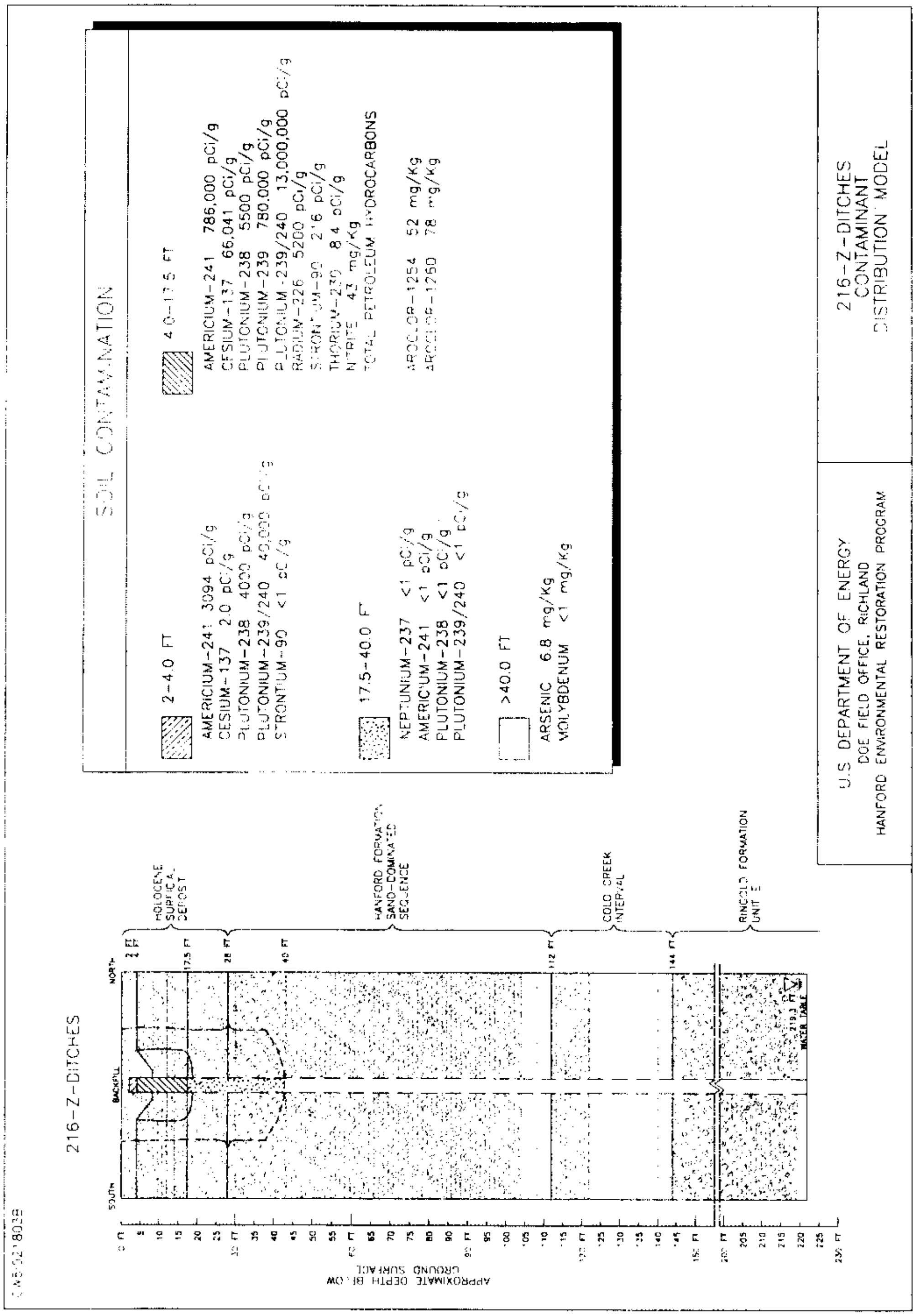


Figure 3-9. Nonradiological Groundwater Plumes in the 200-CW-5 Operable Unit.

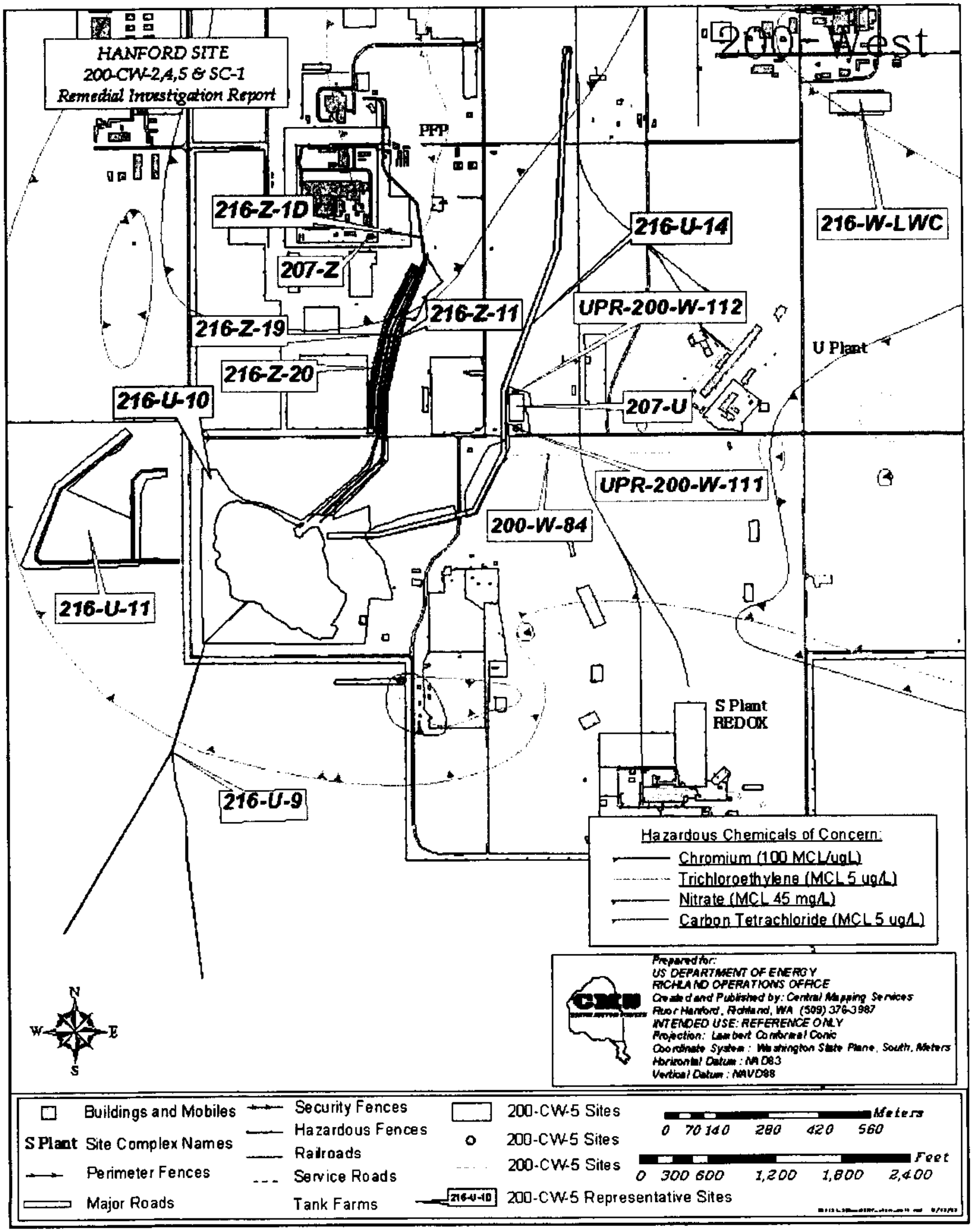
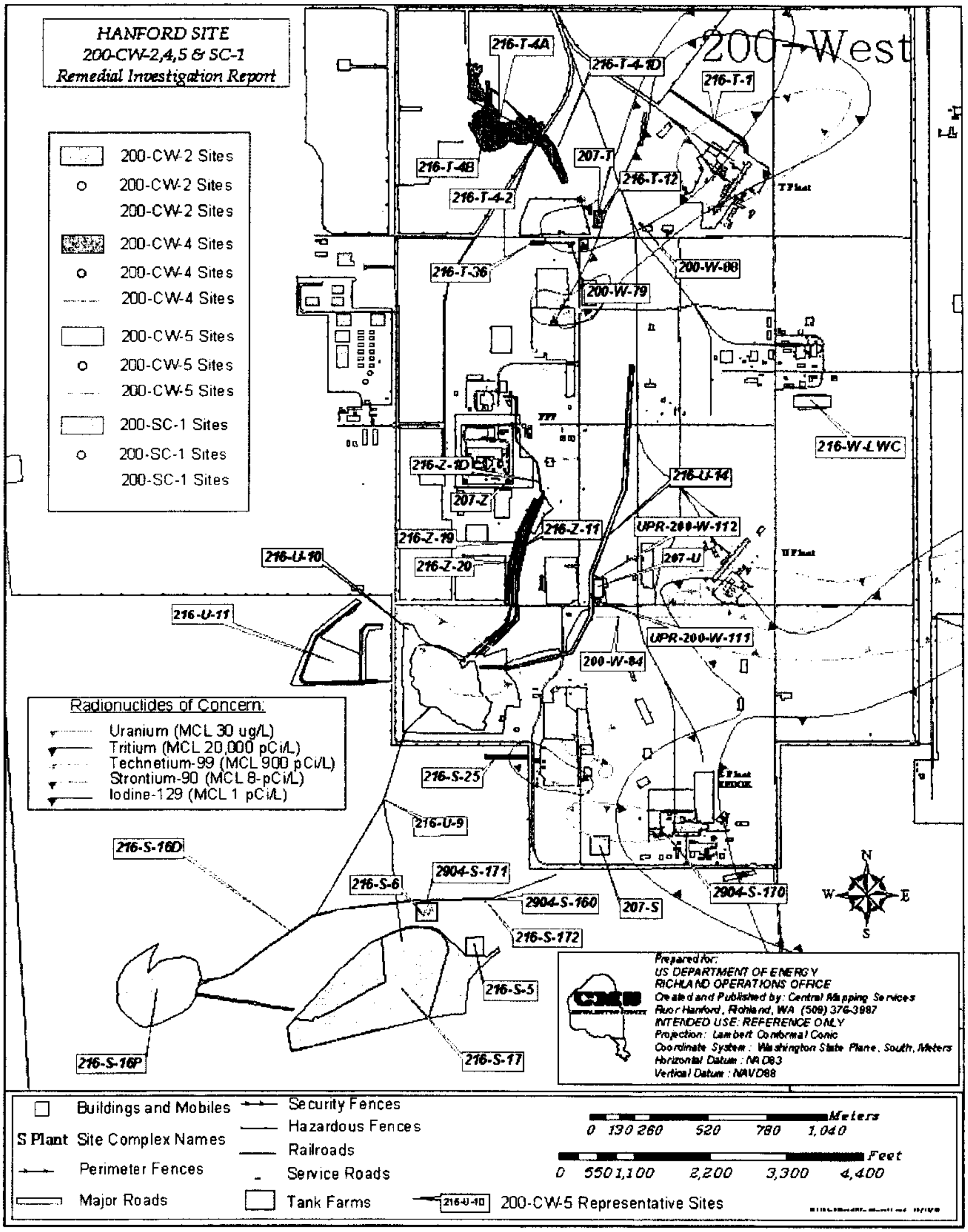
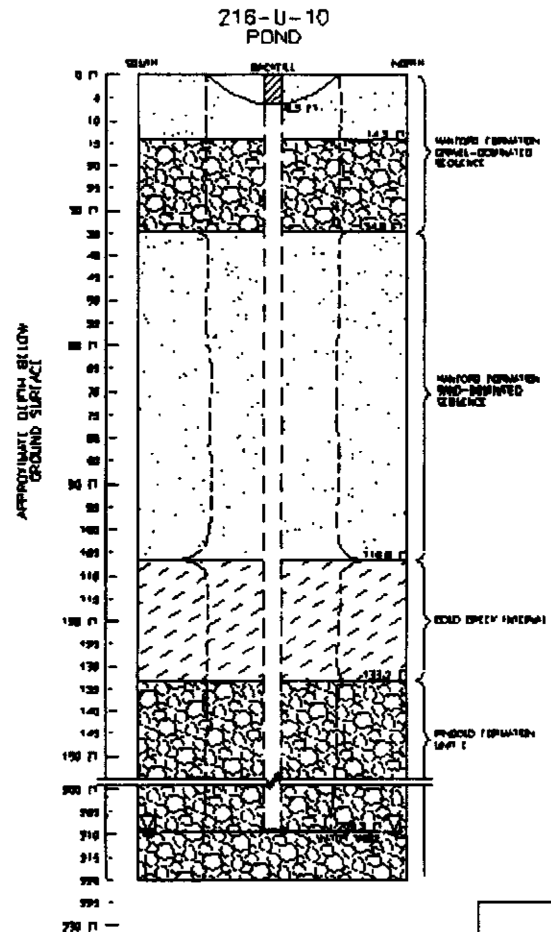


Figure 3-10. Radiological Groundwater Plume in the 200-CW-5 Operable Unit.



CWS:020703A



SOIL CONTAMINATION

0-6.5 FT

AMERICIUM-241 4 3-44 pCi/g
BISMUTH-212 <1 pCi/g
CESIUM-137 8 5-3994 pCi/g
COBALT-60 <1-16 pCi/g
CURIUM-244 <1 pCi/g
EUROPIUM-152 <1 pCi/g
EUROPIUM-154 <1-12 pCi/g
EUROPIUM-155 <1-1.7 pCi/g
NEPTUNIUM-237 <1 pCi/g
PLUTONIUM-238 <1-22 pCi/g
PLUTONIUM-239/240 0 13-75 pCi/g
SODIUM-22 .0056-8.2 pCi/g
SELENIUM-79 1.2-20 pCi/g
STRONTIUM-90 0.6-157 pCi/g
TECHNETIUM-99 0.56-8.8 pCi/g
URANIUM-233/234 65 pCi/g
URANIUM-234 1 2-33 pCi/g
URANIUM-235 0 11-1 1 pCi/g
URANIUM-238 1 1-88 pCi/g

ALUMINUM 31,500 mg/Kg
ANTIMONY 12 mg/Kg
CADMIUM 9.1 mg/Kg
CHROMIUM 63 mg/Kg
MAGNESIUM 8240 mg/Kg
FLOURIDE 23 mg/Kg
SULFATE 2360 mg/Kg
URANIUM 270 mg/Kg
NITROGEN IN NITRITE & NITRATE 145 mg/Kg
KEROSENE 76 mg/Kg

>6.5 FT

AMERICIUM-241 <1 pCi/g
CESIUM-137 1 1-1 5 pCi/g
CURIUM-244 <1 pCi/g
EUROPIUM-152 <1 pCi/g
EUROPIUM-155 <1 pCi/g
PLUTONIUM-238 <1 pCi/g
PLUTONIUM-239/240 0.11-1.5 pCi/g
SELENIUM-79 46 pCi/g
STRONTIUM-90 1.7-28 pCi/g
TECHNETIUM-99 0 12-4.6 pCi/g
URANIUM 234 1.3-56 pCi/g
URANIUM-235 0.11-2.4 pCi/g

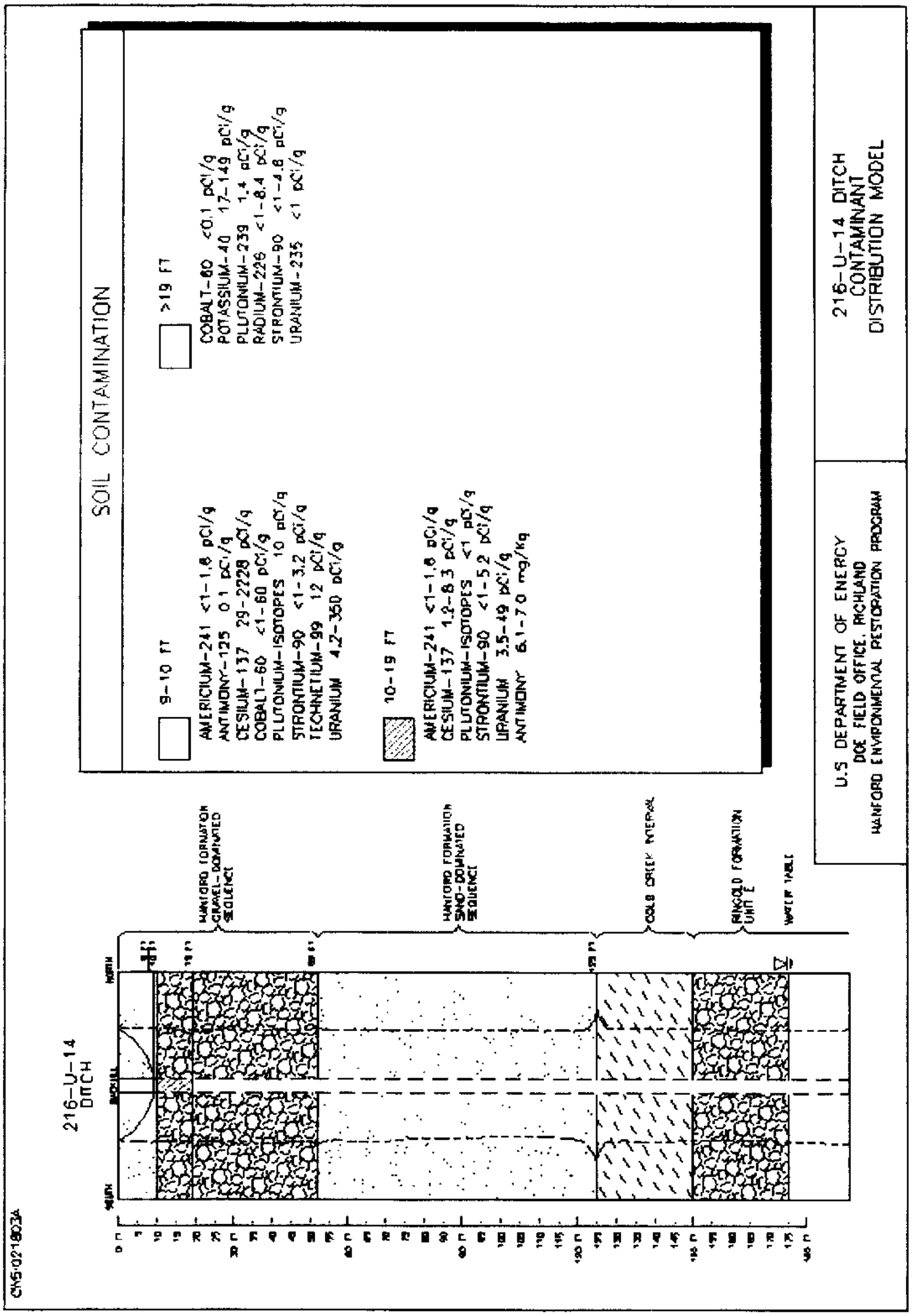
ALUMINUM 12,900 mg/Kg
ANTOMONY 13 mg/Kg
COBALT 21 mg/Kg
CYANIDE 3 mg/Kg
IRON 38,000 mg/Kg
POTASSIUM 21,180 mg/Kg
NITROGEN IN
NITRITE & NITRATE 126 mg/Kg

U.S DEPARTMENT OF ENERGY
DOE FIELD OFFICE, RICHLAND
HANFORD ENVIRONMENTAL RESTORATION PROGRAM

216-U-10 POND
CONTAMINANT
DISTRIBUTION MODEL

Figure 3-11. 216-U-10 Pond Area Contaminant Distribution Model.

Figure 3-12. 216-U-14 Ditch Area Contaminant Distribution Model.



4.0 VADOSE ZONE CONTAMINANT FATE AND TRANSPORT MODELING

The 200 Areas Remediation Project conducted vadose zone modeling to determine the fate and transport of selected contaminants identified as potentially significant risk contributors for the representative sites in the 200-CW-5 OU. Specific site contaminants were selected based on the results of transport screening analyses performed using RESRAD modeling (ANL/EAD-4) and regulatory considerations. The representative waste sites modeled were the 216-Z-11 Ditch (inclusive of data from the 216-Z-1 D Ditch and 216-Z-19 Ditch), the 216-U-10 Pond, and the 216-U-14 Ditch.

Full-scale modeling was performed using the STOMP simulation program (PNNL-12034) to solve numerical equations for unsaturated flow conditions within the vadose zone, to assess which, if any, of the contaminants identified during the RI may pose a future threat to groundwater. The modeling evaluates whether the contaminants migrating from the waste sites will reach groundwater before decaying or attenuating and estimates potential future concentrations in groundwater.

The STOMP code (PNNL-11217) solves coupled conservation equations for component mass that describe subsurface flow in multiple dimensions through variably saturated geologic media (Richards' equation). The primary governing equations describing evaluation of the aqueous flow field parameters are described in Section 4.4. The resulting flow fields are used to solve the conservation equation for solute transport (advection-dispersion equation) with an equilibrium linear sorption coefficient (distribution coefficient) formulation.

4.1 CONTAMINANTS

The nature and extent of contamination at the representative sites are described in Section 3.2. One-dimensional contaminant distribution profiles were presented in Figures 3-8, 3-11, and 3-12, summarizing the findings of the RI. Table 4-1 identifies the contaminants modeled at each of the representative sites.

4.2 REPRESENTATIVE SITE INFORMATION AND HYDRAULIC PROPERTIES GEOLOGY

Physical conceptual models for each representative waste site were constructed based on borehole logs collected from characterization and monitoring wells installed at or near each of the waste sites. The geologic units and formations identified in the 200 West Area are discussed in detail in Chapter 3.0. Figures 3-3 and 3-4 show the vertical cross-sections developed to describe the geology in the vicinity of these waste sites and serve as the framework for the model.

4.3 MODELING METHODOLOGY

The models constructed to simulate the 200-CW-5 OU representative waste sites are two-dimensional vertical cross-section representations of the actual physical systems. Physical conceptual models and selection of model input parameters were based on historical information and data collected during the RI. The geology observed in the characterization boreholes in the waste sites indicates the presence of significant impermeable layers or fine-grained units that would result in perching of water and that would greatly enhance lateral spreading of the contaminants within the vadose zone. The caliche layer associated with the Cold Creek unit slopes southward in the vadose zone and is a significant impediment to the vertical contaminant migration. Therefore, the modeling includes the effects of the sloping layers on lateral spreading in the evaluation. The following steps summarize the modeling activity.

- **Physical Conceptual Model:** A physical conceptual model was developed for each of the representative waste sites, based on geologic logs. Major geologic units were distinguished based on significant differences in textural and hydraulic properties. Common to all three models was the inclusion of a low permeability caliche horizon of the Cold Creek unit. Each layer in the model was assigned values for relevant physical and hydraulic properties (e.g., moisture content, unsaturated and saturated hydraulic conductivity, bulk density) from the best available source, as described in Section 4.4.

- **Model Initialization:** Initial vadose zone moisture profiles for each site were developed by running the models to achieve a hydraulic steady state under a presumed pre-operational infiltration rate of 3.5 mm/yr consistent with the estimates made for the undisturbed shrub-steppe environment existing at Hanford before the beginning of operations (PNL-10285, *Estimated Recharge Rates at the Hanford Site*, and RPP-7884, *Field Investigation Report for Waste Management Area S-SX*. Next, models for the 216-Z-11 and 216-U-14 Ditches were simulated using estimated infiltration rates representing the period of facility operation. Including the operational history of the facilities allowed the model to account for the enhanced drainage and recharge expected to occur after discharges to the soil column ceased because of high residual moisture content within the vadose zone. Following operational simulation for these two models, both models were run to simulate the postoperational period using an infiltration rate of 1.44 cm/yr, based on an average Hanford Site precipitation of 16 cm/yr (6.3 in./yr) and an evaporation/transpiration factor of 91 percent. The evaporation/transpiration factor of 91 percent is a regulatory agreed upon estimate for disturbed but stabilized surface cover. The resulting moisture profile was taken as the initial conditions, to begin the 1000 years fate and transport simulation.

  Attempting to simulate the discharge history of 216-U-10 Pond proved untenable at the scale of the model. 216-U-10 Pond discharges affected the water table throughout the 200 West Area, and attempting to simulate the quantity of water discharged to the pond overwhelmed the model domain. Thus, to simulate enhanced drainage and recharge expected to occur, the model domain was reduced to a length of 200 m (656 ft), and the entire model domain was assumed to be saturated in 1984. The model domain was allowed to drain from that time to the present. The bottom of the model represented an approximation of the current water table elevation.

- **Contaminant Distribution Models**: The model cross section was then populated with contaminant concentrations based on the maximum concentrations observed during the respective remedial investigations. Radiological contaminant inventories were decayed to 2002. Maximum concentrations for each constituent were applied to the model at each sampling interval. For depth intervals without sample results, concentrations were assigned based on the nearest sample results for individual constituents, expected mobilities, and relationships to geologic units.

- **Model Simulation:** Each of the models was run for a simulation period beginning presenting 2002 and extending 1,000 years into the future. Movement and concentration of each constituent throughout the model domain was calculated, based on assigned distribution coefficient (K_d) for each time step throughout the simulation. The resultant breakthrough curves generated for each constituent represent concentration in groundwater immediately downgradient of the representative site as a function of time. The modeling included a simulation period representing the time from waste disposal to the RI/FS data collection effort. Figures showing the model input contaminant distributions are presented in Appendix D. Results of the fate and transport modeling for each of the representative waste sites are discussed in Section 4.5.

4.4 SOIL HYDRAULIC PROPERTIES AND CONTAMINANT SOIL INTERACTION CHARACTERISTICS

Soil hydraulic properties for the different geologic units were developed from the existing database of moisture retention and unsaturated hydraulic conductivity data available at the Hanford Site. In general, soil hydraulic properties describe the amount of water that the soil is capable of containing, the capillary pressure at which the soil retains a certain quantity of water, and the rate at which water is capable of moving through the soil. Capillary pressure refers to the suction exerted by the soil to hold water in place. Measurable properties of interest are the soil bulk density, soil saturated moisture content (or porosity), moisture content as a function of capillary pressure, and hydraulic conductivity as a function of soil moisture.

Moisture retention characteristic curves may be derived that describe the data in terms of an analytical equation. The characteristic curves allow the relationship to be expressed for the entire continuum of values, which is a necessity of modeling. Moisture content often is expressed in terms of the saturation, which is the amount of water contained by the soil relative to the amount that the soil could contain:

$$S_w = [\frac{\Theta_w - \Theta_r}{\Theta_s - \Theta_r}]$$

where

S_w = degree of water saturation of the porous media (dimensionless)

Θ_w = moisture content of the soil (dimensionless)

Θ_s = saturated moisture content of the soil (dimensionless)

Θ_r = residual moisture content of the soil (dimensionless).

The residual moisture content refers to the absolute minimum amount of water retained by the soil regardless of the amount of applied pressure. The residual moisture content is estimated through the curve-fitting process.

The van Genuchten equation frequently is applied to express the saturation in terms of the soil capillary pressure and three fitted variables:

$$S_w = \{1 + (\alpha[\frac{P_g - P_w}{\rho_w g}])^n\}^{-m} \quad \textit{for } P_g - P_w > 0 \quad \textit{i.e. unsaturated conditions}$$

$$S_w = 1 \quad \textit{for } P_g - P_w \leq 0 \quad \textit{i.e. saturated conditions}$$

where

P_g = absolute pressure of the gas phase present (Pa, usually atmospheric pressure when the gas phase is air)

P_w = absolute pressure of the water phase present (Pa)

$P_g - P_w$ = capillary pressure of the soil on the water phase present (Pa)

ρ_w = density of water (kg/m^3)

g = acceleration of gravity (m/s^2)

α (1/m), n, and m are curve fit parameters, $m = 1 - 1/n$

S_w = degree of water saturation of the porous media (dimensionless) as defined as before.

The Mualem equation describes hydraulic conductivity as a function of saturation:

$$k_{rw} = (S_w)^{1/2}\{1 - (1 - [S_w]^{1/m})^m\}^2$$

and

$$K = k_{rw} * K_{sat}$$

where

K = soil permeability (cm^2) or hydraulic conductivity (cm/s)

k_{rw} = relative permeability or hydraulic conductivity

K_{sat} = saturated permeability (cm^2) or saturated hydraulic conductivity (cm/s)

S_w and m are defined as before.

The characterization effort conducted at the representative waste sites produced detailed descriptions of the local geology. WHC-EP-0883, *Variability and Scaling of Hydraulic Properties for 200 Area Soils*, collected and summarized much of the unsaturated hydraulic data collected at the Hanford Site and developed statistical distributions for six general soil types. The characterization effort conducted at the representative waste sites identified more than the six soil types described by WHC-EP-0883, so the statistical distributions served as the basis for determining the hydraulic properties used in this report. Soil hydraulic properties used in the models were kept within two standard deviations of the mean presented in WHC-EP-0883, unless an appropriate soil type match was not available. In those cases, properties were determined from the closest soil type available and extrapolated according to the expected characteristics of the soil type. Table 4-2 presents the soil hydraulic properties and fitted curve parameters for the geologic units identified.

Distribution coefficients for the contaminants were derived from the "Best Estimate" lists in PNNL-11800, *Composite Analysis for Low-Level Waste Disposal in the 200 Area Plateau of the Hanford Site*. Distribution coefficients used in the modeling are shown in Table 4-3.

4.5 RESULTS OF FATE AND TRANSPORT MODELING

Results of the fate and transport modeling for representative sites are discussed in the following subsections.

4.5.1 216-Z-11 Ditch Area

The results of the 216-Z-11 Area modeling indicate that contaminants do not reach groundwater. Plutonium-239/240 and thorium-230 and the polychlorinated biphenyls Aroclor-1254 and Aroclor-1260 are essentially immobile in the environment (have high K_d values) and do not travel much beyond their current location within the vadose zone. Cesium-137 and strontium-90 have relatively short half-lives and decay below detectable limits long before they would be expected to reach the water table.

4.5.2 216-U-10 Pond

The results of the 216-U-10 Pond modeling indicate that selenium-79, technetium-99, cyanide, fluoride and the uranium species reach the groundwater at significant concentrations. The other contaminants of concern with distribution coefficients greater than or equal to 6 mL/g do not reach the groundwater during the 1,000-year simulation period. Those contaminants with distribution coefficients between 3 and 5 mL/g result in essentially nonmeasurable concentrations (i.e., the maximum predicted concentration of magnesium is 1.55×10^{-16} mg/L). Figures 4-1 and 4-2 present breakthrough curves for these contaminants of concern. The results presented for selenium-79 are likely conservative (i.e., biased high) in light of recent studies because the K_d of selenium at the Hanford Site is likely higher than previously assumed. The other radionuclide contaminants of concern are relatively immobile in the environment and do not travel much beyond their current location. Strontium-90 and cesium-137 have relatively short half-lives and decay below detectable limits long before they would be expected to reach the water table. They are not expected to be present anywhere in the vadose zone in appreciable quantity in 1,000 years. Plutonium-239/240 is expected to remain in the environment but is not expected to travel much beyond its current location. These isotopes tend to bind strongly to soil particles and remain fixed, even though their relatively long half-lives result in long residency in the vadose zone.

Mobile constituents technetium-99, selenium-79, and fluoride exhibit double peaks over the 1,000-year period of simulation; this results from the bimodal contaminant distribution indicated in the available sample results. Each of the constituents reported elevated concentrations near the surface, followed by an interval in the vadose zone of non-detects. A single sample collected from borehole 299-W23-231 over a depth interval of 41.1 to 41.7 m (135 to 137 ft) bgs, located just above the caliche layer in the Cold Creek unit, reported above detection concentrations for selenium-79, cyanide, fluoride, and technetium-99. When the initial contaminant distribution model was being constructed, the concentrations of these constituents from this location were linearly scaled upward within the Cold Creek unit over a thickness of approximately 7.5 m (24 ft), to connect with the nearest sample interval for which these constituents were not detected (34.1 m [112 ft] bgs). This scaling of contaminant concentrations may be overly conservative, given that the mobile constituents likely would be concentrated in a thin zone directly above the restrictive caliche layer. However, in the absence of additional soil samples in this zone, the contaminant distribution was not adjusted to reflect this possibility. The result of this conservative distribution will be to increase the peak concentrations observed for these mobile constituents.

Cyanide was detected in only 2 of 36 samples. The maximum sample result of 3 mg/kg was detected 42.0 to 42.7 m (135 to 137 ft) bgs. The predicted high concentration of cyanide (7.94 mg/L) is a consequence of that single sample result.

The predicted concentration of selenium-79 resulted from input based on two sample results collected from borehole 299-W23-231 (20 pCi/g at 0.6 to 1.2 m [2 to 4 ft] and 46 pCi/g at 41.1 to 41.8 m [135 to 137 ft] bgs). An additional sample collected just below the caliche (42.0 to 42.7 m [138 to 140 ft] bgs) reported a selenium-79 concentration of 1.7 pCi/g, which is just above the detection limit. Selenium-79 was modeled using a K_d of 0. Fluoride concentration exhibits two peaks, 2 mg/L after 250 years and approximately 12 mg/L after 800 years. Fluoride concentration in groundwater remains elevated (5.37 mg/L) at the end of the 1,000-year period, exceeding the drinking water maximum contaminant level (MCL) of 4 mg/L.

The concentration of all of the uranium species is increasing at the end of the simulation period of 1000 years, and the concentration of the total uranium (3.64 mg/L) remains above the drinking water MCL (0.03 mg/L). The maximum concentrations of the individual isotopes (uranium-233-234, uranium-234, uranium-235, and uranium-238) are 284 pCi/L, 1,560 pCi/L, 301 pCi/L, and 1,490 pCi/L, respectively.

The peak concentration of technetium-99 in groundwater is 1,360 pCi/L after approximately 125 years, exceeding the MCL of 900 pCi/L. The concentration decreases below the MCL after approximately 250 years and, despite a second peak occurring around 700 years, remains below the MCL for the remainder of the simulation. The distribution of technetium-99 is dominated by two samples reporting concentrations of 8.8 pCi/g and 4.6 pCi/g.

Substantially elevated concentrations of sulfate were detected in near-surface sediments. The simulated transport of sulfate results in a peak groundwater concentration of approximately 1,180 mg/L. This concentration exceeds the secondary drinking water standard for sulfate of 250 mg/L.

4.5.3 216-U-14 Ditch

The results of the 216-U-14 Ditch modeling indicate that technetium-99, sulfide, and uranium reach the groundwater in appreciable concentrations. Figure 4-3 presents the breakthrough curve for technetium-99, sulfide, and uranium. The other radionuclide and metal contaminants of concern are relatively immobile in the environment and do not travel much beyond their current location. Strontium-90 and cesium-137 are not expected to be present anywhere in the vadose zone in appreciable quantity in 1,000 years. Because they have relatively short half-lives they would decay below detectable limits long before reaching the water table. Plutonium-239/240 and antimony are constituents that tend to bind strongly to soil particles and are not expected to travel much beyond their current location. Technetium-99 arrives at the water table approximately 250 years after the start of the simulation and exhibits a peak concentration of 1,360 pCi/L after approximately 620 years. The concentration decreases below its MCL of 900 pCi/L after 860 years and decreases to less than 500 pCi/L by the end of simulation. The distribution of technetium-99 at the 216-U-14 Ditch site was determined from the results of a single sample (12 pCi/g) collected from test pit ETP-1 at a depth of 2.75m (9 ft) bgs. These modeling results suggest that even low concentrations of highly mobile, long-lived radiological constituents may impact groundwater quality.

Uranium (total) reaches the groundwater after approximately 775 years from the start of the simulation. The maximum concentration at the end of the simulation is less than 0.5 pCi/L but is steadily increasing. Uranium is slightly retarded moving through the vadose zone (K_d of 0.6 mL/g). This accounts for delayed arrival time and peak concentration times in comparison with highly mobile constituents like technetium-99 (K_d of 0).

Sulfide was reported in soil samples over a substantial depth interval at concentrations up to 40 mg/kg. The source of sulfide in these soil samples is not apparent, and sulfide typically is not stable in soil. Although simulated transport of sulfide with the model indicates a peak groundwater concentration of approximately 35 mg/L occurring in about 550 years, this actually is unlikely to occur, give the natural reactivity of sulfide in the vadose zone. The residual sulfide (if it can be confirmed to actually exist) most likely will be oxidized to sulfate during transport through the vadose zone.

4.6 CONCLUSIONS

The results of the modeling efforts completed for the three representative waste sites indicate that the majority of the identified contaminants of concern are effectively attenuated in the vadose zone and do not pose a substantial threat to future groundwater quality. The primary mobile radiological constituents include technitium-99, selenium-79, and, to a lesser extent, uranium. Recent studies indicate that selenium-79 is less mobile than previously assumed. The primary mobile nonradiological constituents evaluated include cyanide, sulfate/sulfide, and fluoride. The contaminants did reach the groundwater and result in concentrations above the MCL. Short-lived radionuclides, such as cesium-137 and strontium-90, were shown to decay long before reaching groundwater. Uranium and americium-241 are long-lived radionuclides that are only slightly retarded moving through the vadose zone. Both are predicted to impact groundwater within the simulation timeframe of 1,000 years. Technetium-99, selenium-79, cyanide, fluoride, and sulfate are highly mobile constituents with the potential to impact groundwater quality. In particular, technetium-99 may significantly impact groundwater even when it is detected at relatively low soil concentrations. All of these constituents reach their predicted peak concentrations within the 1000-year simulation period, with most exhibiting temporary exceedance of primary or secondary drinking water standards.

Figure 4-1. Contaminant Distribution Breakthrough Curves for Selenium-79, Technetium-99, Cyanide, and Fluoride at the 216-U-10 Pond.

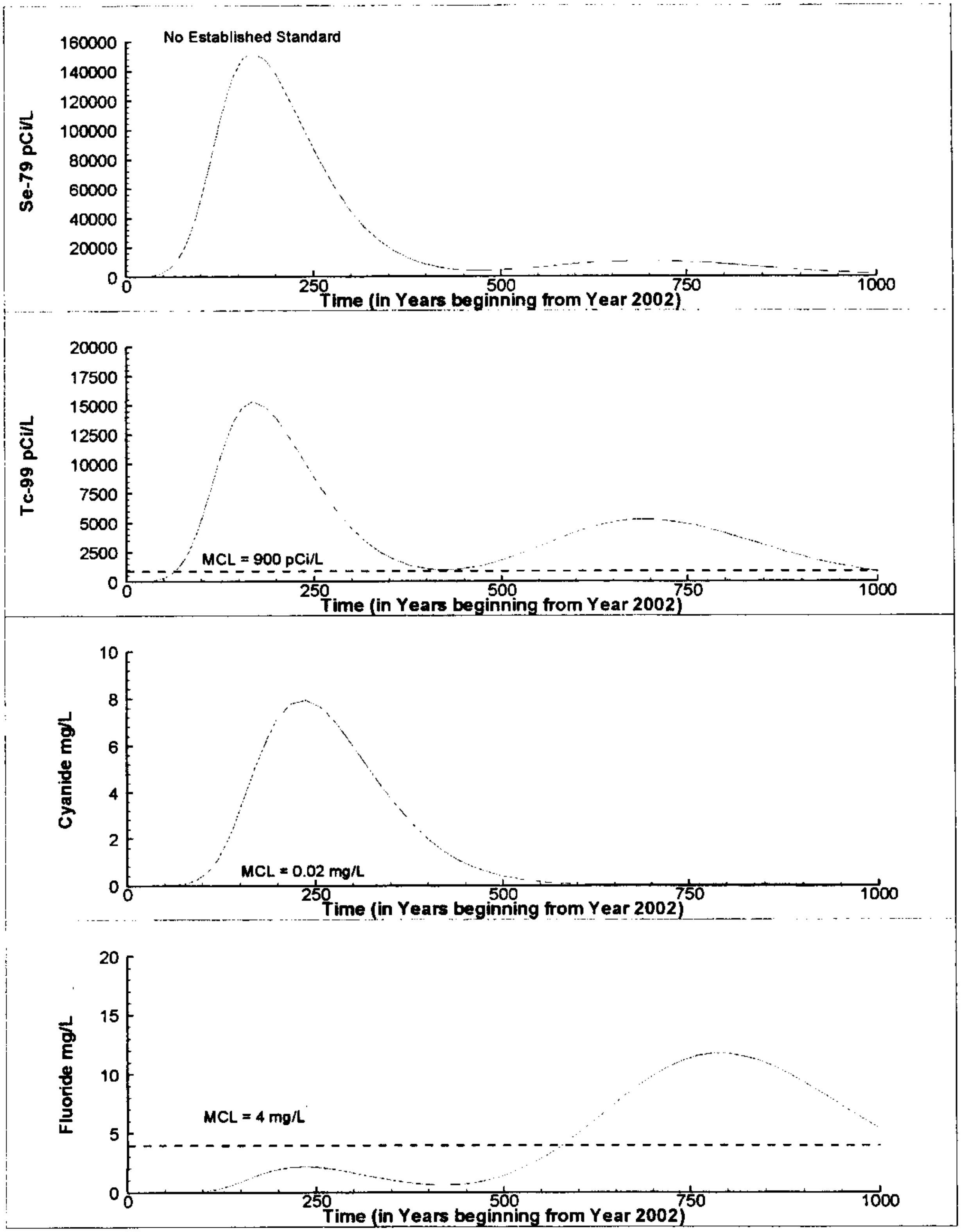


Figure 4-2a. Contaminant Distribution Breakthrough Curves for Uranium and Uranium Isotopes at the 216-U-10 Pond.

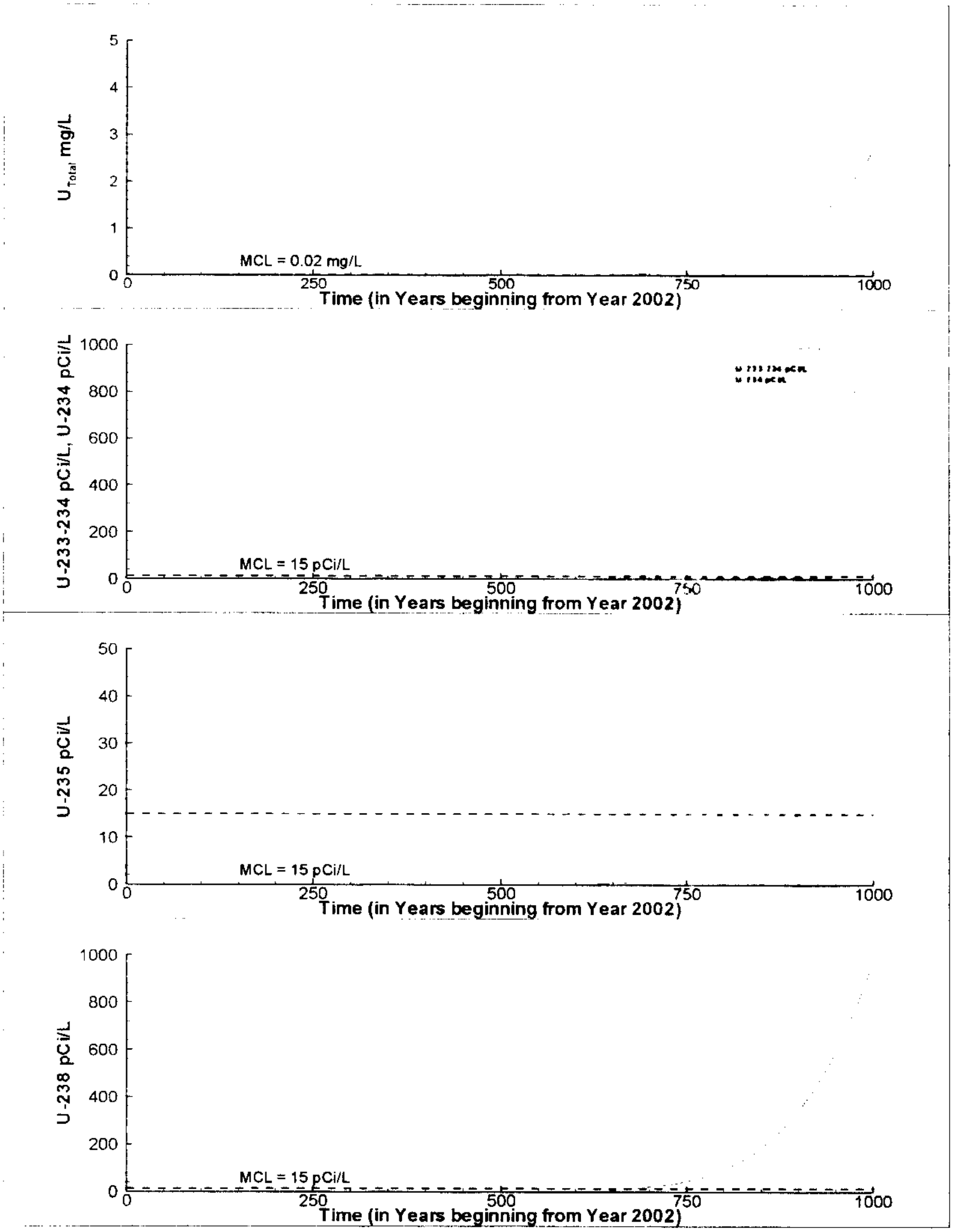


Figure 4-2b. Contaminant Distribution Breakthrough Curves for Uranium and Uranium Isotopes at the 216-U-10 Pond.

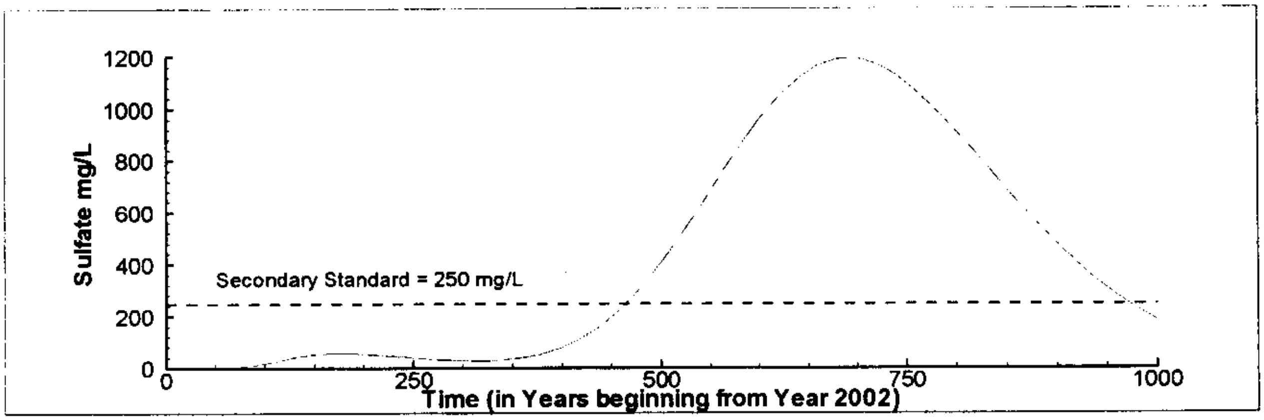


Figure 4-3. Contaminant Distribution Breakthrough Curves for Technetium-99, Uranium, and Sulfide at the 216-U-14 Ditch.

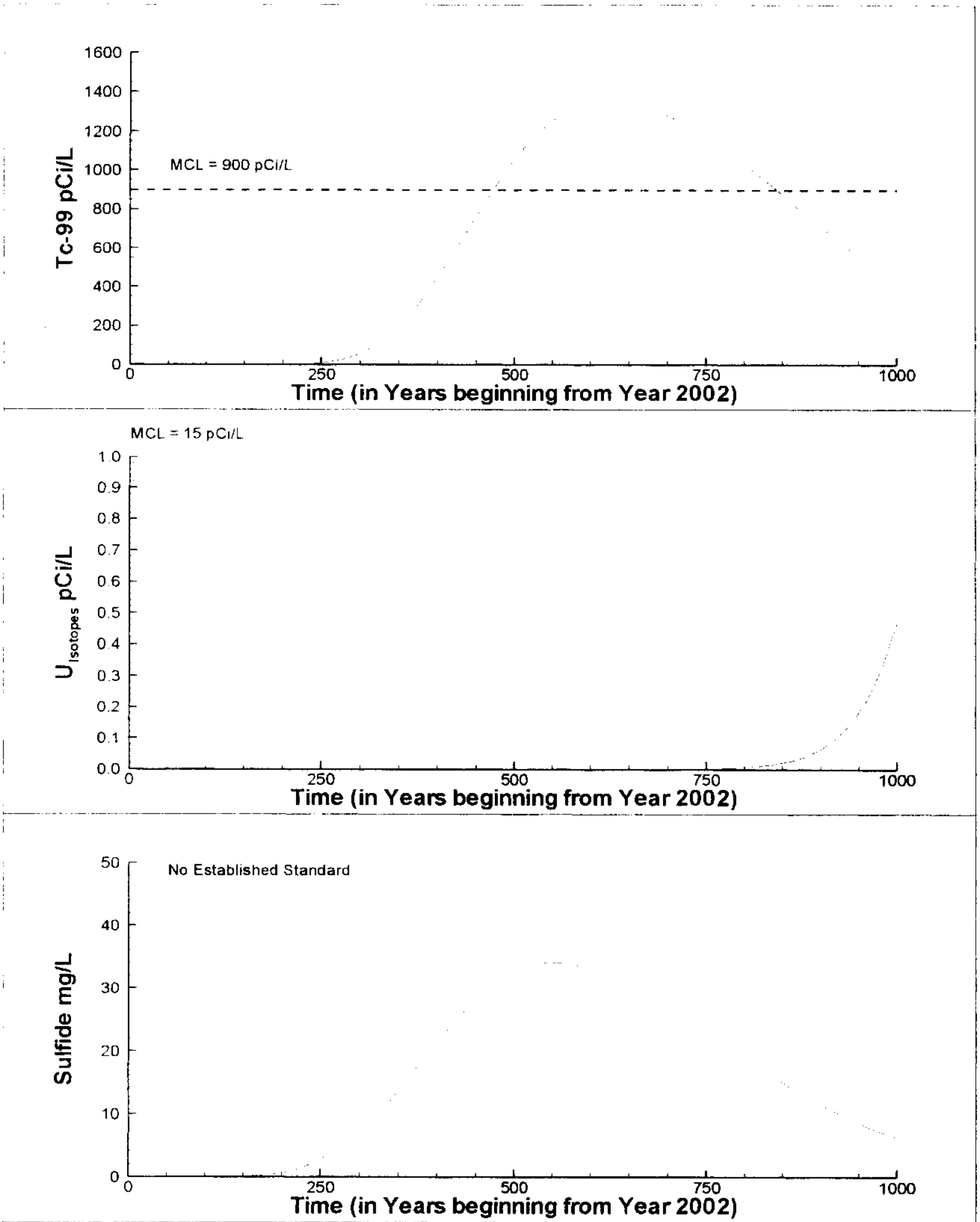


Table 4-1. Contaminants Modeled at the 216-Z-11 Ditch, 216-U-14 Ditch, and 216-U-10 Pond 200-CW-5 Operable Unit Representative Sites.

Type	216-Z-11 Ditch	216-U-14 Ditch	216-U-10 Pond
Radionuclides	Americium-241 Cesium-137 Plutonium-239 Plutonium-239/240 Strontium-90 Thorium-230	Cesium-137 Plutonium-239/240 Strontium-90 Technetium-99	Cesium-137 Plutonium-239/240 Selenium-79 Strontium-90 Technetium-99 Thorium-228 Thorium-232 Uranium-233/234 Uranium-234 Uranium-235 Uranium-238
Nonradioactive Chemicals/Metals	Aroclor-1254 Aroclor-1260	Antimony Sulfide Uranium (total)	Antimony Cadmium Cyanide Fluoride Kerosene Nitrate Sulfate Uranium (total)

Table 4-2. Modeling Soil Properties.

Material Description	Alpha (1/cm)	n	m	Moisture Content (Saturated)	Moisture Content (Residual)	Vertical Saturated Hydraulic Conductivity (cm/s)	Vertical Saturated Hydraulic Conductivity (m/day)	Horizontal Saturated Hydraulic Conductivity (m/day)
Aeolian sand	0.063	1.582	0.3679	0.367	0.030	1.50×10^{-3}	1.30	$1.30 \times 10^{+1}$
Hanford gravel dominated sequence (sand)	0.063	1.582	0.3679	0.367	0.030	1.50×10^{-3}	1.30	$1.30 \times 10^{+1}$
Hanford gravel-dominated sequence (gravel)	0.056	1.215	0.1770	0.183	0.000	1.75×10^{-1}	$1.51 \times 10^{+2}$	$1.51 \times 10^{+3}$
Hanford sand-dominated sequence	0.020	1.318	0.2413	0.433	0.010	6.25×10^{-4}	5.40×10^{-1}	5.40
Cold Creek Interval	0.016	1.372	0.2711	0.445	0.027	1.75×10^{-4}	1.51×10^{-1}	1.51
Ringold Unit E	0.028	1.273	0.2145	0.158	0.001	1.75×10^{-3}	1.51 E+00	$1.51 \times 10^{+1}$

Table 4-3. Comparisons of Modeled K_d Values to Published Values. (2 Pages)

Contaminant	Zone F Category Best Estimate	Value Used in Model
216-Z-11 Ditch	***Distribution Coefficient (mL/g)***	
Amercium-241	300	300
Plutonium-239	200	80
Plutonium-239/240	200	80
Strontium-90	20	8
Thorium-230	1000	40
Aroclor-1254	NA	160
Aroclor-1260	NA	160
216-Z-10 Pond	***Distribution Coefficient (mL/g)***	
Cesium-137	1500	540
Plutonium-239/240	200	80
Selenium-79	0	0
Strontium-90	20	8
Technetium-99	0	0
Thorium-228	1000	40
Thorium-232	1000	40
Uranium-233/234	3	0.6
Uranium-234	3	0.6
Uranium-235	3	0.6
Uranium-238	3	0.6
Antimony	NA	50
Cadmium	NA	6
Cyanide	NA	0.02
Fluoride	NA	0.02
Iron	NA	50
Kerosene	NA	5
Magnesium	NA	5
Nitrate	NA	0
Sulfate	NA	0
Uranium	3	0.6

Table 4-3. Comparisons of Modeled K_d Values to Published Values. (2 Pages)

Contaminant	Zone F Category Best Estimate	Value Used in Model
216-Z-14 Ditch	***Distribution Coefficient (mL/g)***	
Cesium-137	1500	540
Plutonium-239/240	200	80
Strontium-90	20	8
Technetium-99	0	0
Potassium-40	NA	10
Uranium	N/A	20
Antimony	NA	50
Sulfide	NA	0

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5.0 RISK ASSESSMENT

This chapter provides the results of the baseline HHRA for the 200-CW-5 OU representative waste sites. The HHRA addresses pathways associated with shallow zone soil (zero to 4.6 m [zero to 15 ft]) bgs for direct exposure to human receptors, and deep zone soil (from the surface to the water table) for the protection of the groundwater. This chapter also provides the site-specific screening for ecological assessment.

The purpose of this risk assessment (RA) is to determine whether a potential for risk to human health and the environment exists under current and reasonably anticipated future site-use conditions. The results are used, in part, to determine whether remedial action is necessary and to focus the FS.

5.1 CONCEPTUAL SITE MODEL

This conceptual site model (CSM) identifies the means by which human and ecological receptors on or near the 200-CW-5, 200-CW-2, 200-CW-4, and 200-SC-1 waste sites may contact radiological contaminants, nonradiological contaminants, or both in environmental media. The CSM addresses exposures that may result under current site conditions and from reasonably anticipated potential uses of the site and surrounding areas in the future.

The CSM provides a current understanding of the sources of contamination, the physical setting, and current and future land use; and identifies potentially complete human and ecological exposure pathways. Information generated during the RI/FS process has been incorporated into this CSM to identify potential exposure scenarios.

5.1.1 Ecological Setting

This section describes the ecological setting of the 200-CW-5 OU. The ecological setting encompasses the terrestrial habitats and wildlife in the OU. The availability and quality of habitats determines the wildlife types that may be present in the OU.

Environmental monitoring has been an ongoing activity since the early days of the Hanford Site. The monitoring efforts continue today and a significant body of information exists about the ecology of the Central Plateau. The latest data collection efforts focused on the Central Plateau and the 200 Areas were conducted in 2000 and 2001. Information about the ecological setting is presented in more detail in DOE/RL-2001-54.

5.1.1.1 Terrestrial Habitat

The Central Plateau is characterized by native shrub-steppe habitat interspersed with large areas of disturbed ground, dominated by annual grasses and herbaceous plants, especially in the industrialized 200 Areas and outlying waste sites. Baseline vegetation surveys identify three simplified habitat associations: sagebrush/shrub-steppe, grass and herbaceous plants, and disturbed. A detailed discussion of the survey results that support the information presented in this section is provided in DOE/RL-2001-54. Figures showing location and relative abundance of plant and animal species are provided in DOE/RL-2001-54.

5.1.1.1.1 Sagebrush/Shrub-Steppe Group

In the native shrub-steppe, the most prevalent shrub is big sagebrush (sagebrush) (*Artemisia tridentata*), and the understory is dominated by the native perennial, Sandberg's bluegrass (*Poa sandbergii*), and the introduced annual, cheatgrass (*Bromus tectorum*). Other shrubs present in the 200 Areas include rabbitbrush (*Chrysothamnus* spp.), spiny hopsage (*Grayia spinosa*), and antelope bitterbrush (*Purshia tridentata*).

Sagebrush/shrub-steppe habitat associations are dominant outside the fenceline, covering about two-thirds of the Central Plateau. Patches of big sagebrush habitat are located within the 200 East Area and 200 West Area fencelines, respectively.

5.1.1.1.2 Grasses and Herbaceous Plants Group

Native bunchgrasses present include Indian ricegrass (*Oryzopsis hymenoides*), sand dropseed (*Sporobolus cryptandrus*), and needle-and-thread grass (*Stipa comata*). Common herbaceous species include turpentine cymopteris (*Cymopteris terebinthinus*), globemallow (*Sphaeralcea munroana*), balsamroot (*Balsamorhiza careyana*), milkvetch (*Astragalus* spp.), yarrow (*Achillea millefolium*), and daisy (*Erigeron* spp.). These habitats often are associated with disturbed areas and represent a lower quality habitat than the sagebrush/shrub-steppe.

5.1.1.1.3 Disturbed Areas Group

Large areas of disturbed ground dominated by annual grasses and herbaceous plants are present in the 200 East and 200 West Areas. Disturbed and nonvegetated (gravel or asphalt) areas in the 200 Areas have minimal vegetative cover (<10 percent) (WHC-SD-EN-TI-216, *Vegetation Communities Associated with the 100-Area and 200-Area Facilities on the Hanford Site*) and are primarily the result of either mechanical disturbance (e.g., from road clearing or facility construction) or range fire. At the Hanford Site, the ground surface is covered with a fragile thin crust (cryptogamic crust), consisting of mosses, lichen, algae, and bacteria, that protects the soil beneath. By preventing erosion, the cryptogamic crust helps to build the soil below and retains moisture and provides nutrients. This aspect of the soil is crucial to the existence of desert life. Once disturbed, decades (or centuries if the soil has been removed) may pass before a plant community returns to a state comparable to its original condition. The principal colonizers of disturbed sites are non-native annual species such as Russian thistle (*Salsola kali*), Jim Hill mustard (*Sisymbrium altissimum*), and cheatgrass.

Mechanical disturbance typically entails a loss of soil structure and disruption of nutrient cycling, which have a significant effect on the plant species that recolonize a site. Many waste sites have been backfilled with clean soil and planted with crested (*Agropyron cristatum*) or Siberian wheatgrass (*Agropyron sibericum*) to stabilize the surface soil, control soil moisture, or displace more invasive deep-rooted species like Russian thistle (PNNL-6415, *Hanford Site National Environmental Policy Act [NEPA] Characterization*). Most waste sites are treated, as necessary, with herbicide to prevent the uptake of underground contamination by deep-rooted plants. There are varying levels of disturbance at these sites. Some waste sites are highly disturbed and have only a gravel cover, while other sites have light vegetative cover of grasses and herbaceous plants, yet other sites have had vegetation present for some time and are supporting the growth of shrubs. Fire is a major source of disturbed habitat at the Hanford Site; although the 200-CW-5 OU waste sites have not recently been impacted by fire.

5.1.1.2 Wildlife

The largest mammal frequenting the Central Plateau is the mule deer (*Odocoileus hemionus*). While mule deer are much more common along the Columbia River, the few that forage throughout the Central Plateau comprise a distinct group called the Central Population (PNNL-11472, *Hanford Site Environmental Report for Calendar Year 1996*). A large elk herd (*Cervus canadensis*) currently resides on the Fitzner-Eberhardt Arid Lands Ecology Reserve. Occasionally a few elk have been seen just south of the 200 Areas; recently the herd on the Reserve has been thinned, thus the elk currently are not expected to continue expanding their range.

Other mammals common to the Central Plateau are badgers (*Taxidea taxus*), coyotes (*Canis latrans*), Great Basin pocket mice, northern pocket gophers, and deer mice. Jackrabbits (*Lepus californicus*) also are present in low numbers. Pocket gophers and mice (especially Great Basin pocket mice and deer mice) are abundant in the Central Plateau and the 200 Areas, predominantly consume vegetation, and can excavate large amounts of soil as they construct their burrows (Hakonson et al. 1982). Mammals associated with buildings and facilities include Nuttall's cottontails (*Sylvilagus nuttallii*), house mice (*Mus musculus*), Norway rats (*Rattus norvegicus*), and various bat species.

Common bird species in the Central Plateau include western meadowlarks, horned larks, and western kingbirds (*Tyranus verticalis*). Species associated with the industrialized portions of the 200 Areas include rock doves (*Columba livia*), starlings (*Sturnus vulgaris*), black-billed magpies (*Pica pica*), and ravens (*Corvus corax*). Burrowing owls (*Athene cunicularia*) commonly nest in the Central Plateau in abandoned badger or coyote holes. Loggerhead shrikes (*Lanius ludovicianus*) and sage sparrows (*Amphispiza belli*) are common nesting species in habitats dominated by sagebrush. Long-billed curlews (*Numenius americanus*) have been observed nesting on inactive 200 Areas waste sites. More recent characterizations of the 200 Areas have identified western meadowlarks as being the most widely distributed bird species, followed by horned larks and mourning doves (*Zenaida macroura*). Other conspicuous birds include terrestrial game birds (e.g., California quail [*Callipepla californica*], chukar [*Alectoris chukar*], ring-necked pheasant [*Phasianus colchicus*]), passerine species, and raptors (e.g., red-tailed hawk [*Buteo jamaicensis*], northern harrier [*Circus cyaneus*]).

Reptiles found in the Central Plateau include gopher snakes (*Pituophis melanoleucus*) and side-blotched lizards (*Uta stansburiana*). Rattlesnakes (*Crotalus viridis*) also have been observed. Observations of reptiles were not widespread, with only 23 observations of side-blotched lizards at 316 sites surveyed in the 2001 survey (DOE/RL-2001-54).

Three of the most common groups of insects found at the Hanford Site include darkling beetles, grasshoppers, and ants. Darkling beetles are a dominant part of the insect community in the 200 Areas, where they occur with very little seasonal restriction, but exhibit dramatic changes in abundance from year to year (PNL-2253, *Ecology of the 200 Area Plateau Waste Management*

Environs: A Status Report). Grasshoppers are herbivorous insects common in the Central Plateau. Their abundance cycles from year to year, with increased population size from May to July.

5.1.1.3 Sensitive Habitat

Sensitive habitats include those identified by BRMaP as rare or wetlands (or riparian) habitat. Wetlands are protected by the Federal and state governments.

5.1.1.3.1 Rare Habitat in the Central Plateau -Basalt Outcrops

Rare habitats are those important for plant, fish, and wildlife species that have a low availability (DOE/RL-96-32, *Hanford Site Biological Resources Management Plan*). Within the Central Plateau, the only identified rare habitat areas (rated as Level IV in DOE/RL-96-32) are located in proximity to the basalt ridges of Gable Butte and Gable Mountain. These basalt outcrops have limited availability, are associated with rare plant communities, and are easily disturbed. There are no waste sites in close vicinity to these rare habitats.

Wildlife likely to occur in these habitats are birds, such as the prairie falcon, rock wren, poorwill, and chukar; small mammals, such as the yellow-bellied marmot and wood rat; and reptiles, such as rattlesnakes, gopher snakes, and horned lizards.

5.1.1.3.2 Wetlands (Riparian) Habitat in the Central Plateau

Wetlands, or riparian, habitat are transitional lands between terrestrial and aquatic ecosystems where the water table usually is close to the surface but not always. Wetlands offer water and protection for wildlife in an arid environment.

In 1995, all contaminated effluent discharges to liquid waste sites were ceased. Within the Central Plateau, manmade ponds and ditches, including the B Pond Complex located near the 200 East Area, once were present and were sources of riparian habitat. All riparian habitat within the fenceline have been eliminated with the exception of a small riparian area that was identified in the 200 East Area during the 2001 survey. This may be a seasonal wetland; the value of this small riparian area has not been evaluated. No wetland habitat was located in the 200 West Area.

Vernal pools, such as those on Gable Butte and Gable Mountain, are temporary and are considered seasonally flooded wetlands. Approximately 20 vernal pools were located on the eastern end of Umtanum Ridge, near the central part of Gable Butte, and on the eastern end of Gable Mountain. None of these pools are in close proximity to waste sites in the Central Plateau (TNC 1999).

5.1.1.4 Sensitive Species

Sensitive species include threatened and endangered species, which are protected by Federal and state laws. Washington state defines sensitive species as any wildlife species native to the state of Washington that is vulnerable or declining and is likely to become endangered or threatened throughout a significant portion of its range within the state without cooperative management or removal of threats (*Washington Administrative Code* WAC 232-12-297, "Endangered, Threatened, and Sensitive Wildlife Species Classification," Section 2.6).

5.1.1.4.1 Threatened and Endangered Species

Two Federally protected species have been observed at the Hanford Site, the Aleutian Canada Goose and the Bald Eagle (*Haliaeetus leucocephalus*). Both are dependent on the river corridor and rarely are seen in the Central Plateau. As migratory birds, these species are protected under the *Migratory Bird Treaty Act of 1918*.

No plants, invertebrates, amphibians, reptiles, or mammals on the Federal or State of Washington threatened and endangered species lists are known to exist in the Central Plateau.

5.1.1.4.2 Rare Plants

Rare plant species are vascular plant species listed by the Washington Natural Heritage Program (WNHP, 1998, *Washington Rare Plant Species by County*) as endangered, threatened, or sensitive in the state of Washington. The Nature Conservancy (TNC) survey discovered 112 populations of 28 rare plant taxa on the Hanford Site (TNC 1999). Although rare plants were found dispersed throughout the Site, the highest densities occurred on the east end of Umtanum Ridge; the basalt-derived sands near Gable Mountain; the White Bluffs; Rattlesnake Mountain; and Yakima Ridge.

5.1.1.4.3 Mammals of Concern

The state has classified the pygmy rabbit (*Brachylagus idahoensis*) as a candidate endangered species. None have been observed to date in the Central Plateau. The pygmy rabbit is dependent on sagebrush, primarily big sagebrush (*Artemisia tridentata*), and usually is found in areas where big sagebrush grows in very dense stands.

5.1.1.5 New-to-Science Species

The TNC conducted a biodiversity survey of plants, mammals, reptiles and amphibians, birds, and insects at the Hanford Site between 1994 and 1998 (TNC 1999). This survey found two species and one variety of plants and 41 species and two subspecies of insects that had not been known to science. A listing of the new plant and insect species may be viewed at http://www.pnl.gov/ecomon/Species/Species.html.

U.S. Fish and Wildlife and the state of Washington have not yet determined the protective status of these new-to-science species (i.e., are they considered threatened or endangered). The habitat-based management plan at the Hanford Site will offer protection to most of these species.

Eriogonum codium (Umtanum desert buckwheat). The only known population of *Eriogonum codium* consists of approximately 5,200 plants on Umtanum Ridge in Benton County at the western edge of the Site.

Lesquerella tuplashensis (White Bluffs bladderpod). *Lesquerella tuplashensis* is a short-lived perennial that grows on the upper edge of the White Bluffs of the Columbia River in Franklin County.

Astragalus conjunctus var.*rickardii* (Basalt milkvetch). Basalt milkvetch typically is associated with bunchgrass areas within big sagebrush-steppe communities. It has been found on the top and north end of Rattlesnake Mountain at the Hanford Site (TNC 1999). The other known population of A. *conjunctus* var. *rickardii* in Benton County is a small population from the Chandler Butte portion of the Horse Heaven Hills.

Insects were dispersed throughout the Hanford Site, with the new species found in shrub-steppe, areas around the basalt talus, springs, and upland areas. The size, diversity, and relatively undisturbed nature of the Hanford Site shrub-steppe habitat has provided for a large and diverse insect population, of which the new-to-science species are a part. Habitat protection will be key to preserving the insect diversity at the Hanford Site.

With the exception of some of the insects, none of these new-to-science species is expected to be located near the 200-CW-5, 200-CW-2, 200-CW-4, and 200-SC-1 OU waste sites. The presence of the insects near the waste sites is limited because of the disturbed habitat associated with the waste sites.

5.1.1.6 Summary

Through ecological monitoring and sampling activities that have been conducted on the Hanford Site, a very comprehensive set of information on the habitat and species that currently exist in the Central Plateau is available. Given the current understanding of the habitat and wildlife in the Central Plateau, the following three concerns are important for consideration when making decisions on the remediation of waste sites in the Central Plateau.

1. The shrub-steppe habitat at the Hanford Site is one of the largest pieces of shrub-steppe in a region where this habitat is declining. Protection of shrub-steppe habitat at the Hanford Site is critical for the regional ecology. The shrub-steppe habitat also provides for the most diverse community of plants and animals in the upland arid environment. More diverse communities have greater stability and productivity (Tilman et al. 1996, and Tilman 1999). It would follow that more stable and productive ecosystems would be better able to cope with environment stresses, such as contamination. Also, reducing the area of any ecosystem reduces the number of species in that system (Wilson 1989).

2. Individual species whose populations are limited and are designated as sensitive species must be protected. New-to-science species should be afforded similar protection until further study can be performed.

3. The waste sites are disturbed habitats covered with gravel, or grasses, and other small plants. Two aspects of the disturbed habitat must be kept in mind: plant succession is slow in the arid environment; and disturbed areas, such as the waste sites, offer little habitat for animals.

The disturbed areas of the waste sites and fire-damaged terrain offer a lower quality habitat and have less community diversity. The most common organisms are ants, beetles, and mice. Ants tunnel underground and will move soil up to the surface.

5.1.2 Physical Setting

Chapter 2.0 of the 200-CW-5 OU Work Plan provides the site description and the physical setting of waste sites evaluated (DOE-RL-99-66, Rev. 0). This information was incorporated into the conceptual site model to characterize potential exposure pathways.

5.1.3 Characterization of Land Use

As discussed in Section 1.3, the land use within the core zone has been designated as industrial-exclusive in the CLUP EIS (DOE/EIS-0222-F). All of the waste sites associated with the 200-CW-5, 200-CW-2, 200-CW-4, and 200-SC-1 OU are located within the core zone.

Based on DOE/EIS-0222-F and the associated ROD (64 FR 61615), the industrial-exclusive land use is defined as "preserving DOE control of the continuing remediation activities and use of the existing compatible infrastructure required to support activities such as dangerous waste, radioactive waste, and mixed waste treatment, storage, and disposal facilities." The waste sites also meet the definition of an industrial property by meeting the following criteria:

- The 200-CW-5, 200-CW-2, 200-CW-4, and 200-SC-1 OUs do not serve as current residential areas
- The OUs have no potential to serve as future residential areas
- Access to the industrial property by the general public is not allowed or is greatly limited and controlled for safety or security considerations
- Food is not grown or raised on the property.

5.1.4 Groundwater Beneficial Use

Local groundwater is not a current source of drinking water at the 200-CW-5, 200-CW-2, 200-CW-4, and 200-SC-1 OU waste sites. In addition, groundwater beneath the waste sites is not anticipated to become a future source of drinking water until groundwater RBCs are met. Under current conditions, no complete human exposure pathways to groundwater are assumed at the waste sites. Risks associated with current contamination in the groundwater were not evaluated in this RI. The risks for the Central Plateau have been evaluated in PNNL-13788. Groundwater remediation will be addressed through the 200-BP-5, 200-PO-1, 200-UP-1, and 200-ZP-1 OU investigations.

The potential for contaminants to migrate from the soil to the groundwater was evaluated in the risk evaluation. Concentrations in soil were compared to groundwater protection RBCs for the nonradiological constituents. For radiological constituents, the RESRAD output (ANL/EAD-4) provided current and future simulations of contribution to groundwater risk from the movement of vadose contaminants to groundwater. Fate and transport modeling using the STOMP code (PNNL-12034) also were conducted to support evaluation of the protection of groundwater. The results of the STOMP modeling are provided in Chapter 4.0.

5.1.5 Conceptual Exposure Model for Human Health and the Environment

This section describes the potential exposure pathways from site contaminants, based on currently available site information. The conceptual exposure model is formulated according to EPA guidance (EPA/540/R-99/005, *Risk Assessment Guidance for Superfund, Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment) Interim*), with the use of professional judgment and information on contaminant sources, release mechanisms, routes of migration, potential exposure points, potential routes of exposure, and potential receptor groups associated with the site.

An exposure pathway can be described as the physical course that a COPC takes from the point of release to the receptor. Contaminant intake or route of exposure is the means by which a COPC enters a receptor. For an exposure pathway to be complete, all of the following components must be present:

- A contaminant source
- A mechanism of contaminant release and transport
- An exposure point (i.e., a location where people or wildlife can come into contact with the contaminants)
- An exposure route
- A receptor or exposed population.

In the absence of any one of these components, an exposure pathway is considered incomplete and, by definition, there is no risk or hazard. The conceptual exposure model for the waste sites is presented in Figure 5-1.

5.1.5.1 Contaminant Sources

The primary sources of contaminants at the three representative sites are described below.

The representative waste sites in the 200-CW-5 OU received primarily cooling water and steam condensate the 234-5Z Plutonium Finishing Plant (Z Plant) and support facilities and from the 221-U Plant and its support facilities. Contaminated process liquids typically did not come into direct contact with the waste streams, because the steam and cooling water were contained inside circulating coils inside the process. Therefore, the waste streams in these OUs generally are described as containing low-level radionuclides and chemicals from noncontact cooling water and steam condensate. Minor failures (i.e., pinholes and hair line cracks) of the coils used to cool the process vessels provided a pathway for contaminated liquid to enter these waste streams. Other accidental releases, such as operator error, have led to the contamination of the effluent discharged to this OU.

5.1.5.2 Release Mechanisms and Environmental Transport Media

The primary release mechanisms transporting the COPCs from the source, via environmental media, to potential receptors include the following:

- Infiltration, percolation, and leaching contaminants from waste sites to groundwater
- Direct contact with shallow-zone soil contaminant COPCs (receptor contact with onsite shallow-zone soil replaces release and transport)
- Generation of dust emanating from shallow-zone soil to ambient air from wind or during maintenance or construction activities at the site
- Volatilization of chemicals emanating from shallow-zone soil to ambient air at the site.

5.1.5.3 Potentially Complete Human Exposure Pathways and Receptors

On the basis of the current understanding of land-use conditions at and near the site, as represented in Figure 5-1, the most plausible exposure pathways considered for characterizing human health risks are described below.

For the purposes of this RA, the point of compliance for shallow-zone soils is defined as zero to 4.6 m (zero to15 ft) bgs and is evaluated using soil samples collected in this zone. This depth range is a reasonable estimate of the depth of soil that could be excavated and distributed to the surface as a result of development activities. The point of compliance to evaluate the protection of groundwater is defined as those samples collected throughout the soil profile.

Evaluation of radiological constituents in shallow-zone soil (for the direct-contact exposure pathways) was conducted using two different methods. The first evaluation method is considered representative of current site conditions, because it accounts for a depth of clean cover over the waste site. The shielding effects of the clean cover influence the resulting dose and risk estimates. The second evaluation method is considered representative of worst-case conditions; it assumes that no clean cover is present over the top of the representative waste site (i.e., the exposure point concentration [EPC] is representative of the entire shallow zone).

5.1.5.4 Industrial Land-Use Scenario

Under current and future site conditions, onsite industrial workers potentially could be exposed to shallow-zone soils from the site.

The industrial land-use scenario assumes that no groundwater from the waste site will be used for drinking purposes. Industrial soil RBCs for nonradiological constituents consider exposure through the direct contact pathway (incidental soil ingestion and dermal contact) and inhalation of dust and vapors in ambient air. For radiological constituents, potential routes of exposure to shallow-zone soil include external gamma radiation, incidental soil ingestion, and inhalation of dust particulates.

5.1.5.5 Protection of Groundwater

Constituents were evaluated for protection of groundwater. Soil concentrations of nonradiological constituents protective of groundwater RBCs were calculated using Federal MCLs and other groundwater standards. For radiological constituents, future impacts to the groundwater ingestion pathway were evaluated using the STOMP code (PNNL-12034); the results of this analysis are included in Chapter 4.0 of this RI report.

5.1.5.6 Potentially Complete Ecological Exposure Pathways and Receptors

The following ecological exposures potentially associated with the OUs will be considered for characterizing ecological risks:

- Potential current or future direct contact with, or ingestion of, surface soil by invertebrates (e.g., beetles)
- Direct contact with, or ingestion of, surface soil by avian (e.g., western meadowlark) and terrestrial (e.g., coyote) wildlife that may use the waste sites
- Bioaccumulation through ingestion of food items (e.g., plants, prey) consumed by wildlife that may forage at the waste sites.

5.1.5.7 Computation of Exposure Point Concentrations

The EPCs are estimated contaminant concentrations that a receptor may contact and are specific to each exposure medium (i.e., shallow- and deep-zone soils). For the direct contact routes of exposure, EPCs are represented by concentrations directly measured in soil. For the inhalation route, modeling was performed to estimate constituent concentrations in air from particulate or vapor emissions from soil see Appendix E).

Direct Contact Exposure Point Concentrations. The EPCs were calculated using the best statistical estimate of an upper bound on the average exposure concentrations. In accordance with EPA/630/R-92/001, *Framework for Ecological Risk Assessment*, the 95 percent upper confidence limit (UCL) on the mean is considered a conservative upper bound estimate that is not likely to underestimate the mean concentration and most likely overestimates that concentration. The maximum detected concentration was used in place of the 95 percent UCL when the calculated 95 percent UCL was greater than the maximum detected value. The procedure used to identify the statistical distribution type of each data set (i.e., normal or lognormal) and subsequent calculation of the EPC are provided in Appendix E.

Ambient Air Exposure Point Concentrations. Air concentrations were estimated by modeling particulate or vapor emissions from soil. Air concentrations from vapor emissions were estimated using a volatilization factor (VF) for those constituents that are considered volatile. Volatile constituents considered for the inhalation pathway are operationally defined as those constituents with a Henry's Law Constant greater than 10^{-5} atm-m^3/mole and a molecular weight of less than 200 g/M (EPA 2002b). Air concentrations from fugitive dust emissions were estimated using a particulate emissions factor (PEF) for those constituents that are not volatile. The following equation was used to estimate air concentrations from volatile or particulate emissions:

$$Air\ Concentration = C_s \times \left(\frac{1}{PEF} or \frac{1}{VF} \right)$$

where

C_s = soil concentration (mg/kg)

VF = volatilization factor (chemical-specific) (m^3/kg)

PEF = particulate emissions factor (1.32×10^9 m^3/kg).

The VFs for VOCs identified as a COPCs in shallow-zone soil were obtained from the EPA, 2002b, *Region 9 Preliminary Remediation Goals (PRG) 2002 Tables*. The PEF used to estimate fugitive dust emissions was obtained from EPA/540/R-96/018, *Soil Screening Guidance: Users Guide*.

5.2 HUMAN HEALTH RISK ASSESSMENT

This section presents the HHRA for the 200-CW-5 OU representative waste sites. This HHRA contains the following components:

- **Human Health Risk Assessment Guidance.** Lists the guidance documents used for the HHRA
- **Contaminants of Potential Concern for Human Health.** Identifies the constituents considered to be most important to the evaluation of human health risk
- **Human Exposure and Toxicity Assessment**. Identifies the pathways by which potential human exposures could occur; describes how they are evaluated; and evaluates the magnitude, frequency, and duration of these exposures. Identifies the sources of toxicity values used
- **Risk Assessment Results.** Integrates information from the exposure and toxicity assessments to characterize the risks to human health from potential exposure to contaminants in environmental media
- **Identification of Major Uncertainties and Assumptions.** Summarizes the basic assumptions used in the RA, as well as limitations of data and methodology.

5.2.1 Human Health Guidance

The procedures used for the HHRA are consistent with those described in the following DOE and EPA guidance documents:

- *Risk Assessment Guidance for Superfund (RAGS):* Volume I: *Human Health Evaluation Manual, Part A (Interim Final)* (EPA/540/1-89/002)

- *Risk Assessment Guidance for Superfund (RAGS): Volume 1, Human Health Evaluation Manual*, Supplemental Guidance: Standard Default Exposure Factors (OSWER Directive 9285.6-03)
- *Exposure Factor Handbook Volume 1: General Factors* (EPA/600/P-95/002Fa)
- *Risk Assessment Guidance for Superfund,* Volume I: *Human Health Evaluation Manual, Part E, Supplemental Guidance for Dermal Risk Assessment (Interim)* (EPA/540/R-99/005)
- *Proposed Guidelines for Carcinogen Risk Assessment* (EPA/600/P-92/003C)
- *Supplemental Guidance to RAGS: Calculating the Concentration Term* (OSWER Directive 9285.7-081).

5.2.2 Selection of Chemicals of Potential Concern

COPCs are those contaminants that should be carried through the human health risk quantification process. This component of the HHRA process summarizes those contaminants detected in environmental media during the RI and identifies the COPCs for environmental media that are accessible for human exposure. During the course of the HHRA, the COPCs are evaluated to identify and prioritize those contaminants that are estimated to pose an unacceptable risk and thus should be addressed by the FS.

5.2.2.1 Data Used for Contaminants of Potential Concern Selection

Data evaluated for this HHRA include shallow- and deep-zone soil samples collected during 2001 RI activities and from activities conducted before the 2001 RI. A summary of the sources of analytical data used in this RA is provided in Section 1.2 of this RI report.

Radioisotopic data from the 216-U-10 Pond, 216-U-14 Ditch, and 216-Z-11 Ditch Area (including the 216-Z-1D and 216-Z-19 Ditches) were decayed to current conditions (i.e., 2002). The 216-Z-1D and 216-Z-19 Ditches were included in this RA because the two waste sites are adjacent to the 216-Z-11 Ditch and share common areas along their length. A summary of all the samples included in this RA by station identification, sample identification, depth interval, and date of collection is presented in Tables 5-1 through 5-3. The following rules were used to identify data to be used in the HHRA.

- Estimated values flagged with a "B" (inorganics only) or "J" qualifier were treated as detected concentrations.
- Data qualified as rejected (flagged "R") were not used in the risk assessment.
- Only the parent sample result was included in the analysis when field duplicate or split samples were collected.

5.2.2.2 Criteria for Selection of Contaminants of Potential Concern for the Human Health Risk Assessment

Per EPA, Ecology, and DOE guidance documents, the factors considered in identifying COPCs for the study area are as follows:

- Identification of detected contaminants
- Frequency of detection
- Essential nutrients
- Background screening
- Availability of toxicity factors for use in calculating RBCs.

COPCs were identified separately for shallow-zone and deep-zone soil samples from each exposure area. Evaluation of the RA data using these criteria is discussed in the following subsections.

5.2.2.3 Identification of Detected Contaminants

As a conservative measure, all chemicals that were detected at least once in any of the shallow-zone or deep-zone soil samples were carried to the next step in the COPC selection process. Chemicals that were not detected in any of the soil samples (i.e., zero percent frequency of detection) were not selected as COPCs.

Shallow Zone (Evaluation of Human Health Risk Assessment)

The summary statistics for all radiological and nonradiological contaminants detected in shallow-zone soil samples at least once are presented in Tables 5-4 through 5-6.

216-Z-11 Ditch. A total of 30 nonradiological constituents and 15 radiological constituents were detected at least once in shallow soil.

216-U-10 Pond. A total of 47 nonradiological constituents and 26 radiological constituents were detected at least once in shallow soil.

216-U-14 Ditch. A total of 18 nonradiological constituents and 14 radiological constituents were detected at least once in shallow soil.

Deep Zone (Evaluation of Groundwater Protection)

The summary statistics for all radiological and nonradiological contaminants detected in deep-zone soil samples at least once are presented in Tables 5-7 through 5-9.

216-Z-11 Ditch. A total of 30 nonradiological constituents and 16 radiological constituents were detected at least once in deep soil.

216-U-10 Pond. A total of 48 nonradiological constituents and 26 radiological constituents were detected at least once in deep soil.

216-U-14 Ditch. A total of 27 nonradiological constituents and 15 radiological constituents were detected at least once in deep soil.

Frequency of Detection

Constituents detected in shallow-zone or deep-zone soil samples at a frequency of 5 percent or more were carried to the next step of the screening process. In addition, constituents detected at a frequency of less than 5 percent, but with maximum concentrations greater than 10 times the soil RBCs, were retained as COPCs.

Shallow Zone

The frequency of detection screening results for shallow-zone soils is provided below.

216-Z-11 Ditch. As shown in Table 5-4, no constituents were detected at a frequency of less than 5 percent; therefore, all constituents were carried forward into the next screening step.

216-U-10 Pond. As shown in Table 5-5, no constituents were detected at a frequency of less than 5 percent; therefore, all constituents were carried forward into the next screening step.

216-U-14 Ditch. As shown in Table 5-6, no constituents were detected at a frequency of less than 5 percent; therefore, all constituents were carried forward into the next screening step.

Deep Zone

The frequency of detection screening results for deep-zone soils is provided below.

216-Z-11 Ditch. As shown in Table 5-7, no constituents were detected at a frequency of less than 5 percent; therefore, all constituents were carried forward into the next screening step.

216-U-10 Pond. As shown in Table 5-8, selenium, diethyl phthalate, di-n-butyl phthalate, and pyrene were detected at a frequency of less than 5 percent. In addition, maximum concentrations of these constituents did not exceed 10 times their respective soil RBCs. Therefore, these constituents were eliminated from the COPC screening process.

216-U-14 Ditch. As shown in Table 5-9, plutonium-239 was detected at a frequency of less than 5 percent; therefore, this radiological constituent was eliminated from the COPC screening process. In addition, the maximum concentration for plutonium-239 does not exceed 10 times the industrial action level.

Essential Nutrients

Essential nutrients are those constituents considered essential for human nutrition. Recommended daily allowances are developed for essential nutrients to estimate safe and adequate daily dietary intakes (NAS 1989). Because aluminum, calcium, iron, magnesium, potassium, and sodium are considered to be essential nutrients and have no available toxicity factors, they were excluded from further consideration as COPCs.

Background Screening

The next criterion for identifying a COPC is its presence at a concentration higher than naturally occurring levels. Sitewide soil background levels have been established for most metals and radiological constituents at the Hanford Site. The statewide soil background level was used as the background level for cadmium. However, Sitewide and statewide soil background levels are not available for antimony, boron, cyanide, hexavalent chromium, molybdenum, selenium, thallium, americium-241, cobalt-60, europium-152, neptunium-237, selenium-79, sodium-22, and technetium-99; if these metals or radionuclides were detected, they were carried forward into the RA. Because background criteria have not been developed for VOCs, PCBs, or SVOCs in soils at the Hanford Site, any constituent detected in these fractions also was carried forward into the RA.

The maximum detected concentration of each metal or radionuclide detected in shallow-zone or deep-zone soil was compared to the 90th percentile background value. Summaries of metals and radiological constituents compared to background values for each representative waste site are provided in Tables 5-10 through 5-12 for shallow-zone soils and Tables 5-13 through 5-15 for deep-zone soils. A summary of metals detected at concentrations greater than naturally occurring levels is presented in Table 5-16.

Availability of Toxicity Values

If a toxicity value was not available from a reliable source or an appropriate surrogate could not be identified, then the contaminant was not included in the RA. Toxicity values were identified for all COPCs in soil, with the exception of 2,6-di-tert-butyl-p-benzoquinone, diacetone alcohol, tetrahydrofuran, TPH (including diesel oil and kerosene), and general chemical parameters(including ammonia, chloride, fluoride, sulfate, and sulfide). Therefore, the above constituents were not carried forward into the RA.

Although TPH was not carried forward into the RA, constituents (such as polycyclic aromatic hydrocarbons, benzene, toluene, ethylbenzene, and xylenes) that represent the greatest risk to human health are included. Suitable surrogate compounds could not be identified for 2,6-di-tert-butyl-p-benzoquinone, diacetone alcohol, tetrahydrofuran, TPH, and the general chemical parameters; the exclusion of these constituents from this RA potentially could underestimate risk at the site.

Summary of Contaminants Potential Concern

A summary of the COPCs selected for each representative waste site is presented in Table 5-17.

5.2.3 Human Exposure Assessment

The exposure assessment component of the HHRA identifies the populations that may be exposed; the routes by which these individuals may become exposed; and the magnitude, frequency, and duration of potential exposures. The human exposure assessment includes the following components:

- Discussion of the RESRAD risk assessment methodology
- Development of exposure assumptions for potentially complete exposure pathways
- Calculation of chemical intake for COPCs
- Source of toxicity values.

5.2.3.1 RESRAD Risk Assessment Methodology

The RA for radiological constituents was performed using RESRAD Version 6.2 analysis (ANL/EAD-4). The RESRAD model was used to obtain risk and dose estimates from direct contact exposure to radiological constituents present in the shallow-zone soils of the 200-CW-5 OU. The RESRAD model also was used to obtain risk and dose estimates for the protection of groundwater. The results obtained from the RESRAD model for the groundwater protection are useful for screening purposes only. Additional analysis will be performed using the STOMP model (PNNL-12034). The results of the groundwater protection modeling are provided in Chapter 4.0.

5.2.3.2 Human Exposure Assumptions

The estimation of exposure requires numerous assumptions to describe potential exposure scenarios. Upper-bound exposure assumptions are used to estimate "reasonable maximum" exposure (RME) conditions to provide a bounding estimate on exposure. The exposure assumptions and methodology used to develop soil RBCs for nonradiological constituents, and the assumptions and methodology used to calculate risk and dose estimates for radiological constituents, are described in the following sections.

5.2.3.3 Nonradiological Constituents

As discussed in the CSM, groundwater at the waste sites is not used for drinking water purposes. However, exposure assumptions are provided for the groundwater ingestion pathway for the purpose of evaluating the groundwater protection pathway.

The exposure assumptions used to develop industrial soil RBCs, and soil RBCs for the groundwater protection pathway for nonradiological constituents are listed in Tables 5-18 and 5-19, respectively. The scenarios evaluated were selected based on the conceptual exposure model (Section 5.1.5) and are consistent with the reasonably anticipated future land use.

Industrial Land-Use Scenario. Exposure estimates for current and future industrial workers are based on the assumption that a 70-kg adult would contact surface soil 146 days per year during a 20-year period. For the direct contact pathway, an incidental soil ingestion rate of 50 mg/day was assumed. For the inhalation pathway, an inhalation rate of 20 m^3/day was assumed. For the groundwater protection pathway, a drinking water ingestion rate of 2 L/day was assumed.

5.2.3.4 Radiological Constituents

Exposure assumptions and methodology used for developing risk and dose estimates for the industrial land use scenario were obtained from EPA guidance (EPA/540/R-92/003) and the RESRAD users manual (ANL/EAD-4). The exposure assumptions used to calculate risk and dose estimates for the industrial exposure scenario are listed in Table 5-20. The scenarios evaluated were selected based on the conceptual exposure model (Section 5.1.5) and are consistent with the reasonably anticipated future land uses.

The RESRAD model allows the use of site-specific chemical and physical parameters to estimate risk and dose. Site-specific parameters include depth of contamination, depth of a clean cover, soil density, volumetric moisture, and chemical-specific distribution coefficients (K_ds). A detailed list of the site-specific input parameters is provided in Table 5-20.

An analysis of K_ds was conducted based on several studies that have been prepared for the 200 Areas. The K_d values that were selected for use in the RESRAD modeling are provided in Table 4-30 of DOE/RL-2000-35, *200-CW-1 Operable Unit Remedial Investigation Report.* The zone F category values were used because this category represents the type of waste that was disposed to the 200-CW-5 OU waste sites. The zone F category is defined as sources with low organics, low salts, and near-neutral conditions. These K_ds were within the range from the various documents reviewed; additional analysis of K_ds may be conducted in the FS.

Radiological constituents within the shallow zone are evaluated using two separate methods. The first evaluation method is considered representative of current site conditions, because it accounts for the depth of clean cover that currently is over the representative waste site. Radiological constituents are encountered only at depths greater than the clean cover and accounts for the protective shielding effects. It was assumed that there is 1 m (3.2 ft) of clean cover over the 216-Z-11 Ditch, 0.6 m (2 ft) of clean cover over the 216-U-10 Pond, and 2.7 m (8.9 ft) of clean cover over the 216-U-14 Ditch.

The second evaluation method is considered representative of worst-case conditions because it assumes that there is no clean cover over the representative waste site. The absence of clean cover assumes that the radiological constituents are distributed evenly throughout the shallow zone and does not account for the protective effects of shielding by the cover materials.

Industrial Land-Use Scenario

Exposure estimates for the current and future industrial worker are based on the assumption that a 70-kg adult would be onsite 2,000 hours per year with 14 percent of the year spent indoors and 9 percent of the year spent outdoors during a 30-year period. An incidental soil ingestion rate of 100 mg/day and an inhalation rate of 20 m^3/day was assumed. For the groundwater protection pathway, a drinking water ingestion rate of 2 L/day was assumed.

5.2.3.5 Equations for Soil Risk-Based Concentrations

For the majority of nonradiological constituents detected, soil RBCs were obtained from the CLARC Table, Version 3.1 (Ecology Publication No. 94-145, 2001). Soil RBCs were not available for cobalt, nitrate, nitrite, PCB aroclor-1260, and uranium; therefore, soil RBCs were calculated for these constituents. The following subsections provide the equations used to calculate the soil RBCs under the industrial land-use exposure scenario for carcinogens and noncarcinogens. The exposure assumptions used to calculate the RBCs for each exposure scenario are listed in Table 5-18.

Carcinogens. The following equation was used to calculate the industrial soil RBCs for carcinogenic chemicals:

$$Soil\ RBC(mg/kg) = \frac{TR \times BWc \times ATC \times UCF}{CPF_o \times SIR \times ABS_{gi} \times EF \times ED}.$$

Noncarcinogens. The following equation was used to calculate the industrial soil RBCs for noncarcinogenic chemicals:

$$Soil\ RBC(mg/kg) = \frac{THQ \times BW_{nc} \times ATN \times UCF \times RfD_o}{EF \times ED \times SIR \times ABS_{gi}}.$$

Equations for Ambient Air Risk-Based Concentrations

Ambient air RBCs were calculated for all COPCs identified in Section 5.2.2. The following subsections provide the equations used to calculate the ambient air RBCs under the industrial land-use exposure scenario for carcinogens and noncarcinogens. The exposure assumptions used to calculate the RBCs for each exposure scenario are listed in Table 5-18.

Carcinogens. The following equation was used to calculate the industrial ambient air RBCs for carcinogenic chemicals:

$$Air\ RBC(mg/m^3) = \frac{TR \times BWc \times ATC}{CPF_i \times INH \times ABS_{INH} \times EF \times ED}.$$

Noncarcinogens. The following equation was used to calculate the industrial ambient air RBCs for noncarcinogenic chemicals:

$$Air\ RBC(mg/m^3) = \frac{THQ \times BW_{nc} \times ATN \times RfDi}{EF \times ED \times INH \times ABS_{inh}}.$$

5.2.3.6 Equations for Groundwater Risk-Based Concentrations Used in Evaluating Protection of Groundwater

Groundwater RBCs are used to calculated soil concentrations protective of groundwater. For the majority of nonradiological constituents detected, groundwater RBCs were obtained from the CLARC Tables, Version 3.1 (Ecology Publication No. 94-145, 2001). Groundwater RBCs were not available for cobalt, dichloro diphenyl dichloroethane, molybdenum, PCB Aroclor-1260, titanium, and uranium; therefore, groundwater RBCs were calculated for these constituents. The following subsections provide the equations used to calculate the groundwater RBCs for carcinogens and noncarcinogens. The exposure assumptions used to calculate the RBCs are listed in Table 5-19.

Carcinogens. The following equation was used to calculate the groundwater RBCs for carcinogenic chemicals:

$$Groundwater\ RBC(ug/L) = \frac{TR \times BWc \times ATC \times UCF}{CPF \times DWIR \times INH \times DWF \times EF \times ED}.$$

Noncarcinogens. The following equation was used to calculate the groundwater RBCs for noncarcinogenic chemicals:

$$Groundwater\ RBC(ug/L) = \frac{THQ \times BW_{nc} \times ATN \times UCF \times RfD_o}{DWF \times ED \times DWIR \times INH}.$$

5.2.3.7 Equations for Soil Concentrations Protective of Groundwater

The following subsections provide the equations used to calculate the soil concentrations that will not cause an exceedance of the groundwater RBC. The groundwater concentration (C_w) used in the equation was equal to the groundwater RBC unless a Federal drinking water MCL was available. When an MCL was available for a constituent, the lower of the MCL or the groundwater RBC was selected as the groundwater concentration. The three-phase partitioning equation was used to derive soil concentrations protective of groundwater.

$$C_s = C_w \times UCF \times DF \times \left[K_d + \frac{\theta_w + \theta_a \times H'}{\rho_b} \right]$$

where

C_s = calculated soil concentration (mg/kg)

C_w = groundwater RBC (µg/L)

UCF = unit conversion factor (1×10^{-3} mg/µg)

DF = dilution factor (20 unitless)

K_d = distribution coefficient (chemical-specific) (L/kg)

θ_w = water-filled soil porosity (0.3 mL/mL)

θ_a = air-filled soil porosity (0.13 mL/mL)

H' = Henry's law constant (chemical-specific) (dimensionless)

P_b = dry soil bulk density (1.5 kg/L).

When a published K_d was not available, the following equation was used to calculate the distribution coefficient.

$$K_d = K_{oc} \times f_{oc}$$

where

K_d = distribution coefficient (chemical-specific) (L/kg)

K_{oc} = soil organic carbon-water partitioning coefficient (chemical-specific) (mL/g)

F_{oc} = soil fraction of organic carbon (0.001 g/g).

A summary of the chemical-specific values used to calculate soil concentrations protective of groundwater is provided in Table 5-21.

5.2.3.8 Sources of Toxicity Values

The primary source of toxicity values (i.e., cancer potency factors and oral reference doses) is the EPA 2003 *Integrated Risk Information System* (IRIS) database. If a toxicity value is not available from IRIS, then toxicity values published in EPA/540/R-97/036, 1997, *Health Effects Assessment Summary Tables, FY 1997 Update*, (HEAST) for example; EPA, 2002b, *Region 9 Preliminary Remediation Goals (PRG) 2002 Tables*; or EPA, 2002a, *Region 3 Risk-Based Concentration (RBC) 2002 Tables* were used.

Toxicity values used to calculate the soil and groundwater RBCs are presented in Table 5-22 and were obtained from the following sources:

- IRIS, a database prepared and maintained by the EPA and available through the National Center for Environmental Assessment. IRIS is an electronic database containing health risk and EPA regulatory information on specific chemicals (EPA 2003)
- HEAST, provided by the EPA Office of Solid Waste and Emergency Response, is a compilation of toxicity values published in various health effects documents issued by EPA (EPA/540/R-97/036)
- The EPA, 2002b, *Region 9 Preliminary Remediation Goals (PRG) 2002 Tables* (October 2002) at www.epa.gov/docs/region09/waste/sfund/prg/index.html
- The EPA, 2003, *Region 3 Risk-Based Concentration (RBC) Tables* (April 2002) at www.epa.gov/reg3hwmd/risk/index.htm .

5.2.4 Risk Assessment Results for Nonradiological Constituents

All nonradiological COPCs identified in Section 5.2.2 were compared with the industrial soil RBCs developed for the direct contact pathway. Additionally, nonradiological constituents were compared to the soil RBCs protective of groundwater.

All RBCs developed for this site were based on chronic or carcinogenic threats. The true mean soil concentration was compared with its respective RBC. For the purposes of this RI report, contaminant concentrations were compared to risk-based concentrations developed under CERCLA guidance (EPA/540/R-92/003) using the excess lifetime cancer risk range of 10^{-4} to 10^{-6} and using a hazard quotient of 1.0 using an industrial land-use scenario. Because the waste sites in these OUs are within the Core Zone, risk-based concentrations used for screening correspond to a 10^{-5} risk level.

The hazard quotient can be back-calculated by dividing the concentration term by its respective noncancer RBC. As described above, a ratio greater than 1 suggests a potential for adverse health effects.

Carcinogenic risk is expressed as a probability of developing cancer as a result of lifetime exposure. For a given chemical and route of exposure, excess lifetime cancer risk can be back-calculated by dividing the concentration term by its cancer RBC, then multiplying by 10^{-5} (for industrial soil RBCs) to estimate chemical-specific risk. An excess lifetime cancer risk (ELCR) that exceeds the target risk threshold of $1x10^{-5}$ indicates that, as a plausible upper-bound, an individual has a 1-in-100,000 chance of developing cancer as a result of site-related exposure to a carcinogen during a 75-year lifetime under the specific exposure conditions at the site. The acceptable risk level for industrial land use is $1x10^{-5}$. Generally, the EPA considers action to be warranted at a site when cancer risks exceed $1x10^{-4}$ based on an RME scenario. Generally, action is not required for risks falling within $1x10^{-4}$ to $1x10^{-6}$. A hazard index (HI) (the ratio of chemical intake to the reference dose) greater than one indicates that there is some potential for adverse noncancer health effects associated with exposure to the contaminants of concern (OSWER Directive 9285.6-03). Generally, action is not required for hazard quotients (HQ) of less than one.

Comparison of Results to Direct-Contact and Groundwater Protection Risk-Based Concentrations

All representative waste sites evaluated for the 216-CW-5 OU are located in the core zone and were compared to the industrial land-use direct contact industrial soil RBCs and soil RBCs for protection of groundwater. Comparison results for each representative waste site are provided in Tables 5-23 through 5-25 for direct contact and in Tables 5-26 through 5-28 for the groundwater protection pathway.

216-Z-11 Ditch

Direct Contact. As shown in Table 5-23, the true mean concentrations for all constituents are less than their respective industrial soil RBCs.

Groundwater Protection. As shown in Table 5-26, with the exception of Aroclor-1254, Aroclor-1260, and nitrite, the true mean concentration for all constituents is less than their respective soil RBCs. The true mean concentration of Aroclor-1254 (4.3 mg/kg) and Aroclor-1260 (6.5 mg/kg) exceeds the soil RBC of 3.1 mg/kg. The true mean concentration of nitrite (33 mg/kg) exceeds the soil RBC of 13 mg/kg.

216-U-10 Pond

Direct Contact. As shown in Table 5-24, the true mean concentrations for all constituents are less than their respective industrial soil RBCs.

Groundwater Protection. As shown in Table 5-27, with the exception of total uranium, the true mean concentrations for all constituents are less than their respective soil RBCs for groundwater protection. The true mean concentration for total uranium (19 mg/kg) exceeds the soil RBC for groundwater protection of 1.3 mg/kg.

216-U-14 Ditch

Direct Contact. As shown in Table 5-25, the true mean concentrations for all constituents are less than their respective industrial soil RBCs.

Groundwater Protection. As shown in Table 5-28, the true mean concentrations for all constituents are less than their respective soil RBCs for groundwater protection.

Results of Comparison to Ambient Air Risk-Based Concentrations

Shallow-zone soil sample results from each representative waste site were pooled, and the maximum detected concentration of each COPC identified was compared with the industrial ambient air RBC. Maximum air concentrations were calculated using the methodology presented in Section 5.2.3. A comparison of maximum air concentrations to industrial ambient air RBCs for each representative waste site is presented in Tables 5-29 through 5-31. As shown, the maximum air concentrations for all constituents are less than their respective industrial ambient air RBCs.

5.2.5 Risk Assessment Results for Radiological Constituents

All radiological COPCs identified in Section 5.2.2 were evaluated under the industrial and groundwater protection exposure scenarios. The direct contact exposure scenario was evaluated with and without cover material. All representative waste sites were evaluated with the absence of clean cover, assuming a contaminated zone ranging from zero to 4.6 m (zero to 15 ft) (contaminant concentrations are provided in Tables 5-4 through 5-6 for shallow-zone soil and Tables 5-7 through 5-9 for deep-zone soil). When a clean cover was present, the depth of clean cover was assumed to be 1 m (3.2 ft) at the 216-Z-11 Ditch, 0.6 m (2 ft) at the 216-U-10 Pond, and 2.7 m (8.9 ft) at the 216-U-14 Ditch. In addition, exposure times were carried out to 1,000 years or more for each of the representative waste sites.

For the purposes of this RA, the radiation dose limit for the industrial direct-contact exposure scenario is 15 mrem/year (10 CFR 835, "Radiation Protection for Occupational Workers"). This dose limit is developed for members of the public who are unknowingly exposed to radiation and is approximately equivalent to an ELCR of 1×10^{-4}. The radiation dose limit for the groundwater protection exposure pathway is 4 mrem/year, which is based on the co-occurring beta/photo-radioactivity MCL.

5.2.5.1 Summary of Dose and Risk Estimates for Radiological Constituents

A summary of the dose and risk estimates for each of the representative waste sites is provided in Tables 5-32 through 5-35 for direct contact exposure pathway and in Tables 5-36 and 5-37 for the groundwater protection pathway.

For comparative purposes, risk and dose estimates are discussed relative to the following exposure times.

- 50 years is the estimated length of time that DOE will have an onsite presence.
- 150 years is the estimated length of time that institutional controls can be assumed to be effective.

Dose estimates are provided for the exposure time when the target dose limit of 15 mrem/year is achieved.

216-Z-11 Ditch

Industrial Scenario – 1.0 m Clean Cover. The results of the RESRAD dose estimates for shallow-zone soil with clean cover for the industrial, direct-contact scenario are presented in Table 5-32. The total dose from this waste site does not exceed the target dose level of 15 mrem/year at any of the exposure times evaluated.

The results of the RESRAD risk estimates for shallow-zone soil with clean cover for the industrial, direct-contact scenario are presented in Table 5-33. The ELCR does not exceed $1x10^{-5}$ at any of the exposure times evaluated.

Industrial Scenario – Without Cover. The results of the RESRAD dose estimates for shallow-zone soil without clean cover for the industrial, direct-contact scenario are presented in Table 5-34. The exposure routes and radionuclides that are the primary contributors to dose are presented in Figure 5-2. The maximum total dose of 44,700 mrem/year occurs at zero and 1 year at this waste site. The total dose then ranges from 43,800 mrem/year at 50 years to 24,000 mrem/year at 4,000 years[6]. The primary contributors to dose include plutonium-239, and radium-226.

The results of the RESRAD risk estimates for shallow-zone soil without clean cover for the industrial, direct-contact scenario are presented in Table 5-35. The exposure routes and radionuclides that are the primary contributors to risk are presented in Figure 5-3. The maximum ELCR of $2.8x10^{-1}$ occurs at zero and 1 year at this waste site. The ELCR then ranges from $2.7x10^{-1}$ at 50 years to $7.3x10^{-2}$ at 4,000 years; the primary contributors to ELCR include plutonium-239, and radium-226.

[6] Because of limitations of the RESRAD model, the exposure time when the target dose limit of 15 mrem/year is achieved could not be determined.

Groundwater Protection Scenario. The results of the RESRAD dose and risk estimates for the groundwater protection pathway are presented in Tables 5-36 and 5-37, respectively. As shown, there are no radiological constituents at this representative waste site that affect the groundwater pathway.

216-U-10 Pond

Industrial Scenario – 0.6 m Clean Cover. The results of the RESRAD dose estimates for shallow-zone soil with clean cover for the industrial, direct-contact scenario are presented in Table 5-32. The total dose from this waste site does not exceed the target dose level of 15 mrem/year at any of the exposure times evaluated.

The results of the RESRAD risk estimates for shallow-zone soil with clean cover for the industrial, direct contact scenario are presented in Table 5-33. With the exception of the 1,000-year exposure time, the ELCR does not exceed 1×10^{-5} at any of the exposure times evaluated. The ELCR at 1,000 years was 9×10^{-5}. The primary contributors to risk at 1,000 years include thorium-228 (43 percent contribution), radium-226 (21 percent contribution), and radium-228 (23 percent contribution).

Industrial Scenario – Without Cover. The results of the RESRAD dose estimates for the shallow-zone soil without cover for the industrial, direct-contact scenario are presented in Table 5-34. The exposure routes and radionuclides that are the primary contributors to dose are shown in Figure 5-4. The total dose is 846 mrem/year at 50 years, 93 mrem/year at 150 years, and 8.7 mrem/year at 500 years, which is below the target dose limit of 15 mrem/year. The primary contributor to dose is cesium-137 at 50 and 150 years.

The results of the RESRAD risk estimates for shallow-zone soil with clean cover for the industrial, direct-contact scenario are presented in Table 5-35. The exposure routes and radionuclides that are the primary contributors to risk are shown in Figure 5-5. The ELCR is 1.1×10^{-2} at 50 years, 1.2×10^{-3} at 150 years, 9.4×10^{-5} at 500 years, and 8.5×10^{-5} at 1,000 years. The ELCR exceeds 1×10^{-5} at all exposure times evaluated. The primary contributors to risk include cesium-137 (from 50 to 150 years); and thorium-228, radium-226, and radium-228 (from 500 to 1,000 years).

Groundwater Protection Scenario. The results of the RESRAD dose estimates for the groundwater protection pathway are presented in Table 5-36. The radionuclides that are the primary contributors to dose and risk are presented in Figure 5-6. The maximum total dose of 72 mrem/year occurs at 37 years. With the exception of the total dose at 37 years, no other exposure times evaluated exceed the target dose limit of 4 mrem/year. The primary contributor to dose is selenium-79.

The results of the RESRAD risk estimates for the groundwater protection pathway are presented in Table 5-37. The maximum ELCR of 1.7×10^{-4} occurs at 37 years and the ELCR is 1.1×10^{-6} at 50 years. With the exception of the ELCR at 37 years, no other exposure times evaluated exceed the target risk level of 1×10^{-6}. The primary contributor to risk is selenium-79.

All RBCs developed for this site were based on chronic or carcinogenic threats. The true mean soil concentration was compared with its respective RBC. For the purposes of this RI report, contaminant concentrations were compared to risk-based concentrations developed under CERCLA guidance (EPA/540/R-92/003) using the excess lifetime cancer risk range of 10^{-4} to 10^{-6} and using a hazard quotient of 1.0 using an industrial land-use scenario. Because the waste sites in these OUs are within the Core Zone, risk-based concentrations used for screening correspond to a 10^{-5} risk level.

The hazard quotient can be back-calculated by dividing the concentration term by its respective noncancer RBC. As described above, a ratio greater than 1 suggests a potential for adverse health effects.

Carcinogenic risk is expressed as a probability of developing cancer as a result of lifetime exposure. For a given chemical and route of exposure, excess lifetime cancer risk can be back-calculated by dividing the concentration term by its cancer RBC, then multiplying by 10^{-5} (for industrial soil RBCs) to estimate chemical-specific risk. An excess lifetime cancer risk (ELCR) that exceeds the target risk threshold of $1x10^{-5}$ indicates that, as a plausible upper-bound, an individual has a 1-in-100,000 chance of developing cancer as a result of site-related exposure to a carcinogen during a 75-year lifetime under the specific exposure conditions at the site. The acceptable risk level for industrial land use is $1x10^{-5}$. Generally, the EPA considers action to be warranted at a site when cancer risks exceed $1x10^{-4}$ based on an RME scenario. Generally, action is not required for risks falling within $1x10^{-4}$ to $1x10^{-6}$. A hazard index (HI) (the ratio of chemical intake to the reference dose) greater than one indicates that there is some potential for adverse noncancer health effects associated with exposure to the contaminants of concern (OSWER Directive 9285.6-03). Generally, action is not required for hazard quotients (HQ) of less than one.

Comparison of Results to Direct-Contact and Groundwater Protection Risk-Based Concentrations

All representative waste sites evaluated for the 216-CW-5 OU are located in the core zone and were compared to the industrial land-use direct contact industrial soil RBCs and soil RBCs for protection of groundwater. Comparison results for each representative waste site are provided in Tables 5-23 through 5-25 for direct contact and in Tables 5-26 through 5-28 for the groundwater protection pathway.

216-Z-11 Ditch

Direct Contact. As shown in Table 5-23, the true mean concentrations for all constituents are less than their respective industrial soil RBCs.

Groundwater Protection. As shown in Table 5-26, with the exception of Aroclor-1254, Aroclor-1260, and nitrite, the true mean concentration for all constituents is less than their respective soil RBCs. The true mean concentration of Aroclor-1254 (4.3 mg/kg) and Aroclor-1260 (6.5 mg/kg) exceeds the soil RBC of 3.1 mg/kg. The true mean concentration of nitrite (33 mg/kg) exceeds the soil RBC of 13 mg/kg.

216-U-10 Pond

Direct Contact. As shown in Table 5-24, the true mean concentrations for all constituents are less than their respective industrial soil RBCs.

Groundwater Protection. As shown in Table 5-27, with the exception of total uranium, the true mean concentrations for all constituents are less than their respective soil RBCs for groundwater protection. The true mean concentration for total uranium (19 mg/kg) exceeds the soil RBC for groundwater protection of 1.3 mg/kg.

216-U-14 Ditch

Direct Contact. As shown in Table 5-25, the true mean concentrations for all constituents are less than their respective industrial soil RBCs.

Groundwater Protection. As shown in Table 5-28, the true mean concentrations for all constituents are less than their respective soil RBCs for groundwater protection.

Results of Comparison to Ambient Air Risk-Based Concentrations

Shallow-zone soil sample results from each representative waste site were pooled, and the maximum detected concentration of each COPC identified was compared with the industrial ambient air RBC. Maximum air concentrations were calculated using the methodology presented in Section 5.2.3. A comparison of maximum air concentrations to industrial ambient air RBCs for each representative waste site is presented in Tables 5-29 through 5-31. As shown, the maximum air concentrations for all constituents are less than their respective industrial ambient air RBCs.

5.2.5 Risk Assessment Results for Radiological Constituents

All radiological COPCs identified in Section 5.2.2 were evaluated under the industrial and groundwater protection exposure scenarios. The direct contact exposure scenario was evaluated with and without cover material. All representative waste sites were evaluated with the absence of clean cover, assuming a contaminated zone ranging from zero to 4.6 m (zero to 15 ft) (contaminant concentrations are provided in Tables 5-4 through 5-6 for shallow-zone soil and Tables 5-7 through 5-9 for deep-zone soil). When a clean cover was present, the depth of clean cover was assumed to be 1 m (3.2 ft) at the 216-Z-11 Ditch, 0.6 m (2 ft) at the 216-U-10 Pond, and 2.7 m (8.9 ft) at the 216-U-14 Ditch. In addition, exposure times were carried out to 1,000 years or more for each of the representative waste sites.

For the purposes of this RA, the radiation dose limit for the industrial direct-contact exposure scenario is 15 mrem/year (10 CFR 835, "Radiation Protection for Occupational Workers"). This dose limit is developed for members of the public who are unknowingly exposed to radiation and is approximately equivalent to an ELCR of 1×10^{-4}. The radiation dose limit for the groundwater protection exposure pathway is 4 mrem/year, which is based on the co-occurring beta/photo-radioactivity MCL.

5.2.5.1 Summary of Dose and Risk Estimates for Radiological Constituents

A summary of the dose and risk estimates for each of the representative waste sites is provided in Tables 5-32 through 5-35 for direct contact exposure pathway and in Tables 5-36 and 5-37 for the groundwater protection pathway.

For comparative purposes, risk and dose estimates are discussed relative to the following exposure times.

- 50 years is the estimated length of time that DOE will have an onsite presence.
- 150 years is the estimated length of time that institutional controls can be assumed to be effective.

Dose estimates are provided for the exposure time when the target dose limit of 15 mrem/year is achieved.

216-Z-11 Ditch

Industrial Scenario – 1.0 m Clean Cover. The results of the RESRAD dose estimates for shallow-zone soil with clean cover for the industrial, direct-contact scenario are presented in Table 5-32. The total dose from this waste site does not exceed the target dose level of 15 mrem/year at any of the exposure times evaluated.

The results of the RESRAD risk estimates for shallow-zone soil with clean cover for the industrial, direct-contact scenario are presented in Table 5-33. The ELCR does not exceed $1x10^{-5}$ at any of the exposure times evaluated.

Industrial Scenario – Without Cover. The results of the RESRAD dose estimates for shallow-zone soil without clean cover for the industrial, direct-contact scenario are presented in Table 5-34. The exposure routes and radionuclides that are the primary contributors to dose are presented in Figure 5-2. The maximum total dose of 44,700 mrem/year occurs at zero and 1 year at this waste site. The total dose then ranges from 43,800 mrem/year at 50 years to 24,000 mrem/year at 4,000 years[6]. The primary contributors to dose include plutonium-239, and radium-226.

The results of the RESRAD risk estimates for shallow-zone soil without clean cover for the industrial, direct-contact scenario are presented in Table 5-35. The exposure routes and radionuclides that are the primary contributors to risk are presented in Figure 5-3. The maximum ELCR of $2.8x10^{-1}$ occurs at zero and 1 year at this waste site. The ELCR then ranges from $2.7x10^{-1}$ at 50 years to $7.3x10^{-2}$ at 4,000 years; the primary contributors to ELCR include plutonium-239, and radium-226.

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[6] Because of limitations of the RESRAD model, the exposure time when the target dose limit of 15 mrem/year is achieved could not be determined.

Groundwater Protection Scenario. The results of the RESRAD dose and risk estimates for the groundwater protection pathway are presented in Tables 5-36 and 5-37, respectively. As shown, there are no radiological constituents at this representative waste site that affect the groundwater pathway.

216-U-10 Pond

Industrial Scenario – 0.6 m Clean Cover. The results of the RESRAD dose estimates for shallow-zone soil with clean cover for the industrial, direct-contact scenario are presented in Table 5-32. The total dose from this waste site does not exceed the target dose level of 15 mrem/year at any of the exposure times evaluated.

The results of the RESRAD risk estimates for shallow-zone soil with clean cover for the industrial, direct contact scenario are presented in Table 5-33. With the exception of the 1,000-year exposure time, the ELCR does not exceed $1x10^{-5}$ at any of the exposure times evaluated. The ELCR at 1,000 years was $9x10^{-5}$. The primary contributors to risk at 1,000 years include thorium-228 (43 percent contribution), radium-226 (21 percent contribution), and radium-228 (23 percent contribution).

Industrial Scenario – Without Cover. The results of the RESRAD dose estimates for the shallow-zone soil without cover for the industrial, direct-contact scenario are presented in Table 5-34. The exposure routes and radionuclides that are the primary contributors to dose are shown in Figure 5-4. The total dose is 846 mrem/year at 50 years, 93 mrem/year at 150 years, and 8.7 mrem/year at 500 years, which is below the target dose limit of 15 mrem/year. The primary contributor to dose is cesium-137 at 50 and 150 years.

The results of the RESRAD risk estimates for shallow-zone soil with clean cover for the industrial, direct-contact scenario are presented in Table 5-35. The exposure routes and radionuclides that are the primary contributors to risk are shown in Figure 5-5. The ELCR is $1.1x10^{-2}$ at 50 years, $1.2x10^{-3}$ at 150 years, $9.4x10^{-5}$ at 500 years, and $8.5x10^{-5}$ at 1,000 years. The ELCR exceeds $1x10^{-5}$ at all exposure times evaluated. The primary contributors to risk include cesium-137 (from 50 to 150 years); and thorium-228, radium-226, and radium-228 (from 500 to 1,000 years).

Groundwater Protection Scenario. The results of the RESRAD dose estimates for the groundwater protection pathway are presented in Table 5-36. The radionuclides that are the primary contributors to dose and risk are presented in Figure 5-6. The maximum total dose of 72 mrem/year occurs at 37 years. With the exception of the total dose at 37 years, no other exposure times evaluated exceed the target dose limit of 4 mrem/year. The primary contributor to dose is selenium-79.

The results of the RESRAD risk estimates for the groundwater protection pathway are presented in Table 5-37. The maximum ELCR of $1.7x10^{-4}$ occurs at 37 years and the ELCR is $1.1x10^{-6}$ at 50 years. With the exception of the ELCR at 37 years, no other exposure times evaluated exceed the target risk level of $1x10^{-6}$. The primary contributor to risk is selenium-79.

216-U-14 Ditch

Industrial Scenario – 2.7 m Clean Cover. The results of the RESRAD dose estimates for shallow-zone soil with clean cover for the industrial, direct-contact scenario are presented in Table 5-32. The total dose from this waste site does not exceed the target dose level of 15 mrem/year at any of the exposure times evaluated.

The results of the RESRAD risk estimates for shallow-zone soil with clean cover for the industrial, direct-contact scenario are presented in Table 5-33. The ELCR from this waste site does not exceed $1x10^{-5}$ at any of the exposure times evaluated.

Industrial Scenario – Without Cover. The results of the RESRAD dose estimates for the shallow-zone soil without cover for the industrial, direct-contact scenario are presented in Table 5-34. The exposure routes and radionuclides that are the primary contributors to dose are shown in Figure 5-7. The total dose is 437 mrem/year at 50 years, 46 mrem/year at 150 years, and 1.7 mrem/year at 500 years, which is below the target dose limit of 15 mrem/year. The primary contributor to dose is cesium-137 from 50 to 150 years.

The results of the RESRAD risk estimates for shallow-zone soil with clean cover for the industrial, direct-contact scenario are presented in Table 5-35. The exposure routes and radionuclides that are the primary contributors to risk are shown in Figure 5-8. The ELCR is $5.9x10^{-3}$ at 50 years, $6.2x10^{-4}$ at 150 years, $2.4x10^{-5}$ at 500 years, and $1.4x10^{-5}$ at 1,000 years. The ELCR exceeds $1x10^{-5}$ at all exposure times evaluated. The primary contributors to risk include cesium-137 (from 50 to 150 years) and potassium-40 (from 500 to 1,000 years).

Groundwater Protection Scenario. The results of the RESRAD dose estimates for the groundwater protection pathway are presented in Table 5-36. The radionuclides that are the primary contributors to dose and risk are presented in Figure 5-9. The maximum total dose of 17 mrem/year occurs at 37 years. With the exception of the total dose at 37 years, no other exposure times evaluated exceed the target dose limit of 4 mrem/year. The primary contributor to dose is technetium-99.

The results of the RESRAD risk estimates for the groundwater protection pathway are presented in Table 5-37. The maximum ELCR of $9.9x10^{-5}$ occurs at 37 years and the ELCR is $9.6x10^{-5}$ at 50 years. With the exception of the ELCR at 37 and 50 years, no other exposure times evaluated exceed the target risk level of $1x10^{-6}$. The primary contributor to risk is technetium-99.

5.2.6 Uncertainty Analysis

Uncertainties associated with sampling and analysis include the inherent variability (standard error) in the analysis, representativeness of the samples, sampling errors, and heterogeneity of the sample matrix. While the QA/QC program used in conducting the sampling and analysis serves to reduce errors, it cannot eliminate all errors associated with sampling and analysis. A summary of the uncertainties associated with the HHRA is presented in Table 5-38.

5.2.6.1 Uncertainty Associated with Exposure Assessment

Future soil EPCs were assumed to be equal to existing soil concentrations. This assumption does not account for fate and transport processes likely to occur in the future; risk estimates are likely to be overestimated for future exposure scenarios.

The estimation of exposure requires many assumptions to describe potential exposure situations. There are uncertainties regarding the likelihood of exposure, the frequency of contact with contaminated media, the concentration of contaminants at exposure points, and the time period of exposure. These tend to simplify and approximate actual site conditions. In general, these assumptions are intended to be conservative and to yield an overestimate of the true risk or hazard.

The exposure assumptions conservatively estimate the current and future industrial land-use scenario risks. A worker is unlikely to remain at the same place of employment for 146 days a year during a 25-year-exposure duration. The default exposure assumptions for the industrial land-use scenarios likely overestimates risk at the site.

5.2.6.2 Uncertainty Associated with Toxicity Assessment

The toxicological database was also a source of uncertainty. EPA has outlined some of the sources of uncertainty in the RAGS guidance (EPA/540/1-89/002). These sources may include or result from the extrapolation from high to low doses and from animals to humans; the species, gender, age, and strain differences in a toxin's uptake, metabolism, organ distribution, and target site susceptibility; and the human population's variability with respect to diet, environment, activity patterns, and cultural factors.

Suitable surrogate compounds could not be identified for 2,6-di-tert-butyl-p-benzoquinone, diacetone alcohol, tetrahydrofuran, TPH, and the general chemical parameters; the exclusion of these constituents from this RA potentially could underestimate risk at the site.

5.2.6.3 Uncertainty Associated with Risk Characterization

In the risk characterization, the assumption was made that the total risk of developing cancer from exposure to site contaminants is the sum of the risk attributed to each individual contaminant. Likewise, the potential for the development of noncancer adverse effects is the sum of the HQs estimated for exposure to each individual contaminant. This approach, in accordance with EPA guidance, did not account for the possibility that constituents act synergistically or antagonistically.

5.3 ECOLOGICAL RISK SCREENING

DOE/RL-2001-54 presents the screening-level ecological risk assessment for the Central Plateau. This section presents a comparison of contaminant data from the soil sampling conducted in DOE-RL 95-13, WHC-EP-0698, and WHC-EP-0707 against ecological soil indicator concentrations for nonradionuclide and radionuclide constituents provided by Ecology and DOE, respectively. In this RI Report, site-specific screening evaluations were performed for the protection of terrestrial wildlife. Soil EPCs for each representative site were compared with the ecological (wildlife) soil indicator concentrations listed in WAC 173-340-900, Table 749-3. The EPCs are determined based on the statistical validity of either the 95 percent UCL or the maximum value of each constituent sampled. Maximum concentrations were used as EPCs for the 216-U-14 Ditch throughout the comparison tables in this section. The results of the EPC comparison to the WAC 173-340-900, Table 749-3, ecological soil indicator concentrations are provided in Table 5-39.

For radiological constituents, soil screening concentrations called biota concentration guides (BCG) proposed in DOE's technical standard *A Graded Approach for Evaluating Radiation Doses to Aquatic and Terrestrial Biota* (Technical Standard) (DOE-STD-1153-2002) are used in the screening-level evaluation. The Technical Standard (DOE-STD-1153-2002) was prepared for DOE by the Biota Dose Assessment Committee (BDAC) and presents soil screening levels for select radionuclides as well as a methodology for conducting ecological RAs for radionuclide exposure. The DOE graded approach for evaluating radiation doses to biota is a three-step process that is designed to guide a user from an initial, conservative general screening to a more rigorous analysis using site-specific information, if needed. The three-step process is as follows.

- Assemble radionuclide concentration data and knowledge of sources, receptors, and routes of exposure for the area to be evaluated.
- Apply an easy-to-use general screening methodology that provides limiting radionuclide concentration values (i.e., BCGs) in soil, sediment, and water.
- If needed, conduct an analysis through site-specific screening, site-specific analysis, or an actual site-specific biota dose assessment conducted within an ecological risk framework, similar to that recommended by the EPA (EPA/630/R-95/002F, *Guidelines for Ecological Risk Assessment*).

Any steps within the graded approach may be used at any time, but the general screening methodology usually will be the simplest, most cost effective, and least time consuming.

The BCGs contained in the Technical Standard (DOE-STD-1153-2002) are soil radionuclide concentrations judged to be protective of the most sensitive terrestrial organisms, assuming a dose of 0.1 rad/day.[7] Each radionuclide-specific BCG listed in Table 6.4 of the Technical Standard (DOE-STD-1153-2002) represents the limiting radionuclide concentration in environmental media that would not exceed DOE's established or recommended dose standards for biota. Therefore, soil concentrations less than the BCGs are not considered to pose a threat to terrestrial receptors. Table 5-40 provides the results of the screening of radionuclide contaminants against BCGs for the protection of terrestrial wildlife.

The following text summarizes the results of the preliminary terrestrial ecological risk screening process for nonradionuclide and radionuclide contaminants. Contaminants that require further evaluation are identified for assessment during the FS.

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[7] Wildlife species are assumed to be protected at sites containing a dose of up to 0.1 rad/day. Terrestrial plant species are assumed to be protected at sites containing a dose of up to 1 rad/day (DOE-STD-1153-2002).

216-Z-11 Ditches

- Americium-241, cesium-137, plutonium-238, plutonium-239, plutonium-239/240, radium-226, and thorium-228 exceeded the soil BCG screening levels for radionuclides and will require further evaluation in the ecological risk assessment in the FS.
- Aroclor-1260 was identified above the ecological soil indicator screening level for PCBs in WAC 173-340-7490, Table 749-3, and will require further evaluation in the FS.
- Wildlife soil indicator concentrations were not available for comparison. Boron will require further evaluation in the FS.

216-U-10 Pond

- Cesium-137 and strontium-90 concentrations exceeded the soil BCG screening levels for radionuclides and will require further evaluation in the FS.
- Europium-152 and neptunium-237 do not have established soil BCG screening values. These constituents will require further evaluation in the FS.
- Selenium was identified above the ecological soil indicator screening level, as identified in WAC 173-340-7490, Table 749-3, and will require further evaluation in the FS.
- Wildlife soil indicator concentrations were not available for comparison for antimony, silver, thallium, uranium, diethylphthalate, di-n-butylphthalate, or toluene. These constituents will require further evaluation in the FS.

216-U-14 Trench

- All radionuclide soil concentrations were below BCG screening levels; therefore, no additional radionuclide evaluation is required.
- Wildlife soil indicator concentrations were not available for comparison for antimony or silver. These constituents will require further evaluation in the FS.

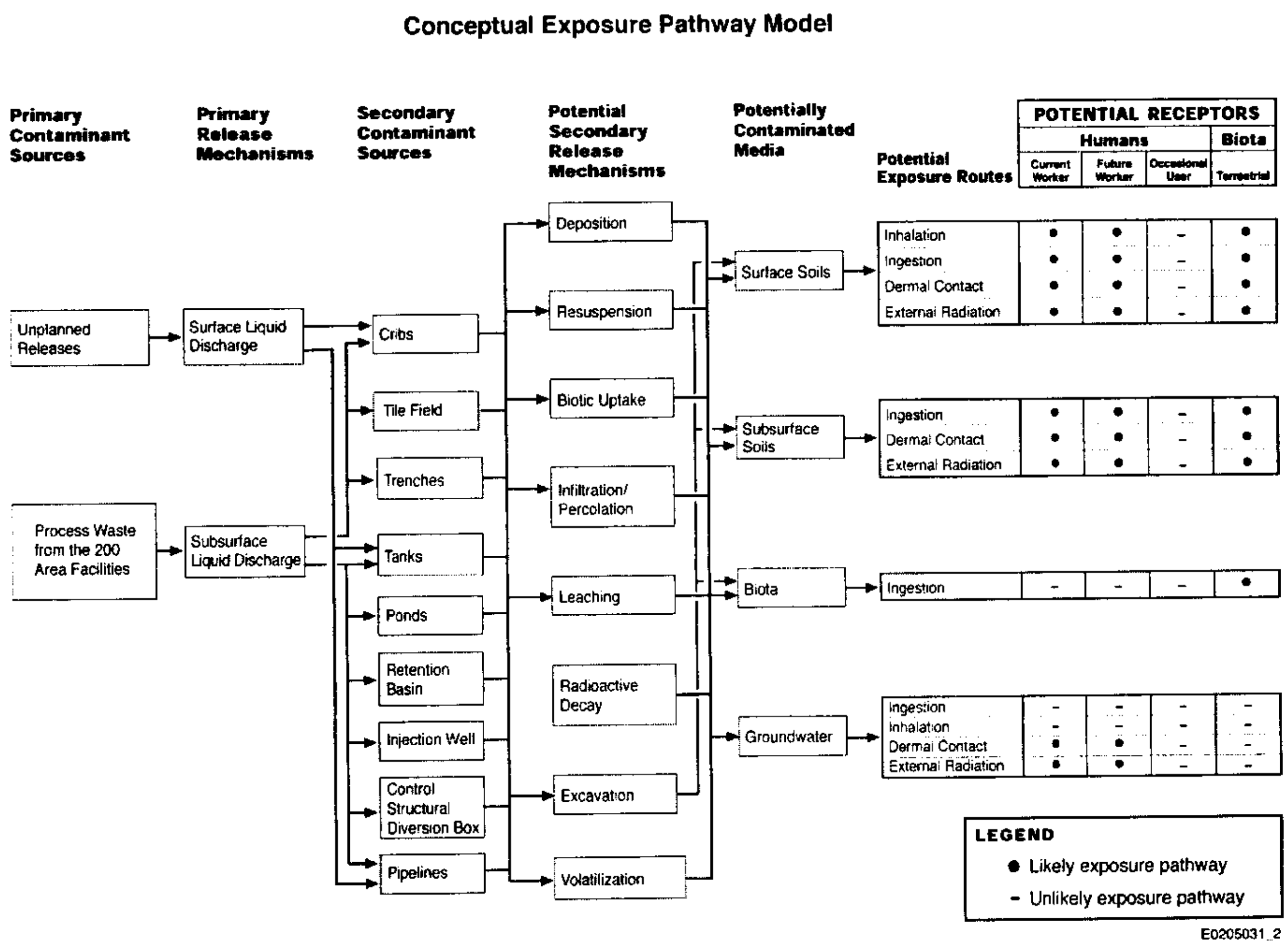
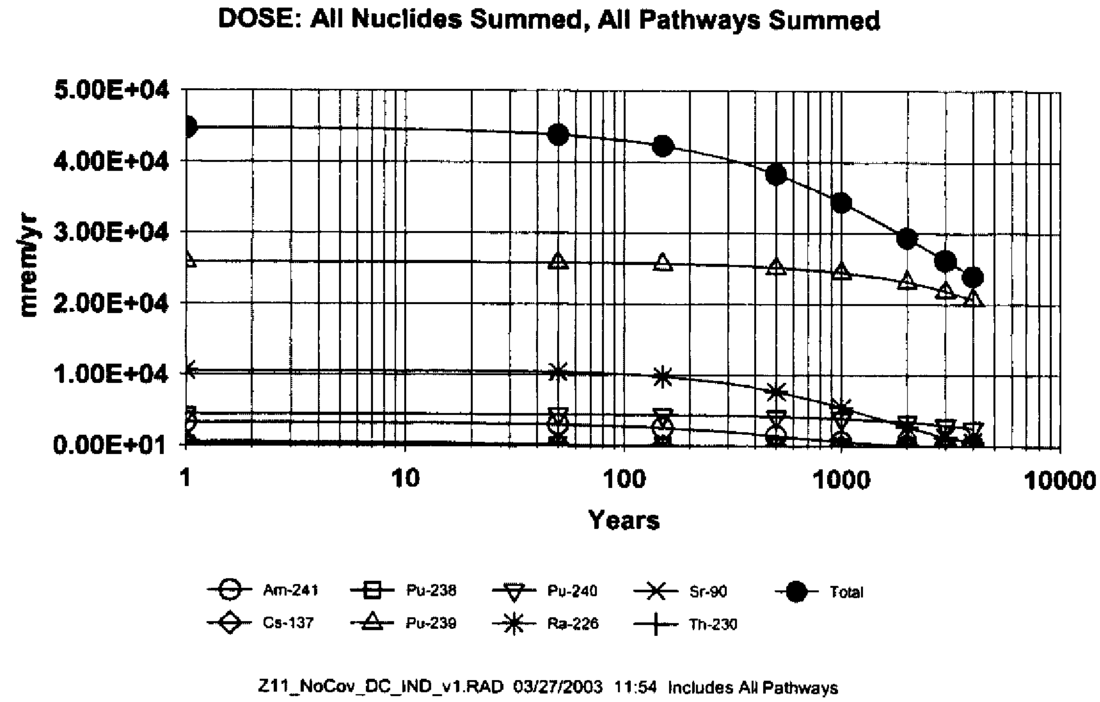


Figure 5-1. Conceptual Exposure Model for the 200-CW-5, 200-CW-2, 200-CW-4, and 200-SC-1 Operable Units.

Figure 5-2. RESRAD Analysis for the 216-Z-11 Ditch – All Radionuclides, All Pathways Dose Estimate (No Cover, Direct Contact, Industrial Scenario).



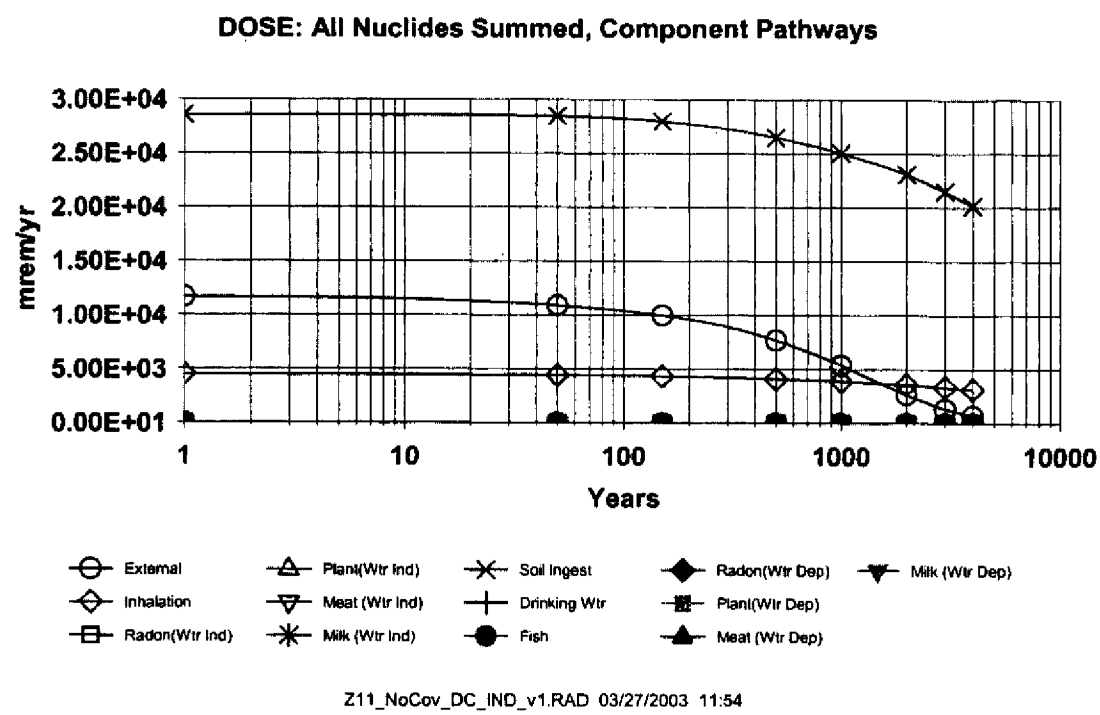
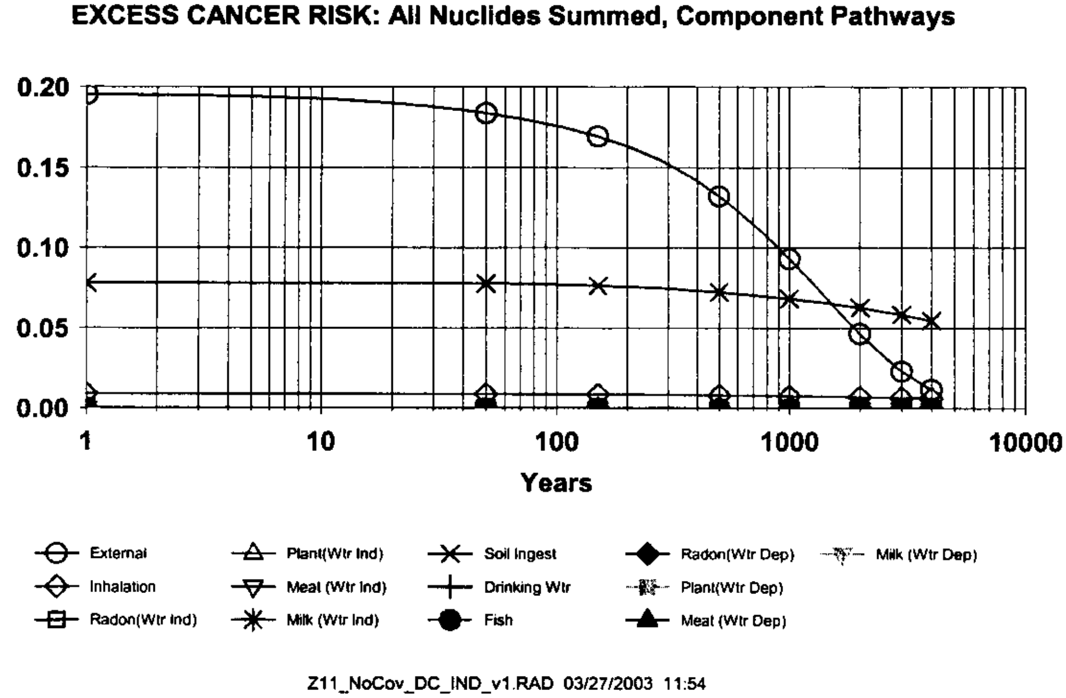


Figure 5-3. RESRAD Analysis for the 216 –Z-11 Ditch – All Radionuclides, All Pathways Risk Estimate (No Cover, Direct Contact, Industrial Scenario).



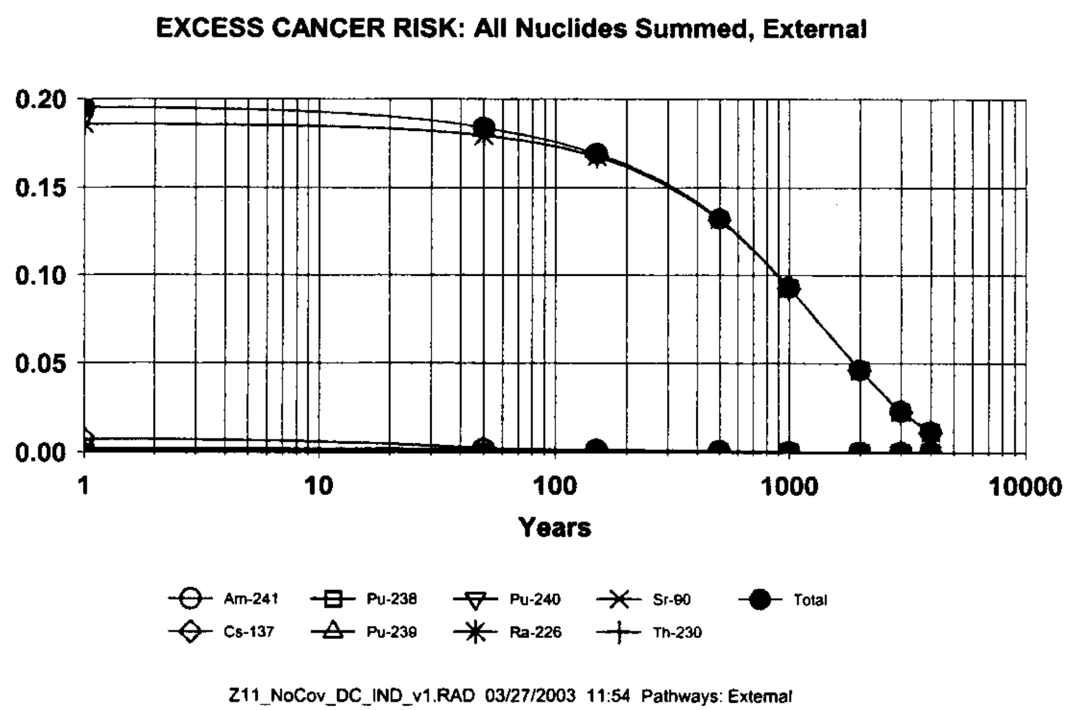
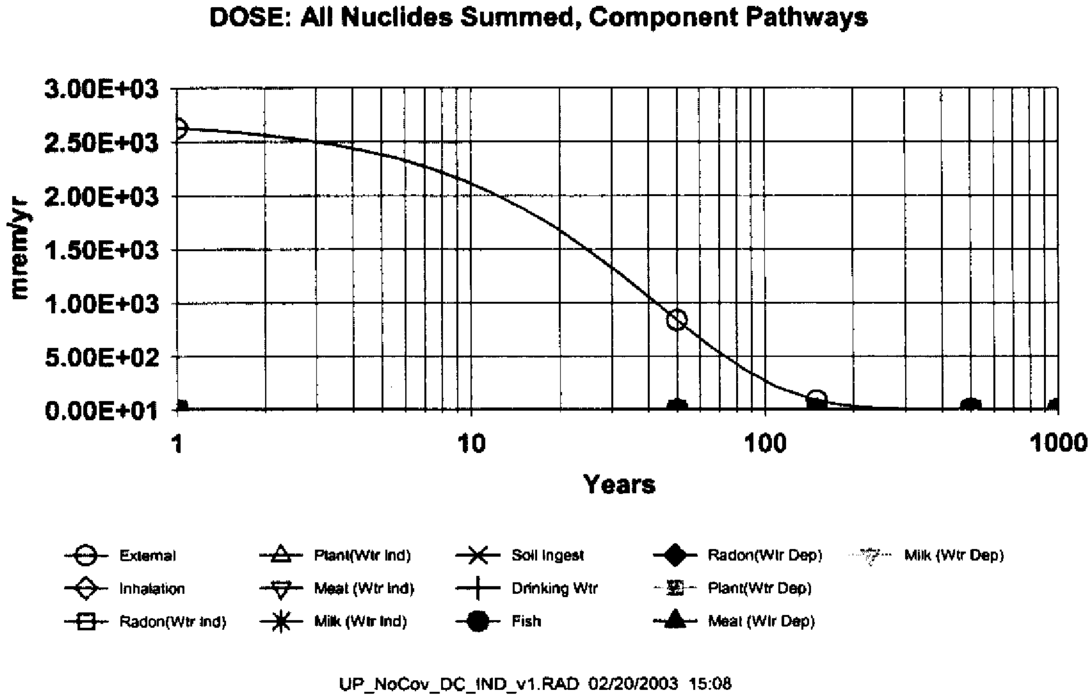


Figure 5-4. RESRAD Analysis for the 216-U-10 Pond – All Radionuclides, All Pathways Dose Estimate (No Cover, Direct Contact, Industrial Scenario).



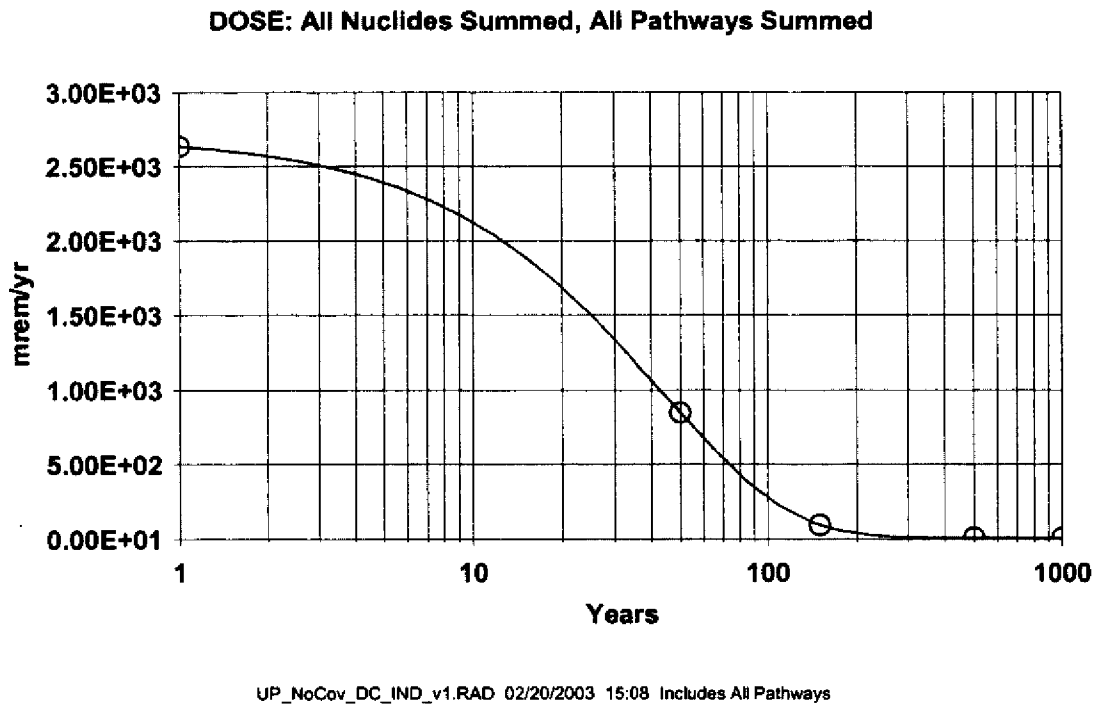
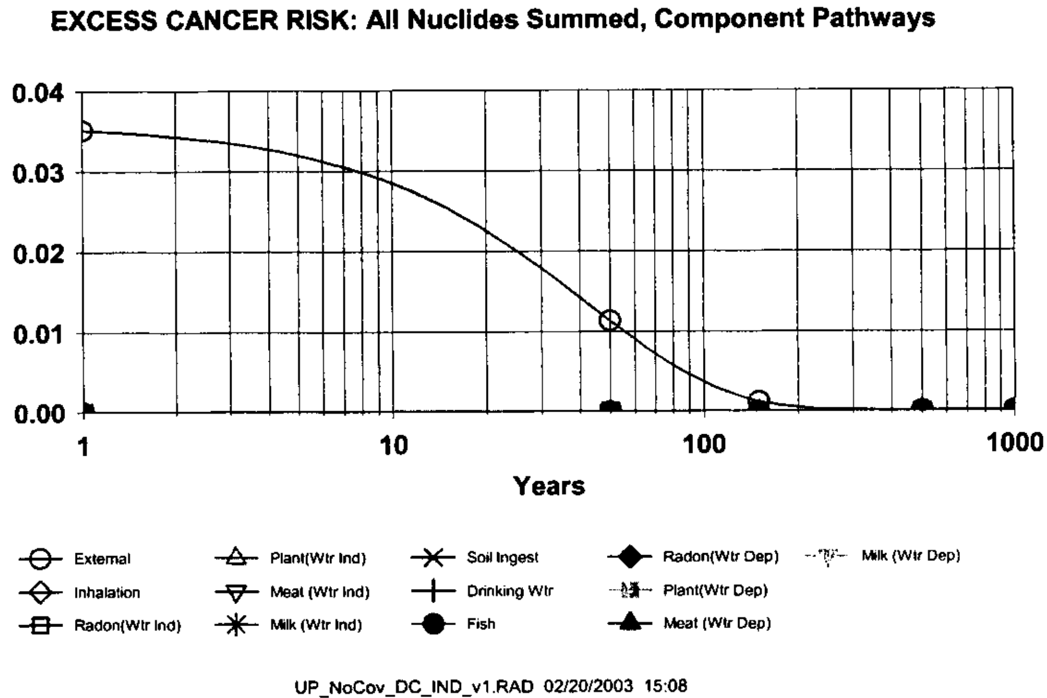


Figure 5-5. RESRAD Analysis for the 216-U-14 Ditch – All Radionuclides, All Pathways Risk Estimate (No Cover, Direct Contact, Industrial Scenario).



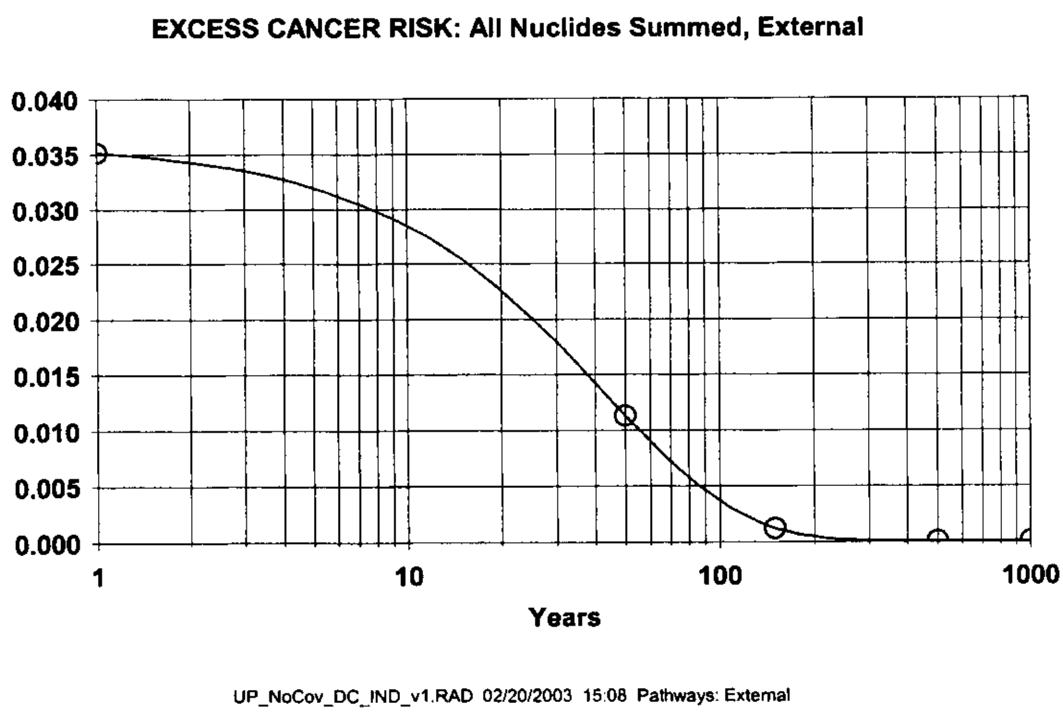
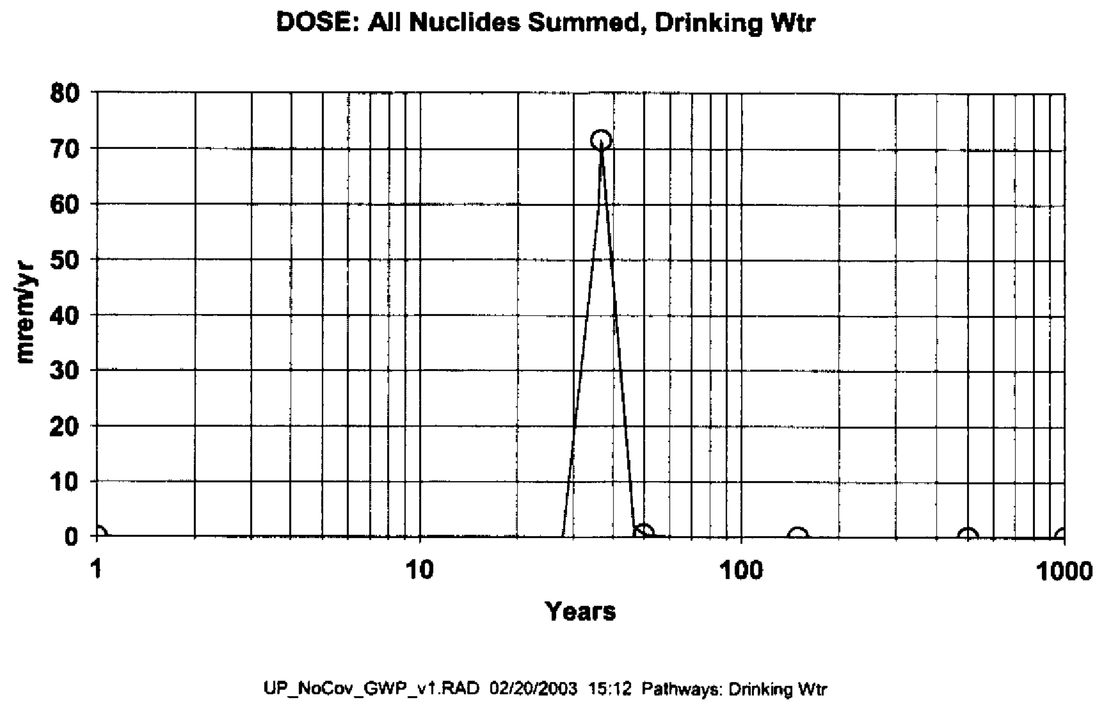


Figure 5-6. RESRAD Analysis for the 216-U-10 Pond– All Radionuclides, Drinking Water Pathway Dose, and Risk Estimates (No Cover).



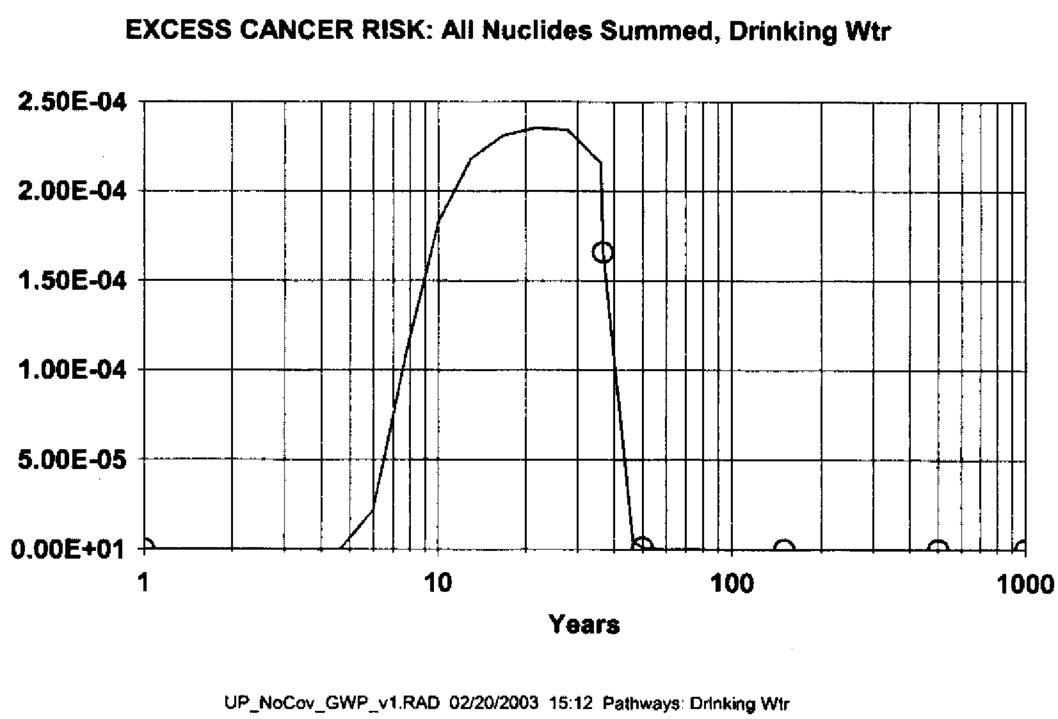
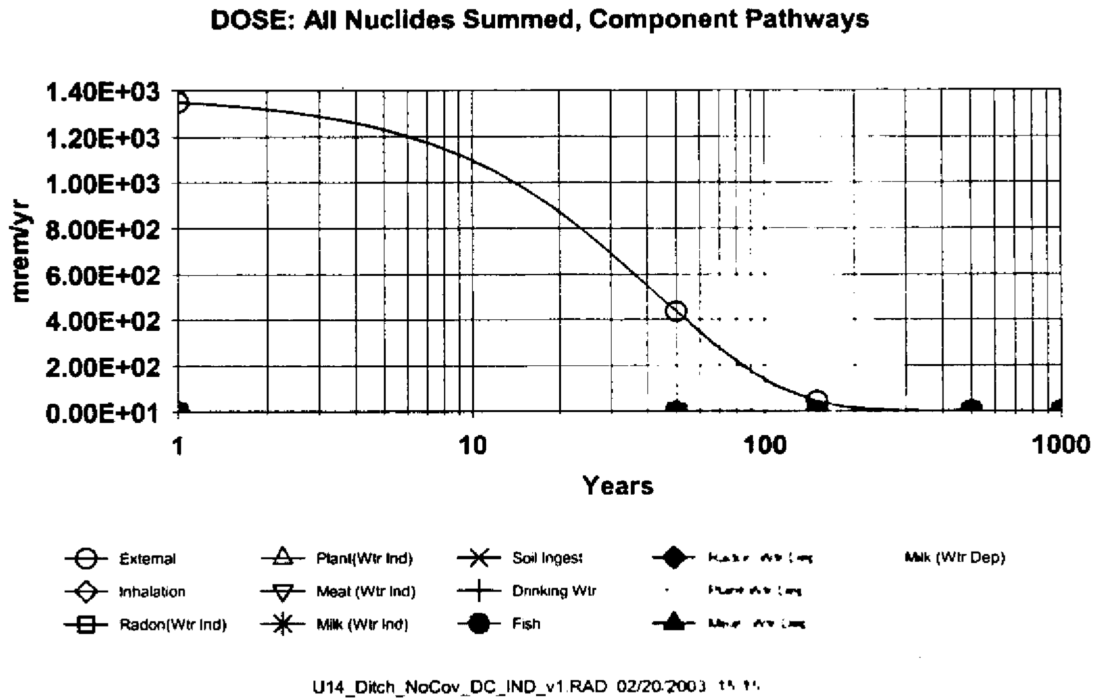


Figure 5-7. RESRAD Analysis for 216-U-14 Ditch – All Radionuclides, All Pathways Dose Estimate (No Cover, Direct Contact, Industrial Scenario).



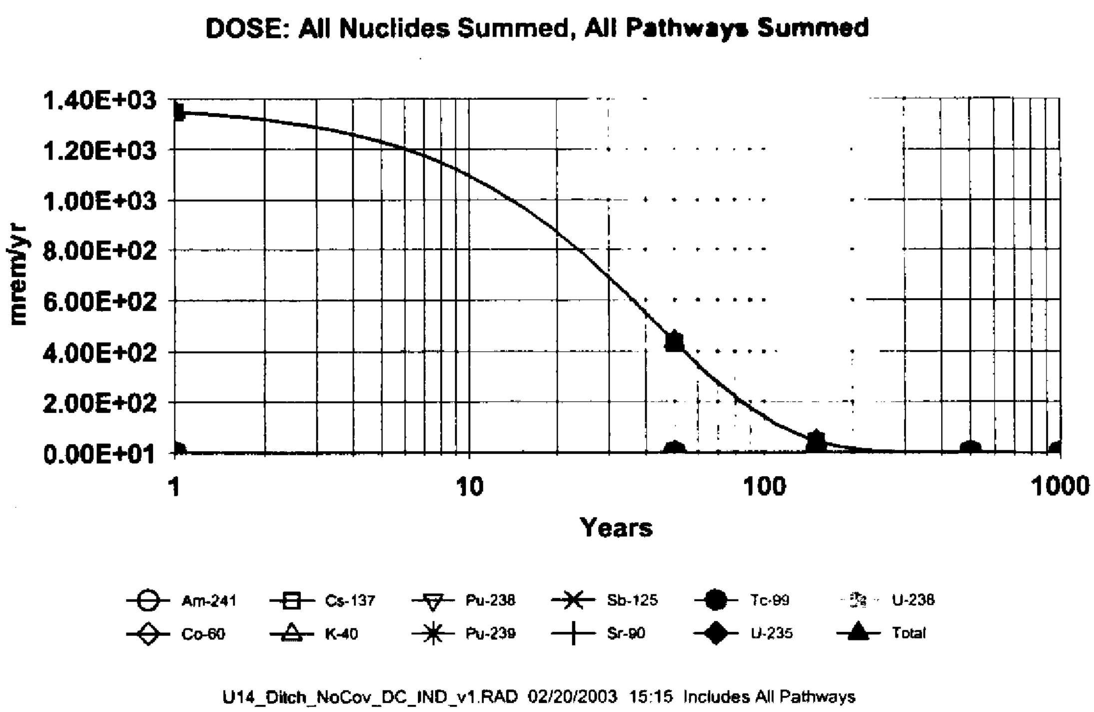
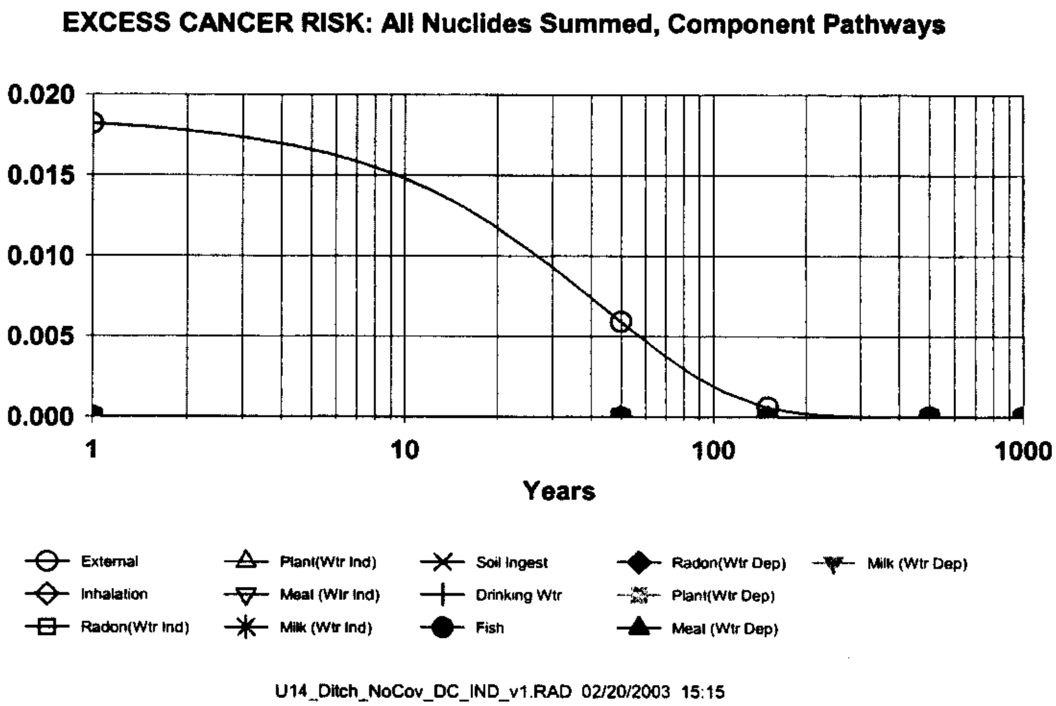


Figure 5-8. RESRAD Analysis for 216-U-14 Ditch – All Radionuclides, All Pathways Risk Estimate (No Cover, Direct Contact, Industrial Scenario).



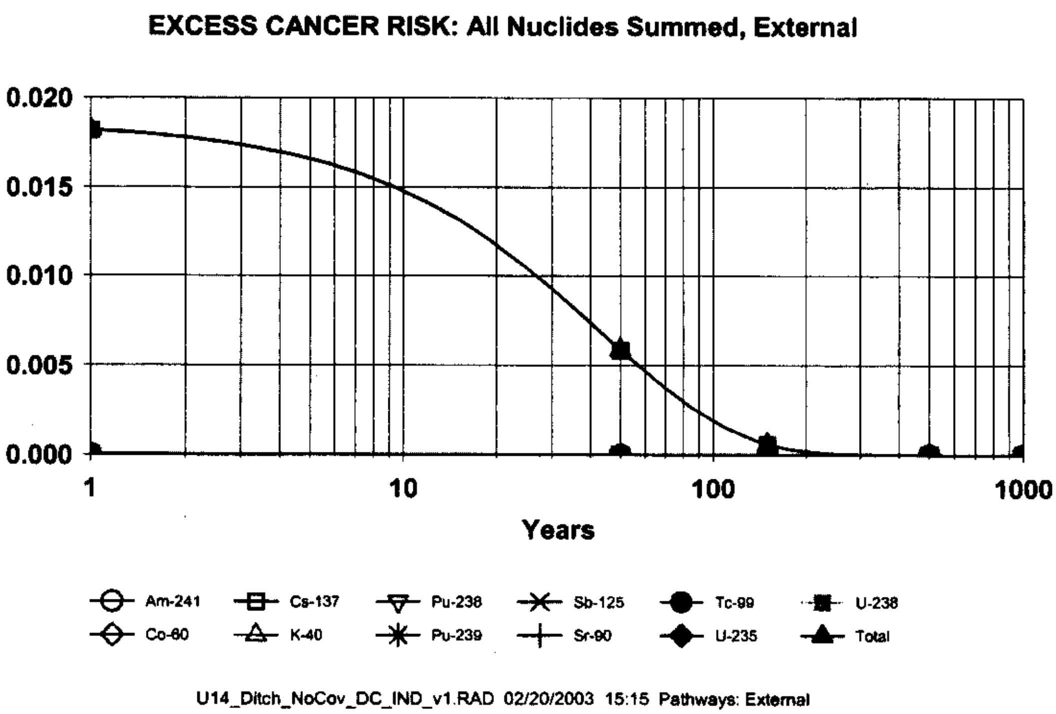
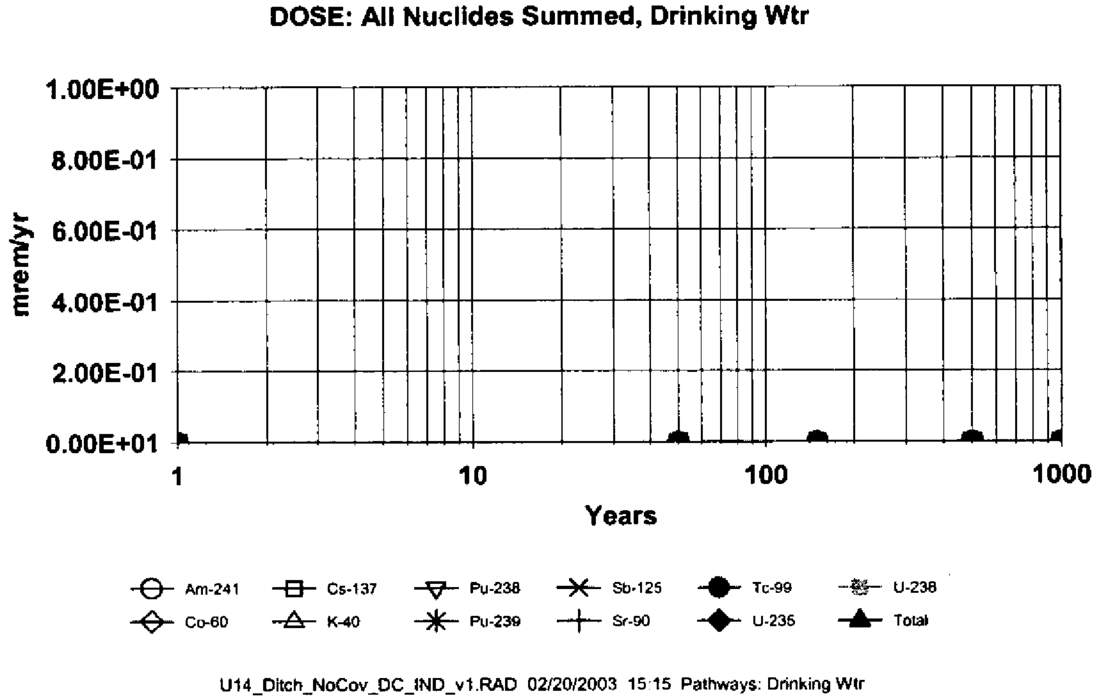


Figure 5-9. RESRAD Analysis for 216-U-14 Ditch – All Radionuclides, Drinking Water Pathway Risk and Dose Estimate (No Cover).



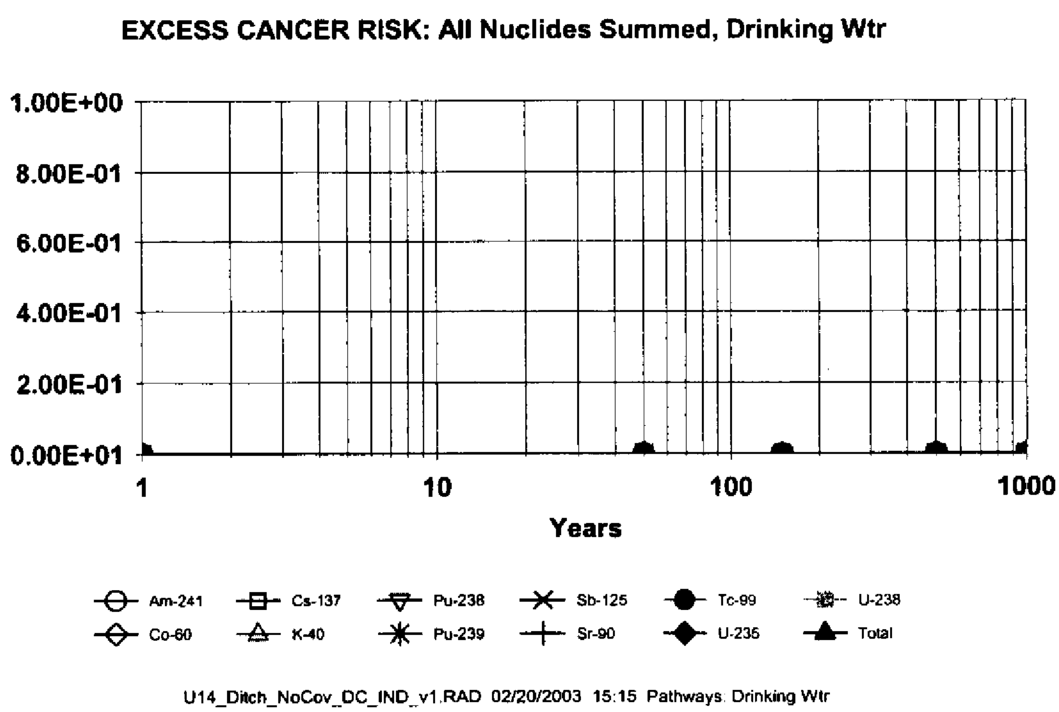


Table 5-1. Summary of Soil Samples Included in the 216-Z-11 Ditch Human Health Risk Assessment. (9 Pages)

Station ID	Sample ID	Depth Interval (ft)	Date Collected	Comment
216-Z-11 Ditch	B14DK8	15-17.5	April 25, 2002	Deep Zone
216-Z-19 Ditch	9-F (4.5-5)	4.5-5	May 1, 1979	Shallow Zone
216-Z-19 Ditch	9-G (4.5-5)	4.5-5	May 1, 1979	Shallow Zone
216-Z-19 Ditch	2-B (4.7-5)	4.7-5	May 1, 1979	Shallow Zone
216-Z-19 Ditch	2-D (4.7-5)	4.7-5	May 1, 1979	Shallow Zone
216-Z-19 Ditch	5-B (4.7-5)	4.7-5	May 1, 1979	Shallow Zone
216-Z-19 Ditch	5-D (4.7-5)	4.7-5	May 1, 1979	Shallow Zone
216-Z-1D Ditch	299-W18-177 (4.9-4.9)	4.9-4.9	January 1, 1981	Shallow Zone
216-Z-1D Ditch	299-W18-178 (4.9-4.9)	4.9-4.9	January 1, 1981	Shallow Zone
216-Z-11 Ditch	299-W18-189 (4.9-4.9)	4.9-4.9	January 1, 1981	Shallow Zone
216-Z-1D Ditch	299-W15-204 (4.9-5.9)	4.9-5.9	January 1, 1981	Shallow Zone
216-Z-19 Ditch	300	5-5	May 1, 1979	Shallow Zone
216-Z-19 Ditch	400	5-5	May 1, 1979	Shallow Zone
216-Z-19 Ditch	500	5-5	May 1, 1979	Shallow Zone
216-Z-19 Ditch	1-C (5-5.2)	5-5.2	May 1, 1979	Shallow Zone
216-Z-19 Ditch	7-A (5-5.2)	5-5.2	May 1, 1979	Shallow Zone
216-Z-19 Ditch	7-E (5-5.2)	5-5.2	May 1, 1979	Shallow Zone
216-Z-19 Ditch	7-F (5-5.2)	5-5.2	May 1, 1979	Shallow Zone
216-Z-19 Ditch	7-G (5-5.2)	5-5.2	May 1, 1979	Shallow Zone
216-Z-19 Ditch	8-C (5-5.2)	5-5.2	May 1, 1979	Shallow Zone
216-Z-19 Ditch	2-B (5-5.5)	5-5.5	May 1, 1979	Shallow Zone
216-Z-19 Ditch	2-D (5-5.5)	5-5.5	May 1, 1979	Shallow Zone
216-Z-19 Ditch	5-B (5-5.5)	5-5.5	May 1, 1979	Shallow Zone
216-Z-19 Ditch	5-D (5-5.5)	5-5.5	May 1, 1979	Shallow Zone
216-Z-19 Ditch	7-A (5.2-5.5)	5.2-5.5	May 1, 1979	Shallow Zone
216-Z-19 Ditch	7-E (5.2-5.5)	5.2-5.5	May 1, 1979	Shallow Zone
216-Z-19 Ditch	7-F (5.2-5.5)	5.2-5.5	May 1, 1979	Shallow Zone
216-Z-19 Ditch	7-G (5.2-5.5)	5.2-5.5	May 1, 1979	Shallow Zone
216-Z-19 Ditch	3-E (5.3-6)	5.3-6	May 1, 1979	Shallow Zone
216-Z-19 Ditch	4-E (5.3-6)	5.3-6	May 1, 1979	Shallow Zone
216-Z-19 Ditch	9-A (5.3-6)	5.3-6	May 1, 1979	Shallow Zone
216-Z-19 Ditch	9-E (5.3-6)	5.3-6	May 1, 1979	Shallow Zone
216-Z-19 Ditch	3-B (5.5-5.7)	5.5-5.7	May 1, 1979	Shallow Zone
216-Z-19 Ditch	3-D (5.5-5.7)	5.5-5.7	May 1, 1979	Shallow Zone
216-Z-19 Ditch	4-B (5.5-5.7)	5.5-5.7	May 1, 1979	Shallow Zone
216-Z-19 Ditch	4-D (5.5-5.7)	5.5-5.7	May 1, 1979	Shallow Zone

Table 5-1. Summary of Soil Samples Included in the 216-Z-11 Ditch Human Health Risk Assessment. (9 Pages)

Station ID	Sample ID	Depth Interval (ft)	Date Collected	Comment
216-Z-19 Ditch	9-B (5.5-5.7)	5.5-5.7	May 1, 1979	Shallow Zone
216-Z-19 Ditch	9-D (5.5-5.7)	5.5-5.7	May 1, 1979	Shallow Zone
216-Z-19 Ditch	7-A (5.5-6)	5.5-6	May 1, 1979	Shallow Zone
216-Z-19 Ditch	7-E (5.5-6)	5.5-6	May 1, 1979	Shallow Zone
216-Z-19 Ditch	7-F (5.5-6)	5.5-6	May 1, 1979	Shallow Zone
216-Z-19 Ditch	7-G (5.5-6)	5.5-6	May 1, 1979	Shallow Zone
216-Z-19 Ditch	1-C (5.7-6)	5.7-6	May 1, 1979	Shallow Zone
216-Z-19 Ditch	3-B (5.7-6)	5.7-6	May 1, 1979	Shallow Zone
216-Z-19 Ditch	3-D (5.7-6)	5.7-6	May 1, 1979	Shallow Zone
216-Z-19 Ditch	4-B (5.7-6)	5.7-6	May 1, 1979	Shallow Zone
216-Z-19 Ditch	4-D (5.7-6)	5.7-6	May 1, 1979	Shallow Zone
216-Z-19 Ditch	8-C (5.7-6)	5.7-6	May 1, 1979	Shallow Zone
216-Z-19 Ditch	9-B (5.7-6)	5.7-6	May 1, 1979	Shallow Zone
216-Z-19 Ditch	9-D (5.7-6)	5.7-6	May 1, 1979	Shallow Zone
216-Z-1D Ditch	299-W15-203 (5.9-5.9)	5.9-5.9	January 1, 1981	Shallow Zone
216-Z-11 Ditch	299-W18-189 (5.9-5.9)	5.9-5.9	January 1, 1981	Shallow Zone
216-Z-1D Ditch	299-W18-192 (5.9-5.9)	5.9-5.9	January 1, 1981	Shallow Zone
216-Z-19 Ditch	1000	6-6	May 1, 1979	Shallow Zone
216-Z-1D Ditch	1905	6-6	January 1, 1959	Shallow Zone
216-Z-19 Ditch	600	6-6	May 1, 1979	Shallow Zone
216-Z-19 Ditch	700	6-6	May 1, 1979	Shallow Zone
216-Z-19 Ditch	800	6-6	May 1, 1979	Shallow Zone
216-Z-19 Ditch	900	6-6	May 1, 1979	Shallow Zone
216-Z-19 Ditch	2-C (6-6.2)	6-6.2	May 1, 1979	Shallow Zone
216-Z-19 Ditch	5-C (6-6.2)	6-6.2	May 1, 1979	Shallow Zone
216-Z-19 Ditch	6-A (6-6.2)	6-6.2	May 1, 1979	Shallow Zone
216-Z-19 Ditch	6-E (6-6.2)	6-6.2	May 1, 1979	Shallow Zone
216-Z-19 Ditch	6-F (6-6.2)	6-6.2	May 1, 1979	Shallow Zone
216-Z-19 Ditch	6-G (6-6.2)	6-6.2	May 1, 1979	Shallow Zone
216-Z-19 Ditch	3-B (6-6.5)	6-6.5	May 1, 1979	Shallow Zone
216-Z-19 Ditch	3-D (6-6.5)	6-6.5	May 1, 1979	Shallow Zone
216-Z-19 Ditch	4-B (6-6.5)	6-6.5	May 1, 1979	Shallow Zone
216-Z-19 Ditch	4-D (6-6.5)	6-6.5	May 1, 1979	Shallow Zone
216-Z-19 Ditch	9-B (6-6.5)	6-6.5	May 1, 1979	Shallow Zone
216-Z-19 Ditch	9-D (6-6.5)	6-6.5	May 1, 1979	Shallow Zone
216-Z-19 Ditch	6-A (6.2-6.5)	6.2-6.5	May 1, 1979	Shallow Zone
216-Z-19 Ditch	6-E (6.2-6.5)	6.2-6.5	May 1, 1979	Shallow Zone

Table 5-1. Summary of Soil Samples Included in the 216-Z-11 Ditch Human Health Risk Assessment. (9 Pages)

Station ID	Sample ID	Depth Interval (ft)	Date Collected	Comment
216-Z-19 Ditch	6-F (6.2-6.5)	6.2-6.5	May 1, 1979	Shallow Zone
216-Z-19 Ditch	6-G (6.2-6.5)	6.2-6.5	May 1, 1979	Shallow Zone
216-Z-19 Ditch	2-C (6.2-7)	6.2-7	May 1, 1979	Shallow Zone
216-Z-19 Ditch	7-E (6.3-7)	6.3-7	May 1, 1979	Shallow Zone
216-Z-19 Ditch	7-B (6.5-6.7)	6.5-6.7	May 1, 1979	Shallow Zone
216-Z-19 Ditch	7-D (6.5-6.7)	6.5-6.7	May 1, 1979	Shallow Zone
216-Z-19 Ditch	6-A (6.5-7)	6.5-7	May 1, 1979	Shallow Zone
216-Z-19 Ditch	6-E (6.5-7)	6.5-7	May 1, 1979	Shallow Zone
216-Z-19 Ditch	6-F (6.5-7)	6.5-7	May 1, 1979	Shallow Zone
216-Z-19 Ditch	6-G (6.5-7)	6.5-7	May 1, 1979	Shallow Zone
216-Z-19 Ditch	8-C (6.6-6.6)	6.6-6.6	May 1, 1979	Shallow Zone
216-Z-19 Ditch	7-B (6.7-7)	6.7-7	May 1, 1979	Shallow Zone
216-Z-19 Ditch	7-D (6.7-7)	6.7-7	May 1, 1979	Shallow Zone
216-Z-1D Ditch	299-W18-188 (6.9-6.9)	6.9-6.9	January 1, 1981	Shallow Zone
216-Z-1D Ditch	299-W18-192 (6.9-6.9)	6.9-6.9	January 1, 1981	Shallow Zone
216-Z-1D Ditch	1900	7-7	January 1, 1959	Shallow Zone
216-Z-1D Ditch	1901	7-7	January 1, 1959	Shallow Zone
216-Z-1D Ditch	1904	7-7	January 1, 1959	Shallow Zone
216-Z-1D Ditch	1907	7-7	January 1, 1959	Shallow Zone
216-Z-19 Ditch	Z-19 Ditch East Bank 100 ft N	7-7	March 24, 1976	Shallow Zone
216-Z-19 Ditch	Z-19 Ditch East Bank 200 ft S1	7-7	March 24, 1976	Shallow Zone
216-Z-19 Ditch	Z-19 Ditch Head-1974	7-7	January 1, 1974	Shallow Zone
216-Z-19 Ditch	Z-19 Ditch Head-1975	7-7	January 1, 1975	Shallow Zone
216-Z-19 Ditch	Z-19 Ditch Head-1976	7-7	January 1, 1976	Shallow Zone
216-Z-19 Ditch	Z-19 Ditch Head-1977	7-7	January 1, 1977	Shallow Zone
216-Z-19 Ditch	Z-19 Ditch Near 16th Street-27	7-7	April 21, 1976	Shallow Zone
216-Z-19 Ditch	Z-19 Ditch NW Bank at U-pond I	7-7	March 24, 1976	Shallow Zone
216-Z-19 Ditch	Z-19 Ditch Outfall (head)-2787	7-7	April 21, 1976	Shallow Zone
216-Z-19 Ditch	Z-19 Ditch U-pond Inlet (delta)	7-7	April 21, 1976	Shallow Zone
216-Z-19 Ditch	Z-19 Ditch West Bank 500 ft-27	7-7	March 24, 1976	Shallow Zone
216-Z-19 Ditch	Z-19 Ditch West Bank Head-2784	7-7	March 24, 1976	Shallow Zone
216-Z-19 Ditch	Z-19 Ditch-16th street crossing	7-7	January 1, 1979	Shallow Zone
216-Z-19 Ditch	Z-19 Ditch-1977	7-7	January 1, 1977	Shallow Zone
216-Z-19 Ditch	Z-19 Ditch-231-Z outfall-1979	7-7	January 1, 1979	Shallow Zone
216-Z-19 Ditch	Z-19 Ditch-234-5 Outfall-1979	7-7	January 1, 1979	Shallow Zone
216-Z-19 Ditch	Z-19 Ditch-High-1978	7-7	January 1, 1978	Shallow Zone
216-Z-19 Ditch	Z-19 Ditch-inlet to U-pond-197	7-7	January 1, 1979	Shallow Zone

Table 5-1. Summary of Soil Samples Included in the 216-Z-11 Ditch Human Health Risk Assessment. (9 Pages)

Station ID	Sample ID	Depth Interval (ft)	Date Collected	Comment
216-Z-19 Ditch	Z-19 Ditch-Low-1978	7-7	January 1, 1978	Shallow Zone
216-Z-19 Ditch	3-C (7-7.2)	7-7.2	May 1, 1979	Shallow Zone
216-Z-19 Ditch	4-C (7-7.2)	7-7.2	May 1, 1979	Shallow Zone
216-Z-19 Ditch	9-C (7-7.3)	7-7.3	May 1, 1979	Shallow Zone
216-Z-19 Ditch	7-B (7-7.5)	7-7.5	May 1, 1979	Shallow Zone
216-Z-19 Ditch	7-D (7-7.5)	7-7.5	May 1, 1979	Shallow Zone
216-Z-19 Ditch	3-C (7.2-7.5)	7.2-7.5	May 1, 1979	Shallow Zone
216-Z-19 Ditch	6-E (7.3-8)	7.3-8	May 1, 1979	Shallow Zone
216-Z-19 Ditch	6-B (7.5-7.7)	7.5-7.7	May 1, 1979	Shallow Zone
216-Z-19 Ditch	6-D (7.5-7.7)	7.5-7.7	May 1, 1979	Shallow Zone
216-Z-19 Ditch	3-C (7.5-8)	7.5-8	May 1, 1979	Shallow Zone
216-Z-11 Ditch	B14DJ9	7.5-10	April 24, 2002	Shallow Zone
216-Z-11 Ditch	B14DK0	7.5-10	April 24, 2002	Shallow Zone
216-Z-11 Ditch	B14DK1	7.5-10	April 24, 2002	Shallow Zone
216-Z-11 Ditch	B14DK2	7.5-10	April 24, 2002	Shallow Zone
216-Z-11 Ditch	B14DK3	7.5-10	April 24, 2002	Shallow Zone
216-Z-11 Ditch	B14DK3-A	7.5-10	April 24, 2002	Shallow Zone
216-Z-11 Ditch	B14JC5	7.5-10	April 24, 2002	Shallow Zone
216-Z-19 Ditch	6-B (7.7-8)	7.7-8	May 1, 1979	Shallow Zone
216-Z-19 Ditch	6-D (7.7-8)	7.7-8	May 1, 1979	Shallow Zone
216-Z-19 Ditch	9-C (7.7-8)	7.7-8	May 1, 1979	Shallow Zone
216-Z-1D Ditch	299-W18-177 (7.9-7.9)	7.9-7.9	January 1, 1981	Shallow Zone
216-Z-1D Ditch	299-W18-188 (7.9-7.9)	7.9-7.9	January 1, 1981	Shallow Zone
216-Z-1D Ditch	299-W18-192 (7.9-7.9)	7.9-7.9	January 1, 1981	Shallow Zone
216-Z-1D Ditch	1902	8-8	January 1, 1959	Shallow Zone
216-Z-1D Ditch	1903	8-8	January 1, 1959	Shallow Zone
216-Z-1D Ditch	1906	8-8	January 1, 1959	Shallow Zone
216-Z-1D Ditch	1908	8-8	January 1, 1959	Shallow Zone
216-Z-19 Ditch	7-C (8-8.2)	8-8.2	May 1, 1979	Shallow Zone
216-Z-19 Ditch	3-C (8-8.3)	8-8.3	May 1, 1979	Shallow Zone
216-Z-19 Ditch	6-B (8-8.5)	8-8.5	May 1, 1979	Shallow Zone
216-Z-19 Ditch	6-D (8-8.5)	8-8.5	May 1, 1979	Shallow Zone
216-Z-11 Ditch	299-W18-195 (8.2-8.5)	8.2-8.5	January 1, 1981	Shallow Zone
216-Z-19 Ditch	3-C (8.3-8.7)	8.3-8.7	May 1, 1979	Shallow Zone
216-Z-11 Ditch	299-W18-195 (8.5-9.5)	8.5-9.5	January 1, 1981	Shallow Zone
216-Z-19 Ditch	2-G (3.2-3.5)	3.2-3.5	May 1, 1979	Shallow Zone
216-Z-19 Ditch	5-A (3.2-3.5)	3.2-3.5	May 1, 1979	Shallow Zone

Table 5-1. Summary of Soil Samples Included in the 216-Z-11 Ditch Human Health Risk Assessment. (9 Pages)

Station ID	Sample ID	Depth Interval (ft)	Date Collected	Comment
216-Z-19 Ditch	5-E (3.2-3.5)	3.2-3.5	May 1, 1979	Shallow Zone
216-Z-19 Ditch	5-F (3.2-3.5)	3.2-3.5	May 1, 1979	Shallow Zone
216-Z-19 Ditch	5-G (3.2-3.5)	3.2-3.5	May 1, 1979	Shallow Zone
216-Z-19 Ditch	8-E (3.3-4)	3.3-4	May 1, 1979	Shallow Zone
216-Z-19 Ditch	1-B (3.5-3.7)	3.5-3.7	May 1, 1979	Shallow Zone
216-Z-19 Ditch	1-D (3.5-3.7)	3.5-3.7	May 1, 1979	Shallow Zone
216-Z-19 Ditch	8-B (3.5-3.7)	3.5-3.7	May 1, 1979	Shallow Zone
216-Z-19 Ditch	8-D (3.5-3.7)	3.5-3.7	May 1, 1979	Shallow Zone
216-Z-19 Ditch	2-A (3.5-4)	3.5-4	May 1, 1979	Shallow Zone
216-Z-19 Ditch	2-E (3.5-4)	3.5-4	May 1, 1979	Shallow Zone
216-Z-19 Ditch	2-F (3.5-4)	3.5-4	May 1, 1979	Shallow Zone
216-Z-19 Ditch	2-G (3.5-4)	3.5-4	May 1, 1979	Shallow Zone
216-Z-19 Ditch	5-A (3.5-4)	3.5-4	May 1, 1979	Shallow Zone
216-Z-19 Ditch	5-E (3.5-4)	3.5-4	May 1, 1979	Shallow Zone
216-Z-19 Ditch	5-F (3.5-4)	3.5-4	May 1, 1979	Shallow Zone
216-Z-19 Ditch	5-G (3.5-4)	3.5-4	May 1, 1979	Shallow Zone
216-Z-19 Ditch	1-B (3.7-4)	3.7-4	May 1, 1979	Shallow Zone
216-Z-19 Ditch	1-D (3.7-4)	3.7-4	May 1, 1979	Shallow Zone
216-Z-19 Ditch	8-B (3.7-4)	3.7-4	May 1, 1979	Shallow Zone
216-Z-19 Ditch	8-D (3.7-4)	3.7-4	May 1, 1979	Shallow Zone
216-Z-11 Ditch	299-W18-189 (3.9-3.9)	3.9-3.9	January 1, 1981	Shallow Zone
216-Z-11 Ditch	299-W18-193 (3.9-3.9)	3.9-3.9	January 1, 1981	Shallow Zone
216-Z-11 Ditch	299-W18-194 (3.9-3.9)	3.9-3.9	January 1, 1981	Shallow Zone
216-Z-19 Ditch	-100	4-4	May 1, 1979	Shallow Zone
216-Z-19 Ditch	-200	4-4	May 1, 1979	Shallow Zone
216-Z-19 Ditch	0	4-4	May 1, 1979	Shallow Zone
216-Z-19 Ditch	100	4-4	May 1, 1979	Shallow Zone
216-Z-19 Ditch	200	4-4	May 1, 1979	Shallow Zone
216-Z-19 Ditch	3-A (4-4.2)	4-4.2	May 1, 1979	Shallow Zone
216-Z-19 Ditch	3-E (4-4.2)	4-4.2	May 1, 1979	Shallow Zone
216-Z-19 Ditch	3-F (4-4.2)	4-4.2	May 1, 1979	Shallow Zone
216-Z-19 Ditch	3-G (4-4.2)	4-4.2	May 1, 1979	Shallow Zone
216-Z-19 Ditch	4-A (4-4.2)	4-4.2	May 1, 1979	Shallow Zone
216-Z-19 Ditch	4-E (4-4.2)	4-4.2	May 1, 1979	Shallow Zone
216-Z-19 Ditch	4-F (4-4.2)	4-4.2	May 1, 1979	Shallow Zone
216-Z-19 Ditch	4-G (4-4.2)	4-4.2	May 1, 1979	Shallow Zone
216-Z-19 Ditch	9-A (4-4.2)	4-4.2	May 1, 1979	Shallow Zone

Table 5-1. Summary of Soil Samples Included in the 216-Z-11 Ditch Human Health Risk Assessment. (9 Pages)

Station ID	Sample ID	Depth Interval (ft)	Date Collected	Comment
216-Z-19 Ditch	9-E (4-4.2)	4-4.2	May 1, 1979	Shallow Zone
216-Z-19 Ditch	9-F (4-4.2)	4-4.2	May 1, 1979	Shallow Zone
216-Z-19 Ditch	9-G (4-4.2)	4-4.2	May 1, 1979	Shallow Zone
216-Z-19 Ditch	1-B (4-4.5)	4-4.5	May 1, 1979	Shallow Zone
216-Z-19 Ditch	1-D (4-4.5)	4-4.5	May 1, 1979	Shallow Zone
216-Z-19 Ditch	8-B (4-4.5)	4-4.5	May 1, 1979	Shallow Zone
216-Z-19 Ditch	8-D (4-4.5)	4-4.5	May 1, 1979	Shallow Zone
216-Z-19 Ditch	3-A (4.2-4.5)	4.2-4.5	May 1, 1979	Shallow Zone
216-Z-19 Ditch	3-E (4.2-4.5)	4.2-4.5	May 1, 1979	Shallow Zone
216-Z-19 Ditch	3-F (4.2-4.5)	4.2-4.5	May 1, 1979	Shallow Zone
216-Z-19 Ditch	3-G (4.2-4.5)	4.2-4.5	May 1, 1979	Shallow Zone
216-Z-19 Ditch	4-A (4.2-4.5)	4.2-4.5	May 1, 1979	Shallow Zone
216-Z-19 Ditch	4-E (4.2-4.5)	4.2-4.5	May 1, 1979	Shallow Zone
216-Z-19 Ditch	4-F (4.2-4.5)	4.2-4.5	May 1, 1979	Shallow Zone
216-Z-19 Ditch	4-G (4.2-4.5)	4.2-4.5	May 1, 1979	Shallow Zone
216-Z-19 Ditch	9-A (4.2-4.5)	4.2-4.5	May 1, 1979	Shallow Zone
216-Z-19 Ditch	9-E (4.2-4.5)	4.2-4.5	May 1, 1979	Shallow Zone
216-Z-19 Ditch	9-F (4.2-4.5)	4.2-4.5	May 1, 1979	Shallow Zone
216-Z-19 Ditch	9-G (4.2-4.5)	4.2-4.5	May 1, 1979	Shallow Zone
216-Z-19 Ditch	1-E (4.3-5)	4.3-5	May 1, 1979	Shallow Zone
216-Z-19 Ditch	2-A (4.3-5)	4.3-5	May 1, 1979	Shallow Zone
216-Z-19 Ditch	2-E (4.3-5)	4.3-5	May 1, 1979	Shallow Zone
216-Z-19 Ditch	5-E (4.3-5)	4.3-5	May 1, 1979	Shallow Zone
216-Z-19 Ditch	2-B (4.5-4.7)	4.5-4.7	May 1, 1979	Shallow Zone
216-Z-19 Ditch	2-D (4.5-4.7)	4.5-4.7	May 1, 1979	Shallow Zone
216-Z-19 Ditch	5-B (4.5-4.7)	4.5-4.7	May 1, 1979	Shallow Zone
216-Z-19 Ditch	5-D (4.5-4.7)	4.5-4.7	May 1, 1979	Shallow Zone
216-Z-19 Ditch	3-A (4.5-5)	4.5-5	May 1, 1979	Shallow Zone
216-Z-19 Ditch	3-E (4.5-5)	4.5-5	May 1, 1979	Shallow Zone
216-Z-19 Ditch	3-F (4.5-5)	4.5-5	May 1, 1979	Shallow Zone
216-Z-19 Ditch	3-G (4.5-5)	4.5-5	May 1, 1979	Shallow Zone
216-Z-19 Ditch	4-A (4.5-5)	4.5-5	May 1, 1979	Shallow Zone
216-Z-19 Ditch	4-E (4.5-5)	4.5-5	May 1, 1979	Shallow Zone
216-Z-19 Ditch	4-F (4.5-5)	4.5-5	May 1, 1979	Shallow Zone
216-Z-19 Ditch	4-G (4.5-5)	4.5-5	May 1, 1979	Shallow Zone
216-Z-19 Ditch	9-A (4.5-5)	4.5-5	May 1, 1979	Shallow Zone
216-Z-19 Ditch	9-E (4.5-5)	4.5-5	May 1, 1979	Shallow Zone

Table 5-1. Summary of Soil Samples Included in the 216-Z-11 Ditch Human Health Risk Assessment. (9 Pages)

Station ID	Sample ID	Depth Interval (ft)	Date Collected	Comment
216-Z-1D Ditch	299-W18-177 (15.1-15.1)	15.1-15.1	January 1, 1981	Deep Zone
216-Z-1D Ditch	299-W18-178 (15.1-15.1)	15.1-15.1	January 1, 1981	Deep Zone
216-Z-1D Ditch	299-W15-203 (16.1-16.1)	16.1-16.1	January 1, 1981	Deep Zone
216-Z-11 Ditch	299-W18-194 (16.1-16.1)	16.1-16.1	January 1, 1981	Deep Zone
216-Z-1D Ditch	299-W18-186 (16.1-17.1)	16.1-17.1	January 1, 1981	Deep Zone
216-Z-1D Ditch	299-W18-187 (16.4-16.4)	16.4-16.4	January 1, 1981	Deep Zone
216-Z-1D Ditch	299-W18-178 (18-18)	18-18	January 1, 1981	Deep Zone
216-Z-1D Ditch	299-W18-177 (19-19)	19-19	January 1, 1981	Deep Zone
216-Z-1D Ditch	299-W18-177 (20-20)	20-20	January 1, 1981	Deep Zone
216-Z-1D Ditch	299-W18-192 (20-20)	20-20	January 1, 1981	Deep Zone
216-Z-11 Ditch	299-W18-193 (20-20)	20-20	January 1, 1981	Deep Zone
216-Z-1D Ditch	299-W18-178 (21-21)	21-21	January 1, 1981	Deep Zone
216-Z-11 Ditch	B14DL1	22.5-25	May 1, 2002	Deep Zone
216-Z-1D Ditch	299-W18-177 (24.9-24.9)	24.9-24.9	January 1, 1981	Deep Zone
216-Z-1D Ditch	299-W18-178 (24.9-24.9)	24.9-24.9	January 1, 1981	Deep Zone
216-Z-1D Ditch	299-W18-177 (29.9-29.9)	29.9-29.9	January 1, 1981	Deep Zone
216-Z-1D Ditch	299-W18-178 (29.9-29.9)	29.9-29.9	January 1, 1981	Deep Zone
216-Z-1D Ditch	299-W18-177 (35.1-35.1)	35.1-35.1	January 1, 1981	Deep Zone
216-Z-1D Ditch	299-W18-178 (35.1-35.1)	35.1-35.1	January 1, 1981	Deep Zone
216-Z-1D Ditch	299-W18-177 (40-40)	40-40	January 1, 1981	Deep Zone
216-Z-1D Ditch	299-W18-178 (40-40)	40-40	January 1, 1981	Deep Zone
216-Z-1D Ditch	299-W18-177 (45.9-45.9)	45.9-45.9	January 1, 1981	Deep Zone
216-Z-11 Ditch	B14DL2	50-52.5	May 3, 2002	Deep Zone
216-Z-11 Ditch	B14DL3	99.5-102	May 7, 2002	Deep Zone
216-Z-11 Ditch	B14DL4	112-114.7	May 8, 2002	Deep Zone
216-Z-11 Ditch	B14DL5	152-154.5	May 10, 2002	Deep Zone
216-Z-11 Ditch	B14DL6	199.8-202	May 15, 2002	Deep Zone
216-Z-11 Ditch	B14KC7	220.7-223	May 17, 2002	Deep Zone
216-Z-11 Ditch	299-W18-194 (2-2)	2-2	January 1, 1981	Shallow Zone
216-Z-19 Ditch	1-A (2-2.2)	2-2.2	May 1, 1979	Shallow Zone
216-Z-19 Ditch	1-E (2-2.2)	2-2.2	May 1, 1979	Shallow Zone
216-Z-19 Ditch	1-F (2-2.2)	2-2.2	May 1, 1979	Shallow Zone
216-Z-19 Ditch	1-G (2-2.2)	2-2.2	May 1, 1979	Shallow Zone
216-Z-19 Ditch	8-A (2-2.2)	2-2.2	May 1, 1979	Shallow Zone
216-Z-19 Ditch	8-E (2-2.2)	2-2.2	May 1, 1979	Shallow Zone
216-Z-19 Ditch	8-F (2-2.2)	2-2.2	May 1, 1979	Shallow Zone
216-Z-19 Ditch	8-G (2-2.2)	2-2.2	May 1, 1979	Shallow Zone

Table 5-1. Summary of Soil Samples Included in the 216-Z-11 Ditch Human Health Risk Assessment. (9 Pages)

Station ID	Sample ID	Depth Interval (ft)	Date Collected	Comment
216-Z-19 Ditch	1-A (2.2-2.5)	2.2-2.5	May 1, 1979	Shallow Zone
216-Z-19 Ditch	1-E (2.2-2.5)	2.2-2.5	May 1, 1979	Shallow Zone
216-Z-19 Ditch	1-F (2.2-2.5)	2.2-2.5	May 1, 1979	Shallow Zone
216-Z-19 Ditch	1-G (2.2-2.5)	2.2-2.5	May 1, 1979	Shallow Zone
216-Z-19 Ditch	8-A (2.2-2.5)	2.2-2.5	May 1, 1979	Shallow Zone
216-Z-19 Ditch	8-E (2.2-2.5)	2.2-2.5	May 1, 1979	Shallow Zone
216-Z-19 Ditch	8-F (2.2-2.5)	2.2-2.5	May 1, 1979	Shallow Zone
216-Z-19 Ditch	8-G (2.2-2.5)	2.2-2.5	May 1, 1979	Shallow Zone
216-Z-19 Ditch	1-A (2.5-3)	2.5-3	May 1, 1979	Shallow Zone
216-Z-19 Ditch	1-E (2.5-3)	2.5-3	May 1, 1979	Shallow Zone
216-Z-19 Ditch	1-F (2.5-3)	2.5-3	May 1, 1979	Shallow Zone
216-Z-19 Ditch	1-G (2.5-3)	2.5-3	May 1, 1979	Shallow Zone
216-Z-19 Ditch	8-A (2.5-3)	2.5-3	May 1, 1979	Shallow Zone
216-Z-19 Ditch	8-E (2.5-3)	2.5-3	May 1, 1979	Shallow Zone
216-Z-19 Ditch	8-F (2.5-3)	2.5-3	May 1, 1979	Shallow Zone
216-Z-19 Ditch	8-G (2.5-3)	2.5-3	May 1, 1979	Shallow Zone
216-Z-11 Ditch	B14DJ8	2.5-5	April 23, 2002	Shallow Zone
216-Z-11 Ditch	299-W18-195 (2.6-2.6)	2.6-2.6	January 1, 1981	Shallow Zone
216-Z-11 Ditch	299-W18-189 (3-3)	3-3	January 1, 1981	Shallow Zone
216-Z-11 Ditch	299-W18-194 (3-3)	3-3	January 1, 1981	Shallow Zone
216-Z-19 Ditch	2-A (3-3.2)	3-3.2	May 1, 1979	Shallow Zone
216-Z-19 Ditch	2-E (3-3.2)	3-3.2	May 1, 1979	Shallow Zone
216-Z-19 Ditch	2-F (3-3.2)	3-3.2	May 1, 1979	Shallow Zone
216-Z-19 Ditch	2-G (3-3.2)	3-3.2	May 1, 1979	Shallow Zone
216-Z-19 Ditch	5-A (3-3.2)	3-3.2	May 1, 1979	Shallow Zone
216-Z-19 Ditch	5-E (3-3.2)	3-3.2	May 1, 1979	Shallow Zone
216-Z-19 Ditch	5-F (3-3.2)	3-3.2	May 1, 1979	Shallow Zone
216-Z-19 Ditch	5-G (3-3.2)	3-3.2	May 1, 1979	Shallow Zone
216-Z-11 Ditch	299-W18-189 (3-3.9)	3-3.9	January 1, 1981	Shallow Zone
216-Z-19 Ditch	2-A (3.2-3.5)	3.2-3.5	May 1, 1979	Shallow Zone
216-Z-19 Ditch	2-E (3.2-3.5)	3.2-3.5	May 1, 1979	Shallow Zone
216-Z-19 Ditch	2-F (3.2-3.5)	3.2-3.5	May 1, 1979	Shallow Zone
216-Z-19 Ditch	5-C (8.6-9)	8.6-9	May 1, 1979	Shallow Zone
216-Z-19 Ditch	3-C (8.7-9)	8.7-9	May 1, 1979	Shallow Zone
216-Z-19 Ditch	7-C (8.7-9)	8.7-9	May 1, 1979	Shallow Zone
216-Z-1D Ditch	299-W15-204 (8.9-8.9)	8.9-8.9	January 1, 1981	Shallow Zone
216-Z-1D Ditch	299-W18-177 (8.9-8.9)	8.9-8.9	January 1, 1981	Shallow Zone

Table 5-1. Summary of Soil Samples Included in the 216-Z-11 Ditch Human Health Risk Assessment. (9 Pages)

Station ID	Sample ID	Depth Interval (ft)	Date Collected	Comment
216-Z-1D Ditch	299-W18-188 (8.9-8.9)	8.9-8.9	January 1, 1981	Shallow Zone
216-Z-1D Ditch	299-W18-192 (8.9-8.9)	8.9-8.9	January 1, 1981	Shallow Zone
216-Z-19 Ditch	3-C (9-9.1)	9-9.1	May 1, 1979	Shallow Zone
216-Z-19 Ditch	6-C (9-9.2)	9-9.2	May 1, 1979	Shallow Zone
216-Z-19 Ditch	9-C (9.3-9.6)	9.3-9.6	May 1, 1979	Shallow Zone
216-Z-19 Ditch	4-C (9.6-9.8)	9.6-9.8	May 1, 1979	Shallow Zone
216-Z-19 Ditch	6-C (9.7-10)	9.7-10	May 1, 1979	Shallow Zone
216-Z-1D Ditch	299-W18-178 (9.8-9.8)	9.8-9.8	January 1, 1981	Shallow Zone
216-Z-1D Ditch	299-W18-192 (9.8-9.8)	9.8-9.8	January 1, 1981	Shallow Zone
216-Z-11 Ditch	299-W18-197 (9.8-9.8)	9.8-9.8	January 1, 1981	Shallow Zone
216-Z-19 Ditch	7-C (10-10.3)	10-10.3	May 1, 1979	Shallow Zone
216-Z-11 Ditch	B14DK4	10-12.5	April 24, 2002	Shallow Zone
216-Z-11 Ditch	B14JC6	10-12.5	April 24, 2002	Shallow Zone
216-Z-11 Ditch	B14JC7	10-12.5	April 24, 2002	Shallow Zone
216-Z-11 Ditch	B14JC8	10-12.5	April 24, 2002	Shallow Zone
216-Z-11 Ditch	B14JC9	10-12.5	April 24, 2002	Shallow Zone
216-Z-11 Ditch	B14JD1	10-12.5	April 25, 2002	Shallow Zone
216-Z-1D Ditch	299-W18-192 (10.5-11.2)	10.5-11.2	January 1, 1981	Shallow Zone
216-Z-19 Ditch	6-C (10.6-11)	10.6-11	May 1, 1979	Shallow Zone
216-Z-11 Ditch	299-W18-195 (10.8-11.2)	10.8-11.2	January 1, 1981	Shallow Zone
216-Z-11 Ditch	299-W18-197 (11.2-11.2)	11.2-11.2	January 1, 1981	Shallow Zone
216-Z-19 Ditch	6-C (11.6-12)	11.6-12	May 1, 1979	Shallow Zone
216-Z-11 Ditch	299-W18-197 (12.1-12.1)	12.1-12.1	January 1, 1981	Shallow Zone
216-Z-11 Ditch	299-W18-199 (12.1-12.1)	12.1-12.1	January 1, 1981	Shallow Zone
216-Z-11 Ditch	299-W18-200 (12.1-12.1)	12.1-12.1	January 1, 1981	Shallow Zone
216-Z-11 Ditch	B14DK5	12.5-15	April 25, 2002	Shallow Zone
216-Z-11 Ditch	299-W18-195 (12.8-13.1)	12.8-13.1	January 1, 1981	Shallow Zone
216-Z-1D Ditch	299-W18-188 (13.1-13.1)	13.1-13.1	January 1, 1981	Shallow Zone
216-Z-1D Ditch	299-W18-192 (13.1-13.1)	13.1-13.1	January 1, 1981	Shallow Zone
216-Z-1D Ditch	299-W18-192 (14.1-14.1)	14.1-14.1	January 1, 1981	Shallow Zone
216-Z-11 Ditch	299-W18-197 (14.1-14.1)	14.1-14.1	January 1, 1981	Shallow Zone

ID = identification.

Table 5-2. Summary of Soil Samples Included in the 216-U-10 Pond Human Health Risk Assessment.

Station ID	Sample ID	Depth Interval (ft)	Date Collected	Comment
299-W23-231	B09WI8	2-4	March 10, 1994	Shallow Zone
Shallow Soil	B0BKN7	3-3.3	April 5, 1994	Shallow Zone
Shallow Soil	B0BKN8	3-3.3	April 5, 1994	Shallow Zone
Shallow Soil	B0BKN9	3-3.3	March 30, 1994	Shallow Zone
Shallow Soil	B0BKP4	3-3.3	March 30, 1994	Shallow Zone
Shallow Soil	B0BKP5	3-3.3	March 30, 1994	Shallow Zone
Shallow Soil	B0BKP6	3-3.3	March 31, 1994	Shallow Zone
Shallow Soil	B0BNQ0	3-3.3	March 31, 1994	Shallow Zone
Shallow Soil	B0BNQ1	3-3.3	March 31, 1994	Shallow Zone
Shallow Soil	B0BNQ2	3-3.3	March 31, 1994	Shallow Zone
Shallow Soil	B0BNQ3	3-3.3	March 31, 1994	Shallow Zone
Shallow Soil	B0BNQ6	3-3.3	March 31, 1994	Shallow Zone
Shallow Soil	B0BNQ7	3-3.3	March 31, 1994	Shallow Zone
Shallow Soil	B0BNQ8	3-3.3	March 31, 1994	Shallow Zone
299-W23-231	B09WI9	4-6	March 10, 1994	Shallow Zone
299-W23-231	B09WJ0	6-8	March 11, 1994	Shallow Zone
Test Pit	B09313	6.5-7.5	August 21, 1993	Shallow Zone
Test Pit	B09316	6.5-6.5	August 21, 1993	Shallow Zone
Test Pit	B09315	9-10	August 22, 1993	Shallow Zone
Test Pit	B09317	9-10	August 22, 1993	Shallow Zone
Test Pit	B09318	15-17	August 22, 1993	Deep Zone
299-W23-231	B09WJ3	15-17	March 14, 1994	Deep Zone
Test Pit	B09319	25-26	August 22, 1993	Deep Zone
299-W23-231	B09WJ4	40-42	March 15, 1994	Deep Zone
299-W23-231	B09WJ5	50-52	March 15, 1994	Deep Zone
299-W23-231	B09WJ7	60-62	March 16, 1994	Deep Zone
299-W23-231	B09WJ9	110-112	March 21, 1994	Deep Zone
299-W23-231	B09WK0	135-137	March 22, 1994	Deep Zone
299-W23-231	B09WK1	135-137	March 22, 1994	Deep Zone
299-W23-231	B09WK2	138-140	March 22, 1994	Deep Zone

ID = identification.

Table 5-3. Summary of Soil Samples Included in the 216-U-14 Ditch Human Health Risk Assessment. (6 Pages)

Station ID	Sample ID	Depth Interval (ft)	Date Collected	Comment
ETP-1	B07CC7	9-9.5	June 26, 1993	Shallow Zone
ETP-2	B07CC4	9-9.5	June 26, 1993	Shallow Zone
ETP-3	B07CC2	9-9.5	June 26, 1993	Shallow Zone
Test Pit #1	Test Pit #1 (West) (9.0-9.5 ft)	9-9.5	June 1, 1992	Shallow Zone
Test Pit #2	Test Pit #2 (Center) (9.0-9.5 ft)	9-9.5	June 1, 1992	Shallow Zone
Test Pit #3	Test Pit #3 (East) (9.0-9.5 ft)	9-9.5	June 1, 1992	Shallow Zone
Test Pit #1	Test Pit #1 (West) (9.5-10.0 ft)	9.5-10	June 1, 1992	Shallow Zone
Test Pit #2	Test Pit #2 (Center) (9.5-10.0 ft)	9.5-10	June 1, 1992	Shallow Zone
Test Pit #3	Test Pit #3 (East) (9.5-10.0 ft)	9.5-10	June 1, 1992	Shallow Zone
299-W18-250	299-W18-250 (5 ft)	5-5	March 1, 1993	Shallow Zone
299-W18-251	299-W18-251 (5 ft)	5-5	March 1, 1993	Shallow Zone
299-W18-33	299-W18-33 (5 ft)	5-5	May 1, 1993	Shallow Zone
299-W19-91	299-W19-91 (5 ft)	5-5	April 1, 1987	Shallow Zone
299-W19-92	299-W19-92 (5 ft)	5-5	April 1, 1987	Shallow Zone
299-W19-93	299-W19-93 (5 ft)	5-5	April 1, 1987	Shallow Zone
299-W23-16	299-W23-16 (5 ft)	5-5	April 1, 1993	Shallow Zone
299-W23-17	299-23-17 (5 ft)	5-5	April 1, 1993	Shallow Zone
299-W19-91	299-W19-91 (15 ft)	15-15	April 1, 1987	Shallow Zone
299-W19-92	299-W19-92 (15 ft)	15-15	April 1, 1987	Shallow Zone
299-W19-93	299-W19-93 (15 ft)	15-15	April 1, 1987	Shallow Zone
Test Pit #1	Test Pit #1 (West) (14.0-15 ft)	14-15	June 1, 1992	Shallow Zone
Test Pit #2	Test Pit #2 (Center) (14.0-15 ft)	14-15	June 1, 1992	Shallow Zone
Test Pit #3	Test Pit #3 (East) (14.0-15 ft)	14-15	June 1, 1992	Shallow Zone
299-W18-250	299-W18-250 (14 ft)	14-14	March 1, 1993	Shallow Zone
299-W18-251	299-W18-251 (14 ft)	14-14	March 1, 1993	Shallow Zone
ETP-2	B07CC5	12-13	June 26, 1993	Shallow Zone
ETP-2	B07CC6	12-13	June 26, 1993	Shallow Zone
Test Pit #1	Test Pit #1 (West) (12.0-13 ft)	12-13	June 1, 1992	Shallow Zone
Test Pit #2	Test Pit #2 (Center) (12.0-13 ft)	12-13	June 1, 1992	Shallow Zone
Test Pit #3	Test Pit #3 (East) (12.0-13 ft)	12-13	June 1, 1992	Shallow Zone
ETP-1	B07CD3	11-13	June 26, 1993	Shallow Zone

Table 5-3. Summary of Soil Samples Included in the 216-U-14 Ditch Human Health Risk Assessment. (6 Pages)

Station ID	Sample ID	Depth Interval (ft)	Date Collected	Comment
ETP-3	B07CC0	11-13	June 26, 1993	Shallow Zone
ETP-3	B07CC1	11-13	June 26, 1993	Shallow Zone
ETP-1	B07CD2	11-12	June 26, 1993	Shallow Zone
299-W18-250	299-W18-250 (11 ft)	11-11	March 1, 1993	Shallow Zone
299-W18-251	299-W18-251 (11 ft)	11-11	March 1, 1993	Shallow Zone
299-W19-92	299-W19-92 (11 ft)	11-11	April 1, 1987	Shallow Zone
299-W18-33	299-W18-33 (10 ft)	10-10	May 1, 1993	Shallow Zone
299-W19-91	299-W19-91 (10 ft)	10-10	April 1, 1987	Shallow Zone
299-W19-93	299-W19-93 (10 ft)	10-10	April 1, 1987	Shallow Zone
299-W23-16	299-W23-16 (10 ft)	10-10	April 1, 1993	Shallow Zone
299-W23-17	299-23-17 (10 ft)	10-10	April 1, 1993	Shallow Zone
ETP-1	B07CD4	15-17	June 26, 1993	Deep Zone
ETP-1	B07CD5	15-17	June 26, 1993	Deep Zone
ETP-2	B07CD0	15-17	June 26, 1993	Deep Zone
ETP-2	B07CD1	15-17	June 26, 1993	Deep Zone
ETP-3	B07CC3	15-17	June 26, 1993	Deep Zone
299-W19-27	299-W19-27 (150 ft)	150-150	April 1, 1987	Deep Zone
299-W19-91	299-W19-91 (150 ft)	150-150	April 1, 1987	Deep Zone
299-W19-92	299-W19-92 (150 ft)	150-150	April 1, 1987	Deep Zone
299-W18-251	299-W18-251 (149 ft)	149-149	March 1, 1993	Deep Zone
299-W18-251	B08CD3	149-149	April 13, 1993	Deep Zone
299-W23-17	299-23-17 (149 ft)	149-149	April 1, 1993	Deep Zone
299-W18-33	299-W18-33 (145 ft)	145-145	May 1, 1993	Deep Zone
299-W19-27	299-W19-27 (145 ft)	145-145	April 1, 1987	Deep Zone
299-W19-91	299-W19-91 (145 ft)	145-145	April 1, 1987	Deep Zone
299-W19-92	299-W19-92 (145 ft)	145-145	April 1, 1987	Deep Zone
299-W19-27	299-W19-27 (140 ft)	140-140	April 1, 1987	Deep Zone
299-W19-91	299-W19-91 (140 ft)	140-140	April 1, 1987	Deep Zone
299-W19-92	299-W19-92 (140 ft)	140-140	April 1, 1987	Deep Zone
299-W18-33	299-W18-33 (135 ft)	135-135	May 1, 1993	Deep Zone
299-W19-91	299-W19-91 (135 ft)	135-135	April 1, 1987	Deep Zone
299-W19-92	299-W19-92 (135 ft)	135-135	April 1, 1987	Deep Zone

Table 5-3. Summary of Soil Samples Included in the 216-U-14 Ditch Human Health Risk Assessment. (6 Pages)

Station ID	Sample ID	Depth Interval (ft)	Date Collected	Comment
299-W23-16	299-W23-16 (135 ft)	135-135	April 1, 1993	Deep Zone
299-W23-17	299-23-17 (135 ft)	135-135	April 1, 1993	Deep Zone
299-W19-21	299-W19-21 (130-135 ft)	130-135	May 1, 1986	Deep Zone
299-W19-91	299-W19-91 (130 ft)	130-130	April 1, 1987	Deep Zone
299-W19-92	299-W19-92 (130 ft)	130-130	April 1, 1987	Deep Zone
299-W18-251	299-W18-251 (128 ft)	128-128	March 1, 1993	Deep Zone
299-W19-91	299-W19-91 (125 ft)	125-125	April 1, 1987	Deep Zone
299-W19-92	299-W19-92 (125 ft)	125-125	April 1, 1987	Deep Zone
299-W19-91	299-W19-91 (120 ft)	120-120	April 1, 1987	Deep Zone
299-W19-92	299-W19-92 (120 ft)	120-120	April 1, 1987	Deep Zone
299-W19-93	299-W19-93 (120 ft)	120-120	April 1, 1987	Deep Zone
299-W19-91	299-W19-91 (115 ft)	115-115	April 1, 1987	Deep Zone
299-W19-92	299-W19-92 (115 ft)	115-115	April 1, 1987	Deep Zone
299-W19-93	299-W19-93 (115 ft)	115-115	April 1, 1987	Deep Zone
299-W19-91	299-W19-91 (110 ft)	110-110	April 1, 1987	Deep Zone
299-W19-92	299-W19-92 (110 ft)	110-110	April 1, 1987	Deep Zone
299-W19-93	299-W19-93 (110 ft)	110-110	April 1, 1987	Deep Zone
299-W19-91	299-W19-91 (105 ft)	105-105	April 1, 1987	Deep Zone
299-W19-92	299-W19-92 (105 ft)	105-105	April 1, 1987	Deep Zone
299-W19-93	299-W19-93 (105 ft)	105-105	April 1, 1987	Deep Zone
299-W19-91	299-W19-91 (100 ft)	100-100	April 1, 1987	Deep Zone
299-W19-92	299-W19-92 (100 ft)	100-100	April 1, 1987	Deep Zone
299-W19-93	299-W19-93 (100 ft)	100-100	April 1, 1987	Deep Zone
299-W18-251	299-W18-251 (98 ft)	98-98	March 1, 1993	Deep Zone
299-W18-251	B08CC0	97.5-97.5	April 6, 1993	Deep Zone
299-W19-91	299-W19-91 (95 ft)	95-95	April 1, 1987	Deep Zone
299-W19-92	299-W19-92 (95 ft)	95-95	April 1, 1987	Deep Zone
299-W19-93	299-W19-93 (95 ft)	95-95	April 1, 1987	Deep Zone
299-W19-91	299-W19-91 (90 ft)	90-90	April 1, 1987	Deep Zone
299-W19-92	299-W19-92 (90 ft)	90-90	April 1, 1987	Deep Zone
299-W19-93	299-W19-93 (90 ft)	90-90	April 1, 1987	Deep Zone
299-W19-21	299-W19-21 (85-90 ft)	85-90	May 1, 1986	Deep Zone

Table 5-3. Summary of Soil Samples Included in the 216-U-14 Ditch Human Health Risk Assessment. (6 Pages)

Station ID	Sample ID	Depth Interval (ft)	Date Collected	Comment
299-W19-91	299-W19-91 (85 ft)	85-85	April 1, 1987	Deep Zone
299-W19-92	299-W19-92 (85 ft)	85-85	April 1, 1987	Deep Zone
299-W19-93	299-W19-93 (85 ft)	85-85	April 1, 1987	Deep Zone
299-W19-91	299-W19-91 (80 ft)	80-80	April 1, 1987	Deep Zone
299-W19-92	299-W19-92 (80 ft)	80-80	April 1, 1987	Deep Zone
299-W19-93	299-W19-93 (80 ft)	80-80	April 1, 1987	Deep Zone
299-W19-91	299-W19-91 (75 ft)	75-75	April 1, 1987	Deep Zone
299-W19-92	299-W19-92 (75 ft)	75-75	April 1, 1987	Deep Zone
299-W19-93	299-W19-93 (75 ft)	75-75	April 1, 1987	Deep Zone
299-W19-91	299-W19-91 (70 ft)	70-70	April 1, 1987	Deep Zone
299-W19-92	299-W19-92 (70 ft)	70-70	April 1, 1987	Deep Zone
299-W19-93	299-W19-93 (70 ft)	70-70	April 1, 1987	Deep Zone
299-W19-21	299-W19-21 (65-70 ft)	65-70	May 1, 1986	Deep Zone
299-W18-250	299-W18-250 (65 ft)	65-65	March 1, 1993	Deep Zone
299-W19-91	299-W19-91 (65 ft)	65-65	April 1, 1987	Deep Zone
299-W19-92	299-W19-92 (65 ft)	65-65	April 1, 1987	Deep Zone
299-W19-93	299-W19-93 (65 ft)	65-65	April 1, 1987	Deep Zone
299-W19-21	299-W19-21 (60-65 ft)	60-65	May 1, 1986	Deep Zone
299-W19-91	299-W19-91 (60 ft)	60-60	April 1, 1987	Deep Zone
299-W19-92	299-W19-92 (60 ft)	60-60	April 1, 1987	Deep Zone
299-W19-93	299-W19-93 (60 ft)	60-60	April 1, 1987	Deep Zone
299-W19-21	299-W19-21 (55-60 ft)	55-60	May 1, 1986	Deep Zone
299-W19-91	299-W19-91 (55 ft)	55-55	April 1, 1987	Deep Zone
299-W19-92	299-W19-92 (55 ft)	55-55	April 1, 1987	Deep Zone
299-W19-93	299-W19-93 (55 ft)	55-55	April 1, 1987	Deep Zone
299-W18-250	299-W18-250 (50 ft)	50-50	March 1, 1993	Deep Zone
299-W18-250	B08CB7	50-50	March 30, 1993	Deep Zone
299-W18-33	299-W18-33 (50 ft)	50-50	May 1, 1993	Deep Zone
299-W18-33	B08CL4	50-50	May 13, 1993	Deep Zone
299-W19-91	299-W19-91 (50 ft)	50-50	April 1, 1987	Deep Zone
299-W19-92	299-W19-92 (50 ft)	50-50	April 1, 1987	Deep Zone
299-W19-93	299-W19-93 (50 ft)	50-50	April 1, 1987	Deep Zone

Table 5-3. Summary of Soil Samples Included in the 216-U-14 Ditch Human Health Risk Assessment. (6 Pages)

Station ID	Sample ID	Depth Interval (ft)	Date Collected	Comment
299-W23-16	299-W23-16 (50 ft)	50-50	April 1, 1993	Deep Zone
299-W23-16	B08CF6	50-50	April 21, 1993	Deep Zone
299-W18-251	299-W18-251 (46 ft)	46-46	March 1, 1993	Deep Zone
299-W18-251	B08CD0	46-46	April 1, 1993	Deep Zone
299-W19-91	299-W19-91 (45 ft)	45-45	April 1, 1987	Deep Zone
299-W19-92	299-W19-92 (45 ft)	45-45	April 1, 1987	Deep Zone
299-W19-93	299-W19-93 (45 ft)	45-45	April 1, 1987	Deep Zone
299-W23-17	299-23-17 (45 ft)	45-45	April 1, 1993	Deep Zone
299-W23-17	B08CF3	45-45	April 13, 1993	Deep Zone
299-W23-17	B08CF4	45-45	April 13, 1993	Deep Zone
299-W18-33	299-W18-33 (40 ft)	40-40	May 1, 1993	Deep Zone
299-W19-91	299-W19-91 (40 ft)	40-40	April 1, 1987	Deep Zone
299-W19-92	299-W19-92 (40 ft)	40-40	April 1, 1987	Deep Zone
299-W19-93	299-W19-93 (40 ft)	40-40	April 1, 1987	Deep Zone
299-W23-16	299-W23-16 (40 ft)	40-40	April 1, 1993	Deep Zone
299-W23-17	299-23-17 (40 ft)	40-40	April 1, 1993	Deep Zone
299-W19-92	299-W19-92 (37 ft)	37-37	April 1, 1987	Deep Zone
299-W19-91	299-W19-91 (35 ft)	35-35	April 1, 1987	Deep Zone
299-W19-92	299-W19-92 (35 ft)	35-35	April 1, 1987	Deep Zone
299-W19-93	299-W19-93 (35 ft)	35-35	April 1, 1987	Deep Zone
299-W19-21	299-W19-21 (30-35 ft)	30-35	May 1, 1986	Deep Zone
299-W18-33	299-W18-33 (30 ft)	30-30	May 1, 1993	Deep Zone
299-W19-91	299-W19-91 (30 ft)	30-30	April 1, 1987	Deep Zone
299-W19-92	299-W19-92 (30 ft)	30-30	April 1, 1987	Deep Zone
299-W19-93	299-W19-93 (30 ft)	30-30	April 1, 1987	Deep Zone
299-W23-16	299-W23-16 (30 ft)	30-30	April 1, 1993	Deep Zone
299-W23-17	299-23-17 (30 ft)	30-30	April 1, 1993	Deep Zone
299-W18-33	299-W18-33 (26 ft)	26-26	May 1, 1993	Deep Zone
299-W18-33	B08CL1	26-26	May 12, 1993	Deep Zone
299-W18-250	299-W18-250 (25 ft)	25-25	March 1, 1993	Deep Zone
299-W18-250	B08CB5	25-25	March 30, 1993	Deep Zone
299-W18-251	299-W18-251 (25 ft)	25-25	March 1, 1993	Deep Zone

Table 5-3. Summary of Soil Samples Included in the 216-U-14 Ditch Human Health Risk Assessment. (6 Pages)

Station ID	Sample ID	Depth Interval (ft)	Date Collected	Comment
299-W18-251	B08CC8	25-25	April 1, 1993	Deep Zone
299-W19-91	299-W19-91 (25 ft)	25-25	April 1, 1987	Deep Zone
299-W19-92	299-W19-92 (25 ft)	25-25	April 1, 1987	Deep Zone
299-W19-93	299-W19-93 (25 ft)	25-25	April 1, 1987	Deep Zone
299-W23-16	299-W23-16 (25 ft)	25-25	April 1, 1993	Deep Zone
299-W23-16	B08CF5	25-25	April 20, 1993	Deep Zone
299-W23-17	299-23-17 (25 ft)	25-25	April 1, 1993	Deep Zone
299-W23-17	B08CD7	25-25	April 12, 1993	Deep Zone
299-W18-250	299-W18-250 (20 ft)	20-20	March 1, 1993	Deep Zone
299-W18-251	299-W18-251 (20 ft)	20-20	March 1, 1993	Deep Zone
299-W18-33	299-W18-33 (20 ft)	20-20	May 1, 1993	Deep Zone
299-W19-91	299-W19-91 (20 ft)	20-20	April 1, 1987	Deep Zone
299-W19-92	299-W19-92 (20 ft)	20-20	April 1, 1987	Deep Zone
299-W19-93	299-W19-93 (20 ft)	20-20	April 1, 1987	Deep Zone
299-W23-16	299-W23-16 (20 ft)	20-20	April 1, 1993	Deep Zone
299-W23-17	299-23-17 (20 ft)	20-20	April 1, 1993	Deep Zone
299-W23-16	299-W23-16 (200 ft)	200-200	April 1, 1993	Deep Zone
299-W23-17	299-23-17 (200 ft)	200-200	April 1, 1993	Deep Zone
ETP-3	B07CB8	18-19	June 26, 1993	Deep Zone
ETP-3	B07CB9	18-19	June 26, 1993	Deep Zone
Test Pit #1	Test Pit #1 (West) (18.0-19 ft)	18-19	June 1, 1992	Deep Zone
Test Pit #2	Test Pit #2 (Center) (18.0-19 ft)	18-19	June 1, 1992	Deep Zone
Test Pit #3	Test Pit #3 (East) (18.0-19 ft)	18-19	June 1, 1992	Deep Zone
299-W18-250	299-W18-250 (18 ft)	18-18	March 1, 1993	Deep Zone
299-W18-251	299-W18-251 (18 ft)	18-18	March 1, 1993	Deep Zone
Test Pit #1	Test Pit #1 (West) (16.0-17 ft)	16-17	June 1, 1992	Deep Zone
Test Pit #2	Test Pit #2 (Center) (16.0-17 ft)	16-17	June 1, 1992	Deep Zone
Test Pit #3	Test Pit #3 (East) (16.0-17 ft)	16-17	June 1, 1992	Deep Zone
299-W18-250	299-W18-250 (16 ft)	16-16	March 1, 1993	Deep Zone
299-W18-251	299-W18-251 (16 ft)	16-16	March 1, 1993	Deep Zone
299-W23-16	299-W23-16 (154 ft)	154-154	April 1, 1993	Deep Zone

ID = identification.

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Table 5-4. Summary of Statistics for Shallow-Zone Soils from the 216-Z-11 Ditch. (2 Pages)

Constituent Name	Units	Number of Samples	Number of Detects	Frequency of Detection	Minimum Nondetected Result	Maximum Nondetected Result	Minimum Detected Result	Maximum Detected Result	Average Detected Result	95UCL Lognormal Result	95UCL Normal Result	Exposure Point Concentration	EPC Basis
nmonia	mg/kg	3	2	67%	3.5	3.5	5.1	8.2	5.0	1,646	10	8.2	Max Detect
uoride	mg/kg	3	2	67%	1.3	1.3	1.5	1.7	1.3	17	2.2	1.7	Max Detect
trate	mg/kg	3	3	100%	--	--	24	43	33	75	49	43	Max Detect
itrite	mg/kg	2	2	100%	--	--	33	43	38	68	68	43	Max Detect
itrogen in Nitrite and Nitrate	mg/kg	3	3	100%	--	--	5.3	7.7	6.8	11	9.0	7.7	Max Detect
ılfate	mg/kg	3	3	100%	--	--	4.2	29	19	823,600	41	29	Max Detect
rsenic	mg/kg	4	3	75%	19	19	3.7	6.2	6.2	16	9.2	6.2	Max Detect
arium	mg/kg	4	4	100%	--	--	0.77	88	42	$1.19x10^{+18}$	98	88	Max Detect
eryllium	mg/kg	4	3	75%	0.97	0.97	0.22	0.25	0.30	0.66	0.44	0.25	Max Detect
oron	mg/kg	4	4	100%	--	--	0.77	24	6.7	$5.10x10^{+6}$	20	24	Max Detect
admium	mg/kg	4	1	25%	0.030	0.97	0.050	0.050	0.14	173,263	0.41	0.050	Max Detect
hromium	mg/kg	4	4	100%	--	--	8.7	11	9.6	11	11	11	Max Detect
opper	mg/kg	4	4	100%	--	--	14	30	20	46	29	30	Max Detect
exavalent Chromium	mg/kg	3	1	33%	0.43	0.46	0.54	0.54	0.33	3.8	0.64	0.54	Max Detect
ead	mg/kg	4	3	75%	19	19	5.8	7.1	7.2	10	9.2	7.1	Max Detect
ithium	mg/kg	1	1	100%	--	--	0.63	0.63	0.63	0		0.63	Max Detect
lagnesium	mg/kg	4	4	100%	--	--	4,200	4,760	4,575	4,956	4,881	4,760	Max Detect
langanese	mg/kg	4	4	100%	--	--	333	365	353	375	371	365	Max Detect
lercury	mg/kg	4	2	50%	0.020	0.020	0.080	0.66	0.19	$3.06x10^{+8}$	0.56	0.66	Max Detect
lolybdenum	mg/kg	4	3	75%	9.7	9.7	0.63	0.77	1.7	271	4.2	0.77	Max Detect
ickel	mg/kg	4	4	100%	--	--	9.7	11	10	11	11	11	Max Detect
ilver	mg/kg	4	1	25%	0.050	1.9	0.69	0.69	0.43	$1.25x10^{+9}$	0.99	0.69	Max Detect
anadium	mg/kg	4	4	100%	--	--	50	58	54	60	58	58	Max Detect
inc	mg/kg	4	4	100%	--	--	45	63	51	64	61	63	Max Detect
roclor-1254	mg/kg	4	1	25%	0.036	0.038	52	52	13	$4.66x10^{+37}$	44	52	Max Detect
roclor-1260	mg/kg	4	1	25%	0.036	0.038	78	78	19	$4.86x10^{+41}$	65	78	Max Detect
mericium-241	pCi/g	286	284	99%	0.19	15	0.014	$7.87x10^{+6}$	30,441	4,727	76,152	76,152	Normal
erium-139	pCi/g	3	3	100%	--	--	0.12	1,400	467	$3.01x10^{+110}$	1,829	1,400	Max Detect
esium-137	pCi/g	187	184	98%	0.040	0.040	0.0021	66,041	365	1.1	951	951	Normal
lutonium-238	pCi/g	62	54	87%	0.034	0.46	0.015	5,500	350	11,747	605	5,500	Max Detect
lutonium-239	pCi/g	15	15	100%	--	--	8.8	780,000	144,627	$1.07x10^{+8}$	264,257	780,000	Max Detect
lutonium-239/240	pCi/g	268	266	99%	0.46	0.53	0.0010	$1.30x10^{+7}$	51,807	14,720	132,229	132,229	Normal
otassium-40	pCi/g	14	14	100%	--	--	1.7	16	12	17	13	13	Normal
adium-226	pCi/g	12	12	100%	--	--	0.40	5,200	850	$1.39x10^{+7}$	1,880	5,200	Max Detect
adium-228	pCi/g	4	2	50%	0.37	0.37	0.69	0.81	0.47	15	0.85	0.81	Max Detect
trontium-90	pCi/g	30	23	77%	2.5	9.6	0.28	216	15	23	29	23	Log Normal
horium-228	pCi/g	4	1	25%	0.47	1.8	0.66	0.66	0.58	3.4	0.90	0.66	Max Detect

Table 5-4. Summary of Statistics for Shallow-Zone Soils from the 216-Z-11 Ditch. (2 Pages)

Constituent Name	Units	Number of Samples	Number of Detects	Frequency of Detection	Minimum Nondetected Result	Maximum Nondetected Result	Minimum Detected Result	Maximum Detected Result	Average Detected Result	95UCL Lognormal Result	95UCL Normal Result	Exposure Point Concentration	EPC Basis
ıorium-230	pCi/g	4	3	75%	1.1	1.1	0.50	8.4	4.0	920,598	8.7	8.4	Max Detect
ıorium-232	pCi/g	4	1	25%	0.70	1.7	0.71	0.71	0.57	1.6	0.85	0.71	Max Detect
·anium-233/234	pCi/g	4	1	25%	0.68	2.5	0.36	0.36	0.75	9.7	1.3	0.36	Max Detect
·anium-238	pCi/g	4	2	50%	1.1	1.2	0.44	0.77	0.59	0.89	0.76	0.77	Max Detect
s(2-ethylhexyl) phthalate	mg/kg	3	1	33%	0.33	0.36	0.042	0.042	0.13	70	0.26	0.042	Max Detect
›tal petroleum hydrocarbons	mg/kg	1	1	100%	--	--	27	27	27	0		27	Max Detect
ːetone	mg/kg	3	3	100%	--	--	0.0040	0.014	0.0080	0.37	0.017	0.014	Max Detect
ethylene chloride	mg/kg	3	2	67%	0.0060	0.0060	0.0050	0.0080	0.0053	0.051	0.0096	0.0080	Max Detect

ional parameter.
e point concentration.
e/polychlorinated biphenyl.
radiological.
atile organic compound.
roleum hydrocarbon.
onfidence limit.
organic compound.

Table 5-5. Summary of Statistics for Shallow-Zone Soils from the 216-U-10 Pond. (3 Pages)

Constituent Name	Units	Number of Samples	Number of Detects	Frequency of Detection	Minimum Nondetected Result	Maximum Nondetected Result	Minimum Detected Result	Maximum Detected Result	Average Detected Result	95UCL Lognormal Result	95UCL Normal Result	Exposure Point Concentration	EPC Basis
hloride	mg/kg	19	10	53%	0.40	0.40	0.90	24	3.8	26	6.2	24	Max Detect
luoride	mg/kg	19	7	37%	0.40	1.0	0.40	23	1.8	3.0	3.9	3.0	Log Normal
erosene	mg/kg	7	1	14%	5.0	29	76	76	15	141	35	76	Max Detect
itrogen in Nitrite and Nitrate	mg/kg	19	13	68%	2.5	2.5	3.3	145	21	63	38	63	Log Normal
ulfate	mg/kg	19	16	84%	1.5	37	1.6	2,360	156	852	370	852	Log Normal
otal organic carbon	mg/kg	3	3	100%	--	--	1,000	2,000	1,400	4,792	2,292	2,000	Max Detect
luminum	mg/kg	19	19	100%	--	--	4,350	31,500	7,961	9,476	10,380	9,476	Log Normal
ntimony	mg/kg	19	1	5%	3.6	17	12	12	5.0	6.1	5.9	6.1	Log Normal
rsenic	mg/kg	19	19	100%	--	--	1.4	10	3.4	4.2	4.3	4.2	Log Normal
arium	mg/kg	19	19	100%	--	--	69	331	106	126	136	126	Log Normal
eryllium	mg/kg	19	17	89%	0.45	0.46	0.28	0.78	0.49	0.57	0.55	0.55	Normal
admium	mg/kg	19	3	16%	0.30	1.3	0.54	9.1	1.1	1.6	2.0	1.6	Log Normal
alcium	mg/kg	19	19	100%	--	--	3,560	57,000	11,855	16,048	17,724	16,048	Log Normal
hromium	mg/kg	19	19	100%	--	--	5.1	83	14	18	21	18	Log Normal
obalt	mg/kg	19	19	100%	--	--	7.9	15	12	13	13	13	Normal
opper	mg/kg	19	17	89%	13	16	10	163	24	31	39	31	Log Normal
yanide	mg/kg	19	1	5%	0.24	5.2	0.15	0.15	0.57	0.77	0.78	0.15	Max Detect
ron	mg/kg	19	19	100%	--	--	15,800	26,000	21,389	22,671	22,564	22,564	Normal
ead	mg/kg	19	19	100%	--	--	3.0	107	15	20	25	20	Log Normal
agnesium	mg/kg	19	19	100%	--	--	2,790	8,240	4,844	5,381	5,373	5,381	Log Normal
anganese	mg/kg	19	19	100%	--	--	229	1,580	398	457	513	457	Log Normal
ercury	mg/kg	19	3	16%	0.050	0.10	0.080	1.4	0.14	0.18	0.27	0.18	Log Normal
ickel	mg/kg	19	19	100%	--	--	5.9	131	18	22	29	22	Log Normal
otassium	mg/kg	19	19	100%	--	--	442	2,110	1,312	1,536	1,458	1,458	Normal
elenium	mg/kg	19	1	5%	0.18	1.4	1.4	1.4	0.30	0.39	0.42	0.39	Log Normal
ilver	mg/kg	19	15	79%	0.62	1.0	0.98	24	2.5	3.5	4.6	3.5	Log Normal
odium	mg/kg	19	16	84%	124	138	121	476	183	239	222	239	Log Normal
hallium	mg/kg	19	4	21%	0.38	1.2	0.32	0.61	0.29	0.35	0.34	0.35	Log Normal
itanium	mg/kg	19	19	100%	--	--	810	2,420	1,546	1,734	1,700	1,700	Normal
ranium	mg/kg	19	19	100%	--	--	1.4	270	20	29	44	29	Log Normal
anadium	mg/kg	19	19	100%	--	--	24	73	49	57	55	55	Normal
inc	mg/kg	19	19	100%	--	--	27	645	91	119	153	119	Log Normal

Table 5-5. Summary of Statistics for Shallow-Zone Soils from the 216-U-10 Pond. (3 Pages)

Constituent Name	Units	Number of Samples	Number of Detects	Frequency of Detection	Minimum Nondetected Result	Maximum Nondetected Result	Minimum Detected Result	Maximum Detected Result	Average Detected Result	95UCL Lognormal Result	95UCL Normal Result	Exposure Point Concentration	EPC Basis
Aroclor-1254	mg/kg	6	1	17%	0.034	0.056	0.041	0.041	0.023	0.034	0.031	0.034	Log Normal
Aroclor-1260	mg/kg	6	2	33%	0.034	0.036	0.048	0.15	0.045	0.21	0.088	0.15	Max Detect
Dichlorodiphenyl dichloroethane	mg/kg	6	1	17%	0.0034	0.0056	0.0036	0.0036	0.0023	0.0031	0.0029	0.0031	Log Normal
Americium-241	pCi/g	19	17	89%	0.0014	0.0070	0.083	44	4.4	524	8.4	44	Max Detect
Bismuth-214	pCi/g	12	12	100%	--	--	0.23	0.49	0.41	0.45	0.44	0.44	Normal
Cesium-137	pCi/g	19	18	95%	9.42×10^{-5}	9.42×10^{-5}	0.10	3,994	346	$1.93 \times 10^{+8}$	717	3,994	Max Detect
Cobalt-60	pCi/g	19	6	32%	0.0020	0.080	0.0089	16	0.84	2.4	2.3	2.4	Log Normal
Curium-244	pCi/g	19	2	11%	0.0012	0.017	0.0085	0.024	0.0031	0.0054	0.0053	0.0054	Log Normal
Europium-152	pCi/g	19	5	26%	0.018	6.0	0.047	0.43	0.22	0.33	0.49	0.33	Log Normal
Europium-154	pCi/g	19	3	16%	0.0013	4.0	0.068	12	0.75	34	1.8	12	Max Detect
Europium-155	pCi/g	19	2	11%	0.0072	8.0	0.022	1.7	0.32	0.90	0.71	0.90	Log Normal
Gross alpha	pCi/g	19	18	95%	0.13	0.13	6.8	658	64	449	124	449	Log Normal
Gross beta	pCi/g	19	19	100%	--	--	25	3,700	395	1,101	740	1,101	Log Normal
Neptunium-237	pCi/g	19	3	16%	0.0040	0.027	0.033	0.28	0.026	0.048	0.052	0.048	Log Normal
Plutonium-238	pCi/g	19	9	47%	0.0031	0.034	0.035	22	1.7	397	3.7	22	Max Detect
Plutonium-239/240	pCi/g	19	16	84%	0.018	0.033	0.023	75	9.1	1,448	17	75	Max Detect
Potassium-40	pCi/g	19	19	100%	--	--	9.7	15	13	14	14	14	Normal
Radium-226	pCi/g	15	14	93%	5.0	5.0	0.37	0.90	0.69	0.85	0.93	0.85	Log Normal
Radium-228	pCi/g	13	13	100%	--	--	0.17	0.99	0.33	0.41	0.43	0.41	Log Normal
Selenium-79	pCi/g	19	9	47%	0.44	1.0	0.87	20	3.2	10	5.5	10	Log Normal
Sodium-22	pCi/g	19	3	16%	5.25×10^{-4}	0.90	0.0056	8.2	0.46	10	1.2	8.2	Max Detect
Strontium-90	pCi/g	19	17	89%	0.084	0.15	0.14	157	12	107	26	107	Log Normal
Technetium-99	pCi/g	19	6	32%	0.045	0.80	0.12	8.8	0.86	2.2	1.7	2.2	Log Normal
Thorium-228	pCi/g	3	2	67%	5.0	5.0	0.035	0.038	0.86	$2.28 \times 10^{+241}$	3.3	0.038	Max Detect
Thorium-232	pCi/g	14	14	100%	--	--	0.45	2.6	0.84	1.0	1.1	1.0	Log Normal
Uranium-233/234	pCi/g	3	3	100%	--	--	0.52	85	29	$1.66 \times 10^{+35}$	111	85	Max Detect
Uranium-234	pCi/g	16	16	100%	--	--	0.50	33	3.8	6.4	7.3	6.4	Log Normal
Uranium-235	pCi/g	19	10	53%	0.013	1.6	0.043	1.1	0.18	0.61	0.29	0.61	Log Normal
Uranium-238	pCi/g	19	19	100%	--	--	0.50	88	6.7	9.7	15	9.7	Log Normal
2,6-di-tert-Butyl-p-benzoquinone	mg/kg	2	2	100%	--	--	0.012	0.012	0.012	0.012	0.012	0.012	Max Detect

Table 5-5. Summary of Statistics for Shallow-Zone Soils from the 216-U-10 Pond. (3 Pages)

Constituent Name	Units	Number of Samples	Number of Detects	Frequency of Detection	Minimum Nondetected Result	Maximum Nondetected Result	Minimum Detected Result	Maximum Detected Result	Average Detected Result	95UCL Lognormal Result	95UCL Normal Result	Exposure Point Concentration	EPC Basis
·is(2-ethylhexyl) phthalate	mg/kg	19	2	11%	0.33	5.6	0.042	0.087	0.36	0.50	0.63	0.087	Max Detect
·iacetone alcohol	mg/kg	14	2	14%	0.0032	10	0.0051	0.0051	0.36	0.59	0.99	0.0051	Max Detect
·iethylphthalate	mg/kg	19	1	5%	0.33	5.6	0.067	0.067	0.37	0.47	0.63	0.067	Max Detect
·i-n-butylphthalate	mg/kg	19	1	5%	0.13	5.6	0.053	0.053	0.36	0.49	0.63	0.053	Max Detect
·otal petroleum hydrocarbons - diesel range	mg/kg	13	1	8%	10	76	10	10	8.5	12	13	10	Max Detect
,1,1-Trichloroethane	mg/kg	6	1	17%	0.010	0.017	0.0010	0.0010	0.0052	0.018	0.0072	0.0010	Max Detect
-Butanone	mg/kg	6	1	17%	0.010	0.012	0.047	0.047	0.012	0.054	0.026	0.047	Max Detect
·cetone	mg/kg	6	1	17%	0.010	0.025	0.19	0.19	0.038	1.2	0.099	0.19	Max Detect
·arbon disulfide	mg/kg	6	1	17%	0.010	0.012	0.0070	0.0070	0.0057	0.0064	0.0063	0.0064	Log Normal
·hloroform	mg/kg	6	1	17%	0.010	0.012	0.0020	0.0020	0.0048	0.0079	0.0060	0.0020	Max Detect
·oluene	mg/kg	6	2	33%	0.010	0.011	0.0020	0.017	0.0067	0.018	0.011	0.017	Max Detect

ventional parameter.
osure point concentration.
icide/polychlorinated biphenyl.
ayed radiological.
ivolatile organic compound.
l petroleum hydrocarbon.
er confidence limit.
atile organic compound.

Table 5-6. Summary of Statistics for Shallow-Zone Soils from the 216-U-14 Ditch.

nt	Constituent Name	Units	Number of Samples	Number of Detects	Frequency of Detection	Minimum Nondetected Result	Maximum Nondetected Result	Minimum Detected Result	Maximum Detected Result	Average Detected Result	95UCL Lognormal Result	95UCL Normal Result	Exposure Point Concentration	EPC Basis
	Sulfide	mg/kg	3	3	100%	--	--	20	20	20	20	20	20	Max Detect
	Antimony	mg/kg	3	3	100%	--	--	6.1	6.5	6.3	6.7	6.6	6.5	Max Detect
	Arsenic	mg/kg	3	3	100%	--	--	0.82	1.4	1.2	3.1	1.8	1.4	Max Detect
	Barium	mg/kg	3	3	100%	--	--	63	86	71	105	93	86	Max Detect
	Beryllium	mg/kg	3	3	100%	--	--	0.22	0.29	0.25	0.34	0.31	0.29	Max Detect
	Chromium	mg/kg	3	3	100%	--	--	6.9	7.1	7.0	7.3	7.2	7.1	Max Detect
	Cobalt	mg/kg	3	3	100%	--	--	6.1	7.1	6.7	7.8	7.5	7.1	Max Detect
	Copper	mg/kg	3	3	100%	--	--	14	15	14	15	15	15	Max Detect
	Lead	mg/kg	3	3	100%	--	--	2.3	3.4	2.9	4.5	3.8	3.4	Max Detect
	Manganese	mg/kg	3	3	100%	--	--	220	290	250	337	311	290	Max Detect
	Nickel	mg/kg	3	3	100%	--	--	4.4	6.2	5.5	8.6	7.2	6.2	Max Detect
	Potassium	mg/kg	3	3	100%	--	--	560	730	630	842	780	730	Max Detect
	Silver	mg/kg	3	3	100%	--	--	2.9	3.3	3.1	3.5	3.4	3.3	Max Detect
	Sodium	mg/kg	3	3	100%	--	--	290	320	300	335	329	320	Max Detect
	Vanadium	mg/kg	3	3	100%	--	--	60	68	65	73	72	68	Max Detect
	Zinc	mg/kg	3	3	100%	--	--	40	44	42	46	45	44	Max Detect
	Americium-241	pCi/g	25	13	52%	0.80	1.0	0.49	1.6	0.71	0.66	0.67	0.66	Log Normal
	Antimony-125	pCi/g	1	1	100%	--	--	0.10	0.10	0.10	0		0.10	Max Detect
	Cesium-137	pCi/g	34	21	62%	0.040	0.60	0.070	2,228	196	5,959	247	2,228	Max Detect
	Cobalt-60	pCi/g	22	8	36%	0.028	0.33	0.010	0.62	0.14	0.11	0.12	0.11	Log Normal
	Plutonium-238/239	pCi/g	12	12	100%	--	--	0.26	2.1	0.72	1.3	1.1	1.3	Log Normal
	Plutonium-239/240	pCi/g	1	1	100%	--	--	10	10	10	0		10	Max Detect
	Potassium-40	pCi/g	29	23	79%	1.1	1.1	1.2	18	12	31	12	12	Normal
	Radium	pCi/g	3	1	33%	1.0	1.0	1.0	1.0	1.0	3.0	1.2	1.0	Max Detect
	Radium-226	pCi/g	9	6	67%	0.010	0.070	0.040	0.66	0.29	5.0	0.35	0.66	Max Detect
	Strontium-90	pCi/g	30	17	57%	2.50×10^{-7}	0.81	9.78×10^{-4}	5.2	1.3	$6.85 \times 10^{+6}$	1.2	1.2	Normal
	Technetium-99	pCi/g	1	1	100%	--	--	12	12	12	0		12	Max Detect
	Uranium	pCi/g	13	13	100%	--	--	2.8	350	57	399	107	350	Max Detect
	Uranium-235	pCi/g	9	4	44%	0.010	0.20	0.040	0.13	0.075	0.43	0.086	0.086	Normal
	Uranium-238	pCi/g	12	12	100%	--	--	0.11	1.1	0.31	0.53	0.48	0.53	Log Normal
	Acetone	mg/kg	1	1	100%	--	--	0.012	0.012	0.012	0		0.012	Max Detect
	Methylene chloride	mg/kg	3	3	100%	--	--	0.0010	0.0020	0.0013	0.0060	0.0023	0.0020	Max Detect

= conventional parameter.
= exposure point concentration.
= decayed radiological.
= upper confidence limit.
volatile organic compound.

Table 5-7. Summary of Statistics for Deep-Zone Soils from the 216-Z-11 Ditch. (2 Pages)

Constituent Name	Units	Number of Samples	Number of Detects	Frequency of Detection	Minimum Nondetected Result	Maximum Nondetected Result	Minimum Detected Result	Maximum Detected Result	Average Detected Result	95UCL Lognormal Result	95UCL Normal Result	Exposure Point Concentration	EPC Basis
monia	mg/kg	10	7	70%	3.0	3.5	3.3	8.2	4.4	7.7	5.9	5.9	Normal
ɔride	mg/kg	10	2	20%	1.3	1.4	1.5	1.7	0.85	1.1	1.1	1.1	Log Normal
:ate	mg/kg	10	6	60%	1.3	1.4	2.4	43	15	693	24	24	Normal
:ite	mg/kg	3	3	100%	--	--	23	43	33	85	50	43	Max Detect
rogen in Nitrite and Nitrate	mg/kg	10	6	91%	0.20	0.22	2.2	7.7	3.2	288	5.0	5.0	Normal
fate	mg/kg	10	10	100%	--	--	2.2	29	13	41	19	29	Max Detect
enic	mg/kg	11	10	91%	19	19	1.0	6.8	4.3	7.4	5.7	6.8	Max Detect
:ium	mg/kg	11	11	100%	--	--	0.21	117	47	95,997	73	73	Normal
:yllium	mg/kg	11	10	91%	0.97	0.97	0.14	0.84	0.39	0.62	0.52	0.62	Log Normal
ron	mg/kg	11	11	100%	--	--	0.21	24	2.9	9.1	6.7	9.1	Log Normal
dmium	mg/kg	11	3	27%	0.020	0.97	0.050	0.20	0.081	0.30	0.16	0.20	Max Detect
romium	mg/kg	11	11	100%	--	--	5.5	19	11	14	13	14	Log Normal
pper	mg/kg	11	11	100%	--	--	11	30	16	19	19	19	Log Normal
xavalent Chromium	mg/kg	10	4	40%	0.41	0.46	0.46	1.9	0.47	0.82	0.77	0.82	Log Normal
ad	mg/kg	11	10	91%	19	19	2.4	7.1	5.1	7.0	6.3	7.0	Log Normal
hium	mg/kg	1	1	100%	--	--	0.63	0.63	0.63	0		0.63	Max Detect
ıgnesium	mg/kg	11	11	100%	--	--	2,890	5,430	4,175	4,675	4,589	4,589	Normal
ınganese	mg/kg	11	11	100%	--	--	252	397	322	353	349	349	Normal
ercury	mg/kg	11	2	18%	0.020	0.020	0.080	0.66	0.075	0.22	0.18	0.22	Log Normal
ɔlybdenum	mg/kg	11	10	91%	9.7	9.7	0.56	0.82	1.0	1.5	1.7	0.82	Max Detect
ckel	mg/kg	11	11	100%	--	--	7.1	15	10	12	12	12	Log Normal
ver	mg/kg	11	2	18%	0.040	1.9	0.060	0.69	0.17	0.75	0.35	0.69	Max Detect
nadium	mg/kg	11	11	100%	--	--	31	79	53	61	60	60	Normal
ıc	mg/kg	11	11	100%	--	--	30	63	43	48	48	48	Log Normal
oclor-1254	mg/kg	11	1	9%	0.033	0.038	52	52	4.7	71	13	52	Max Detect
oclor-1260	mg/kg	11	1	9%	0.033	0.038	78	78	7.1	157	20	78	Max Detect
nericium-241	pCi/g	314	306	97%	0.017	15	0.0070	$7.87 \times 10^{+6}$	27,727	4,772	69,362	69,362	Normal
rium-139	pCi/g	2	3	100%	--	--	0.12	1,400	467	$3.01 \times 10+^{110}$	1,829	1,400	Max Detect
sium-137	pCi/g	194	184	95%	0.040	0.040	0.0021	66,041	352	1.1	916	916	Normal
ptunium-237	pCi/g	11	1	9%	0.0040	0.028	0.060	0.060	0.0094	0.024	0.019	0.024	Log Normal
ıtonium-238	pCi/g	90	75	83%	0.034	0.46	0.0030	5,500	241	3,224	418	3,224	Log Normal
ıtonium-239	pCi/g	14	15	100%	--	--	8.8	780,000	144,627	$1.07 \times 10^{+8}$	264,257	780,000	Max Detect
ıtonium-239/240	pCi/g	296	288	97%	0.035	0.53	0.0010	$1.30 \times 10^{+7}$	46,907	18,976	119,721	119,721	Normal
tassium-40	pCi/g	21	21	100%	--	--	1.7	16	11	14	13	13	Log Normal
dium-226	pCi/g	19	19	100%	--	--	0.29	5,200	537	36,271	1,117	5,200	Max Detect
dium-228	pCi/g	11	9	82%	0.37	0.37	0.37	1.1	0.61	0.99	0.77	0.77	Normal

Table 5-7. Summary of Statistics for Deep-Zone Soils from the 216-Z-11 Ditch. (2 Pages)

Constituent Name	Units	Number of Samples	Number of Detects	Frequency of Detection	Minimum Nondetected Result	Maximum Nondetected Result	Minimum Detected Result	Maximum Detected Result	Average Detected Result	95UCL Lognormal Result	95UCL Normal Result	Exposure Point Concentration	EPC Basis
·ontium-90	pCi/g	37	23	62%	2.5	9.6	0.28	216	12	12	23	12	Log Normal
ıorium-228	pCi/g	11	6	55%	0.17	1.8	0.37	0.96	0.50	1.0	0.66	0.66	Normal
ıorium-230	pCi/g	11	10	91%	1.1	1.1	0.33	8.4	1.8	4.9	3.4	4.9	Log Normal
ıorium-232	pCi/g	11	8	73%	0.70	1.7	0.28	1.00	0.55	0.73	0.67	0.73	Log Normal
·anium-233/234	pCi/g	11	7	64%	0.45	2.5	0.36	0.64	0.55	0.78	0.72	0.64	Max Detect
·anium-238	pCi/g	11	9	82%	1.1	1.2	0.37	0.82	0.57	0.67	0.65	0.67	Log Normal
s(2-ethylhexyl) phthalate	mg/kg	10	3	30%	0.33	0.36	0.042	0.057	0.14	0.23	0.17	0.057	Max Detect
›tal petroleum hydrocarbons	mg/kg	1	1	100%	--	--	27	27	27	0		27	Max Detect
:etone	mg/kg	10	10	100%	--	--	0.0040	0.031	0.0075	0.010	0.0093	0.010	Log Normal
ethylene chloride	mg/kg	10	9	90%	0.0060	0.0060	0.0020	0.012	0.0060	0.011	0.0080	0.0080	Normal

ntional parameter.
ure point concentration.
ide/polychlorinated biphenyl.
ed radiological.
olatile organic compound.
›etroleum hydrocarbon.
confidence limit.
le organic compound.

Table 5-8. Summary of Statistics for Deep-Zone Soils from the 216-U-10 Pond. (3 Pages)

Constituent Name	Units	Number of Samples	Number of Detects	Frequency of Detection	Minimum Nondetected Result	Maximum Nondetected Result	Minimum Detected Result	Maximum Detected Result	Average Detected Result	95UCL Lognormal Result	95UCL Normal Result	Exposure Point Concentration	EPC Basis
ride	mg/kg	29	14	48%	0.40	0.40	0.40	24	3.2	11	4.8	11	Log Normal
ride	mg/kg	29	9	31%	0.40	1.2	0.40	23	1.3	1.4	2.7	1.4	Log Normal
sene	mg/kg	17	1	6%	5.0	30	76	76	9.8	14	17	14	Log Normal
gen in Nitrite and Nitrate	mg/kg	29	16	55%	2.5	2.5	3.3	145	16	30	27	30	Log Normal
ite	mg/kg	29	26	90%	1.5	37	1.6	2,360	107	194	245	194	Log Normal
l organic carbon	mg/kg	3	3	100%	--	--	1,000	2,000	1,400	4,792	2,292	2,000	Max Detect
ninum	mg/kg	29	29	100%	--	--	4,010	31,500	7,868	8,851	9,462	8,851	Log Normal
mony	mg/kg	29	2	7%	3.5	17	12	13	5.0	6.1	5.9	6.1	Log Normal
nic	mg/kg	29	29	100%	--	--	0.68	10	3.2	3.8	3.8	3.8	Log Normal
um	mg/kg	29	29	100%	--	--	59	331	104	116	123	116	Log Normal
llium	mg/kg	29	26	90%	0.45	0.54	0.28	1.0	0.50	0.58	0.56	0.56	Normal
nium	mg/kg	29	4	14%	0.29	1.3	0.46	9.1	0.90	1.0	1.5	1.0	Log Normal
ium	mg/kg	29	29	100%	--	--	3,560	70,900	14,082	17,865	19,296	17,865	Log Normal
omium	mg/kg	29	29	100%	--	--	5.1	83	13	15	18	15	Log Normal
alt	mg/kg	29	29	100%	--	--	7.9	21	12	13	13	13	Log Normal
per	mg/kg	29	25	86%	13	16	10	163	20	23	30	23	Log Normal
nide	mg/kg	29	2	7%	0.17	5.2	0.15	3.0	0.61	0.80	0.81	0.80	Log Normal
	mg/kg	29	29	100%	--	--	15,800	38,000	22,310	23,698	23,730	23,698	Log Normal
l	mg/kg	29	29	100%	--	--	2.0	107	11	12	18	12	Log Normal
nesium	mg/kg	29	29	100%	--	--	2,790	8,240	5,183	5,670	5,641	5,670	Log Normal
ganese	mg/kg	29	29	100%	--	--	229	1,580	398	437	473	437	Log Normal
cury	mg/kg	29	3	10%	0.050	0.12	0.080	1.4	0.11	0.11	0.19	0.11	Log Normal
kel	mg/kg	29	29	100%	--	--	5.9	131	16	17	23	17	Log Normal
ssium	mg/kg	29	29	100%	--	--	442	2,180	1,323	1,514	1,454	1,454	Normal
nium	mg/kg	29	1	3%	0.18	1.4	1.4	1.4	0.28	0.32	0.36	0.32	Log Normal
er	mg/kg	29	23	79%	0.62	1.1	0.98	24	2.1	2.4	3.4	2.4	Log Normal
um	mg/kg	29	26	90%	124	138	121	476	184	218	210	218	Log Normal
lium	mg/kg	29	5	17%	0.38	1.2	0.32	0.61	0.28	0.32	0.32	0.32	Log Normal
nium	mg/kg	29	29	100%	--	--	753	2,420	1,580	1,765	1,721	1,721	Normal
nium	mg/Kg	29	28	97%	1.2	1.2	1.4	270	19	22	36	22	Log Normal
adium	mg/kg	29	29	100%	--	--	24	74	52	58	56	56	Normal
	mg/kg	29	29	100%	--	--	27	645	73	78	113	78	Log Normal

Table 5-8. Summary of Statistics for Deep-Zone Soils from the 216-U-10 Pond. (3 Pages)

Constituent Name	Units	Number of Samples	Number of Detects	Frequency of Detection	Minimum Nondetected Result	Maximum Nondetected Result	Minimum Detected Result	Maximum Detected Result	Average Detected Result	95UCL Lognormal Result	95UCL Normal Result	Exposure Point Concentration	EPC Basis
lor-1254	mg/kg	16	1	6%	0.034	0.056	0.041	0.041	0.020	0.022	0.023	0.022	Log Normal
lor-1260	mg/kg	16	2	13%	0.034	0.041	0.048	0.15	0.028	0.035	0.043	0.035	Log Normal
lorodiphenyl dichloroethane	mg/kg	16	1	6%	0.0034	0.0056	0.0036	0.0036	0.0020	0.0022	0.0022	0.0022	Log Normal
ricium-241	pCi/g	29	26	90%	0.0014	0.0070	0.0066	44	3.0	264	5.6	44	Max Detect
uth-214	pCi/g	15	15	100%	--	--	0.23	0.80	0.46	0.53	0.52	0.53	Log Normal
um-137	pCi/g	29	21	72%	9.42×10^{-5}	0.018	0.10	8,313	513	$9.76 \times 10^{+10}$	1,045	8,313	Max Detect
lt-60	pCi/g	29	6	21%	0.0020	0.080	0.0089	16	0.55	0.26	1.5	0.26	Log Normal
um-244	pCi/g	29	3	10%	0.0012	0.017	0.0049	0.024	0.0028	0.0040	0.0043	0.0040	Log Normal
pium-152	pCi/g	29	7	24%	0.0025	6.0	0.047	0.43	0.16	0.19	0.33	0.19	Log Normal
pium-154	pCi/g	29	3	10%	0.0013	4.0	0.068	12	0.50	1.8	1.2	1.8	Log Normal
pium-155	pCi/g	29	6	21%	0.0072	8.0	0.021	1.7	0.22	0.22	0.47	0.22	Log Normal
s alpha	pCi/g	29	28	97%	0.13	0.13	3.8	658	47	121	87	121	Log Normal
s beta	pCi/g	29	29	100%	--	--	18	9,480	597	925	1,182	925	Log Normal
unium-237	pCi/g	29	3	10%	0.0040	0.027	0.033	0.28	0.018	0.018	0.035	0.018	Log Normal
onium-238	pCi/g	29	11	38%	0.0024	0.034	0.035	22	1.1	16	2.4	16	Log Normal
onium-239/240	pCi/g	28	18	64%	0.0020	0.033	0.023	75	6.2	1,726	11	75	Max Detect
ssium-40	pCi/g	29	29	100%	--	--	9.7	16	13	13	13	13	Normal
um-226	pCi/g	20	19	95%	5.0	5.0	0.36	1.1	0.70	0.82	0.87	0.82	Log Normal
um-228	pCi/g	18	18	100%	--	--	0.17	0.99	0.34	0.41	0.42	0.41	Log Normal
nium-79	pCi/g	29	12	41%	0.44	1.0	0.87	46	3.9	7.4	6.9	7.4	Log Normal
um-22	pCi/g	29	3	10%	5.25×10^{-4}	0.90	0.0056	8.2	0.31	0.68	0.79	0.68	Log Normal
ntium-90	pCi/g	29	21	72%	0.0017	0.15	0.14	157	9.8	6,072	19	157	Max Detect
netium-99	pCi/g	29	8	28%	0.044	0.80	0.12	8.8	0.75	1.3	1.3	1.3	Log Normal
rium-228	pCi/g	5	4	80%	5.0	5.0	0.028	0.042	0.53	2,678	1.6	0.042	Max Detect
rium-232	pCi/g	19	19	100%	--	--	0.45	2.6	0.87	1.0	1.1	1.0	Log Normal
nium-233/234	pCi/g	5	5	100%	--	--	0.48	85	17	$2.40 \times 10^{+6}$	53	85	Max Detect
nium-234	pCi/g	24	24	100%	--	--	0.48	56	5.1	6.8	9.6	6.8	Log Normal
nium-235	pCi/g	29	18	62%	0.011	1.6	0.031	2.4	0.22	0.49	0.37	0.49	Log Normal
nium-238	pCi/g	28	28	100%	--	--	0.43	88	6.6	7.8	13	7.8	Log Normal
li-tert-Butyl-p-benzoquinone	mg/kg	2	2	100%	--	--	0.012	0.012	0.012	0.012	0.012	0.012	Max Detect
2-ethylhexyl) phthalate	mg/kg	29	3	10%	0.33	5.6	0.042	0.11	0.30	0.33	0.47	0.11	Max Detect

Table 5-8. Summary of Statistics for Deep-Zone Soils from the 216-U-10 Pond. (3 Pages)

Constituent Name	Units	Number of Samples	Number of Detects	Frequency of Detection	Minimum Nondetected Result	Maximum Nondetected Result	Minimum Detected Result	Maximum Detected Result	Average Detected Result	95UCL Lognormal Result	95UCL Normal Result	Exposure Point Concentration	EPC Basis
etone alcohol	mg/kg	21	5	24%	0.0032	10	0.0048	0.0051	0.24	0.063	0.65	0.0051	Max Detect
hylphthalate	mg/kg	29	1	3%	0.33	5.6	0.067	0.067	0.31	0.33	0.47	0.067	Max Detect
-butylphthalate	mg/kg	29	1	3%	0.13	5.6	0.053	0.053	0.30	0.33	0.47	0.053	Max Detect
ne	mg/kg	29	1	3%	0.33	5.6	0.080	0.080	0.31	0.32	0.47	0.080	Max Detect
l petroleum hydrocarbons - diesel range	mg/kg	13	1	8%	10	76	10	10	8.5	12	13	10	Max Detect
l-Trichloroethane	mg/kg	16	1	6%	0.010	0.017	0.0010	0.0010	0.0054	0.0071	0.0061	0.0010	Max Detect
ıtanone	mg/kg	16	1	6%	0.010	0.012	0.047	0.047	0.0081	0.0098	0.013	0.0098	Log Normal
tone	mg/kg	16	2	13%	0.010	0.025	0.010	0.19	0.018	0.021	0.038	0.021	Log Normal
oon disulfide	mg/kg	16	1	6%	0.010	0.012	0.0070	0.0070	0.0056	0.0059	0.0059	0.0059	Log Normal
oroform	mg/kg	16	3	19%	0.010	0.012	0.0010	0.0020	0.0048	0.0072	0.0056	0.0020	Max Detect
ıene	mg/kg	16	2	13%	0.010	0.012	0.0020	0.017	0.0060	0.0073	0.0074	0.0073	Log Normal

ntional parameter.
ure point concentration.
ide/polychlorinated biphenyl.
ed radiological.
olatile organic compound.
etroleum hydrocarbon.
confidence limit.
le organic compound.

Table 5-9. Summary of Statistics for Deep-Zone Soils from the 216-U-14 Ditch. (2 Pages)

t	Constituent Name	Units	Number of Samples	Number of Detects	Frequency of Detection	Minimum Nondetected Result	Maximum Nondetected Result	Minimum Detected Result	Maximum Detected Result	Average Detected Result	95UCL Lognormal Result	95UCL Normal Result	Exposure Point Concentration	EPC Basis
	Chloride	mg/kg	11	7	64%	0.20	0.20	0.40	41	4.1	26	11	26	Log Normal
	Fluoride	mg/kg	11	6	55%	0.10	0.10	0.30	0.60	0.21	0.63	0.31	0.31	Normal
	Nitrate	mg/kg	11	5	45%	0.20	0.20	0.40	7.0	1.0	5.5	2.1	5.5	Log Normal
	Sulfate	mg/kg	11	10	91%	0.50	0.50	1.0	34	5.8	28	11	28	Log Normal
	Sulfide	mg/kg	15	8	53%	10	10	10	40	14	23	18	23	Log Normal
	Antimony	mg/kg	13	4	31%	0.20	0.20	6.1	7.0	2.1	43	3.6	3.6	Normal
	Arsenic	mg/kg	13	13	100%	--	--	0.82	3.7	1.9	2.5	2.3	2.5	Log Normal
	Barium	mg/kg	17	17	100%	--	--	63	110	84	91	90	90	Normal
	Beryllium	mg/kg	17	11	65%	0.0030	0.0030	0.21	0.80	0.27	121	0.38	0.38	Normal
	Chromium	mg/kg	17	17	100%	--	--	5.0	17	9.7	12	11	12	Log Normal
	Cobalt	mg/kg	17	17	100%	--	--	5.1	13	8.6	9.6	9.5	9.6	Log Normal
	Copper	mg/kg	17	17	100%	--	--	9.0	15	13	14	14	14	Normal
	Lead	mg/kg	13	13	100%	--	--	2.3	5.7	3.5	4.0	4.0	4.0	Log Normal
	Manganese	mg/kg	17	17	100%	--	--	220	470	329	366	360	360	Normal
	Nickel	mg/kg	17	17	100%	--	--	0.80	69	13	23	19	23	Log Normal
	Potassium	mg/kg	8	8	100%	--	--	560	730	638	683	680	683	Log Normal
	Silver	mg/kg	15	6	40%	0.020	0.020	2.7	3.3	1.2	952	2.0	2.0	Normal
	Sodium	mg/kg	17	17	100%	--	--	230	560	326	367	365	367	Log Normal
	Thallium	mg/kg	8	1	13%	0.0050	0.0050	0.12	0.12	0.017	0.11	0.045	0.11	Log Normal
	Vanadium	mg/kg	17	17	100%	--	--	35	69	61	66	65	65	Normal
	Zinc	mg/kg	17	17	100%	--	--	40	54	45	47	47	47	Log Normal
	Aroclor-1254	mg/kg	6	1	17%	0.0010	0.0010	0.0070	0.0070	0.0016	0.013	0.0038	0.0070	Max Detect
	Americium-241	pCi/g	68	19	28%	0.80	1.0	0.30	1.6	0.71	0.56	0.58	0.58	Normal
	Antimony-125	pCi/g	1	1	100%	--	--	0.10	0.10	0.10	0		0.10	Max Detect
	Cesium-137	pCi/g	162	69	43%	0.030	2.0	0.070	2,228	60	2.4	52	52	Normal
	Cobalt-60	pCi/g	113	22	19%	0.028	0.44	0.010	0.62	0.071	0.058	0.064	0.064	Normal
	Plutonium-238/239	pCi/g	18	18	100%	--	--	0.26	2.1	0.59	0.81	0.83	0.81	Log Normal
	Plutonium-239	pCi/g	49	1	2%	0.40	6.1	1.4	1.4	1.4	0.32	0.42	0.32	Log Normal
	Plutonium-239/240	pCi/g	1	1	100%	--	--	10	10	10	0		10	Max Detect
	Potassium-40	pCi/g	147	138	94%	1.1	13	1.1	131	15	18	17	17	Normal
	Radium	pCi/g	6	1	17%	1.0	1.0	1.0	1.0	1.0	0.78	0.75	0.75	Normal
	Radium-226	pCi/g	94	70	74%	0.010	0.26	0.010	8.4	0.55	0.78	0.61	0.78	Log Normal
	Strontium-90	pCi/g	77	47	61%	2.50E-07	0.82	9.78×10^{-4}	5.2	0.97	30,034	0.86	0.86	Normal
	Technetium-99	pCi/g	1	1	100%	--	--	12	12	12	0		12	Max Detect
	Uranium	pCi/g	19	19	100%	--	--	2.8	350	40	100	75	100	Log Normal
	Uranium-235	pCi/g	94	43	46%	0.010	0.45	0.010	0.23	0.076	0.085	0.072	0.085	Log Normal

Table 5-9. Summary of Statistics for Deep-Zone Soils from the 216-U-14 Ditch. (2 Pages)

t	Constituent Name	Units	Number of Samples	Number of Detects	Frequency of Detection	Minimum Nondetected Result	Maximum Nondetected Result	Minimum Detected Result	Maximum Detected Result	Average Detected Result	95UCL Lognormal Result	95UCL Normal Result	Exposure Point Concentration	EPC Basis
	Uranium-238	pCi/g	47	47	100%	--	--	0.020	1.1	0.23	0.29	0.29	0.29	Log Normal
	Bis(2-ethylhexyl) phthalate	mg/kg	4	1	25%	0.010	0.010	0.097	0.097	0.028	2,558	0.082	0.097	Max Detect
	2-Butanone	mg/kg	3	3	100%	--	--	0.033	0.047	0.040	0.059	0.052	0.047	Max Detect
	Acetone	mg/kg	4	2	50%	0.10	0.10	0.012	0.016	0.032	0.67	0.057	0.016	Max Detect
	Methylene chloride	mg/kg	9	9	100%	--	--	0.0010	0.0030	0.0016	0.0022	0.0020	0.0020	Normal
	Tetrahydrofuran	mg/kg	3	3	100%	--	--	0.018	0.025	0.021	0.031	0.027	0.025	Max Detect

conventional parameter.
exposure point concentration.
pesticide/polychlorinated biphenyl.
decayed radiological.
semivolatile organic compound.
total petroleum hydrocarbon.
upper confidence limit.
volatile organic compound.

Table 5-10. Comparison of Maximum Detected Values in Shallow-Zone Soils from the 216-Z-11 Ditch to Background Concentrations.

Constituent Class	Constituent Name	Units	Maximum Detected Result	90th Percentile Background Concentration	Does Maximum Concentration Exceed Background?
CONV	Nitrate (as nitrate)	mg/kg	43	52	No
CONV	Nitrite	mg/kg	43	na	NA
CONV	Nitrate (as N)	mg/kg	7.7	12	No
METAL	Arsenic	mg/kg	6.2		No
METAL	Barium	mg/kg	88	132	No
METAL	Beryllium	mg/kg	0.25	1.5	No
METAL	Boron	mg/kg	24	na	NA
METAL	Cadmium	mg/kg	0.050	1.0	No
METAL	Chromium	mg/kg	11	19	No
METAL	Copper	mg/kg	30	22	Yes
METAL	Hexavalent Chromium	mg/kg	0.54	na	NA
METAL	Lead	mg/kg	7.1	10	No
METAL	Lithium	mg/kg	0.63	na	NA
METAL	Manganese	mg/kg	365	512	No
METAL	Mercury	mg/kg	0.66	0.33	Yes
METAL	Molybdenum	mg/kg	0.77	na	NA
METAL	Nickel	mg/kg	11	19	No
METAL	Silver	mg/kg	0.69	0.73	No
METAL	Vanadium	mg/kg	58	85	No
METAL	Zinc	mg/kg	63	68	No
RAD_D	Americium-241	pCi/g	$7.87 \times 10^{+6}$	na	NA
RAD_D	Cerium-139	pCi/g	1,400	na	NA
RAD_D	Cesium-137	pCi/g	66,041	1.1	Yes
RAD_D	Plutonium-238	pCi/g	5,500	0.0038	Yes
RAD_D	Plutonium-239	pCi/g	780,000	na	NA
RAD_D	Plutonium-239/240	pCi/g	$1.30 \times 10^{+7}$	0.025	Yes
RAD_D	Potassium-40	pCi/g	16	17	No
RAD_D	Radium-226	pCi/g	5,200	0.82	Yes
RAD_D	Radium-228	pCi/g	0.81	1.3	No
RAD_D	Strontium-90	pCi/g	216	0.18	Yes
RAD_D	Thorium-228	pCi/g	0.66	1.3	No
RAD_D	Thorium-230	pCi/g	8.4	1.1	Yes
RAD_D	Thorium-232	pCi/g	0.71	1.3	No
RAD_D	Uranium-233/234	pCi/g	0.36	1.1	No
RAD_D	Uranium-238	pCi/g	0.77	1.1	No

CONV = conventional parameter.
na = not available.
NA = not applicable; contaminant does not have a background concentration and is carried forward to the risk assessment.
RAD = decayed radiological.

Table 5-11. Comparison of Maximum Detected Values in Shallow-Zone Soils from the 216-U-10 Pond to Background Concentrations. (2 Pages)

Constituent Class	Constituent Name	Units	Maximum Detected Result	90th Percentile Background Concentration	Does Maximum Concentration Exceed Background?
CONV	Nitrogen in Nitrite and Nitrate	mg/kg	145	12	Yes
METAL	Antimony	mg/kg	12	na	NA
METAL	Arsenic	mg/kg	10	20	No
METAL	Barium	mg/kg	331	132	Yes
METAL	Beryllium	mg/kg	0.78	1.5	No
METAL	Cadmium	mg/kg	9.1	1.0	Yes
METAL	Chromium	mg/kg	83	19	Yes
METAL	Cobalt	mg/kg	15	16	No
METAL	Copper	mg/kg	163	22	Yes
METAL	Cyanide	mg/kg	0.15	na	NA
METAL	Iron	mg/kg	26,000	32,600	No
METAL	Lead	mg/kg	107	10	Yes
METAL	Manganese	mg/kg	1,580	512	Yes
METAL	Mercury	mg/kg	1.4	0.33	Yes
METAL	Nickel	mg/kg	131	19	Yes
METAL	Selenium	mg/kg	1.4	na	NA
METAL	Silver	mg/kg	24	0.73	Yes
METAL	Thallium	mg/kg	0.61	na	NA
METAL	Titanium	mg/kg	2,420	2,570	Yes
METAL	Uranium	mg/kg	270	3.21	Yes
METAL	Vanadium	mg/kg	73	85	No
METAL	Zinc	mg/kg	645	68	Yes
RAD_D	Americium-241	pCi/g	44	na	NA
RAD_D	Cesium-137	pCi/g	3,994	1.1	Yes
RAD_D	Cobalt-60	pCi/g	16	na	NA
RAD_D	Europium-152	pCi/g	0.43	na	NA
RAD_D	Europium-154	pCi/g	12	0.033	Yes
RAD_D	Europium-155	pCi/g	1.7	0.054	Yes
RAD_D	Neptunium-237	pCi/g	0.28	na	NA
RAD_D	Plutonium-238	pCi/g	22	0.0038	Yes
RAD_D	Plutonium-239/240	pCi/g	75	0.025	Yes
RAD_D	Potassium-40	pCi/g	15	17	No

Table 5-11. Comparison of Maximum Detected Values in Shallow-Zone Soils from the 216-U-10 Pond to Background Concentrations. (2 Pages)

Constituent Class	Constituent Name	Units	Maximum Detected Result	90th Percentile Background Concentration	Does Maximum Concentration Exceed Background?
RAD_D	Radium-226	pCi/g	0.90	0.82	Yes
RAD_D	Radium-228	pCi/g	0.99	1.3	No
RAD_D	Selenium-79	pCi/g	20	na	NA
RAD_D	Sodium-22	pCi/g	8.2	na	NA
RAD_D	Strontium-90	pCi/g	157	0.18	Yes
RAD_D	Technetium-99	pCi/g	8.8	na	NA
RAD_D	Thorium-228	pCi/g	0.038	1.3	No
RAD_D	Thorium-232	pCi/g	2.6	1.3	Yes
RAD_D	Uranium-233/234	pCi/g	85	1.1	Yes
RAD_D	Uranium-234	pCi/g	33	1.1	Yes
RAD_D	Uranium-235	pCi/g	1.1	0.11	Yes
RAD_D	Uranium-238	pCi/g	88	1.1	Yes

CONV = conventional parameter.
na = not available.
NA = Not applicable; contaminant does not have a background concentration and is carried forward to the risk assessment.
RAD = decayed radiological.

Table 5-12. Comparison of Maximum Detected Values in Shallow-Zone Soils from the 216-U-14 Ditch to Background Concentrations.

Constituent Class	Constituent Name	Units	Maximum Detected Result	90th Percentile Background Concentration	Does Maximum Concentration Exceed Background?
METAL	Antimony	mg/kg	6.5	na	NA
METAL	Arsenic	mg/kg	1.4	20	No
METAL	Barium	mg/kg	86	132	No
METAL	Beryllium	mg/kg	0.29	1.5	No
METAL	Chromium	mg/kg	7.1	19	No
METAL	Cobalt	mg/kg	7.1	16	No
METAL	Copper	mg/kg	15	22	No
METAL	Lead	mg/kg	3.4	10	No
METAL	Manganese	mg/kg	290	512	No
METAL	Nickel	mg/kg	6.2	19	No
METAL	Silver	mg/kg	3.3	0.73	Yes
METAL	Vanadium	mg/kg	68	85	No
METAL	Zinc	mg/kg	44	68	No
RAD_D	Americium-241	pCi/g	1.6	na	NA
RAD_D	Antimony-125	pCi/g	0.10	na	NA
RAD_D	Cesium-137	pCi/g	2,228	1.1	Yes
RAD_D	Cobalt-60	pCi/g	0.62	0.0038	Yes
RAD_D	Plutonium-238/239	pCi/g	2.1	na	NA
RAD_D	Plutonium-239/240	pCi/g	10	0.025	Yes
RAD_D	Potassium-40	pCi/g	18	17	Yes
RAD_D	Radium-226	pCi/g	0.66	0.82	No
RAD_D	Strontium-90	pCi/g	5.2	0.18	Yes
RAD_D	Technetium-99	pCi/g	12	na	NA
RAD_D	Uranium	pCi/g	350	2.27	Yes
RAD_D	Uranium-235	pCi/g	0.13	0.11	Yes
RAD_D	Uranium-238	pCi/g	1.1	1.1	Yes

Notes:
na = not available.
NA = Not applicable; contaminant does not have a background concentration and is carried forward to the risk assessment.
RAD = decayed radiological.

Table 5-13. Comparison of Maximum Detected Values in Deep-Zone Soils from the 216-Z-11 Ditch to Background Concentrations.

Constituent Class	Constituent Name	Units	Maximum Detected Result	90th Percentile Background Concentration	Does Maximum Concentration Exceed Background?
CONV	Nitrate (as Nitrate)	mg/kg	43	52	No
CONV	Nitrite	mg/kg	43	na	NA
CONV	Nitrate (as N)	mg/kg	7.7	12	No
METAL	Arsenic	mg/kg	6.8	20	No
METAL	Barium	mg/kg	117	132	No
METAL	Beryllium	mg/kg	0.84	1.5	No
METAL	Boron	mg/kg	24	na	NA
METAL	Cadmium	mg/kg	0.20	1.0	No
METAL	Chromium	mg/kg	19	19	Yes
METAL	Copper	mg/kg	30	22	Yes
METAL	Hexavalent Chromium	mg/kg	1.9	na	NA
METAL	Lead	mg/kg	7.1	10	No
METAL	Lithium	mg/kg	0.63	33.5	No
METAL	Manganese	mg/kg	397	512	No
METAL	Mercury	mg/kg	0.66	0.33	Yes
METAL	Molybdenum	mg/kg	0.82	na	NA
METAL	Nickel	mg/kg	15	19	No
METAL	Silver	mg/kg	0.69	0.73	No
METAL	Vanadium	mg/kg	79	85	No
METAL	Zinc	mg/kg	63	68	No
RAD_D	Americium-241	pCi/g	$7.87 \times 10^{+6}$	na	NA
RAD_D	Cerium-139	pCi/g	1,400	na	NA
RAD_D	Cesium-137	pCi/g	66,041	1.1	Yes
RAD_D	Neptunium-237	pCi/g	0.060	na	NA
RAD_D	Plutonium-238	pCi/g	5,500	0.0038	Yes
RAD_D	Plutonium-239	pCi/g	780,000	na	NA
RAD_D	Plutonium-239/240	pCi/g	$1.30 \times 10^{+7}$	0.025	Yes
RAD_D	Potassium-40	pCi/g	16	17	No
RAD_D	Radium-226	pCi/g	5,200	0.82	Yes
RAD_D	Radium-228	pCi/g	1.1	1.3	No
RAD_D	Strontium-90	pCi/g	216	0.18	Yes
RAD_D	Thorium-228	pCi/g	0.96	1.3	No
RAD_D	Thorium-230	pCi/g	8.4	1.1	Yes
RAD_D	Thorium-232	pCi/g	1.00	1.3	No
RAD_D	Uranium-233/234	pCi/g	0.64	1.1	No
RAD_D	Uranium-238	pCi/g	0.82	1.1	No

CONV = conventional parameter.
na = not available.
NA = Not applicable; contaminant does not have a background concentration and is carried forward to the risk assessment.
RAD = decayed radiological.

Table 5-14. Comparison of Maximum Detected Values in Deep-Zone Soils from the 216-U-10 Pond to Background Concentrations. (2 Pages)

Constituent Class	Constituent Name	Units	Maximum Detected Result	90th Percentile Background Concentration	Does Maximum Concentration Exceed Background?
CONV	Nitrogen in Nitrite and Nitrate	mg/kg	145	12	Yes
METAL	Antimony	mg/kg	13	na	NA
METAL	Arsenic	mg/kg	10	20	No
METAL	Barium	mg/kg	331	132	Yes
METAL	Beryllium	mg/kg	1.0	1.5	No
METAL	Cadmium	mg/kg	9.1	1.0	Yes
METAL	Chromium	mg/kg	83	19	Yes
METAL	Cobalt	mg/kg	21	16	Yes
METAL	Copper	mg/kg	163	22	Yes
METAL	Cyanide	mg/kg	3.0	na	NA
METAL	Iron	mg/kg	38,000	32,600	Yes
METAL	Lead	mg/kg	107	10	Yes
METAL	Manganese	mg/kg	1,580	512	Yes
METAL	Mercury	mg/kg	1.4	0.33	Yes
METAL	Nickel	mg/kg	131	19	Yes
METAL	Selenium	mg/kg	1.4	na	NA
METAL	Silver	mg/kg	24	0.73	Yes
METAL	Thallium	mg/kg	0.61	na	NA
METAL	Titanium	mg/kg	2,420	2,570	No
METAL	Uranium	mg/kg	270	3.21	Yes
METAL	Vanadium	mg/kg	74	85	No
METAL	Zinc	mg/kg	645	68	Yes
RAD_D	Americium-241	pCi/g	44	na	NA
RAD_D	Bismuth-214	pCi/g	0.80	na	NA
RAD_D	Cesium-137	pCi/g	8,313	1.1	Yes
RAD_D	Cobalt-60	pCi/g	16	na	NA
RAD_D	Europium-152	pCi/g	0.43	na	NA
RAD_D	Europium-154	pCi/g	12	0.033	Yes
RAD_D	Europium-155	pCi/g	1.7	0.054	Yes
RAD_D	Neptunium-237	pCi/g	0.28	na	NA
RAD_D	Plutonium-238	pCi/g	22	0.0038	Yes
RAD_D	Plutonium-239/240	pCi/g	75	0.025	Yes
RAD_D	Potassium-40	pCi/g	16	17	No
RAD_D	Radium-226	pCi/g	1.1	0.82	Yes
RAD_D	Radium-228	pCi/g	0.99	1.3	No

Table 5-14. Comparison of Maximum Detected Values in Deep-Zone Soils from the 216-U-10 Pond to Background Concentrations. (2 Pages)

Constituent Class	Constituent Name	Units	Maximum Detected Result	90th Percentile Background Concentration	Does Maximum Concentration Exceed Background?
RAD_D	Selenium-79	pCi/g	46	na	NA
RAD_D	Sodium-22	pCi/g	8.2	na	NA
RAD_D	Strontium-90	pCi/g	157	0.18	Yes
RAD_D	Technetium-99	pCi/g	8.8	na	NA
RAD_D	Thorium-228	pCi/g	0.042	1.3	No
RAD_D	Thorium-232	pCi/g	0.6	1.3	Yes
RAD_D	Uranium 233/234	pCi/g	85	1.1	Yes
RAD_D	Uranium-234	pCi/g	56	1.1	Yes
RAD_D	Uranium-235	pCi/g	2.4	0.11	Yes
RAD_D	Uranium-238	pCi/g	88	1.1	Yes

CONV = conventional parameter.

na = not available.

NA = not applicable; contaminant does not have a background concentration and is carried forward to the risk assessment.

RAD = decayed radiological.

Table 5-15. Comparison of Maximum Detected Values in Deep-Zone Soils from the 216-U-14 Ditch to Background Concentrations.

Constituent Class	Constituent Name	Units	Maximum Detected Result	90th Percentile Background Concentration	Does Maximum Concentration Exceed Background?
CONV	Nitrate (as nitrate)	mg/Kg	7.0	52	No
METAL	Antimony	mg/Kg	7.0	na	NA
METAL	Arsenic	mg/Kg	3.7	20	No
METAL	Barium	mg/Kg	110	132	No
METAL	Beryllium	mg/Kg	0.80	1.5	No
METAL	Chromium	mg/Kg	17	19	No
METAL	Cobalt	mg/Kg	13	16	No
METAL	Copper	mg/Kg	15	22	No
METAL	Lead	mg/Kg	5.7	10	No
METAL	Manganese	mg/Kg	470	512	No
METAL	Nickel	mg/Kg	69	19	Yes
METAL	Silver	mg/Kg	3.3	0.73	Yes
METAL	Thallium	mg/Kg	0.12	na	NA
METAL	Vanadium	pCi/g	69	85	No
METAL	Zinc	pCi/g	54	68	No
RAD_D	Americium-241	pCi/g	1.6	na	NA
RAD_D	Antimony-125	pCi/g	0.10	na	NA
RAD_D	Cesium-137	pCi/g	2,228	1.1	Yes
RAD_D	Cobalt-60	pCi/g	0.62	0.0038	Yes
RAD_D	Plutonium-238/239	pCi/g	2.1	na	NA
RAD_D	Plutonium-239	pCi/g	1.4	0.025	Yes
RAD_D	Plutonium-239/240	pCi/g	10	0.025	Yes
RAD_D	Potassium-40	pCi/g	131	17	Yes
RAD_D	Radium-226	pCi/g	8.4	0.82	Yes
RAD_D	Strontium-90	pCi/g	5.2	0.18	Yes
RAD_D	Technetium-99	pCi/g	12	na	NA
RAD_D	Uranium	pCi/g	350	2.27	Yes
RAD_D	Uranium-235	pCi/g	0.23	0.11	Yes
RAD_D	Uranium-238	pCi/g	1.1	1.1	Yes

Notes:
CONV = conventional parameter.
na = not available.
NA = not applicable; contaminant does not have a background concentration and is carried forward to the risk assessment.
RAD = decayed radiological.

Table 5-16. Summary of Metals and Radionuclides that Exceed the Background Screening for the Human Health Risk Assessment. (2 Pages)

Constituent Name	216-Z-11 Ditch		216-U-10 Pond		216-U-14 Ditch	
	Shallow Zone	Deep Zone	Shallow Zone	Deep Zone	Shallow Zone	Deep Zone
Nitrate (as N)			X	X		
Antimony			X[1]	X[1]	X[1]	X[1]
Arsenic						
Barium			X	X		
Beryllium						
Boron	X[1]	X[1]				
Cadmium			X	X		
Chromium		X	X	X		
Cobalt				X		
Copper	X	X	X	X		
Cyanide			X[1]	X[1]		
Hexavalent chromium	X[1]	X[1]				
Lead			X	X		
Manganese			X	X		
Mercury	X	X	X	X		
Molybdenum	X[1]	X[1]				
Nickel			X	X		X
Selenium			X[1]	X[1]		
Silver			X	X	X	X
Thallium			X[1]	X[1]		X[1]
Uranium			X	X		
Vanadium						
Zinc			X	X		
Americium-241	X[1]	X[1]	X[1]	X[1]	X[1]	X[1]
Antimony-125					X[1]	X[1]
Cesium-137	X	X	X	X	X	X
Cobalt-60			X[1]	X[1]	X[1]	X[1]
Europium-152			X[1]	X[1]		
Europium-154			X	X		
Europium-155			X	X		
Neptunium-237		X[1]	X[1]	X[1]		
Plutonium-238	X	X	X	X		
Plutonium-238/239					X	X
Plutonium-239/240	X	X	X	X	X	X
Potassium-40					X	X
Radium-226	X	X	X	X		X
Radium-228						

Table 5-16. Summary of Metals and Radionuclides that Exceed the Background Screening for the Human Health Risk Assessment. (2 Pages)

Constituent Name	216-Z-11 Ditch		216-U-10 Pond		216-U-14 Ditch	
	Shallow Zone	Deep Zone	Shallow Zone	Deep Zone	Shallow Zone	Deep Zone
Selenium-79			X[1]	X[1]		
Sodium-22			X[1]	X[1]		
Strontium-90	X	X	X	X	X	X
Technetium-99			X[1]	X[1]	X[1]	X[1]
Thorium-228						
Thorium-230	X	X				
Thorium-232			X	X		
Uranium-233/234			X	X		
Uranium-234			X	X		
Uranium-235			X	X	X	X
Uranium-238			X	X	X	X

[1] Indicates that a background value was not available for this constituent.

Note – Blank cells indicate that constituents were not present in concentrations that exceeded the background screening values.

Table 5-17. Summary of COPCs Identified at Each Representative Waste Site. (2 Pages)

Constituent Name	216-Z-11 Ditch		216-U-10 Pond		216-U-14 Ditch	
	Shallow Zone	Deep Zone	Shallow Zone	Deep Zone	Shallow Zone	Deep Zone
Chloride			X	X		X
Fluoride	X	X	X	X		X
Nitrate (as N)			X	X		
Nitrite (as N)	X	X				
Sulfate	X	X	X	X		X
Antimony			X	X	X	X
Arsenic						
Barium			X	X		
Boron	X	X				
Cadmium			X	X		
Chromium		X	X	X		
Cobalt				X		
Copper	X	X	X	X		
Cyanide			X	X		
Hexavalent chromium	X	X				
Lead			X	X		
Manganese			X	X		
Mercury	X	X	X	X		
Molybdenum	X	X				
Nickel			X	X		X
Selenium			X	X		
Silver			X	X	X	X
Thallium			X	X		X
Uranium			X	X		
Zinc			X	X		
PCB-1254	X	X	X	X		X
PCB-1260	X	X	X	X		
DDD			X	X		
Americium-241	X	X	X	X	X	X
Antimony-125					X	X
Cesium-137	X	X	X	X	X	X
Cobalt-60			X	X	X	X
Europium-152			X	X		
Europium-154			X	X		
Europium-155			X	X		
Neptunium-237		X	X	X		
Plutonium-238	X	X	X	X		

Table 5-17. Summary of COPCs Identified at Each Representative Waste Site. (2 Pages)

Constituent Name	216-Z-11 Ditch		216-U-10 Pond		216-U-14 Ditch	
	Shallow Zone	Deep Zone	Shallow Zone	Deep Zone	Shallow Zone	Deep Zone
Plutonium-238/239					X	X
Plutonium-239/240	X	X	X	X	X	X
Potassium-40					X	X
Radium-226	X	X	X	X		X
Selenium-79			X	X		
Sodium-22			X	X		
Strontium-90	X	X	X	X	X	X
Technetium-99			X	X	X	X
Thorium-230	X	X				
Thorium-232			X	X		
Uranium-233/234			X	X		
Uranium-234			X	X		
Uranium-235			X	X	X	X
Uranium-238			X	X	X	X
Bis(2-ethylhexyl)phthalate	X	X	X	X		X
Diethylphthalate			X			
Di-n-butylphthalate			X			
1,1,1-Trichloroethane			X	X		
2-Butanone			X	X		X
Acetone	X	X	X	X	X	X
Carbon Disulfide			X	X		
Chloroform			X	X		
Methylene Chloride	X	X			X	X
Toluene			X	X		

Table 5-18. Summary of Exposure Assumptions for Industrial Soil and Ambient Air Risk-Based Concentrations.

Parameter	Symbol	Units	Industrial Land Use [a, b]
Target Risk -	TR	unitless	1x10-5
Target Hazard Quotient	THQ	unitless	1
Oral reference dose	RfDo	mg/kg-day	chemical specific
Oral cancer potency factor	CPFo	kg-day/mg	chemical specific
Inhalation reference dose	CPFi	mg/kg-day	chemical specific
Inhalation cancer potency factor	RfDi	kg-day/mg	chemical specific
Unit conversion factor	UCF	mg/kg	$1.00x10^{+6}$
Body Weight –adult	BWa	kg	70
Carcinogenic Averaging Time	ATC	years	75
Noncarcinogenic Averaging Time	ATN	years	20
Exposure Frequency	EF	unitless	0.4
Exposure Duration	ED	years	20
Incidental Soil Ingestion Rate	SIR	mg/day	50
Inhalation rate – carcinogens	INHc	m^3/day	20
Inhalation rate – noncarcinogens	INHnc	m^3/day	20
Gastrointestinal Absorption Factor	ABSgi	unitless	1
Inhalation Absorption Fraction	ABSinh	unitless	1

Source:
a. WAC 173-340-745, "Soil Cleanup Standards for Industrial Properties," (equations 745-1 and 745-2)
b. WAC 173-340-750 (4), Cleanup Standards to Protect Air Quality," "Method C Air Cleanup Levels."

Table 5-19. Summary of Exposure Assumptions for Risk-Based Concentrations for Groundwater Protection.

Parameter	Symbol	Units	WAC 173-340-720 Method B Parameter [a]
Target Risk -	TR	unitless	1.00×10^{-6}
Target Hazard Quotient	THQ	unitless	1
Oral reference dose	RfDo	mg/kg-day	chemical specific
Cancer potency factor	CPF	kg-day/mg	chemical specific
Unit conversion factor	UCF	μg/mg	1000
Body Weight – carcinogens	BW	kg	70
Body Weight – noncarcinogens	BW	kg	16
Carcinogenic Averaging Time	ATC	years	75
Noncarcinogenic Averaging Time	ATN	years	6
Drinking water fraction	DWF	unitless	1
Exposure Duration – carcinogens	ED	years	30
Exposure Duration – noncarcinogens	ED	years	6
Drinking water ingestion rate – carcinogens	DWIR	L/day	2
Drinking water ingestion rate – noncarcinogens	DWIR	L/day	1
Inhalation Correction Factor - volatile compound	INH	unitless	2
Inhalation Correction Factor - nonvolatile compound	INH	unitless	1

Source:
a. WAC 173-340-720, Ground Water Cleanup Standards," (equations 720-1 and 720-2)

Table 5-20. Summary of RESRAD Input Parameters. (7 Pages)

Description	Parameter	216-U-10 Pond	216-U-14 Ditch	216-Z-11 Ditch	Rationale and Citation
Exposure Pathways		External Gamma: Active Inhalation: Active Plant Ingestion: Suppressed Meat Ingestion: Suppressed Milk Ingestion: Suppressed Aquatic Foods: Suppressed Drinking Water: Suppressed Soil Ingestion: Active Radon: Suppressed			Based on 200-CW-5 work plan (DOE/RL-99-66) conceptual exposure model and refinement of the model as part of the RI; for protection of groundwater evaluation, only the drinking water pathway is active.
R011- Contaminated Zone (CZ)	Area of CZ	121405	4156	972	Site-specific areas from WIDS
	Thickness of CZ (No Cover-DC)	4.6	4.6	4.6	Assumes that site is contaminated at 95% upper confidence limit (UCL) from surface to 4.6 m bgs.
	Thickness of CZ (No Cover GWP)	1.5	3	3	Represents actual thickness of contamination based on RI results
	Length Parallel to Aquifer Flow	500	9	9	Site-specific
	Radiation Dose Limit (Residential Scenario)	15	15	15	
	Radiation Dose Limit (Industrial Scenario)	100 (15)	100 (15)	100 (15)	
	Elapsed Time Since Waste Placement	0	0	0	Environmental samples were collected in 1999.
Exposure Point Concentration (EPC)	EPCs	chemical-specific	chemical-specific	chemical-specific	All data are decayed to 2002
R013-Cover and CZ Hydrological Data	Cover depth (no cover)	0	0	0	Assumes that site is contaminated at 95% UCL from surface to 4.6 m bgs.

Table 5-20. Summary of RESRAD Input Parameters. (7 Pages)

Description	Parameter	216-U-10 Pond	216-U-14 Ditch	216-Z-11 Ditch	Rationale and Citation
	Cover depth (Cover)	0.6	2.7	1	Represents actual conditions of cover based on RI results
	Cover material density	1.5	1.8	1.5	Site-specific
	Cover erosion rate	0.001	0.001	0.001	RESRAD Default
	Density of CZ	1.3	1.5	1.8	Site-specific values based on RI results
	CZ erosion rate	0.001	0.001	0.001	RESRAD Default
	CZ Total Porosity	0.53	0.43	0.33	Site-specific values based on physical property samples from RI and WHC-EP-0883.
	CZ Field Capacity	0.2	0.2	0.2	Site-specific values based on physical property samples from RI and WHC-EP-0883.
	CZ Hydraulic conductivity	0.06	2.2	22	WHC-SD-EN-SE-004
	CZ b parameter	5.3	5.3	4.05	RESRAD Table E:2; Environmental Restoration Contractor (ERC) memorandum dated June 30, 1999 (McMahon 1999)
	Humidity in air	8	8	8	RESRAD Default
	Evapotranspiration coefficient	0.656	0.656	0.656	EPA, Region 10 guidance; Letter from EPA
	Precipitation	0.16	0.16	0.16	Based on 16 cm (6.3 inches) average annual rainfall (DOE-RL-90-07)
	Irrigation rate	0	0	0	RESRAD Default
	Irrigation mode	Overhead	Overhead	Overhead	RESRAD Default
	Runoff coefficient	0.2	0.2	0.2	RESRAD Default

Table 5-20. Summary of RESRAD Input Parameters. (7 Pages)

Description	Parameter	216-U-10 Pond	216-U-14 Ditch	216-Z-11 Ditch	Rationale and Citation
	Watershed area for nearby stream or pond	$1.00x10^{+6}$	$1.00x10^{+6}$	$1.00x10^{+6}$	RESRAD Default
	Accuracy for water/soil computations	0.001	0.001	0.001	RESRAD Default
R014 - Saturated Zone (SZ) hydrological data	Density of SZ	2.23	2.23	2.23	Site-specific value based on RI results and BHI-01177.
	SZ Total porosity	0.158	0.158	0.158	Site-specific values based on physical property samples from RI and WHC-EP-0883.
	SZ Effective porosity	0.158	0.158	0.158	Site-specific values based on physical property samples from RI and WHC-EP-0883.
	SZ Field Capacity	0.04	0.04	0.04	Site-specific values based on physical property samples from RI and WHC-EP-0883.
	SZ Hydraulic conductivity	5519	5519	5519	WHC-SD-EN-SE-004
	SZ b parameter	4.05	4.05	4.05	RESRAD Table E:2; Environmental Restoration Contractor (ERC) memorandum dated June 30, 1999 (McMahon 1999)
	Water table drop rate	0.001	0.001	0.001	RESRAD Default
	Well pump intake depth below water table	4.6	4.6	4.6	Typical RCRA well screen length
	Nondispersion (ND) or mass-balance	ND	ND	ND	RESRAD Default
	Well pumping rate	250	250	250	RESRAD Default
	Number of unsaturated strata	3	3	3	Site-specific
R015 - Uncontaminated and Unsaturated Strata Hydrological Data	Thickness - Strata 1	10	10	10	Site-specific values based on RI results and current water table elevation data

Table 5-20. Summary of RESRAD Input Parameters. (7 Pages)

Description	Parameter	216-U-10 Pond	216-U-14 Ditch	216-Z-11 Ditch	Rationale and Citation
	Thickness - Strata 2	30	30	30	Site-specific values based on RI results and current water table elevation data
	Thickness - Strata 3	23.2	23.2	23.2	Site-specific values based on RI results and current water table elevation data
	Soil Density (Strata 1)	1.98	1.98	1.98	Hanford formation gravel dominated sequence
	Soil Density (Strata 2)	1.5	1.5	1.5	Hanford formation sand dominated sequence and Cold Creek Interval
	Soil Density (Strata 3)	2.23	2.23	2.23	Ringold Unit E silty sandy gravel
	Total porosity/Effective porosity (Strata 1)	0.253	0.253	0.253	Site-specific value based on RI results and BHI-01177.
	Total porosity/Effective porosity (Strata 2)	0.435	0.435	0.435	Site-specific values based on physical property samples from RI and WHC-EP-0883.
	Total porosity/Effective porosity (Strata 3)	0.158	0.158	0.158	Site-specific values based on physical property samples from RI and WHC-EP-0883.
	Field capacity	0.04	0.04	0.04	Site-specific values based on physical property samples from RI and WHC-EP-0883.
	Soil-specific b parameter	4.05	4.05	4.05	RESRAD Table E:2; Environmental Restoration Contractor (ERC) memorandum dated June 30, 1999 (McMahon 1999)
	Hydraulic conductivity (Strata 1)	757	757	757	
	Hydraulic conductivity (Strata 2)	138	138	138	
	Hydraulic conductivity (Strata 3)	552	552	552	WHC-SD-EN-SE-004

Table 5-20. Summary of RESRAD Input Parameters. (7 Pages)

Description	Parameter	216-U-10 Pond	216-U-14 Ditch	216-Z-11 Ditch	Rationale and Citation
R016 - Distribution Coefficients and Leach Rates for Individual Radionuclides	Distribution Coefficients (K_d) for Contaminated Zone, Uncontaminated Zone and Saturated Zone	Am-241: 300		Pu-238/239/240: 200	PNNL-11800
		Co-60: 1200		Ra-226/228: 20	
		Cs-137: 1500		Sr-90: 20	
		Cm-244: 100		Tc-99: 0	
		Eu-152/154/155: 300		Th-228/230/232: 1000	
		Na-22: 10		U-232/234/235/238: 3	
		Np-237: 15		Sb-125: 0	
				Se-79: 0	
	Saturated leach rate	0	0	0	RESRAD Default
	Saturated solubility	0	0	0	RESRAD Default
R017 - Inhalation and External Gamma	Inhalation rate	7300	7300	7300	WDOH/320-015
	Mass loading for inhalation	0.0001	0.0001	0.0001	WDOH/320-015
	Dilution length for airborne dust	3	3	3	RESRAD Default
	Exposure duration	30	30	30	WAC 173-340-750 and EPA/540/R-92/003
	Inhalation shielding factor	0.4	0.4	0.4	RESRAD Default
	External gamma shielding factor	0.8	0.8	0.8	WDOH/320-015
	Indoor time fraction (Industrial Scenario)	0.137	0.137	0.137	200 Area Industrial scenario; On-site 2000 hr/yr (indoors 60%)
	Outdoor time fraction (Industrial Scenario)	0.091	0.091	0.091	200 Area Industrial scenario; On-site 2000 hr/yr (outdoors 40%)
R018 - Ingestion Pathway Data, Dietary Parameters	Shape factor	1	1	1	RESRAD Default
	Fruits, vegetables, and grain consumption	110	110	110	WDOH/320-015

Table 5-20. Summary of RESRAD Input Parameters. (7 Pages)

Description	Parameter	216-U-10 Pond	216-U-14 Ditch	216-Z-11 Ditch	Rationale and Citation
	Leafy vegetable consumption	2.7	2.7	2.7	WDOH/320-015
	Milk consumption	100	100	100	WDOH/320-015
	Meat and poultry consumption	36	36	36	WDOH/320-015
	Fish consumption	5	5	5	WDOH/320-015
	Other seafood consumption	0.9	0.9	0.9	WDOH 1997
	Soil Ingestion	36.5	36.5	36.5	WDOH 1997
	Drinking water intake	730	730	730	WDOH/320-015
	Drinking water contamination fraction	1	1	1	RESRAD Default
	Household water contamination fraction	1	1	1	RESRAD Default
	Livestock water contamination fraction	1	1	1	RESRAD Default
	Irrigation water contamination fraction	0	0	0	RESRAD Default
	Aquatic food contamination fraction	1	1	1	RESRAD Default
	Plant food contamination fraction	-1	-1	-1	RESRAD Default
	Meat contamination fraction	-1	-1	-1	RESRAD Default
R019 - Ingestion Pathway Data, Nondietary	Milk contamination fraction	-1	-1	-1	RESRAD Default
	Livestock fodder intake for meat	68	68	68	RESRAD Default
	Livestock fodder intake for milk	55	55	55	RESRAD Default
	Livestock water intake for meat	50	50	50	RESRAD Default
	Livestock water intake for milk	160	160	160	RESRAD Default
	Livestock intake of soil	0.5	0.5	0.5	RESRAD Default
	Mass loading for foliar deposition	0.0001	0.0001	0.0001	RESRAD Default
	Depth of soil mixing layer	0.15	0.15	0.15	RESRAD Default

Table 5-20. Summary of RESRAD Input Parameters. (7 Pages)

Description	Parameter	216-U-10 Pond	216-U-14 Ditch	216-Z-11 Ditch	Rationale and Citation
	Depth of roots	3	3	3	RESRAD Default
	Groundwater fractional usage - drinking water	1	1	1	RESRAD Default
	Groundwater fractional usage - household usage	1	1	1	RESRAD Default
	Groundwater fractional usage - livestock water	1	1	1	RESRAD Default
	Groundwater usage - irrigation	0	0	0	RESRAD Default
R021 - Radon		Not used			

BHI-01177, 1998, *Borehole Summary Report for the 216-B-2-2 Ditch,* Bechtel Hanford, Inc., Richland, Washington.

DOE/RL-90-07, 1992, *Remedial Investigation/Feasibility Study Work Plan for the 100-B/C-1 Operable Unit,* U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE/RL-99-66, 2000, *200-CW-5 U-Pond/Z Ditches Cooling Water Group Operable Unit RI/FS Work Plan,* Rev 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

EPA 540/R-92/003, 1991, *Risk Assessment Guidance for Superfund: Volume I -- Human Health Evaluation Manual (Part B. Development of Risk-Based Preliminary Remediation Goals),* U.S. Environmental Protection Agency, Washington, D.C.

McMahon, W. J., 1999, "Estimation of the Soil-Specific Exponential Parameter (b)," (Interoffice Memorandum to J. D. Fancher, Memorandum No. 070578 dated June 30, 1999), Environmental Restoration Contractor, Environmental Restoration Team, Richland, Washington.

PNNL-11800, 1998, Composite Analysis for Low-Level Waste Disposal in the 200 Area Plateau of the Hanford Site, Pacific Northwest National Laboratory, Richland, Washington.

Resource Conservation and Recovery Act of 1976, 42 USC 6901, et seq.

WAC 173-340-750, "Cleanup Standards to Protect Air Quality."

WDOH/320-015, 1997, Hanford Guidance for Radiological Cleanup, Rev. 1, Washington State Department of Health, Olympia, Washington.

WHC-SD-EN-SE-004, 1993, *Site Characterization Report: Results of Detailed Evaluation of the Suitability of the Site Proposed for Disposal of 200 Areas Treated Effluent,* Westinghouse Hanford Company, Richland, Washington.

CZ = contaminated zone.
DC = direct contact.
EPA = U.S. Environmental Protection Agency.
EPC = exposure point concentration.
ERC = Environmental Restoration Contractor.
GWP = groundwater protection.
K_d = distribution coefficient.
ND = nondispersion.
RCRA = *Resource Conservation and Recovery Act of 1976.*
RESRAD = RESidual RADioactivity.
RI = remedial investigation.
SZ = saturation zone.
UCL = upper confidence limit.
WIDS = Waste Information Data System.

Table 5-21. Summary of Chemical/Physical Parameters for Soil Risk-Based Concentrations Protective of Groundwater. (3 Pages)

Chemical Name	Groundwater RBC (µg/L)	Groundwater RBC Basis	K_d (L/kg)	Source*	HLC (dimensionless)	Source	K_{oc}	Source
1,1,1-Trichloroethane	200	MCL	0.14	2	0.71	1	135	1
2-Butanone	4,800	WAC 173-340-720 B	0.13	2	0.0057	3	134	3
Acetone	800	WAC 173-340-720 B	$5.75x10^{-4}$	2	0.0016	1	0.58	1
Antimony	6.0	MCL	45	1	--	--	--	--
Aroclor 1254	0.50	MCL	309	2	--	--	309,000	1
Aroclor 1260	0.50	MCL	309	2	--	--	309,000	1
Barium	1,120	WAC 173-340-720 B	41	1	--	--	--	--
bis(2-ethylhexyl) phthalate	6.3	WAC 173-340-720 B	111	2	$4.18x10^{-6}$	1	111,123	1
Boron	1,440	WAC 173-340-720 B	3.0	7	--	--	--	--
Cadmium	5.0	MCL	6.7	1	--	--	--	--
Carbon Disulfide	800	WAC 173-340-720 B	0.046	2	1.2	1	46	1
Chromium, Hexavalent	48	WAC 173-340-720 B	19	1	--	--	--	--
Chromium, Total	100	MCL	1,000	1	--	--	--	--
Cobalt	960	WAC 173-340-720 B	45	4	--	--	--	--
Copper	592	WAC 173-340-720 B	22	1	--	--	--	--
Cyanide	200	MCL	0	5	--	--	--	--

Table 5-21. Summary of Chemical/Physical Parameters for Soil Risk-Based Concentrations Protective of Groundwater. (3 Pages)

Chemical Name	Groundwater RBC (µg/L)	Groundwater RBC Basis	K_d (L/kg)	Source*	HLC (dimensionless)	Source	K_{oc}	Source
DDD	0.37	WAC 173-340-720 B	46	2	1.64×10^{-4}	1	45,800	1
Diethylphthalate	12,800	WAC 173-340-720 B	0.082	2	1.85×10^{-5}	1	82	1
Di-n-butylphthalate	1,600	WAC 173-340-720 B	1.6	2	3.85×10^{-8}	1	1,567	1
Fluoride	4,000	MCL	0	5	--	--	--	--
Lead	15	MCL	10,000	1	--	--	--	--
Manganese	50	SMCL	50	6	--	--	--	--
Mercury	2.0	MCL	52	1	0.47	1	--	--
Methylene Chloride	5.0	MCL	0.010	2	0.090	1	10	1
Molybdenum	80	WAC 173-340-720 B	10	8	--	--	--	--
Nickel	100	MCL	65	1	--	--	--	--
Nitrate	10,000	MCL	0	5	--	--	--	--
Nitrite	1,000	MCL	0	5	--	--	--	--
Pyrene	480	WAC 173-340-720 B	68	1	4.51×10^{-4}	1	67,992	1
Selenium	50	MCL	5.0	1	--	--	--	--
Silver	80	WAC 173-340-720 B	8.3	1	--	--	--	--
Sulfate	250,000	SMCL	0	5	--	--	--	--
Sulfide	--	--	--	--	--	--	--	--
Thallium	1.1	WAC 173-340-720 B	71	1	--	--	--	--
Titanium	$6.40 \times 10^{+7}$	WAC 173-340-720 B	1,000	4	--	--	--	--

Table 5-21. Summary of Chemical/Physical Parameters for Soil Risk-Based Concentrations Protective of Groundwater. (3 Pages)

Chemical Name	Groundwater RBC (µg/L)	Groundwater RBC Basis	K_d (L/kg)	Source*	HLC (dimensionless)	Source	K_{oc}	Source
Toluene	1,000	MCL	0.14	2	0.27	1	140	1
Uranium, Total	30	MCL	2.0	6	--	--	--	--
Zinc	4,800	WAC 173-340-720 B	62	1	--	--	--	--

Notes:
*1. Ecology 94-145, *Cleanup Levels & Risk Calculations under the Model Toxics Control Act Cleanup Regulation (CLARC) Version 3.1.*
*2. Ecology 94-145, $K_d = K_{oc}/1000$.
*3. Region IX preliminary remediation goals.
*4. ORNL
*5. Conservative assumption.
*6. DOE/RL-99-51, 2000, *Remedial Design Report and Remedial Action Work Plan for the 100-HR-3 Groundwater Operable Unit In Situ Redox Manipulation.*
*7. DOE/RL-92-05, 1993, *B Plant Source Aggregate Area Management Study Report.*
*8. ANL/EAIS-8, 1993, *Data Collection Handbook to Support Modeling Impacts of Radioactive Material in Soil.*
-- Not applicable.
HLC = Henry's law constant.
MCL = maximum contaminant level.
RBC = risk-based concentration.
SMCL = secondary maximum contaminant level.
WAC = *Washington Administrative Code.*

Table 5-22. Summary of Toxicity Values Used to Calculate Risk-Based Concentrations. (2 Pages)

Chemical Name	Oral Cancer Potency Factor $(mg/kg\text{-}day)^{-1}$	Source	Oral Reference Dose (mg/kg-day)	Source	Inhalation Cancer Potency Factor $(mg/kg\text{-}day)^{-1}$	Source	Inhalation Reference Dose (mg/kg-day)	Source	VF[a] (m^3/kg)
1,1,1-Trichlororethane	--	--	0.9	c	--	--	3	c	
2-Butanone	--	--	--	--	--	--	0.285714286	a	$1.94x10^{+4}$
Acetone	--	--	--	--	--	--	0.1	r	$1.26x10^{+4}$
Antimony	--	--	--	--	--	--	--	--	--
Aroclor-1254	--	--	--	--	2	a	0.00002	r	--
Aroclor-1260	2	a	--	--	2	a	--	--	--
Barium	--	--	--	--	--	--	0.000142857	c	--
Bis(2-ethylhexyl) phthalate	--	--	--	--	0.014	r	0.022	r	--
Boron	--	--	--	--	--	--	0.005714286	c	--
Cadmium	--	--	--	--	6.3	a	--	--	--
Carbon disulfide	--	--	--	--	--	--	0.2	a	$1.19x10^{+3}$
Chromium	--	--	--	--	294	a	--	--	--
Cobalt	--	--	0.06	b	--	--	--	--	--
Copper	--	--	--	--	--	--	--	--	--
Cyanide	--	--	0.02	a	--	--	--	--	--
DDD	0.24	a	--	--	--	--	--	--	--
Diethylphthalate	--	--	--	--	--	--	0.8	r	--
Di-n-butylphthalate	--	--	--	--	--	--	0.1	r	--
Fluoride	--	--	--	--	--	--	--	--	--
Hexavalent Chromium	--	--	0.003	a	0.042	c	$2.28571x10^{-6}$	a	--
Lead	--	--	--	--	--	--	--	--	--
Lithium	--	--	0.02	d	--	--	--	--	--
Manganese	--	--	--	--	--	--	0.000014	a	--
Mercury	--	--	--	--	--	--	--	--	--

Table 5-22. Summary of Toxicity Values Used to Calculate Risk-Based Concentrations. (2 Pages)

Chemical Name	Oral Cancer Potency Factor $(mg/kg\text{-}day)^{-1}$	Source	Oral Reference Dose (mg/kg-day)	Source	Inhalation Cancer Potency Factor $(mg/kg\text{-}day)^{-1}$	Source	Inhalation Reference Dose (mg/kg-day)	Source	VF[a] (m^3/kg)
Methylene chloride	--	--	--	--	0.001645	a	0.857142857	c	$2.43x10^{+6}$
Molybdenum	--	--	0.005	a	--	--	--	--	--
Nickel	--	--	--	--	--	--	--	--	--
Nitrate	--	--	1.6	a	--	--	--	--	--
Nitrite	--	--	0.1	a	--	--	--	--	--
Pyrene	--	--	--	--	--	--	0.03	r	--
Selenium	--	--	--	--	--	--	--	--	--
Silver	--	--	--	--	--	--	--	--	--
Thallium	--	--	--	--	--	--	--	--	--
Titanium	--	--	4	d	--	--	$8.60x10^{-3}$	d	--
Toluene	--	--	--	--	--	--	0.11	c	$3.55x10^{+6}$
Uranium	--	--	--	--	--	--	--	--	--
Zinc	--	--	--	--	--	--	--	--	--

Notes:

a. US EPA. The Integrated Risk Information System (IRIS 2003), a database available through the EPA National Center for Environmental Assessment (NCEA). http://www.epa.gov/iris/

b. US EPA Region IX Preliminary Remediation Goals Table. October, 2002, available at http://www.epa.gov/region09/waste/sfund/prg/s1_01.htm

c. US EPA. Health Effects Assessment Summary Tables (HEAST) FY 1997 Update, EPA 540 R-97/036. July 1997.

d. US EPA Region III Risk Based Concentration Table, available on the Internet at www.epa.gov/reg3hwmd/risk/index.htm. April 2, 2002.

R = route to route extrapolation.
VF = volatilization factor.
X = withdrawn.
-- = not applicable.

Table 5-23. Comparison of True Mean Shallow Soil Concentrations from the 216-Z-11 Ditch to Soil Risk-Based Concentrations.

Constituent Class	Constituent Name	Units	Number of Samples	Number of Detects	Frequency of Detection	Average Detected Result	Industrial Soil RBC	Does Average Concentration Exceed Industrial Soil RBC?
CONV	Ammonia	mg/kg	3	2	67%	5.0	--	--
CONV	Fluoride	mg/kg	3	2	67%	1.3	--	--
CONV	Nitrite	mg/kg	2	2	100%	38	350,000	No
CONV	Sulfate	mg/kg	3	3	100%	19	--	--
METAL	Boron	mg/kg	4	4	100%	6.7	315,000	No
METAL	Copper	mg/kg	4	4	100%	20	129,500	No
METAL	Hexavalent Chromium	mg/kg	3	1	33%	0.33	10,500	No
METAL	Mercury	mg/kg	4	2	50%	0.19	1,050	No
METAL	Molybdenum	mg/kg	4	3	75%	1.7	17,500	No
PEST/PCB	Aroclor-1254	mg/kg	4	1	25%	13	70	No
PEST/PCB	Aroclor-1260	mg/kg	4	1	25%	19	66	No
SVOC	Bis(2-ethylhexyl) phthalate	mg/kg	3	1	33%	0.13	9,375	No
TPH	Total petroleum hydrocarbons	mg/kg	1	1	100%	27	1,000	No
VOC	Acetone	mg/kg	3	3	100%	0.0080	350,000	No
VOC	Methylene chloride	mg/kg	3	2	67%	0.0053	17,500	No

Notes:
-- = not applicable.
CONV = conventional parameter.
PEST/PCB = pesticide/polychlorinated biphenyl.
RBC = risk-based concentration.
SVOC = semivolatile organic compound.
TPH = total petroleum hydrocarbon.
VOC = volatile organic compound.

Table 5-24. Comparison of True Mean Shallow Soil Concentrations from the 216-U-10 Pond to Direct Contact Soil Risk-Based Concentrations. (2 Pages)

Constituent Class	Constituent Name	Units	Number of Samples	Number of Detects	Frequency of Detection	Average Detected Result	Industrial Soil RBC	Does Average Concentration Exceed Industrial Soil RBC?
METAL	Antimony	mg/kg	19	1	5%	5.0	1,400	No
METAL	Arsenic	mg/kg	19	19	100%	3.4	88	No
METAL	Barium	mg/kg	19	19	100%	106	245,000	No
METAL	Cadmium	mg/kg	19	3	16%	1.1	3,500	No
METAL	Chromium	mg/kg	19	19	100%	14	10,500	No
METAL	Copper	mg/kg	19	17	89%	24	129,500	No
METAL	Cyanide	mg/kg	19	1	5%	0.57	70,000	No
METAL	Lead	mg/kg	19	19	100%	15	750	No
METAL	Manganese	mg/kg	19	19	100%	398	490,000	No
METAL	Mercury	mg/kg	19	3	16%	0.14	1,050	No
METAL	Nickel	mg/kg	19	19	100%	18	70,000	No
METAL	Selenium	mg/kg	19	1	5%	0.30	17,500	No
METAL	Silver	mg/kg	19	15	79%	2.5	17,500	No
METAL	Thallium	mg/kg	19	4	21%	0.29	280	No
METAL	Uranium	mg/kg	19	19	100%	20	24,500	No
METAL	Zinc	mg/kg	19	19	100%	91	$1.05x10^{+6}$	No
Pest/PCB	Aroclor-1254	mg/kg	6	1	17%	0.023	70	No
Pest/PCB	Aroclor-1260	mg/kg	6	2	33%	0.045	66	No
Pest/PCB	DDD	mg/kg	6	1	17%	0.0023	547	No
SVOC	2,6-di-tert-Butyl-p-benzoquinone	mg/kg	2	2	100%	0.012	--	No
SVOC	Bis(2-ethylhexyl) phthalate	mg/kg	19	2	11%	0.36	9,375	No
SVOC	Diacetone alcohol	mg/kg	14	2	14%	0.36	--	No
SVOC	Diethylphthalate	mg/kg	19	1	5%	0.37	$2.80x10^{+6}$	No
SVOC	Di-n-butylphthalate	mg/kg	19	1	5%	0.36	350,000	No

Table 5-24. Comparison of True Mean Shallow Soil Concentrations from the 216-U-10 Pond to Direct Contact Soil Risk-Based Concentrations. (2 Pages)

Constituent Class	Constituent Name	Units	Number of Samples	Number of Detects	Frequency of Detection	Average Detected Result	Industrial Soil RBC	Does Average Concentration Exceed Industrial Soil RBC?
TPH	Total petroleum hydrocarbons - diesel range	mg/kg	13	1	8%	8.5	2,000	No
VOC	1,1,1-Trichloroethane	mg/kg	6	1	17%	0.0052	$3.15 \times 10^{+6}$	No
VOC	2-Butanone	mg/kg	6	1	17%	0.012	$2.10 \times 10^{+6}$	No
VOC	Acetone	mg/kg	6	1	17%	0.038	350,000	No
VOC	Carbon disulfide	mg/kg	6	1	17%	0.0057	350,000	No
VOC	Chloroform	mg/kg	6	1	17%	0.0048	21,516	No
VOC	Toluene	mg/kg	6	2	33%	0.0067	700,000	No

Notes:
PEST/PCB = pesticide/polychlorinated biphenyl.
RBC = risk-based concentration.
SVOC = semivolatile organic compound.
TPH = total petroleum hydrocarbon.
VOC = volatile organic compound.

Table 5-25. Comparison of True Mean Shallow Soil Concentrations from the 216-U-14 Ditch to Industrial Direct Contact Soil Risk-Based Concentrations.

Constituent Class	Constituent Name	Units	Number of Samples	Number of Detects	Frequency of Detection	Average Detected Result	Industrial Soil RBC	Does Average Concentration Exceed Industrial Soil RBC?
CONV	Sulfide	mg/kg	3	3	100%	20.0	--	No
METAL	Antimony	mg/kg	3	3	100%	6.5	1,400	No
METAL	Silver	mg/kg	3	3	100%	3.3	17,500	No
VOC	Acetone	mg/kg	1	1	100%	0.012	350,000	No
VOC	Methylene chloride	mg/kg	3	3	100%	0.0020	17,500	No

Notes:
CONV = conventional parameter.
RBC = risk-based concentration.
VOC = volatile organic compound.

Table 5-26. Comparison of True Mean Deep-Zone Soil Concentrations from the 216-Z-11 Ditch to Soil Risk-Based Concentrations for Groundwater Protection.

Constituent Class	Constituent Name	Units	Number of Samples	Number of Detects	Frequency of Detection	Average Detected Result	GWP RBC	Does True Mean Exceed GWP RBC?
CONV	Ammonia	mg/kg	10	7	70%	4.4	--	--
CONV	Fluoride	mg/kg	10	2	20%	0.85	16	No
CONV	Nitrite (as N02)	mg/kg	3	3	100%	33	13	Yes
CONV	Sulfate	mg/kg	10	10	100%	13	1,000	No
METAL	Boron	mg/kg	11	11	100%	2.9	11	No
METAL	Total Chromium	mg/kg	11	11	100%	11	2,000	No
METAL	Copper	mg/kg	11	11	100%	16	263	No
METAL	Hexavalent Chromium	mg/kg	10	4	40%	0.47	18	No
METAL	Mercury	mg/kg	11	2	18%	0.075	2.1	No
METAL	Molybdenum	mg/kg	11	10	91%	1.0	16	No
PEST/	Aroclor-1254	mg/kg	11	1	9%	4.7	3.1	Yes
PEST/	Aroclor-1260	mg/kg	11	1	9%	7.1	0	Yes
SVOC	Bis(2-ethylhexyl) phthalate	mg/kg	10	3	30%	0.14	14	No
TPH	Total petroleum hydrocarbons	mg/kg	1	1	100%	27	--	--
VOC	Acetone	mg/kg	10	10	100%	0.0075	3.2	No
VOC	Methylene chloride	mg/kg	10	9	90%	0.0060	0.022	No

Notes:

-- = not applicable.
CONV = conventional parameter.
GWP = groundwater protection.
PEST/PCB = pesticide/polychlorinated biphenyl.
RBC = risk-based concentration.
SVOC = semivolatile organic compound.
TPH = total petroleum hydrocarbon.
VOC = volatile organic compound.

Table 5-27. Comparison of True Mean Deep-Zone Soil Concentrations from the 216-U-10 Pond to Soil Risk-Based Concentrations for Groundwater Protection. (2 Pages)

Constituent Class	Constituent Name	Units	Number of Samples	Number of Detects	Frequency of Detection	Average Detected Result	GWP RBC	Does True Mean Exceed GWP RBC?
CONV	Chloride	mg/kg	29	14	48%	3.2	1,000	No
CONV	Fluoride	mg/kg	29	9	31%	1.3	16	No
CONV	Kerosene	mg/kg	17	1	6%	9.8	--	No
CONV	Nitrogen in Nitrite and Nitrate	mg/kg	29	16	55%	16	40	No
CONV	Sulfate	mg/kg	29	26	90%	107	1,000	No
METAL	Antimony	mg/kg	29	2	7%	5.0	5.4	No
METAL	Barium	mg/kg	29	29	100%	104	923	No
METAL	Cadmium	mg/kg	29	4	14%	0.90	0.69	Yes
METAL	Chromium	mg/kg	29	29	100%	13	18	No
METAL	Cobalt	mg/kg	29	29	100%	12	868	No
METAL	Copper	mg/kg	29	25	86%	20	263	No
METAL	Cyanide	mg/kg	29	2	7%	0.61	0.80	No
METAL	Lead	mg/kg	29	29	100%	11	3,000	No
METAL	Manganese	mg/kg	29	29	100%	398	50	Yes
METAL	Mercury	mg/kg	29	3	10%	0.11	2.1	No
METAL	Nickel	mg/kg	29	29	100%	16	130	No
METAL	Selenium	mg/kg	29	1	3%	0.28	5.2	No
METAL	Silver	mg/kg	29	23	79%	2.1	14	No
METAL	Thallium	mg/kg	29	5	17%	0.28	1.6	No
METAL	Uranium	mg/kg	29	28	97%	19	1.3	Yes
METAL	Zinc	mg/kg	29	29	100%	73	5,971	No
Pest/PCB	Aroclor-1254	mg/kg	16	1	6%	0.020	3.1	No
Pest/PCB	Aroclor-1260	mg/kg	16	2	13%	0.028	3.1	No

Table 5-27. Comparison of True Mean Deep-Zone Soil Concentrations from the 216-U-10 Pond to Soil Risk-Based Concentrations for Groundwater Protection. (2 Pages)

Constituent Class	Constituent Name	Units	Number of Samples	Number of Detects	Frequency of Detection	Average Detected Result	GWP RBC	Does True Mean Exceed GWP RBC?
Pest/PCB	DDD	mg/kg	16	1	6%	0.0020	0.34	No
SVOC	2,6-di-tert-Butyl-p-benzoquinone	mg/kg	2	2	100%	0.012	--	No
SVOC	Bis(2-ethylhexyl) phthalate	mg/kg	29	3	10%	0.30	14	No
SVOC	Diacetone alcohol	mg/kg	21	5	24%	0.24	--	No
SVOC	Diethylphthalate	mg/kg	29	1	3%	0.31	72	No
SVOC	Di-n-butylphthalate	mg/kg	29	1	3%	0.30	57	No
SVOC	Pyrene	mg/kg	29	1	3%	0.31	655	No
TPH	Total petroleum hydrocarbons - diesel range	mg/kg	13	1	8%	8.5	--	No
VOC	1,1,1-Trichloroethane	mg/kg	16	1	6%	0.0054	1.6	No
VOC	2-Butanone	mg/kg	16	1	6%	0.0081	32	No
VOC	Acetone	mg/kg	16	2	13%	0.018	3.2	No
VOC	Carbon disulfide	mg/kg	16	1	6%	0.0056	5.7	No
VOC	Chloroform	mg/kg	16	3	19%	0.0048	0.038	No
VOC	Toluene	mg/kg	16	2	13%	0.0060	7.3	No

Notes:

-- = not applicable.
CONV = conventional parameter.
GWP = groundwater protection.
PEST/PCB = pesticide/polychlorinated biphenyl.
RBC = risk-based concentration.
SVOC = semivolatile organic compound.
TPH = total petroleum hydrocarbon.
VOC = volatile organic compound.

Table 5-28. Comparison of True Mean Deep-Zone Soil Concentrations from the 216-U-14 Ditch to Soil Risk-Based Concentrations for Groundwater Protection.

Constituent Class	Constituent Name	Units	Number of Samples	Number of Detects	Frequency of Detection	Average Detected Result	GWP RBC	Does True Mean Exceed GWP RBC?
CONV	Chloride	mg/kg	11	7	64%	4.1	1,000	No
CONV	Fluoride	mg/kg	11	6	55%	0.21	16	No
CONV	Sulfate	mg/kg	11	5	45%	5.8	1,000	No
CONV	Sulfide	mg/kg	11	10	91%	14	NA	No
METAL	Antimony	mg/kg	15	8	53%	2.1	5.4	No
METAL	Nickel	mg/kg	13	4	31%	13	130	No
METAL	Silver	mg/kg	13	13	100%	1.2	14	No
METAL	Thallium	mg/kg	17	17	100%	0.017	1.6	No
PEST/PCB	Aroclor-1254	mg/kg	17	11	65%	0.0016	3.1	No
SVOC	Bis(2-ethylhexyl) phthalate	mg/kg	17	17	100%	0.028	14	No
VOC	2-Butanone	mg/kg	17	17	100%	0.040	32	No
VOC	Acetone	mg/kg	17	17	100%	0.032	3.2	No
VOC	Methylene chloride	mg/kg	13	13	100%	0.0016	0.022	No
VOC	Tetrahydrofuran	mg/kg	17	17	100%	0.021	--	--

Notes:

--	=	not applicable.
CONV	=	conventional parameter
GWP	=	groundwater protection
PEST/PCB	=	pesticide/polychlorinated biphenyl
RBC	=	risk-based concentration
SVOC	=	semivolatile organic compound
VOC	=	volatile organic compound

Table 5-29. Comparison of Maximum Shallow-Zone Soil Concentrations from the 216-Z-11 Ditch to Industrial Ambient Air Risk-Based Concentrations .

Constituent Class	Constituent Name	Units	Number of Samples	Number of Detects	Frequency of Detection	Maximum Detected Result	PEF or VF (m^3/kg)	1/PEF or 1/VF (kg/m^3)	Max Air Concentration (mg/m^3)	Industrial Ambient Air RBC (mg/m^3)	Does Maximum Air Concentration Exceed Ambient Air Industrial RBC?
METAL	Boron	mg/kg	4	4	100%	24	$1.32x10^{+9}$	$7.58x10^{-10}$	$1.80x10^{-8}$	0.020	No
METAL	Copper	mg/kg	4	4	100%	30	$1.32x10^{+9}$	$7.58x10^{-10}$	$2.30x10^{-8}$	--	--
METAL	Hexavalent Chromium	mg/kg	3	1	33%	0.54	$1.32x10^{+9}$	$7.58x10^{-10}$	$4.09x10^{-10}$	$2.98x10^{-7}$	No
METAL	Mercury	mg/kg	4	2	50%	0.66	$1.32x10^{+9}$	$7.58x10^{-10}$	$4.98x10^{-10}$	--	--
METAL	Molybdenum	mg/kg	4	3	75%	0.77	$1.32x10^{+9}$	$7.58x10^{-10}$	$5.83x10^{-10}$	--	--
PEST/PCB	Aroclor-1254	mg/kg	4	1	25%	52	$1.32x10^{+9}$	$7.58x10^{-10}$	$3.94x10^{-8}$	$4.38x10^{-5}$	No
PEST/PCB	Aroclor-1260	mg/kg	4	1	25%	78	$1.32x10^{+9}$	$7.58x10^{-10}$	$5.88x10^{-8}$	$4.38x10^{-5}$	No
SVOC	Bis(2-ethylhexyl) phthalate	mg/kg	3	1	33%	0.042	$1.32x10^{+9}$	$7.58x10^{-10}$	$3.18x10^{-11}$	0.0063	No
TPH	Total petroleum hydrocarbons	mg/kg	1	1	100%	27	$1.32x10^{+9}$	$7.58x10^{-10}$	$2.02x10^{-8}$	--	--
VOC	Acetone	mg/kg	3	3	100%	0.014	12,554	$7.97x10^{-5}$	$1.12x10^{-6}$	0.35	No
VOC	Methylene chloride	mg/kg	3	2	67%	0.0080	2,425	$4.12x10^{-4}$	$3.30x10^{-6}$	0.053	No

Notes:
PEF = particulate emissions factor.
PEST/PCB = pesticide/polychlorinated biphenyl.
RBC = risk-based concentration.
SVOC = semivolatile organic compound.
TPH = total petroleum hydrocarbon.
VF = volatilization factor.
VOC = volatile organic compound.

Table 5-30. Comparison of Maximum Shallow-Zone Soil Concentrations from the 216-U-10 Pond to Industrial Ambient Air Risk-Based Concentrations. (2 Pages)

Constituent Class	Constituent Name	Units	Number of Samples	Number of Detects	Frequency of Detection	Maximum Detected Result	PEF or VF (m^3/kg)	1/PEF or 1/VF (kg/m^3)	Maximum Air Concentration (mg/m^3)	Industrial Ambient Air RBC (mg/m^3)	Does Maximum Air Concentration Exceed Ambient Air Industrial RBC?
METAL	Antimony	mg/kg	19	1	5%	12	$1.32x10^{+9}$	$7.58x10^{-10}$	$9.39x10^{-9}$	--	No
METAL	Arsenic	mg/kg	19	19	100%	10	$1.32x10^{+9}$	$7.58x10^{-10}$	$7.88x10^{-9}$	$5.81x10^{-6}$	No
METAL	Barium	mg/kg	19	19	100%	331	$1.32x10^{+9}$	$7.58x10^{-10}$	$2.51x10^{-7}$	$5.00x10^{-4}$	No
METAL	Cadmium	mg/kg	19	3	16%	9.1	$1.32x10^{+9}$	$7.58x10^{-10}$	$6.89x10^{-7}$	$1.39x10^{-5}$	No
METAL	Chromium	mg/kg	19	19	100%	83	$1.32x10^{+9}$	$7.58x10^{-10}$	$6.27x10^{-8}$	$2.98x10^{-7}$	No
METAL	Copper	mg/kg	19	17	89%	163	$1.32x10^{+9}$	$7.58x10^{-10}$	$1.23x10^{-7}$	--	No
METAL	Cyanide	mg/kg	19	1	5%	0.15	$1.32x10^{+9}$	$7.58x10^{-10}$	$1.14x10^{-10}$	0.0030	No
METAL	Lead	mg/kg	19	19	100%	107	$1.32x10^{+9}$	$7.58x10^{-10}$	$8.11x10^{-8}$	--	No
METAL	Manganese	mg/kg	19	19	100%	1,580	$1.32x10^{+9}$	$7.58x10^{-10}$	$1.20x10^{-6}$	$4.90x10^{-5}$	No
METAL	Mercury	mg/kg	19	3	16%	1.4	$1.32x10^{+9}$	$7.58x10^{-10}$	$1.06x10^{-9}$	--	No
METAL	Nickel	mg/kg	19	19	100%	131	$1.32x10^{+9}$	$7.58x10^{-10}$	$9.92x10^{-8}$	--	No
METAL	Selenium	mg/kg	19	1	5%	1.4	$1.32x10^{+9}$	$7.58x10^{-10}$	$1.06x10^{-9}$	--	No
METAL	Silver	mg/kg	19	15	79%	24	$1.32x10^{+9}$	$7.58x10^{-10}$	$1.81x10^{-8}$	--	No
METAL	Thallium	mg/kg	19	4	21%	0.61	$1.32x10^{+9}$	$7.58x10^{-10}$	$4.62x10^{-10}$	--	No
METAL	Uranium	mg/kg	19	19	100%	270	$1.32x10^{+9}$	$7.58x10^{-10}$	$2.05x10^{-7}$	--	No
METAL	Zinc	mg/kg	19	19	100%	645	$1.32x10^{+9}$	$7.58x10^{-10}$	$4.89x10^{-7}$	--	No
Pest/PCB	Aroclor-1254	mg/kg	6	1	17%	0.041	$1.32x10^{+9}$	$7.58x10^{-10}$	$3.11x10^{-11}$	$4.38x10^{-5}$	No
Pest/PCB	Aroclor-1260	mg/kg	6	2	33%	0.15	$1.32x10^{+9}$	$7.58x10^{-10}$	$1.14x10^{-10}$	$4.38x10^{-5}$	No
Pest/PCB	DDD	mg/kg	6	1	17%	0.0036	$1.32x10^{+9}$	$7.58x10^{-10}$	$2.73x10^{-12}$	--	No
SVOC	2,6-di-tert-Butyl-p-benzoquinone	mg/kg	2	2	100%	0.012	$1.32x10^{+9}$	$7.58x10^{-10}$	$9.11x10^{-12}$	--	No
SVOC	Bis(2-ethylhexyl)	mg/kg	19	2	11%	0.087	$1.32x10^{+9}$	$7.58x10^{-10}$	$6.59x10^{-11}$	0.0063	No

Table 5-30. Comparison of Maximum Shallow-Zone Soil Concentrations from the 216-U-10 Pond to Industrial Ambient Air Risk-Based Concentrations. (2 Pages)

Constituent Class	Constituent Name	Units	Number of Samples	Number of Detects	Frequency of Detection	Maximum Detected Result	PEF or VF (m^3/kg)	1/PEF or 1/VF (kg/m^3)	Maximum Air Concentration (mg/m^3)	Industrial Ambient Air RBC (mg/m^3)	Does Maximum Air Concentration Exceed Ambient Air Industrial RBC?
	phthalate										
SVOC	Diacetone alcohol	mg/kg	14	2	14%	0.0051	$1.32x10^{+9}$	$7.58x10^{-10}$	$3.89x10^{-12}$	--	No
SVOC	Diethylphthalate	mg/kg	19	1	5%	0.067	$1.32x10^{+9}$	$7.58x10^{-10}$	$5.08x10^{-11}$	2.8	No
SVOC	Di-n-butylphthalate	mg/kg	19	1	5%	0.053	$1.32x10^{+9}$	$7.58x10^{-10}$	$4.02x10^{-11}$	0.35	No
TPH	Total petroleum hydrocarbons - diesel range	mg/kg	13	1	8%	10	$1.32x10^{+9}$	$7.58x10^{-10}$	$7.58x10^{-9}$	--	No
VOC	1,1,1-Trichloroethane	mg/kg	6	1	17%	0.0010	2,391	$4.18x10^{-4}$	$4.18x10^{-7}$	11	No
VOC	2-Butanone	mg/kg	6	1	17%	0.047	19,422	$5.15x10^{-5}$	$2.42x10^{-6}$	1.0	No
VOC	Acetone	mg/kg	6	1	17%	0.19	12,554	$7.97x10^{-5}$	$1.51x10^{-5}$	0.35	No
VOC	Carbon disulfide	mg/kg	6	1	17%	0.0070	1,190	$8.40x10^{-4}$	$5.88x10^{-6}$	0.70	No
VOC	Chloroform	mg/kg	6	1	17%	0.0020	2,933	$3.41x10^{-4}$	$6.82x10^{-7}$	0.0011	No
VOC	Toluene	mg/kg	6	2	33%	0.017	3,553	$2.81x10^{-4}$	$4.78x10^{-6}$	0.39	No

Notes:

-- = not available.
PEF = particulate emissions factor.
PEST/PCB = pesticide/polychlorinated biphenyl.
RBC = risk-based concentration.
SVOC = semivolatile organic compound.
TPH = total petroleum hydrocarbon.
VF = volatilization factor.
VOC = volatile organic compound.

Table 5-31. Comparison of Maximum Shallow-Zone Soil Concentrations from the 216-U-14 Ditch to Industrial Ambient Air Risk-Based Concentrations.

Constituent Class	Constituent Name	Units	Number of Samples	Number of Detects	Frequency of Detection	Maximum Detected Result	PEF or VF (m^3/kg)	1/PEF or 1/VF (kg/m^3)	Max Air Concentration (mg/m^3)	Industrial Ambient Air RBC (mg/m^3)	Does Maximum Air Concentration Exceed Ambient Air Industrial RBC?
METAL	Antimony	mg/kg	3	3	100%	6.5	$1.32 \times 10^{+9}$	7.58×10^{-10}	4.92×10^{-9}	--	--
METAL	Silver	mg/kg	3	3	100%	3.3	$1.32 \times 10^{+9}$	7.58×10^{-10}	2.50×10^{-9}	--	--
VOC	Acetone	mg/kg	1	1	100%	0.012	12,554	7.97×10^{-5}	9.56×10^{-7}	0.35	No
VOC	Methylene chloride	mg/kg	3	3	100%	0.0020	2,425	4.12×10^{-4}	8.25×10^{-7}	0.053	No

Notes:

-- = not applicable.
PEF = particulate emissions factor.
RBC = risk-based concentration.
VF = volatilization factor.
VOC = volatile organic compound.

Table 5-32. Industrial, Direct-Contact Scenario – With Cover Material.

Scenario	Total Dose (mrem/yr)	Time (years)	Primary Radionuclide	Percentage of Total Dose	Primary Pathway
Industrial, Cover, Direct Contact	***216-U-10 Pond***				
	$5.13x10^{-1}$	0	Cesium-137	95.2%	Ground
	$5.06x10^{-1}$	1	Cesium-137	95.7%	Ground
	$3.21x10^{-1}$	50	Cesium-137	97.8%	Ground
	$1.51x10^{-1}$	150	Cesium-137	85.8%	Ground
	2.60	500	Thorium-232	36.2%	Ground
			Plutonium-239	34.7%	
			Radium-226	13.8%	
	7.59	1,000	Thorium-232	42.6%	Ground
			Plutonium-239	34.2%	
			Radium-226	11.5%	
	216-U-14 Ditch				
	$1.53x10^{-16}$	0	Potassium-40	85.7%	Ground
	$1.53x10^{-16}$	1	Potassium-40	86.5%	Ground
	$2.56x10^{-16}$	50	Potassium-40	96.4%	Ground
	$8.89x10^{-16}$	150	Potassium-40	99.4%	Ground
	$7.65x10^{-14}$	500	Potassium-40	100%	Ground
	$4.47x10^{-11}$	1,000	Potassium-40	100%	Ground
	216-Z-11 Ditch				
	$4.28x10^{-2}$	0	Radium-226	99.0%	Ground
	$4.28x10^{-2}$	1	Radium-226	99.1%	Ground
	$4.11x10^{-2}$	50	Radium-226	99.7%	Ground
	$3.82x10^{-2}$	150	Radium-226	100%	Ground
	$2.99x10^{-2}$	500	Radium-226	100%	Ground
	$2.11x10^{-2}$	1000	Radium-226	99.9%	Ground

Table 5-33. Summary of RESRAD Modeling for Radionuclide Risk, Industrial, Direct-Contact Scenario - With Cover Material.

Scenario	Total Risk	Time (years)	Primary Radionuclide	Percentage of Total Risk	Primary Pathway
Industrial, Cover, Direct Contact	***216-U-10 Pond***				
	8.16×10^{-6}	0	Cesium-137	97.6%	Ground
	8.08×10^{-6}	1	Cesium-137	97.7%	Ground
	5.26×10^{-6}	50	Cesium-137	97.3%	Ground
	2.56×10^{-6}	150	Cesium-137	82.3%	Ground
	3.25×10^{-5}	500	Thorium-232	59.7%	Ground
			Radium-226	22.9%	
	8.53×10^{-5}	1,000	Thorium-228	42.7%	Ground
			Radium-226	20.8%	
			Radium-228	22.7%	
	216-U-14 Ditch				
	3.05×10^{-21}	0	Potassium-40	91.4%	Ground
	3.07×10^{-21}	1	Potassium-40	91.7%	Ground
	5.42×10^{-21}	50	Potassium-40	97.1%	Ground
	1.89×10^{-20}	150	Potassium-40	99.5%	Ground
	1.63×10^{-18}	500	Potassium-40	100%	Ground
	9.53×10^{-16}	1,000	Potassium-40	100%	Ground
	216-Z-11 Ditch				
	7.59×10^{-7}	0	Radium-226	99.3%	Ground
	7.58×10^{-7}	1	Radium-226	99.3%	Ground
	7.29×10^{-7}	50	Radium-226	99.8%	Ground
	6.79×10^{-7}	150	Radium-226	82.2%	Ground
				17.8%	
	5.32×10^{-7}	500	Radium-226	100%	Ground
	3.78×10^{-7}	1000	Radium-226	100%	Ground

Table 5-34. Industrial, Direct-Contact Scenario - Without Cover Material.

Scenario	Total Dose (mrem/yr)	Time (years)	Primary Radionuclide	Percentage of Total Dose	Primary Pathway
Industrial, No Cover, Direct Contact	***216-U-10 Pond***				
	$2.70x10^{+3}$	0	Cesium-137	98.0%	Ground
	$2.64x10^{+3}$	1	Cesium-137	98.2%	Ground
	$8.46x10^{+2}$	50	Cesium-137	98.6%	Ground
	$9.29x10^{+1}$	150	Cesium-137	89.0%	Ground
	8.70	500	Thorium-232	37.3%	Ground
			Plutonium-239	30.8%	
			Radium-226	15.0%	
	7.59	1,000	Thorium-232	42.6%	Ground
			Plutonium-239	34.2%	
	216-U-14 Ditch				
	$3.24x10^{+1}$	0	Cesium-137	89.0%	Ground
	$3.16x10^{+1}$	1	Cesium-137	89.0%	Ground
	$1.20x10^{+1}$	50	Cesium-137	75.6%	Ground
	3.55	150	Potassium-40	63.7%	Ground
	1.89	500	Potassium-40	81.0%	Ground
	1.21	1,000	Potassium-40	72.3%	Ground
			Plutonium-239	27.0%	Ground
	216-Z-11 Ditch				
	$4.47x10^{+4}$	0	Plutonium-239	57.9%	Ground
			Radium-226	23.5%	
	$4.47x10^{+4}$	1	Plutonium-239	57.9%	Ground
			Radium-226	23.6%	
	$4.38x10^{+4}$	50	Plutonium-239	58.9%	Ground
			Radium-226	23.8%	
	$4.23x10^{+4}$	150	Plutonium-239	60.7%	Ground
			Radium-226	23.1%	
	$3.84x10^{+4}$	500	Plutonium-239	65.6%	Ground
			Radium-226	19.9%	
	$3.48x10^{+4}$	1,000	Plutonium-239	71.3%	Ground
			Radium-226	15.7%	

Table 5-35. Industrial, Direct-Contact Scenario - Without Cover Material.

Scenario	Total Risk	Time (years)	Primary Radionuclide	Percentage of Total Risk	Primary Pathway
Industrial, No Cover, Direct Contact	***216-U-10 Pond***				
	3.60×10^{-2}	0	Cesium-137	99.1%	Ground
	3.52×10^{-2}	1	Cesium-137	99.2%	Ground
	1.14×10^{-2}	50	Cesium-137	99.0%	Ground
	1.22×10^{-3}	150	Cesium-137	91.5%	Ground
	9.40×10^{-5}	500	Thorium-228	38.8%	Ground
			Radium-226	25.0%	
			Radium-228	20.7%	
	8.53×10^{-5}	1,000	Thorium-228	42.7%	Ground
			Radium-228	22.7%	
			Radium-226	20.8%	
	216-U-14 Ditch				
	1.87×10^{-2}	0	Cesium-137	99.8%	Ground
	1.82×10^{-2}	1	Cesium-137	99.8%	Ground
	5.90×10^{-3}	50	Cesium-137	99.3%	Ground
	6.16×10^{-4}	150	Cesium-137	94.3%	Ground
	2.41×10^{-5}	500	Potassium-40	95.0%	Ground
	1.40×10^{-5}	1,000	Potassium-40	93.5%	Ground
	216-Z-11 Ditch				
	2.83×10^{-1}	0	Plutonium-239	23.9%	Ground
			Radium-226	66.0%	
	2.82×10^{-1}	1	Plutonium-239	23.9%	Ground
			Radium-226	66.0%	
	2.70×10^{-1}	50	Plutonium-239	24.9%	Ground
			Radium-226	66.6%	
	2.54×10^{-1}	150	Radium-226	66.0%	Ground
			Plutonium-239	26.3%	
	2.13×10^{-1}	500	Radium-226	61.9%	Ground
			Plutonium-239	30.8%	
	1.69×10^{-1}	1,000	Radium-226	54.9%	Ground
			Plutonium-239	37.7%	

Table 5-36. Summary of RESRAD Modeling for Radionuclide Dose Rates, Groundwater Protection.

Scenario	Total Dose (mrem/yr)	Time (years)	Primary Radionuclide	Percentage of Total Dose	Primary Pathway
Groundwater Protection, No Cover	***216-U-10 Pond***				
	0.00	0	--	--	Drinking Water
	0.00	1	--	--	Drinking Water
	$7.16x10^{+1}$	37	Selenium-79	97.1%	Drinking Water
	$4.72x10^{-1}$	50	Selenium-79	97.1%	Drinking Water
	$9.11x10^{-18}$	150	Selenium-79	97.1%	Drinking Water
	0.00	500	--	--	Drinking Water
	0.00	1,000	--	--	Drinking Water
	216-U-14 Ditch				
	0.00	0	--	--	Drinking Water
	0.00	1	--	--	Drinking Water
	$1.65x10^{+1}$	36.9	Technetium-99	100%	Drinking Water
	$1.63x10^{+1}$	50	Technetium-99	100%	Drinking Water
	$2.81x10^{-8}$	150	Technetium-99	100%	Drinking Water
	0.00	500	--	--	Drinking Water
	0.00	1,000	--	--	Drinking Water
	216-Z-11 Ditch				
	0.00	0	--	--	Drinking Water
	0.00	1	--	--	Drinking Water
	0.00	50	--	--	Drinking Water
	0.00	150	--	--	Drinking Water
	0.00	500	--	--	Drinking Water
	0.00	1,000	--	--	Drinking Water

Table 5-37. Summary of RESRAD Modeling for Radionuclide Risk, Groundwater Protection.

Scenario	Total Risk	Time (years)	Primary Radionuclide	Percentage of Total Risk	Primary Pathway
Groundwater Protection, No Cover	***216-U-10 Pond***				
	0.00	0	--	--	Drinking Water
	0.00	1	--	--	Drinking Water
	1.66×10^{-4}	37	Selenium-79	96.4%	Drinking Water
	1.13×10^{-6}	50	Selenium-79	96.4%	Drinking Water
	2.18×10^{-23}	150	Selenium-79	96.4%	Drinking Water
	0.00	500	--	--	Drinking Water
	0.00	1,000	--	--	Drinking Water
	216-U-14 Ditch				
	0.00	0	--	--	Drinking Water
	0.00	1	--	--	Drinking Water
	9.93×10^{-5}	36.93	Technetium-99	100%	Drinking Water
	9.64×10^{-6}	50	Technetium-99	100%	Drinking Water
	1.66×10^{-13}	150	Technetium-99	100%	Drinking Water
	0.00	500	--	--	Drinking Water
	0.00	1,000	--	--	Drinking Water
	216-Z-11 Ditch				
	0.00	0	--	--	Drinking Water
	0.00	1	--	--	Drinking Water
	0.00	50	--	--	Drinking Water
	0.00	150	--	--	Drinking Water
	0.00	500	--	--	Drinking Water
	0.00	1,000	--	--	Drinking Water

Table 5-38. Uncertainties Associated with Human Health Risk Estimations. (2 Pages)

Uncertainty Factor (UF)	Effects of Uncertainty	Comment
I. Uncertainty in Environmental Sampling and Analysis		
Estimates of chemical concentrations	May underestimate or overestimate risk	Sampling errors, sample representativeness, and variability in chemical analyses will affect chemical concentrations. Available analytical data may not accurately reflect site conditions. Chemical concentrations may change as a result of migration or degradation.
II. Uncertainty in Fate and Transport		
Source concentrations assumed constant over time	May underestimate or overestimate risk	Did not account for environmental fate, transport, or transfer, which may alter contaminant concentrations.
III. Exposure Assessment		
Exposure assumptions	May under- or overestimate risk	Assumptions regarding media intake, population characteristics, and exposure patterns may not characterize exposures.
Use of applied dose to estimate risks	May over- or underestimate risks	Assumes that the absorption of the chemical is the same as it was in the study that derived the toxicity value. Assumes that absorption is equivalent across species (animal to humans). Absorption may vary with age and species.
Population characteristics	May over- or underestimate risks	Assumes weight, lifespan, and ingestion rate, are potentially representative for a potentially exposed population.
Intake	May underestimate risks	Assumes all intake of COPCs is from the exposure medium being evaluated (no relative source contribution).
IV. Toxicity Assessment		
Slope Factor	May overestimate risks	Slope factors are upperbound UCLs derived from a linearized model. Considered unlikely to underestimate risk.
Toxicity values derived from animal studies	May over- or underestimate risks	Extrapolation from animal to humans may induce error because of differences in pharmacokinetics, target organs, and population variability.
Toxicity values derived primarily from high doses (most exposures are at low doses)	May over- or underestimate risks	Assumes linearity at low doses. Tends to have conservative exposure assumptions.
Toxicity values	May over- or underestimate risks	Not all values represent the same degree of certainty. All are subject to change, as new evidence becomes available.
Toxicity data not available for all constituents	Risks could not be estimated	Potential negative effects of exposure to these constituents are not quantifiable.
Surrogate toxicity values	May over- or underestimate risks	Assumes toxicity of structurally similar compound is equivalent.

Table 5-38. Uncertainties Associated with Human Health Risk Estimations. (2 Pages)

Uncertainty Factor (UF)	Effects of Uncertainty	Comment
Toxicity values derived from short-term tests to predict chronic exposures	May over- or underestimate risks	Assumes that the dose-response observed from short-term exposure to high concentrations is similar to exposure to low concentration environmental exposures.
Toxicity values derived from homogeneous animal populations	May over- or underestimate risks	Human populations may have a wide range of sensitivities to a chemical.
V. Risk Estimation		
Estimation of risks across exposure routes	May under- or overestimate risk	Some exposure routes have greater uncertainty associated with their risk estimates than others.
Cumulative risk estimates	May under- or overestimate risk	Assumes additivity of risks from multiple chemicals; may have synergistic or antagonistic effects.
Cancer risk estimates (no threshold assumed)	May overestimate risks	Possibility that some thresholds do exist.
Cancer risk estimate (low dose) linearity	May overestimate risks	Response at low doses is not known.

COPC = contaminant of potential concern.
UCL = upper confidence limit.

Table 5-39. Comparison of Shallow-Zone Soil Exposure Point Concentrations to Background Concentrations and to Ecological Screening Levels for Nonradionuclides. (3 Pages)

Constituent Name	Constituent Class	Units	Exposure Point Concentration	90th Percentile Background Concentration	Does Maximum Concentration Exceed Background?	Soil Indicator Value[a] (Wildlife)	COEC	Justification
216-U-10								
Aluminum	METAL	mg/kg	9,476	11,800	No	TBD	No	Below Background
Antimony	METAL	mg/kg	6.1	NA	No	TBD		Requires Further Evaluation[a]
Arsenic	METAL	mg/kg	4.2	20	No	7	No	Below Background
Barium	METAL	mg/kg	126	132	No	102	No	Below Background
Beryllium	METAL	mg/kg	0.55	1.5	No	TBD	No	Below Background
Cadmium	METAL	mg/kg	1.6	1.0	Yes	14	No	Below 749-3[b]
Chromium	METAL	mg/kg	18	18.5	No	67	No	Below Background
Cobalt	METAL	mg/kg	13	15.7	No	TBD	No	Below Background
Copper	METAL	mg/kg	31	22.0	Yes	217	No	Below 749-3[b]
Iron	METAL	mg/kg	22,564	32,600	No	TBD	No	Below Background
Lead	METAL	mg/kg	20	10.2	Yes	118	No	Below 749-3[b]
Manganese	METAL	mg/kg	457	512	No	1500	No	Below Background
Mercury	METAL	mg/kg	0.18	0.33	No	5.5	No	Below 749-3[b]
Nickel	METAL	mg/kg	22	19.1	Yes	980	No	Below 749-3[b]
Selenium	METAL	mg/kg	0.39	NA	No	0.3	Yes	Requires Further Evaluation
Silver	METAL	mg/kg	3.5	0.73	Yes	TBD		Requires Further Evaluation
Thallium	METAL	mg/kg	0.35	0.3 to 0.6	Yes	TBD		Requires Further Evaluation
Total Uranium	METAL	mg/kg	29	NA	No	TBD		Requires Further Evaluation

Table 5-39. Comparison of Shallow-Zone Soil Exposure Point Concentrations to Background Concentrations and to Ecological Screening Levels for Nonradionuclides. (3 Pages)

Constituent Name	Constituent Class	Units	Exposure Point Concentration	90th Percentile Background Concentration	Does Maximum Concentration Exceed Background?	Soil Indicator Value [a] (Wildlife)	COEC	Justification
Vanadium	METAL	mg/kg	55	85.1	No	TBD	No	Below Background
Zinc	METAL	mg/kg	119	67.8	Yes	360	No	Below 749-3 [b]
216-U-14 Ditch								
Antimony	METAL	mg/kg	6.5	NA	No	TBD		Requires Further Evaluation
Arsenic	METAL	mg/kg	1.4	20	No	7	No	Below Background
Barium	METAL	mg/kg	86	132	No	102	No	Below Background
Beryllium	METAL	mg/kg	0.29	1.5	No	TBD	No	Below Background
Chromium	METAL	mg/kg	7.1	18.5	No	67	No	Below Background
Cobalt	METAL	mg/kg	7.1	15.7	No	TBD	No	Below Background
Copper	METAL	mg/kg	15	22.0	No	217	No	Below Background
Lead	METAL	mg/kg	3.4	10.2	No	118	No	Below Background
Manganese	METAL	mg/kg	290	512	No	1500	No	Below Background
Nickel	METAL	mg/kg	6.2	19.1	No	980	No	Below Background
Silver	METAL	mg/kg	3.3	0.73	Yes	TBD		Requires Further Evaluation
Vanadium	METAL	mg/kg	68	85.1	No	TBD	No	Below Background
Zinc	METAL	mg/kg	44	67.8	No	360	No	Below Background
216-Z-11 Ditches								
Arsenic	METAL	mg/kg	6.2	20	No	7	No	Below Background
Barium	METAL	mg/kg	88	132	No	102	No	Below 749-3 [b]
Beryllium	METAL	mg/kg	0.25	1.5	No	TBD	No	Below Background
Boron	METAL	mg/kg	24	NA	No	TBD		Requires Further Evaluation

Table 5-39. Comparison of Shallow-Zone Soil Exposure Point Concentrations to Background Concentrations and to Ecological Screening Levels for Nonradionuclides. (3 Pages)

Constituent Name	Constituent Class	Units	Exposure Point Concentration	90th Percentile Background Concentration	Does Maximum Concentration Exceed Background?	Soil Indicator Value[a] (Wildlife)	COEC	Justification
Cadmium	METAL	mg/kg	0.050	1.0	No	14	No	Below Background
Chromium	METAL	mg/kg	11	18.5	No	67	No	Below Background
Copper	METAL	mg/kg	30	22	Yes	217	No	Below 749-3[b]
Hexavalent Chromium	METAL	mg/kg	0.54	NA	No	67	No	Below 749-3[b]
Lead	METAL	mg/kg	7.1	10.2	No	118	No	Below Background
Magnesium	METAL	mg/kg	4,760	NA	No	--	No	Not a 749-3 indicator contaminant
Manganese	METAL	mg/kg	365	512	No	1,500	No	Below Background
Mercury	METAL	mg/kg	0.66	0.33	Yes	5.5	No	Below 749-3[b]
Molybdenum	METAL	mg/kg	0.77	NA	No	7	No	Below 749-3[b]
Nickel	METAL	mg/kg	11	19.1	No	980	No	Below Background
Silver	METAL	mg/kg	0.69	0.73	No	TBD	No	Below Background
Vanadium	METAL	mg/kg	58	85.1	No	TBD	No	Below Background
Zinc	METAL	mg/kg	63	67.8	No	360	No	Below Background

[a] This evaluation will be performed in the FS and will include the Phase II Ecological Evaluation of the Hanford 200 Areas (DOE/RL-2001-54) and the results of the ecological data quality objectives and sampling and analysis plan that will be created for the Central Plateau.
[b] WAC –173-340-900, "Tables," Table 749-3.

COEC = contaminant of ecological concern.
NA = not available.
TBD = to be determined.

Table 5-40. Comparison of Shallow-Zone Soil Exposure Point Concentrations to Background and to Ecological Screening Values for Radionuclides (Units in pCi/g). (3 Pages)

Constituent Name	Number of Samples	Number of Detects	Frequency of Detection	Exposure Point Concentration	90th Percentile Background Concentration	Exceeds Background?	Biota Concentration Guide	COEC?	Justification
216-U-10 (U-Pond)									
Americium-241	19	17	89%	44	NA	No	4,000	No	Below BCG
Cesium-137	19	18	95%	3,994	0.919	Yes	200	Yes	Requires Further Evaluation
Cobalt-60	19	6	32%	16	0.008	Yes	700	No	Below BCG
Europium-152	19	5	26%	0.43	NA	No	TBD		Requires Further Evaluation
Europium-154	19	3	16%	12	0.033	Yes	1,000	No	Below BCG
Europium-155	19	2	11%	1.7	0.054	Yes	20,000	No	Below BCG
Neptunium-237	19	3	16%	0.28	NA	No	TBD		Requires Further Evaluation
Plutonium-238	19	9	47%	22	0.005	Yes	5,400	No	Below BCG
Plutonium-239/240	19	16	84%	75	0.0192	Yes	6,000	No	Below BCG
Potassium-40	19	19	100%	15	16.6	No	TBD	No	Below background
Radium-226	15	14	93%	0.90	0.815	Yes	50	No	Below BCG
Radium-228	13	13	100%	0.99	NA	No	40	No	Below BCG
Strontium-90	19	17	89%	157	0.167	Yes	20	Yes	Requires Further Evaluation
Technetium-99	19	6	32%	8.8	NA	No	4,000	No	Below BCG
Thorium-228	3	2	67%	0.038	NA	No	2,200	No	Below BCG
Thorium-232	14	14	100%	2.6	1.32	Yes	2,000	No	Below BCG
Uranium-233/234	3	3	100%	85	1.1	Yes	5,000	No	Below BCG
Uranium-235	19	10	53%	1.1	0.11	Yes	3,000	No	Below BCG
Uranium-238	19	19	100%	88	1.1	Yes	2,000	No	Below BCG

Table 5-40. Comparison of Shallow-Zone Soil Exposure Point Concentrations to Background and to Ecological Screening Values for Radionuclides (Units in pCi/g). (3 Pages)

Constituent Name	Number of Samples	Number of Detects	Frequency of Detection	Exposure Point Concentration	90th Percentile Background Concentration	Exceeds Background?	Biota Concentration Guide	COEC?	Justification
216-U-14 Ditch									
Americium-241	25	13	52%	1.6	NA	No	4,000	No	Below BCG
Antimony-125	1	1	100%	0.10	NA	No	10,000	No	Below BCG
Cesium-137	34	21	62%	2,228	0.191	Yes	200	Yes	Requires Further Evaluation
Cobalt-60	22	8	36%	0.62	0.0084	Yes	700	No	Below BCG
Plutonium-238/239	12	12	100%	2.1	0.0047	Yes	5,400	No	Below BCG
Plutonium-239/240	1	1	100%	10	0.019	Yes	6,000	No	Below BCG
Radium-226	9	6	67%	0.66	0.815	No	50	No	Below Background
Strontium-90	30	17	57%	5.2	0.167	Yes	20	No	Below BCG
Technetium-99	1	1	100%	12	NA	No	4,000	No	Below BCG
Total Uranium	13	13	100%	350	1.1	Yes	5,000	No	Below BCG
Uranium-235	9	4	44%	0.13	0.11	No	3,000	No	Below Background
Uranium-238	12	12	100%	1.1	1.1	No	2,000	No	Below Background
216-Z-11 Ditches									
Americium-241	286	284	99%	76,152	NA	No	4,000	Yes	Requires Further Evaluation
Cesium-137	187	184	98%	951	0.919	Yes	200	Yes	Requires Further Evaluation
Plutonium-238	62	54	87%	5,500	0.0047	Yes	5,400	Yes	Requires Further Evaluation
Plutonium-239	15	15	100%	780,000	NA	No	6,000	Yes	Requires Further Evaluation

Table 5-40. Comparison of Shallow-Zone Soil Exposure Point Concentrations to Background and to Ecological Screening Values for Radionuclides (Units in pCi/g). (3 Pages)

Constituent Name	Number of Samples	Number of Detects	Frequency of Detection	Exposure Point Concentration	90th Percentile Background Concentration	Exceeds Background?	Biota Concentration Guide	COEC?	Justification
Plutonium-239/240	268	266	99%	132,229	0.0192	Yes	6,000	Yes	Requires Further Evaluation
Radium-226	12	12	100%	5,200	0.815	Yes	50	Yes	Requires Further Evaluation
Radium-228	4	2	50%	0.81	NA	No	40	No	Below BCG
Strontium-90	30	23	77%	23	0.167	Yes	20	Yes	Requires Further Evaluation
Thorium-228	4	1	25%	0.66	NA	No	TBD		Requires Further Evaluation
Thorium-232	4	1	25%	0.71	1.32	No	2,000	No	Below Background
Uranium-233/234	4	1	25%	0.36	1.1	No	5,000	No	Below Background
Uranium-238	4	2	50%	0.77	1.1	No	5,000	No	Below Background

[a] No biota concentration guide available for comparison

BCG = biota concentration guide.
TBD = to be determined.
NA = none available.

6.0 CONCLUSIONS AND PATH FORWARD

The 200-CW-5, 200-CW-2, 200-CW-4, and 200-SC-1 OUs consist of CERCLA past-practice waste sites and will be remediated under the CERCLA process. These OUs also include three RCRA past-practice waste sites; therefore, while the CERCLA process will be used to fulfill the RCRA corrective action requirements, additional documentation to support the *Hanford Facility RCRA Permit* will be required in accordance with the Implementation Plan (DOE/RL-98-28). Tasks to be completed following the RI include preparing an FS, a proposed plan and proposed permit modification, and an ROD and permit modification, as described in the Implementation Plan (DOE/RL-98-28).

6.1 CONCLUSIONS

The purpose of this RI Report was to determine if sufficient data have been collected to support risk assessment and remedial decision making, to estimate risks at the representative sites based on the data collected during the RI and other existing data, to determine the need to proceed with an FS, and to determine those constituents and site-specific considerations that need to be addressed in the FS. The first purpose was met; the data collected were of sufficient quantity and quality to support both the risk assessment activities and to proceed to the FS to support evaluation of remedial alternatives and identify preferred remedial actions. The second purpose was achieved by the estimation of risk for human health in Chapter 5.0. A screening of potential ecological risk was included in Chapter 5.0. These risk estimates indicate that an FS will be required to evaluate remedial alternatives. Those constituents and site specific considerations that the FS needs to address are presented in Tables 6-1 and 6-2. Further ecological risk evaluation will be needed in the FS.

6.2 REMEDIAL INVESTIGATION REPORT SUMMARY

The RI was conducted according to the 200-CW-5 OU Work Plan (DOE-RL-99-66) and DOE/RL-2002-24. The data were evaluated against the DQOs identified in the DQO summary report (BHI-01294). The data were found through a data quality assessment to have met the DQOs established for this work. Contaminants were identified at three representative sites, the 216-Z-11 Ditch (inclusive of the 216-Z-1D and 216-Z-19 Ditches), 216-U-10 Pond, and 216-U-14 Ditch that may present significant risk to human health and the environment. The data from these sites were used to estimate the risk, determine the need to proceed with an FS, and determine those constituents and site-specific considerations that need to be addressed in the FS. This RI report also provides data to support the evaluation of alternatives in the FS with regard to meeting potential applicable or relevant and appropriate requirements, and risk reduction.

The evaluation of the representative sites involved site characterization, refinement of the contaminant distribution and exposure models, a baseline risk evaluation, ecological risk screening and fate and transport modeling. The data are considered sufficient for human health and ecological risk assessment and for remedial decision making.

6.2.1 Characterization

Drilling, GeoProbe soil probes, GPR, geophysical logging and soil sampling and analysis were used to characterize the 216-Z-11 Ditch Area. Data from the 216-Z-11 Ditch were collected during recent characterization efforts in 2002. Data from the 216-Z-1D and 216-Z-19 Ditches are included in the evaluation of the 216-Z-11 Ditch because of shared boundaries along their length, because of uncertainties associated with the location of data collected in the 216-Z Ditch Area, and because transuranic levels of contamination are present. Data from the 216-Z-1D and 216-Z-19 Ditches were collected before the 200-CW-5 RI was conducted and are reported in WHC-EP-0707. Soil samples were collected to the top of the water table in the 216-Z-11 Ditch Area.

Drilling, test pit excavations, GeoProbe soil probes, geophysical logging and soil sampling and analysis were used to characterize the 216-U-10 Pond and 216-U-14 Ditch. Data from the 216-U-10 Pond and the 216-U-14 Ditch were collected before the 200-CW-5 RI was conducted. No additional data were collected at these sites during the RI, with the exception of the geophysical data, because the DQO summary report (BHI-01294) indicates that the information collected before the RI was sufficient for remedial decision making. Data used to evaluate these sites are from DOE/RL-95-13 and WHC-EP-0698. Soil samples were collected to a maximum depth of 42.7 m (140 ft) at the 216-U-10 Pond. Soil samples were collected to the top of the water table at the 216-U-14 Ditch.

6.2.2 Contaminant Distribution Models and Exposure Models

The conceptual contaminant distribution models and the conceptual exposure model previously developed in the Work Plan (DOE/RL 99-66, Rev. 0) were revised based on the data obtained during the RI and other data collection activities. The contaminant distribution models are presented in Chapter 3.0, but generally can be described as follows.

- Contamination associated with less mobile COCs (such as cesium, plutonium, and strontium) are detected in the highest concentrations near the bottom of waste sites.
- Contaminant concentrations generally decrease with depth below the waste site bottom.
- Most of the contamination remains high in the vadose zone above the water table.
- Highly mobile COCs (such as technetium) have passed through the vadose zone and are detected sporadically across the vadose zone in low concentrations.

The exposure pathway model for the OU is presented in Section 5.1.5 and is generally summarized as follows.

- Potentially contaminated media include sediments, shallow-zone soils, deep-zone soils, biota, and groundwater.
- Potential receptors are mainly current and future workers (based on the current land-use assumptions) and terrestrial biota.

- Exposure pathways include ingestion, dermal contact, inhalation, and exposure to external radiation.

6.2.3 Contaminants of Concern and Site Risks

Contaminants of concern were identified by following a data evaluation process that is based on regulatory guidance and professional judgment. Nonradioactive constituents analyzed in the RI were screened based on detection (constituents with no detections were eliminated), comparison to background, and comparison to regulatory requirements. Estimates for cancer risk and HQ/HI also were generated. Radiological constituents were screened based on detection and background. Radiological dose and cancer risk to receptors were evaluated using RESRAD. Contaminants with the potential to affect groundwater were evaluated using the STOMP code. The COCs, relative risks, and radiological dose rates for each waste site are summarized in Table 6-1. Based on the results of the data evaluation, Table 6-2 identifies those COCs that must be considered for remedial action in the FS.

6.2.4 Ecological Screening

Constituents in this report were compared to ecological soil screening indicators in WAC-173-340-900, Table 749-3, and DOE-STD-1153-2002. The ecological COCs that will be carried forward to the FS for further ecological risk evaluation are identified in Table 6-1.

6.2.5 Fate and Transport Modeling Using the STOMP Code

Vadose zone modeling using the STOMP code was conducted to determine the fate and transport of selected contaminants identified as potentially-significant risk contributors for the representative sites in the 200-CW-5 OU. Specific site contaminants were selected based on the results of transport screening analyses performed using RESRAD modeling (ANL/EAD-4) and regulatory considerations. The results of the fate and transport modeling indicate that most contaminants of concern are effectively attenuated in the vadose and do not pose a substantial threat to future groundwater quality during the 1000 year simulation. Contaminants that impact groundwater in the future in significant concentrations include technitium-99, selenium-79, uranium, cyanide, and fluoride. All of these constituents reach their predicted peak concentrations within the 1000-year simulation. Short-lived radionuclides, such as cesium-137 and strontium-90 were shown to decay long before reaching groundwater.

6.3 PATH FORWARD

6.3.1 Feasibility Study

The FS will follow CERCLA guidance and the strategy in the Implementation Plan (DOE/RL-98-28). Although some refinement is expected during the FS, Appendix D of the Implementation Plan satisfies the requirements for the screening phase (steps 1 through 6) of the

FS process. The potential ARARs, preliminary RAOs, PRGs, general response actions, and the screening-level analysis of alternatives are incorporated by reference into RI. As a result of the work completed in the Implementation Plan (DOE/RL-98-28), the FS report will focus on the final phase of the FS, which consists of refining and analyzing in detail a limited number of alternatives identified in the screening phase. Remedial action alternatives considered applicable to the 200-CW-5, 200-CW-2, 200-CW-4, and 200-SC-1 OUs include the following:

- No action
- Institutional controls/monitored natural attenuation
- Engineered surface barriers
- Excavation and disposal with or without ex situ treatment
- In situ grouting or stabilization
- In situ vitrification.

One additional alternative (excavation, ex situ treatment, and geologic disposal of transuranic waste) was identified in the Implementation Plan (DOE/RL-98-28) because of the potential for these OUs to contain transuranic waste. Plutonium and americium exceeding 100,000 pCi/g were detected in the 216-Z-11 Ditch Area.

An initial activity of the FS will be the detailed evaluation of available information for the analogous waste sites in the OUs. Data will be compiled to evaluate the applicability of the contaminant distribution models and relative risks developed in the RI report for the representative sites to the analogous sites. Sites that are determined not to be analogous to the representative sites will be evaluated against representative sites from other OUs; they may also be reassigned to a more appropriate OU. The sites that are determined to be analogous to one or more of the representative sites will be evaluated for appropriate remedial measures through the FS process. Additional data needs may be identified during the FS process and during the DQO to support the confirmatory sampling for these analogous sites.

6.3.2 Proposed Plan and Proposed RCRA Permit Modification

The decision-making process for the waste sites within 200-CW-5, 200-CW-2, 200-CW-4, and 200-SC-1 OUs will be based on the use of a proposed plan and a ROD. The proposed plan will include a draft permit modification with unit-specific permit conditions for the RPP sites. A modification to the Hanford Facility RCRA Permit will be used to incorporate the decision in the permit for these sites. During the RI/FS process, a number of options for development of proposed plans and RODs will be evaluated. Remedial decisions may proceed on an OU by OU basis, but alternative site groupings may be considered for waste sites in the Central Plateau. Several alternatives are currently under consideration, some of which may be utilized for the waste sites addressed in this RI Report.

Three alternatives to the OU by OU remediation approach have been identified to provide flexibility in the decision-making process, facilitate early action, and remediate and close specific areas or zones. Examples of these alternatives are presented below.

High Risk Waste Sites Identified for Early Action

This alternative accelerates the start of remedial actions and closure of waste sites that present an ongoing or expected future threat to groundwater. Some high-risk sites have already been identified for early actions within the B/C Cribs and Trenches are and near U Plant, PUREX, and PFP. The 216-A-6 and 216-A-30 Cribs are two sites within the 200-SC-1 OU likely to be considered among the high-risk sites near PUREX for inclusion in a proposed plan and ROD that promotes early action. These waste sites are also analogous to the 216-A-10 Crib, a representative waste site within the 200-PW-2 Operable Unit, which could lead to realignments in future proposed plans and RODs.

Regional Site Closure

Waste site remedial decision making may be realigned under a regional closure strategy that aligns wastes sites into groups defined by geographical zones. For example, several waste sites within the 200-CW-5 OU are within the U Plant Area and would be considered for inclusion in a U-Plant area closure via proposed plans and RODs.

Waste Site Grouping by Characteristics or Hazards

A third example of remedial decision-making strategies would be based on a specific characteristic or hazard that mandate additional requirements, such as supplemental potential ARARs, or more robust remedial alternatives. Several waste sites within the 200-CW-5 OU (the 216-Z-1, 216-Z-11, and 216-Z-19 Ditches and the 216-U-10 Pond) are suspected to contain concentrations of transuranic radionuclides in excess of the 100n/Ci per gram concentration limit for designation as TRU waste. Waste sites containing concentrations of TRU radionuclides above 100 nCi/gram may require selective removal actions or more protective barrier designs to prevent intrusion based on this particular hazard. Such alternatives might not be required for other cooling water sites within 200-CW-5 OU where only low-levels of these radionuclides are present. Grouping 200-CW-5 OU waste sites with other suspect TRU contaminated soil sites (and possibly burial grounds) could streamline the decision-making process and tailor the requirements and alternatives to these specific hazards.

Following the completion of the FS, a proposed plan will be prepared that identifies a preferred remedial alternative for each of the waste sites. In addition to identifying preferred alternatives, the proposed plan will:

- Provide a summary of the completed RI/FS.
- Provide criteria by which analogous waste sites within the OUs will be evaluated after the ROD to confirm that the contaminant distribution model for the site is consistent with the preferred alternative.
- Identify performance standards and potential ARARs for the OUs or other site groupings.

After the public review process is complete, the lead regulatory agency for these OUs will decide on the remedial actions to be taken and document those decisions in a ROD. If alternative decision-making strategies are employed, lead agency realignments may be considered in consultations between EPA and Ecology.

6.4 POST-RECORD-OF-DECISION ACTIVITIES AND ANALOGOUS SITE APPROACH

The ROD for these OUs will cover all the sites in the OUs, not just the representative sites characterized under the RI. This analogous site approach is described in more detail in the Implementation Plan (DOE/RL-98-28). The basic approach is that the representative sites contain types, concentrations, and distributions of contaminants similar to those at the other sites in the OU, because the sites are grouped on the basis of similar site histories and processes. The sites, therefore, share similar risks and a similar need for remedial action. The data collected for the representative sites will be considered to be analogous to the remaining sites (Section 1.3).

After the ROD has been issued, a remedial design report and remedial action work plan will be prepared to detail the scope of the remedial action. As part of this activity, DQOs will be established and SAPs will be prepared to direct confirmatory/remedial design, and verification sampling and analysis efforts. Prior to the start of remediation, confirmation/remedial design sampling will be performed to ensure that sufficient characterization data are available to confirm that the selected remedy is appropriate for the waste sites within the ROD, to collect data necessary for the remedial design, and to support final cumulative risk assessment for the entire 200 Area NPL Site. Verification sampling will be performed after the remedial action is complete to determine if ROD requirements have been met and if the remedy was protective of human health and the environment. Additional guidance for confirmatory and verification sampling is provided in Section 6.2 of DOE/RL-98-28.

The remedial design report/remedial action work plan will include an integrated schedule of remediation activities for waste sites and releases covered by the ROD or RODs. The available options for remedy implementation throughout the 200 Area will be explored during the course of the RI/FS process and may be reflected in the remedial action work plan. Following the completion of the remediation effort, closeout activities will be performed as discussed in Section 2.4 of DOE/RL-98-28.

Table 6-1. Contaminants of Concern, Risk, and Dose Summary.

Nonradiological			Radiological[a]							
Total Excess Lifetime Cancer Risk from Shallow Nonradiological COCs	Nonradiological Exceeding GWP soil RBC	Nonradiological COCs Exceeding Ecological Screening Levels (WAC 173-340, Table 749-3)	Total Maximum Excess Lifetime Cancer Risk from Radiological COCs	Total Maximum Dose Rate/Time	Primary Risk Contributor	Primary Dose Contributor	Total Excess Lifetime Cancer Risk Drinking Water	Total Maximum Dose Rate for groundwater @ years	Radiological COCs Exceeding Ecological Screening Levels
<1 x 10^{-5}	Aroclor-1254 Aroclor-1260 Nitrite	Aroclor-1260 Boron	2.83x10^{-1} for no cover scenario.	4.7x10^{4} mrem/yr @ 0 years for no cover scenario.	Radium-226	Plutonium-239 Radium-226	0	0 mrem/yr @ 0 years	Americium-241 Cesium-137 Plutonium-238 Plutonium-239 Plutonium-239/240 Radium-226 Strontium-90 Thorium-228
			7.59x10^{7} for cover scenario.	4.28x10-^{2} mrem/yr @ 0 years for cover scenario	Radium-226	Radium-226	0	0 mrem/yr @ 37 years	
<1 x 10^{-5}	Cadmium Manganese Uranium	Antimony Selenium Silver Thallium Uranium Diethylphthalate Di-n-butylphthalate Toluene	3.6x10^{-2} for no cover scenario.	2.7x10^{3} mrem/yr @ 0 years for no cover scenario.	Cesium-137	Cesium-137	0	0 mrem/yr @ 0 years	Cesium-137 Europium-152 Neptunium-237 Strontium-90
			8.16x10^{-6} for cover scenario.	5.31x10^{-1} mrem/yr @ 0 years for cover scenario.	Cesium-137	Cesium-137	9.93x10^{-5}	1.68x10^{1} mrem/yr @ 37 years for Technetium-99	
<1 x 10^{-5}	None	Antimony Silver	1.87x10^{-2} for no cover scenario	1.38x10^{3} mrem/yr @ 0 years for no cover scenario .	Cesium-137	Cesium-137	0	0 mrem/yr @ 0 years	Cesium-137
			3.05x10^{-21} for cover scenario.	1.53x10^{-16} mrem/yr @ 0 years for cover scenario.	Potassium-40	Potassium-40	1.66x10^{-4}	7.16x10^{1} mrem/yr @ 37 years for Selenium-79	

inated zone from 0 to 15 ft bgs with no cover; clean cover above contaminated zone = 3.2 ft at the 216-Z-11 Ditch, 8.9 ft at the 216-U-14 Ditch, 2.0 ft at the 216-U-10 Pond.

Modeling using the STOMP Code indicated that selenium-79, technetium-99, uranium, fluoride, and cyanide will impact groundwater in the future.

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Table 6-2. Preliminary List of Contaminants for Confirmatory Sampling Phase at the 200-CW-5, 200-CW-2, 200-CW-4, and 200-SC-1 Operable Units.

Radioactive Constituents	
Americium-241	Potassium-40
Cesium-137	Radium-226
Europium-152	Strontium-90
Neptunium-237	Thorium-228
Plutonium-238	Selenium-79
Plutonium-239	Technetium-99
Plutonium-239/240	
Chemical Constituents	
Antimony	Nitrite
Aroclor-1254	Selenium
Aroclor-1260	Silver
Boron	Toluene
Diethylphthalate	Thallium
Di-n-butylphthalate	Total uranium

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