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Rev. 0

Remedial Investigation Data Quality Objectives Summary Report for the 200-PW-2 Uranium-Rich Process Waste Group Operable Unit

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Office of Environmental Restoration

Submitted by: Bechtel Hanford, Inc.

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Remedial Investigation Data Quality Objectives Summary Report for the 200-PW-2 Uranium-Rich Process Waste Group Operable Unit

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EXECUTIVE SUMMARY

This data quality objective (DQO) summary report supports site characterization decisions for remedial investigation (RI) at representative waste sites and treatment, storage, and disposal (TSD) units in the 200-PW-2 Uranium-Rich Process Waste Group Operable Unit (OU). The 200-PW-2 OU consists of 24 *Resource Conservation and Recovery Act of 1976* (RCRA) past-practice waste sites (consisting mostly of cribs and trenches), three RCRA TSD units, and five unplanned release sites. The OU designation and waste site assignments are defined in the *200 Areas Remedial Investigation/Feasibility Study Implementation Plan - Environmental Restoration Program* (hereinafter referred to as the Implementation Plan) (DOE-RL 1999). Waste sites in the 200-PW-2 OU received mostly process drainage, process distillate discharge, and miscellaneous condensates containing significant concentrations of chemicals and radionuclides from U Plant, the Reduction-Oxidation (REDOX) Plant, the Plutonium-Uranium Extraction (PUREX) Plant, B Plant (i.e., Waste Encapsulation and Storage Facility [WESF]), and the Semiworks Facility. Data collected during the RI will be used to determine if the waste sites are contaminated above levels that will require remedial action, to support evaluation of remedial alternatives and/or closure strategies, and to verify or refine the preliminary conceptual contaminant distribution models.

This DQO effort follows the concepts developed in the Implementation Plan (DOE-RL 1999) for using analogous site contaminant data to reduce the amount of characterization required to support RI/feasibility study (FS) decisions. These concepts involve grouping sites with similar process histories, structures, and contaminants and then choosing one or more representative sites for comprehensive field investigation, including sampling during RI activities. Findings from the RI at representative sites are then used to make remedial action decisions for all of the waste sites in the OU. Analogous sites for which field data have not been (or will not be) collected are assumed to have chemical characteristics similar to the representative sites that are characterized. A Record of Decision for the OU will be obtained through the RI/FS process using the data collected during the RI. This will be supplemented with a RCRA Permit modification for the three TSD units. The analogous sites (i.e., those not sampled during the RI)

will be addressed during the confirmatory sampling phase to ensure that the remedial action specified in the Record of Decision is appropriate and to provide design data as needed. Following remedial actions, verification samples will be collected to support site closeout.

For the 200-PW-2 OU, four representative waste sites (one of which is a TSD unit) and two other TSD units have been identified. The goals of the RI are to provide the data needed to support remedial decisions and to refine the preliminary conceptual contaminant distribution and exposure models for this OU. The data will be generated mainly through soil sampling and analysis.

The Washington State Department of Ecology's document, *Guidance on Sampling and Data Analysis* (Ecology 1995), was used in developing the sampling design for the RI. Because the data will not be used to demonstrate compliance with a cleanup level, focused (biased) soil sampling of areas selected with the highest contamination potential was selected over an area-wide (unbiased) sample design. The concentrations of all contaminants in each soil sample will be compared directly with the cleanup levels. A statistical analysis of the sampling data is not appropriate for focused sampling schemes and is, therefore, not used in this report. The locations of samples exceeding the cleanup level will be used to delineate the areas of soil contamination requiring a decision on the need for remediation.

The proposed sampling locations were selected with the goal of intersecting the areas of highest contamination and determining the vertical extent of contamination. The nature (e.g., contaminant type and concentration) and the vertical extent of the contamination are the major RI data needs. For representative sites where sufficient data have been collected to support the RI/FS process, additional sampling will not be conducted; however, for these sites, geophysical logging of nearby existing boreholes will be conducted. For sites that have not been adequately characterized, a borehole will be drilled to the groundwater table and soil samples will be collected from the entire length of the borehole. Geophysical logging of planned and existing boreholes will also be performed.

The contaminants of potential concern were identified through process history information and previous data collection efforts. Analytical performance criteria were based on *Model Toxics Control Act* chemical compliance criteria (*Washington Administrative Code* 173-340) and other applicable or relevant and appropriate requirements. In the absence of applicable or relevant and appropriate requirements, other preliminary action levels were identified to determine analytical performance criteria. These levels provide the basis for identifying the laboratory or field screening detection limits required to support remedial action decisions. A modified version of the U.S. Environmental Protection Agency's DQO guidance (EPA 1994) was used to identify project data quality needs, evaluate sampling and analysis options, and document project data quality decisions.

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ACRONYMS

AA	alternative action
AEA	alpha energy analysis
ARAR	applicable or relevant and appropriate requirement
bgs	below ground surface
BHI	Bechtel Hanford, Inc.
CERCLA	*Comprehensive Environmental Response, Compensation, and Liability Act of 1980*
CFR	*Code of Federal Regulations*
CHI	CH2M Hill Hanford, Inc.
COC	contaminant of concern
COPC	contaminant of potential concern
CVAA	cold vapor atomic absorption
DOE	U.S. Department of Energy
DQO	data quality objective
DR	decision rule
DS	decision statement
Ecology	Washington State Department of Ecology
EMI	electromagnetic imaging
EPA	U.S. Environmental Protection Agency
FS	feasibility study
GC	gas chromatograph
GCMS	gas chromatography/mass spectrometry
GEA	gamma energy analysis
GPC	gas proportional counter
GPR	ground-penetrating radar
GW	groundwater
HPGe	high-purity germanium
IC	ion chromatography
ICP	inductively coupled plasma
ICPMS	inductively coupled plasma mass spectrometer
IDW	investigation-derived waste
MCL	maximum contamination level
MTCA	*Model Toxics Control Act*
NaI	sodium iodide
OU	operable unit
PCB	polychlorinated biphenyl
PQL	practical quantitation limit
PRG	preliminary remediation goal
PSQ	principal study question
PUREX	Plutonium-Uranium Extraction (Plant)
RCRA	*Resource Conservation and Recovery Act of 1976*
RDR/RAWP	remedial design report/remedial action work plan

REDOX	Reduction-Oxidation (Plant)
RESRAD	RESidual RADioactivity dose model
RFI	*Resource Conservation and Recovery Act* field investigation
RI	remedial investigation
RL	U.S. Department of Energy, Richland Operations Office
ROD	Record of Decision
RPP	*Resource Conservation and Recovery Act of 1976* past-practice
SAP	sampling and analysis plan
SGL	spectral gamma logging
SVOC	semi-volatile organic compound
TOC	total organic carbon
Tri-Party Agreement	*Hanford Federal Facility Agreement and Consent Order*
TSD	treatment, storage, and disposal
UCL	upper confidence limit
UPR	unplanned release
URP	uranium recovery process
VOA	volatile organic analysis
WAC	*Washington Administrative Code*
WDOH	Washington State Department of Health
WESF	Waste Encapsulation and Storage Facility
WIDS	Waste Information Data System

METRIC CONVERSION CHART

Into Metric Units

If You Know	*Multiply By*	*To Get*
Length		
inches	25.4	millimeters
inches	2.54	centimeters
feet	0.305	meters
yards	0.914	meters
miles	1.609	kilometers
Area		
sq. inches	6.452	sq. centimeters
sq. feet	0.093	sq. meters
sq. yards	0.0836	sq. meters
sq. miles	2.6	sq. kilometers
acres	0.405	hectares
Mass (weight)		
ounces	28.35	grams
pounds	0.454	kilograms
ton	0.907	metric ton
Volume		
teaspoons	5	milliliters
tablespoons	15	milliliters
fluid ounces	30	milliliters
cups	0.24	liters
pints	0.47	liters
quarts	0.95	liters
gallons	3.8	liters
cubic feet	0.028	cubic meters
cubic yards	0.765	cubic meters
Temperature		
Fahrenheit	subtract 32, then multiply by 5/9	Celsius
Radioactivity		
picocuries	37	millibecquerel

Out of Metric Units

If You Know	*Multiply By*	*To Get*
Length		
millimeters	0.039	inches
centimeters	0.394	inches
meters	3.281	feet
meters	1.094	yards
kilometers	0.621	miles
Area		
sq. centimeters	0.155	sq. inches
sq. meters	10.76	sq. feet
sq. meters	1.196	sq. yards
sq. kilometers	0.4	sq. miles
hectares	2.47	acres
Mass (weight)		
grams	0.035	ounces
kilograms	2.205	pounds
metric ton	1.102	ton
Volume		
milliliters	0.033	fluid ounces
liters	2.1	pints
liters	1.057	quarts
liters	0.264	gallons
cubic meters	35.315	cubic feet
cubic meters	1.308	cubic yards
Temperature		
Celsius	multiply by 9/5, then add 32	Fahrenheit
Radioactivity		
millibecquerel	0.027	picocuries

1.0 STEP 1 -- STATE THE PROBLEM

The purpose of data quality objective (DQO) Step 1 is to clearly and concisely state the problem to ensure that the focus of the study will be unambiguous.

1.1 INTRODUCTION

This summary report has been developed to support the remedial investigation/feasibility study (RI/FS) and remedial action decision-making processes for the 200-PW-2 Operable Unit (OU). The 200-PW-2 OU is being remediated under a *Resource Conservation and Recovery Act of 1976* (RCRA) approach. The 200-PW-2 OU originally consisted of 31 RCRA past-practice (RPP) waste sites and 3 RCRA treatment, storage, and disposal (TSD) units. The waste sites include cribs, trenches, buried tanks, pipelines, and unplanned releases (UPRs). Four representative sites have been identified for the 200-PW-2 OU in the *Waste Site Grouping for 200 Area Soil Investigations* report (DOE-RL 1997b) and in the *200 Areas Remedial Investigation/Feasibility Study Implementation Plan -- Environmental Restoration Program* (hereinafter referred to as the Implementation Plan) (DOE-RL 1999).

This DQO summary report focuses on the development of sampling designs for the representative (typical and worst-case) sites identified in the waste site grouping report (DOE-RL 1997b) and the Implementation Plan (DOE-RL 1999). All of the representative waste sites chosen for the 200-PW-2 OU are liquid waste disposal cribs and include the 216-A-19, 216-B-12, 216-U-8, and 216-U-12 waste sites (the latter site being one of the TSD units in this OU). In addition, there are also two other TSD units, 216-A-10 and 216-A-36B, which are being included in this assessment planning process.

The Washington State Department of Ecology (Ecology) document, *Guidance on Sampling and Data Analysis* (Ecology 1995), was used during this DQO process to support the selection of an appropriate sampling approach. Table 1 of the Ecology guidance summarizes approaches for sampling and data analysis considered acceptable to Ecology. This guidance shows that a focused sampling approach may be used to investigate a site that is known to be contaminated, and contaminated regions may be identified for sampling and analysis.

The 200-PW-2 OU waste sites and six UPR sites received mostly process drainage, process distillate discharge, and miscellaneous condensates from U Plant, the Reduction-Oxidation (REDOX) Plant (i.e., S Plant), the Plutonium-Uranium Extraction (PUREX) Plant (i.e., A Plant), B Plant (i.e., Waste Encapsulation and Storage Facility [WESF]), and the Semiworks Facility (i.e., C Plant). The waste was disposed to the vadose zone through cribs and trenches.

A map of the Hanford Site is provided in Figure 1-1 and depicts the 200 Areas and vicinity (i.e., the location of the 200-PW-2 OU). Figures 1-2 through 1-4 identify the locations of the 200-PW-2 OU waste sites and the associated source facilities.

Figure 1-1. Location of the Hanford Site and 200-PW-2 Operable Unit Waste Sites.

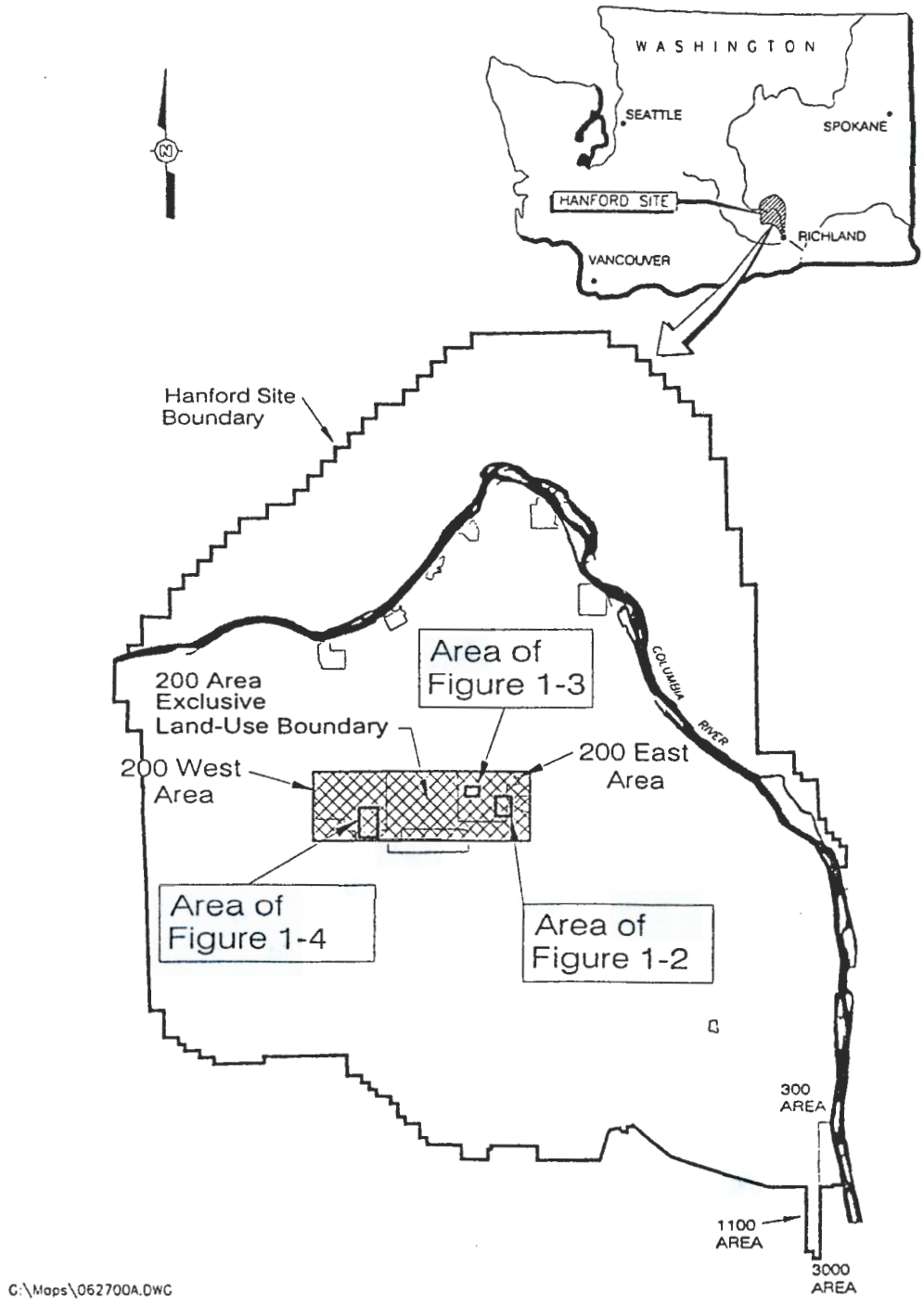

Figure 1-2. 200-PW-2 Operable Unit Waste Sites Located in the 200 East Area.

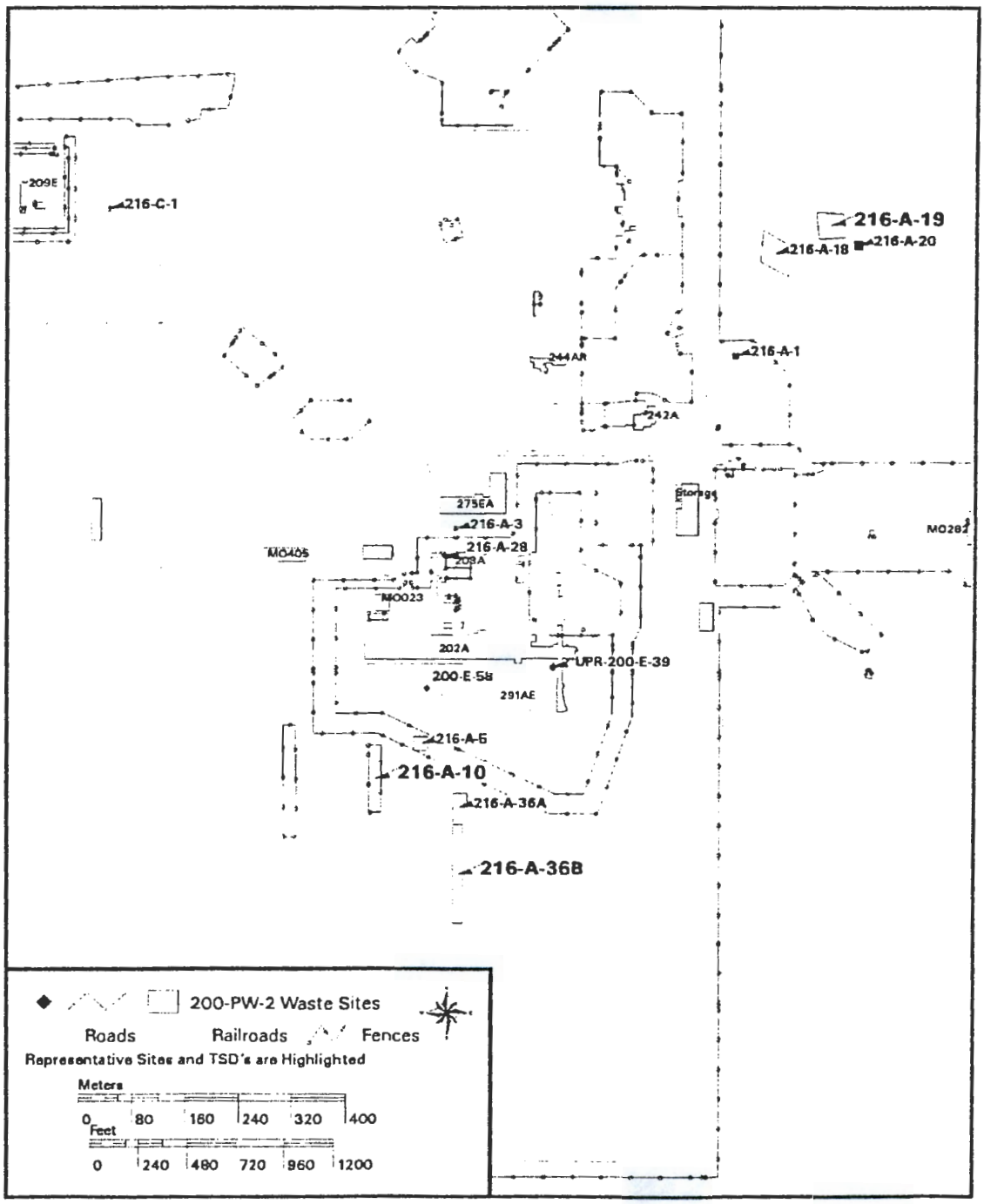

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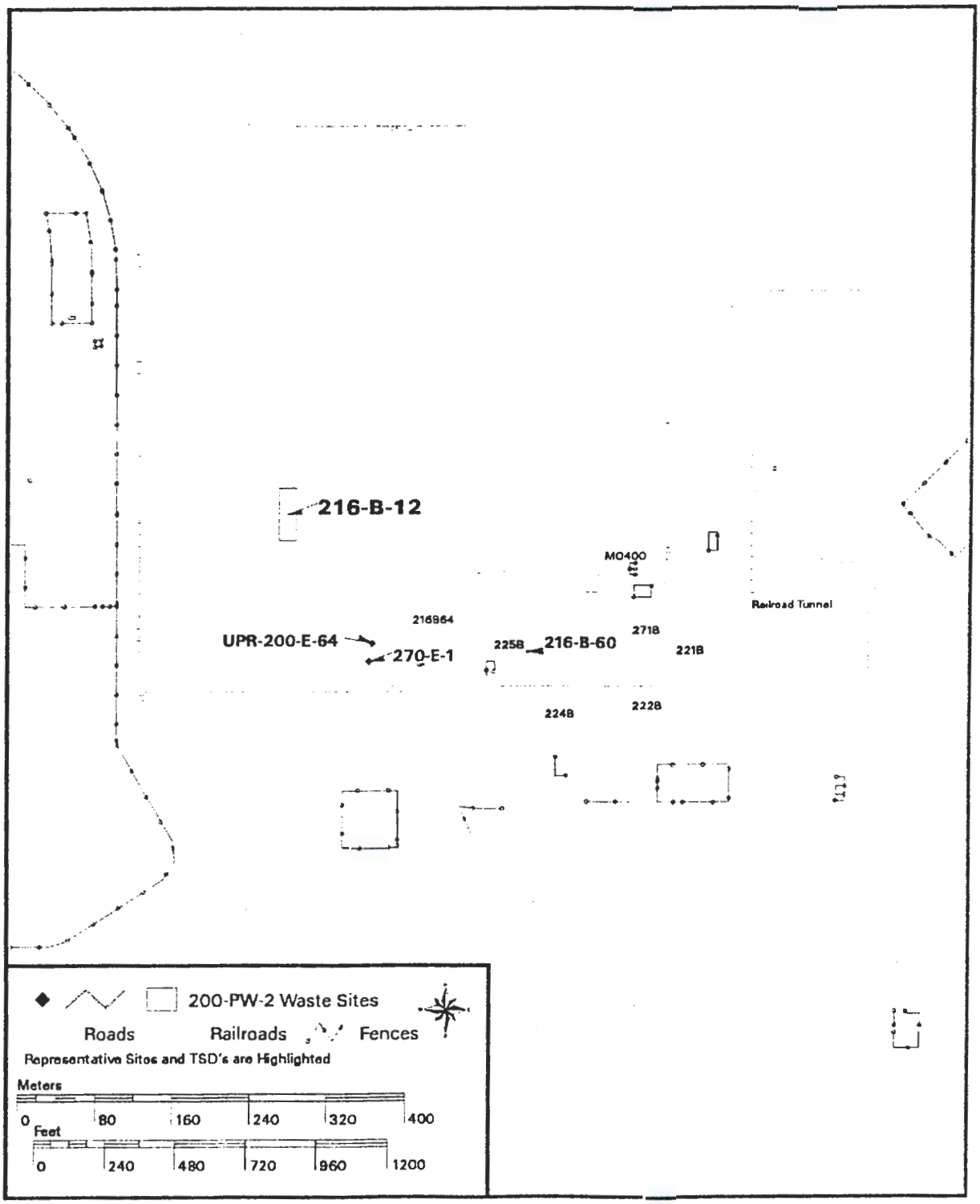
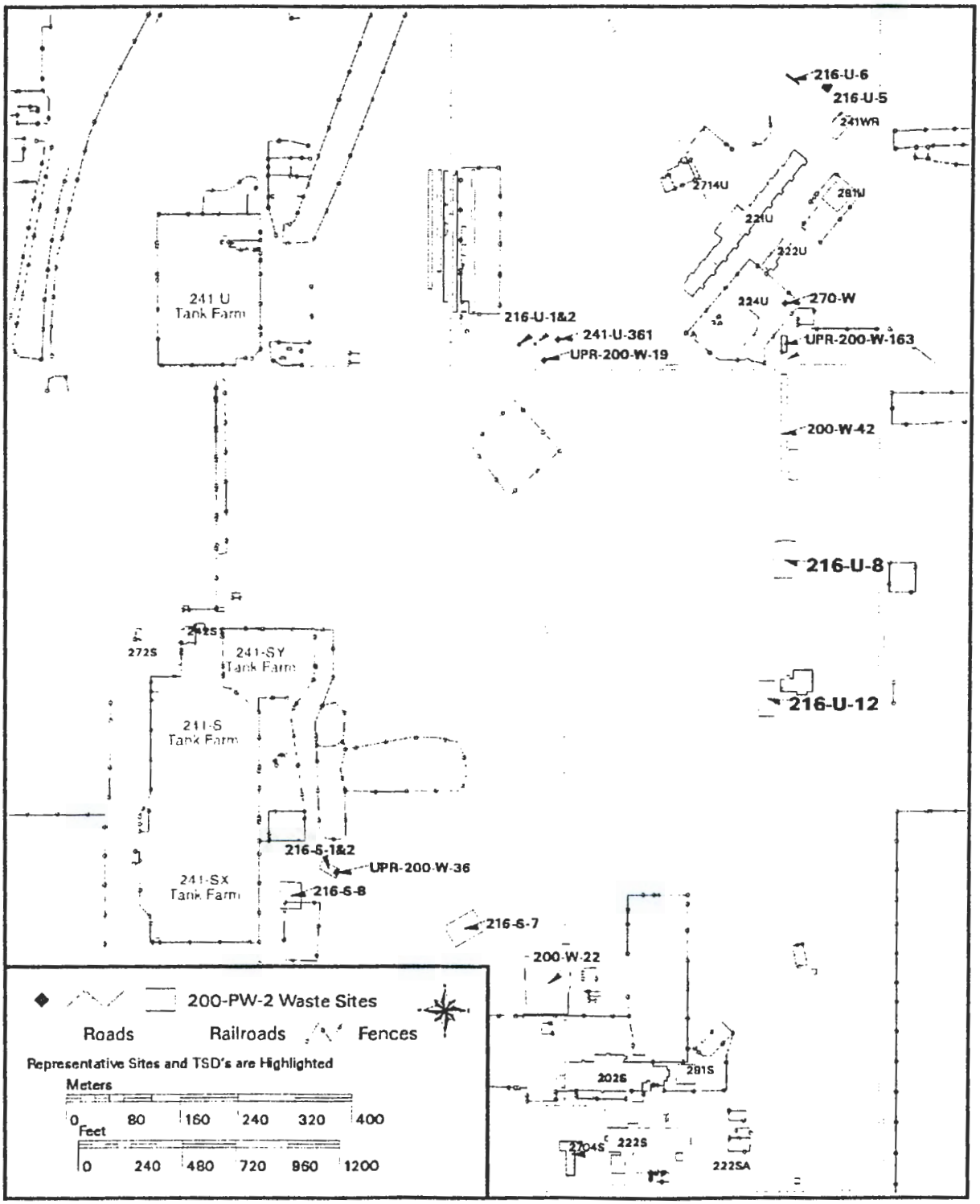
Figure 1-3. Additional 200-PW-2 Operable Unit Waste Sites Located in the 200 East Area.



BHI:maa 6/27/00 /home/maaye/amls/uwaste2e_2.aml Plotted 22-JAN-2001 Rev 2

Figure 1-4. 200-PW-2 Operable Unit Waste Sites Located in the 200 West Area.



BHI maa 06/21/00 /home/uuaye/arnls/uwaste2w.aml Plotted 22-JAN-2001 Rev 4

1.2 PROJECT SCOPE

This DQO summary report focuses on the representative waste sites associated with the 200-PW-2 Uranium-Rich Process Waste Group OU. The scope of this project includes the DQO process and the development of a sampling and analysis plan (SAP) for the four representative sites (note that the 216-U-12 Crib is a RCRA TSD unit and is a representative site) and the remaining two RCRA TSD units, for a total of six sites, hereinafter collectively referred to as "representative sites." The DQO summary report and SAP will provide the basis for the RI for the 200-PW-2 sites and the RCRA facility investigation (RFI) for the 200-PW-2 sites. The Implementation Plan (DOE-RL 1999) presents a consistent approach to data collection activities associated with 200 Area assessment and remediation activities. The activities include all phases of sampling required to support the completion of the integrated RCRA/*Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA) process outlined in Section 2.3 and depicted in Figure 2-2 of the Implementation Plan (DOE-RL 1999). Specific activities include the following:

1. Data collection at representative sites defined for the waste group-specific OU work plan, with an emphasis on verifying the conceptual models. This will support preparation of a focused feasibility study and remedial action decision making.

2. Data collection after the Record of Decision (ROD) to confirm that all other sites in the specific waste group OU meet the conceptual models. In addition, data collection activities will be included as part of the remedy selected for the waste group and will provide site-specific information for preparation of the remedial design report/remedial action work plan (RDR/RAWP).

3. Data collection, as defined in the RDR/RAWP, to verify that remedial actions associated with a remove, treat, and dispose remedy have met the required objectives.

4. Data collection defined as part of the post-closure monitoring plan section in a closure plan for a RCRA TSD unit or RPP site.

This DQO process supports the data collection (from item 1) that will support the evaluation of remedial alternatives and RI/FS decision making. Additional DQO processes will be conducted to define the sampling requirements for the other phases of data collection.

An RI/FS work plan will be prepared that satisfies, in concert with the Implementation Plan (DOE-RL 1999), the requirements of both the RI and the RFI. The data acquired during the RI will support the RI/FS and RFI/corrective measures study processes for this OU. For ease of preparation and readability (and as described in the Implementation Plan [DOE-RL 1999]), the RI/FS terminology will be used throughout the DQO summary report and work plan documents.

1.3 PROJECT OBJECTIVES

The objective of the DQO process for the 200-PW-2 Uranium-Rich Process Waste Group OU is to determine the environmental measures necessary to support the RI/FS process and remedial decision making, including refinement of the preliminary conceptual contaminant distribution model. Additionally, the DQO process supports development of a SAP for the RI, which will be included as an appendix to the RI/FS work plan for the OU.

Possible alternatives identified in the Implementation Plan (DOE-RL 1999) include the following:

- No action alternative (no institutional controls)
- Engineered multi-media barrier
- Excavation and disposal of waste
- In situ vitrification of soil
- In situ grouting or stabilization
- Monitored natural attenuation (with institutional controls).

1.4 PROJECT ASSUMPTIONS

Project assumptions for the RI include the following

- The DQO process will follow BHI-EE-01, *Environmental Investigations Procedures*, Procedure 1.2, "Data Quality Objectives," and Section 6.1 of the Implementation Plan (DOE-RL 1999).

- The 200-PW-2 OU waste group is a source waste group and the investigations will focus on vadose zone soil contamination.

- The Implementation Plan (DOE-RL 1999) outlines the assessment and remediation approach to be followed for the OU:

  - Define the regulatory framework

  - Generally identify the characterization approach

  - Provide background information on 200 Area site conditions, operational history, and secondary plans (e.g., quality assurance, health and safety, information management, and waste management)

  - Provide governing assumptions, including preliminary applicable or relevant and appropriate requirements (ARARs), land-use considerations, remedial action objectives, and remedial action alternatives.

- The analogous site approach will be used. Characterization will be limited to representative waste sites and TSD units, and the characterization data will be used to reach remedial decisions for all waste sites within the OU. The DQO effort will focus on representative waste sites within the OU. Preliminary representative waste sites have been selected in the waste site grouping report (DOE-RL 1997b) and the Implementation Plan (DOE-RL 1999) that were considered to be representative of typical and worst-case conditions for the OU. Representative waste sites for the 200-PW-2 OU include the following:

  - 216-A-19 Trench (second choice worst-case site)
  - 216-B-12 Crib (second choice typical site)
  - 216-U-8 Crib (first choice worst-case site).

  The TSD units in the 200-PW-2 OU are as follows:

  - 216-A-10 Crib
  - 216-A-36B Crib
  - 216-U-12 Crib (also identified as the first choice typical site).

  The 216-U-8 Crib was chosen as a worst-case site because of its high contaminant inventory and current level of characterization. The 216-A-19 Trench was chosen as the second choice worst-case site because of its high contaminant inventory (and the highest uranium inventory) from a process waste stream. The 216-B-12 and 216-U-12 Cribs are typical waste sites for the OU. The 216-B-12 Crib was selected for its contaminant inventory and the fact that it received a second process condensate that added high inventories of fission products. The 216-U-12 Crib was selected for its typical uranium inventory and current level of characterization. Table A-1 of the waste site grouping report (DOE-RL 1997b) compares the waste sites by contaminant inventories received, effluent volume received, and effluent volume versus pore space volume beneath the waste sites.

  Twenty-eight specific waste sites and UPRs within the OU are listed in Appendix G of the Implementation Plan (DOE-RL 1999). This list was subsequently updated by the Waste Information Data System (WIDS), bringing the current total to 34 sites. Sites identified in the 200-PW-2 OU, in addition to the representative and TSD sites, are listed below:

  - 200-E-58
  - 200-W-22
  - 200-W-23
  - 200-W-42
  - 216-A-1
  - 216-A-18
  - 216-A-20
  - 216-A-28
  - 216-A-3
  - 216-A-36A
  - 216-A-5
  - 216-S-7
  - 216-S-8
  - 216-U-1&2
  - 216-U-5
  - 216-U-6
  - 241-U-361
  - 270-E-1
  - 270-W
  - UPR-200-E-39
  - UPR-200-E-40
  - UPR-200-E-64

- 216-B-60
- 216-C-1
- 216-S-1&2
- UPR-200-W-163
- UPR-200-W-19
- UPR-200-W-36.

Characterization of these waste sites is not included in this DQO process. In the spring of 2000, an effort was initiated to evaluate the waste sites identified in the 200-PW-2 OU following the waste site reclassification process, as described in *Tri-Party Agreement Handbook Management Procedures*, Guideline Number TPA-MP-14, "Maintenance of the Waste Information Data System (WIDS)" (DOE-RL 1990). As a result of that process, waste sites 200-W-23 and UPR-200-E-40 were reclassified as "rejected" sites and will no longer be considered. The total number of sites remaining in the 200-PW-2 OU, therefore, is 32.

- A review of the representative sites is a key component of the DQO process. The representative sites identified in the waste site grouping report (DOE-RL 1997b) and the Implementation Plan (DOE-RL 1999) will be revisited with the DQO scoping team members and key decision makers to ensure that the appropriate sites are chosen. The final selection of representative waste sites is considered flexible (i.e., different waste sites may be selected as representative sites, or additional representative sites may be added) and will consider critical data needs of other Groundwater/Vadose Zone core projects (e.g., the Science and Technology Project and the Site-Wide Groundwater Monitoring Project). Integration of characterization efforts will promote more efficient and cost-effective use of resources while still obtaining the necessary data to support the objectives for the 200-PW-2 OU. Active participation by other Groundwater/Vadose Zone core projects will be solicited to provide input to the DQO process.

- Extensive characterization of the 216-U-8 and 216-U-12 Cribs was conducted as part of the 200-UP-2 OU remedial investigation in the early 1990s. The adequacy of the data to support the RI/FS process is evaluated in Section 3.0.

- Existing characterization data from waste sites within the OUs and analogous data (i.e., borehole logging results from the vicinity of the waste sites) will be used to support the DQO process and prepare the work plan. Based on historical site uses and current contaminant of potential concern (COPC) information, it is expected that waste site contaminants of concern (COCs) will exceed action levels and that remediation will be required at most sites; however, it is possible that COC action levels will not be exceeded. In this instance, follow-up verification sampling during the confirmatory, design, and verification phases would be conducted to ensure that site closeouts without remediation are adequately supported. These activities would be conducted under separate DQO processes.

- The DQOs will be used to prepare a SAP to be included in the 200-PW-2 RI/FS work plan.

- A preliminary conceptual contaminant distribution model for the 200-PW-2 OU waste group was developed in the waste site grouping report (DOE-RL 1997b). This preliminary conceptual contaminant distribution model provides an initial prediction of the nature and extent of the primary COCs. Models for individual representative sites will be developed as part of the DQO effort and work plan preparation.

- Remedial actions will likely be required to achieve ARARs, including the soil cleanup standards of the *Model Toxics Control Act* (MTCA) (*Washington Administrative Code* [WAC] 173-340) for chemical contaminants and radiological dose limits to be determined in the future. For purposes of this DQO process, a dose limit of 100 mrem/yr above natural background for radionuclides in soil is assumed as a reasonable and representative range of acceptable dose limits. In accordance with 10 *Code of Federal Regulations* (CFR) 20 and 10 CFR 835, the total effective dose equivalent for members of the public entering a controlled area is 100 mrem/yr. Because the waste sites in this OU are contained within the exclusive land-use boundary for the 200 Areas, an industrial land-use scenario is assumed.

- Potential data uses that need to be considered when developing DQOs include preliminary conceptual contaminant distribution model refinement; evaluation of remedial action alternatives, remedial action decisions, and risk assessment; and worker health and safety.

- The data collected will support investigation-derived waste (IDW) disposal. The IDW will be designated by Bechtel Hanford, Inc. (BHI) Waste Management after evaluating analytical data, process knowledge, and other inputs (e.g., groundwater listed waste code requirements).

- At this point in time and based on the available information reviewed for this DQO process, the only regulated dangerous wastes that have been identified for the representative sites or for any of the sites in the OU relate to the corrosivity of nitric acid (D002) and state toxicity of ammonia (WT02) discharges. Characteristic heavy metal constituents will be evaluated based on total analytical results. Toxicity characteristic leaching procedures may be conducted if total results exceed 20 times the regulatory standards identified in WAC 173-303-090.

- Mobile contaminants were disposed at the sites within this waste group and groundwater has been impacted in the past by waste sites in this OU. However, evaluation of groundwater contamination and remediation is not included in the scope of the work plan.

The RI (i.e., initial OU characterization) will validate or provide the basis to refine the preliminary conceptual contaminant distribution models for the waste sites in the OU from the characterization of representative waste sites. The preliminary conceptual contaminant distribution models and the preliminary exposure model will be used to develop and evaluate remedial action alternatives applicable to the OU in a FS/closure plan. The RI/FS will form the basis for selecting a preferred remedial action in a proposed plan for the waste sites. The RPP sites will be incorporated into the RCRA Permit through the permit modification process.

1.5 PROJECT ISSUES

Project issues include both the global issues that transcend the specific DQO process and the technical issues that are unique to the project. Both global and project technical issues have the potential to impact the sampling design or the DQOs for the project.

1.5.1 Global Issues

One global issue was identified during the interview meeting between Ecology, the U.S. Environmental Protection Agency (EPA), and the U.S. Department of Energy, Richland Operations Office (RL), which was the preliminary action level for exposure to radionuclides. Current activities to evaluate cleanup levels are underway for the 100 and 300 Areas, and similar activities will also be conducted for the 200 Areas. For the purpose of this DQO summary report, a preliminary action level of 100 mrem for annual dose exposure to radionuclides will be used to evaluate appropriate analytical requirements. This level falls in the representative range of potential cleanup standards based on current land-use assumptions, regulatory requirements, and other requirements. The final cleanup standards will be proposed in the FS and proposed plan and will be approved in the ROD for the OU.

1.5.2 Project Technical Issues

Historical records for the 216-S-1&2 wase site indicate that the waste site received 1,200 g of plutonium during operation. Extensive site characterization activities were conducted after discharge to the crib was ceased but did not confirm the presence of plutonium. This site is not identified as a representative site because this level of plutonium is not typical of the remaining sites in the OU. Sampling of this waste site will take place during remedial design activities to confirm the conceptual model for this site. Should excavation be selected as the remedial alternative for this site and the material be designated as transuranic waste, then stringent health and safety restrictions will be imposed on workers and work practices, and appropriate requirements for management and disposition of transuranic waste will be incorporated.

1.6 WASTE SITES AND OPERATING HISTORY

The 200-PW-2 Uranium-Rich Process Waste Group OU consists of 32 waste sites located in the Hanford Site's 200 East and 200 West Areas. Figures 1-1 through 1-4 depict the locations of the study areas relative to the 200 Areas. The 200-PW-2 OU waste sites and five UPR sites received mostly process drainage, process distillate discharge, and miscellaneous condensates. Most of the waste discharged to the soil column in this OU was generated at U Plant, REDOX Plant, PUREX Plant, B Plant (i.e., WESF), and the Semiworks Facility (C Plant) from 1952 through 1988.

1.6.1 Plant History

The U Plant was constructed in 1944 based on the design of T and B Plants and was initially used to train personnel for the uranium/plutonium separation and purification operations

conducted in T and B Plants. During the training phase, only water was used in the plant systems and no waste streams were generated. However, in 1951 U Plant was modified for the uranium recovery process (URP). From 1952 to 1958, U Plant was used to recover unprocessed uranium stored in the single-shell tanks for reuse in the reactor plants and for waste volume reduction at T and B Plants. A later operation conducted at U Plant was the "scavenging" or precipitation of long-lived fission products from the settling process before discharge to the soil column. The final operation of U Plant was the conversion of uranyl nitrate hexahydrate (UNH) to uranium trioxide (UO_3). This operation was accomplished by calcinating the UNH in a batch process within the 224-U Building. In 1957, the batch conversion of UNH to UO_3 was renovated. The two calcinators previously used were removed and replaced with six newer calcinators. The operation was updated to a continuous flow, and the 224-U Building became known as the UO_3 Plant.

The UO_3 Plant operated from 1958 until 1972 when the PUREX Plant was placed in stand-down mode. During that time, the UO_3 Plant converted UNH from the PUREX Plant and REDOX Plant to UO_3 powder. The powder was packaged at the UO_3 Plant, stored, and sent offsite to Oak Ridge National Laboratory in Tennessee, and later to Fernald, Ohio, where the UO_3 powder was converted to uranium metal and returned to the Hanford Site's 300 Area for fuel extrusion re-work. The UO_3 Plant resumed operations in 1984 to process UNH from the PUREX Plant. Because the feed lines from the REDOX Plant and 221-U Building were no longer in use, they were disconnected and capped in the UO_3 Plant. Operations of the UO_3 Plant ceased in 1988.

The REDOX Plant was the first continuous plutonium-separation operation at the Hanford Site. Not only did the REDOX Plant separate weapons-grade plutonium from the irradiated fuel rods, but it also recovered unspent uranium. The REDOX Plant used the solvent extraction process, which used hexone (methyl isobutyl ketone, or MIBK) and aluminum nitrate nanohydrate (ANN) in nitric acid, to complete these separations within the anionic resin columns. The REDOX Plant operations began in 1952 and continued until 1967.

The PUREX Plant process replaced the REDOX Plant's separation process. The PUREX Plant process used a recoverable salting agent, proving to be economically more feasible, generating less waste, and operating more safely than the REDOX Plant's process. The construction of the PUREX Plant was completed in late 1955. The PUREX Plant operated continuously from November 1955 until 1972, separating weapons-grade plutonium and depleted uranium products from irradiated fuel. The PUREX Plant was placed in standby mode from 1972 until 1983 and then restarted in 1983, continuing operations until 1985 when it was deactivated. Since initial operation of the PUREX Plant, it has been modified to reprocess several types of fuel to obtain various products, including zirconium alloy (zircaloy)-clad fuel with several different enrichments ranging from 0.72% to 2.1% of uranium-235 exposed at various durations (300 to approximately 3,000 megawatt days/ton of uranium) to obtain fuel-grade plutonium; slightly enriched uranium and neptunium; uranium metals; uranium and plutonium oxides; and several thoria targets.

B Plant was constructed in 1944. From 1945 to 1952, B Plant operations consisted of a batch-wise, inorganic chemical separation of weapons-grade plutonium from irradiated uranium. This was known as the bismuth phosphate/lanthanum fluoride process. From 1952 to 1965, B Plant was used for various waste treatment operations. In 1963, the 221-B Building began recovering strontium, cerium, and rare earth metals using an acid-side, oxalate-precipitation process as part of the Phase I processing for the 221-B Building waste fractionization project. Phase I processing at the 221-B Building ended in June 1966 to accommodate Phase III construction. The Phase III waste fractionization processing began at the 221-B Building in 1968. This process separated the long-lived radionuclides strontium-90 and cesium-137 from high-level PUREX and REDOX Plant wastes and stored a concentrated solution of strontium-90 and cesium-137 at the 221-B Building. In 1968, B Plant underwent renovations, and WESF was added. Waste factionization and encapsulation efforts continued until 1986.

The Semiworks aggregate area was composed of two primary facilities: the 201-C Process Building and the Critical Mass Laboratory (209-E Building). The 201-C Process Building was constructed in 1949 as a pilot plant for reprocessing reactor fuel, first using the REDOX Plant's chemical process, and then using the PUREX Plant's chemical process in 1954. In 1961, the building was again converted to recover strontium from fission product waste. This facility operated until 1967 and remained in safe-storage mode until decommissioning began in 1983.

Liquid waste generated at U Plant, PUREX Plant, REDOX Plant, WESF/221-B Building, and C Plant were routed to underground storage tanks (e.g., various B Plant, REDOX Plant, PUREX Plant, and U Plant tank farms) through an underground transfer system. The liquid waste was then evaporated (concentrated) and often neutralized before routing for various disposal options. The storage tanks were used to settle the heavier constituents out of the liquid effluents, forming sludge. The liquid supernatants in the tanks were ultimately discharged to the soil column via cribs, drains, trenches, and injection/reverse wells. Process distillate and drainage liquids were also sent to cribs and trenches via this underground network (WIDS).

Cribs and drains were designed to inject or percolate wastewater into the soil column. French drains were generally constructed of steel or concrete pipe. Cribs are shallow excavations that are either backfilled with permeable material or are voids created by wooden or concrete structures. The cribs and drains typically received low-level radioactive waste for disposal, and most cribs were designed to receive liquid until a specific retention, volume, or radionuclide capacity was met.

Trenches are shallow, long, narrow, unlined excavations and were often located adjacent to other trenches. Some of the trenches have been backfilled and marked as a single group of trenches.

1.6.2 Process Information

The processes at U Plant, REDOX Plant, PUREX Plant, WESF, and the Semiworks Facility that generated the primary waste streams to the 200-PW-2 OU waste sites included the following:

- U Plant: Waste wasgenerated in the 221-U and 224-U Buildings as part of the URP. Waste streams included aqueous and organic solvent extraction wastes from uranium recovery

operations of original bismuth phosphate/lanthanum fluoride separation process wastes, process drainage, process distillate drainage, and miscellaneous off-gas condensates from the 291-U-1 stack, waste treatment condensers, nitric acid and solvent recoveries, 241 and 244 vaults (waste treatment/storage), and 224-U storm drainage waste streams.

- REDOX Plant: Waste was generated in the 202-S Building. Waste streams were mainly aqueous and organic solvent extraction wastes from several REDOX Plant operations, including process drainage, process distillate drainage, and miscellaneous off-gas condensates from the silver filter, air sparger, ruthenium tetraoxide scrubber, waste treatment condensers, solvent recovery, and 240 and 241 vaults (waste treatment/storage) waste streams.

- PUREX Plant: Waste was generated in the 202-A, 203-A, 206-A, 293-A, 294-A, and 295-A Buildings. Waste streams were mainly aqueous and organic solvent extraction wastes from several PUREX Plant operations, including process drainage, process distillate drainage, and miscellaneous off-gas condensates from the acid absorbers, ammonia scrubber, nitric acid fractionalization, waste treatment condensers, solvent recoveries, nitric acid storage, and waste treatment/storage waste streams.

- WESF/221-B Building: The waste fractionization process included a thermal evaporation concentrator in cell 23 to concentrate process wastewater prior to disposal. This system was used to concentrate low-level radioactive waste after the cesium and strontium waste fractionization process was shut down in 1984. Double-shell tank waste was received at the 221-B Building to be processed through the low-level waste concentrator until 1986. The 221-B Building did not receive double-shell tank wastes after April 1986, and processing of these wastes was completed by late 1986. Other sources of low-level waste included miscellaneous sumps and drains in the WESF, which diverted decontamination waste solutions generated in the WESF process cells. Another contributor was a liquid collection system located beneath the 40 cells in the 221-B Building that collected cell drainage from decontamination work and water washdowns in the processing section of the 221-B Building. The concentrator also processed wastes produced by the cleanout of various process vessels at the 221-B Building and the WESF through 1986 (Peterson 1990). The process condensate was disposed in the 216-B-12 Crib beginning in May 1967. In November 1973, the process condensate was diverted to the 216-B-62 Crib.

- Semiworks Facility: The 216-C-1 Crib received 23,400,000 L (6,180,000 gal) of liquid waste. Until September 1955, the crib received REDOX and PUREX Plant high-salt waste, process condensate from the 201-C Process Building and material described as "cold-run" waste from the REDOX and PUREX processes. From September 1955 to June 1957, the crib also received high-salt, cold-run waste from the 201-C Process Building (WHC 1992a). The WIDS database estimates approximately 153 m^3 (200 yd^3) of contaminated soil at this site.

Figures 1-5, 1-6, and 1-7 show graphical representations of the U Plant, PUREX Plant, and REDOX Plant processes and the corresponding waste streams that were discharged to the 200-PW-2 OU waste sites.

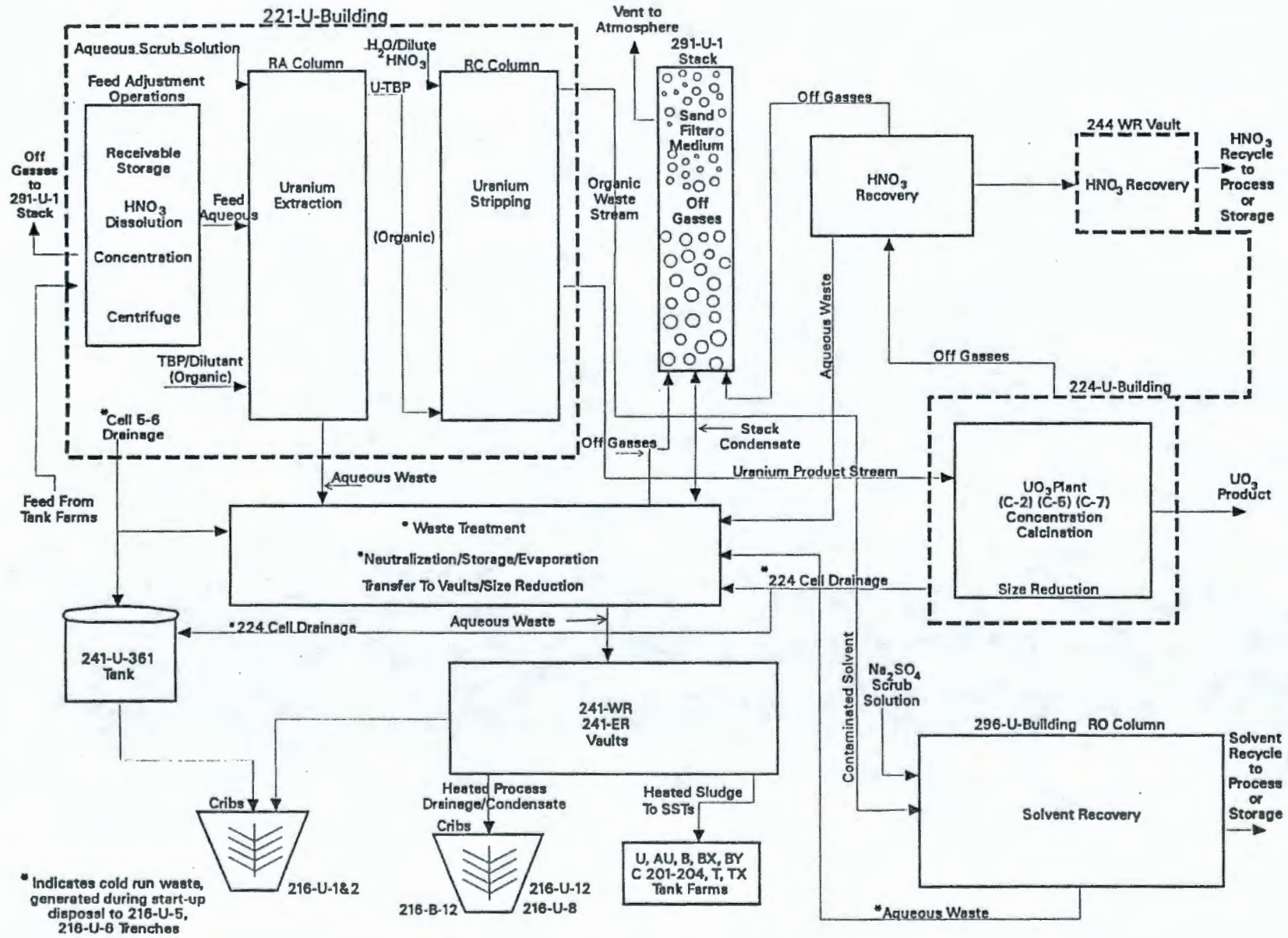


Figure 1-5. Plant Processes and Waste Streams at the U Plant.

Figure 1-6. Plant Processes and Waste Streams at the PUREX Plant.

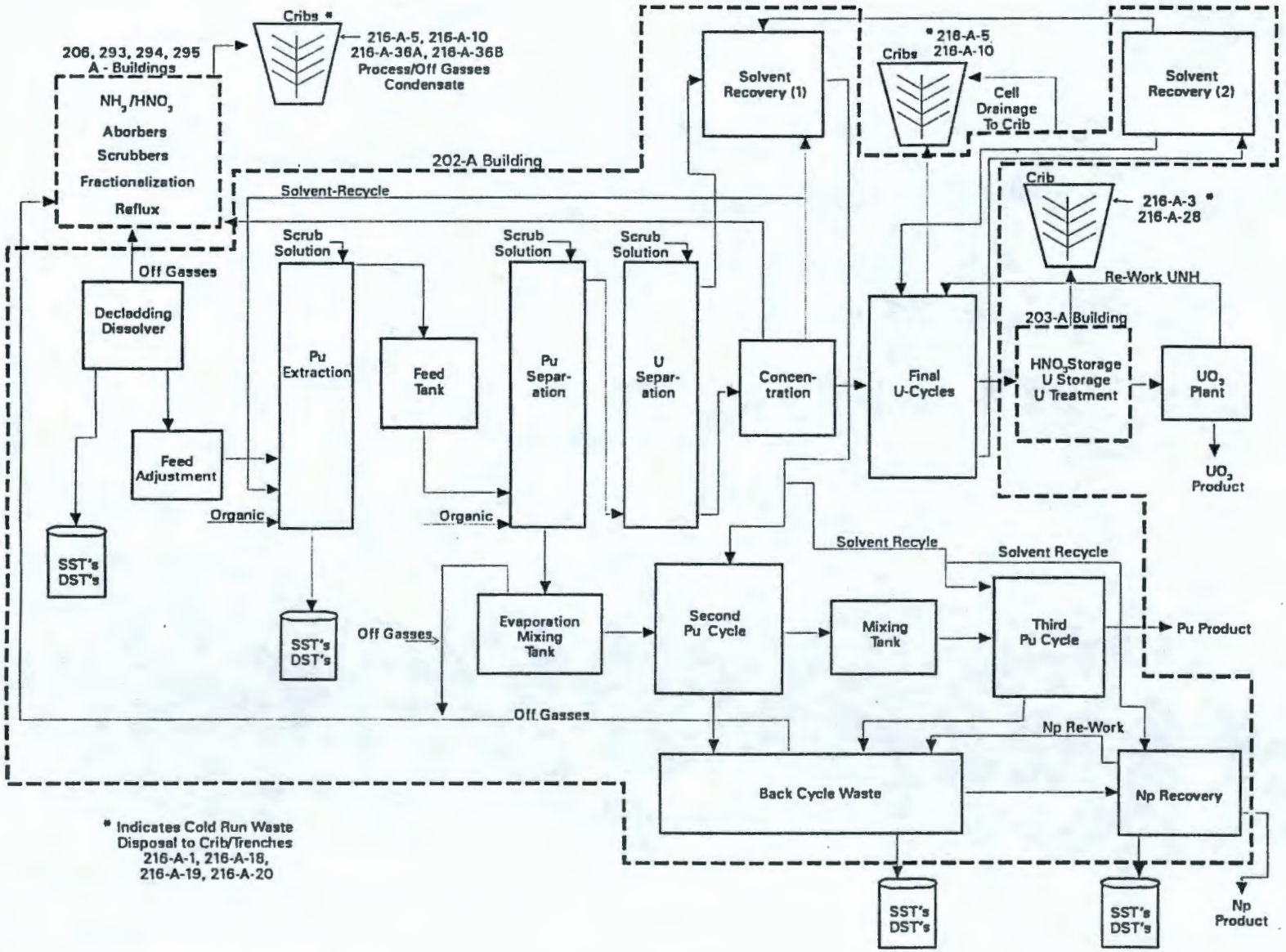
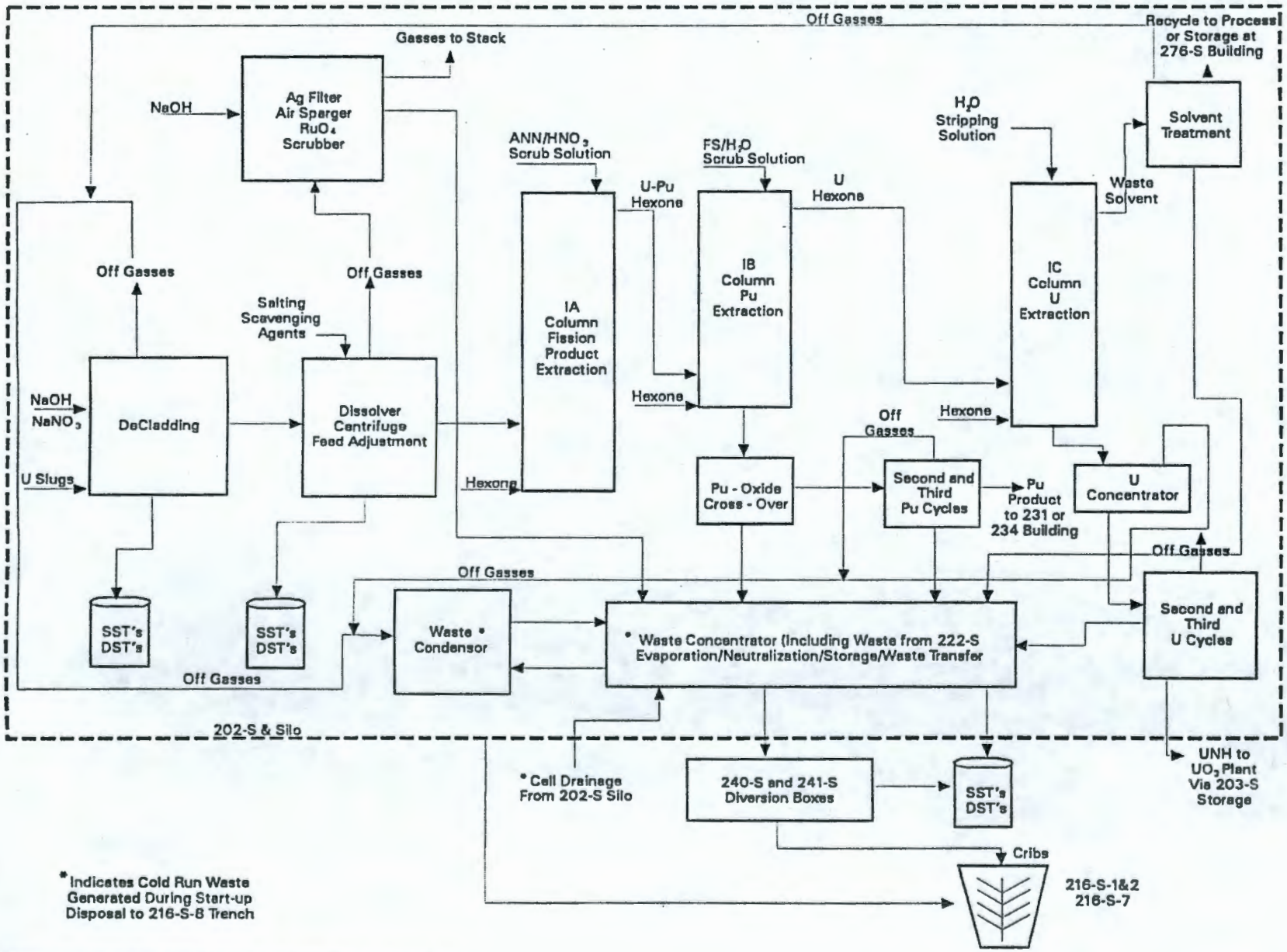


Figure 1-7. Plant Processes and Waste Streams at the REDOX Plant.



1.7 WORKSHEETS FOR STEP 1 -- STATE THE PROBLEM

Tables 1-1, 1-2, 1-3, and 1-4 identify the DQO scoping team members, DQO workshop team members, DQO integration team members, and key decision makers, respectively. The scoping team developed the DQO checklist and binder prior to the internal seven-step process. The DQO workshop team members participated in the seven-step DQO process, and the key decision makers provided external review of the results of the process.

Table 1-1. DQO Scoping Team Members.

Name	Organization	Area of Expertise (Role)
Roy Bauer/Mary Todd	CHI Environmental Engineering	DQO Workbook/Facilitator
Janet Badden	CHI Regulatory Support/ Environmental Science	Regulatory
Karl Fecht	BHI Environmental Technologies	Geological
Russ Fabre	BHI Craft Supervisor	Field Support
Mike Faurote	CHI Geosciences	Technical Staff, Author
Bruce Ford	BHI Site Assessments	BHI Project Manager
Rob Sitsler	BHI Radiological Control Engineering	Radiological Control Engineering
Larry Hulstrom	CHI Environmental Engineering	200-PW-2 Task Lead, Author
Barry Vedder	BHI Regulatory Support	Regulatory
Doug Bowers	CHI Sample/Data Management	Sampling Data Management/Site Sampling History
Bill McMahon	CHI Geosciences	Technical Staff, Author
Jim Sharpe	CHI Regulatory Support/ Environmental Science	Cultural/Biological Issues
Kevin Singleton	CH2M Hill, Inc.	Technical Staff, Author
Wendy Thompson	BHI Environmental Technologies	Sampling/Field Analysis
Rich Weiss	CHI Sample/Data Management	Radiochemical and Analytical, Data Management
Curt Wittreich	CHI Environmental Engineering	CHI Project Management
Michelle Yates	CHI Environmental Engineering	Technical Staff, Author

CHI = CH2M Hill Hanford, Inc.

Table 1-2. DQO Workshop Team Members.

Name	Organization	Area of Expertise (Role)
Roy Bauer/Mary Todd	CHI Environmental Engineering	DQO Workbook/Facilitator
Rob Sitsler	BHI Radiological Control Engineering	Radiological Control Engineering
Bruce Ford	BHI Site Assessments	BHI Project Manager
Larry Hulstrom	CHI Environmental Engineering	200-PW-2 Task Lead/Author
Greg Borden	BHI Waste Management	Waste Management Support
Barry Vedder	BHI Regulatory Support	Regulatory Support
Kevin Singleton	CH2M HILL, Inc.	Technical Staff/Author
Wendy Thompson	BHI Environmental Technologies	Sampling/Field Analysis
Rich Weiss	CHI Sample/Data Management	Radiochemical and Analytical
Curt Wittreich	CHI Environmental Engineering	CHI Project Management
Michelle Yates	CHI Environmental Engineering	Technical Staff, Author

Table 1-3. DQO Integration Team Members.

Name	Organization	Area of Expertise (Role)
John Zachara	Pacific Northwest National Laboratory	Science &Technology Manager
Brett Simpson	CH2M HILL Group	S&T Inventory/Modeling
Mike Coony	Fluor Hanford Inc.	Characterization of Systems/ Inventory/Modeling
Bruce Williams/Steve Reidel/ Jon Lindberg	Pacific Northwest National Laboratory	RCRA and Site-Wide Groundwater Monitoring

Table 1-4. DQO Key Decision Makers.

Name	Organization	Area of Expertise (Role)
Bryan Foley	DOE	DOE Project Manager
Zelma Jackson-Maine	Ecology[a]	Ecology Project Manager
Doug Sherwood	EPA	EPA Project Manager

[a] Regulatory lead for 200-PW-2 OU.
DOE = U.S. Department of Energy

Table 1-5 lists the key sources of existing documents and data collected from previous investigations that were reviewed by the DQO team.

Table 1-5. Existing Documents and Data Sources for 200-PW-2 Operable Unit. (5 Pages)

Reference	Summary
200 Areas Waste Sites Handbook, Vols. I and II, RHO-CD-673 (Maxfield 1979)	Waste site descriptions, releases, waste discharge information, and management reports.
B Plant Aggregate Area Management Study Technical Baseline Report, WHC-IP-0809 (WHC 1991b)	Waste unit descriptions including cribs, french drains, septic tanks, and drain fields, trenches and ditches, ponds, catch tanks, settling tanks, diversion boxes, underground tank farms designed for high-level liquid wastes, and the lines and encasements that connect them. Waste sites are described separately.
200-UP-2 Operable Unit Technical Baseline Report, WHC-EP-0400 (WHC 1991a)	Technical baseline information for the 200-UP-2 OU. Contains information on liquid waste disposal sites in the vicinity of and related to U Plant operations.
Limited Field Investigation for the 200-UP-2 Operable Unit, DOE/RL-95-13 (DOE-RL 1995b)	Summarizes the data collection and analysis activities conducted during the limited field investigation and presents the associated qualitative risk assessment.
216-U-12 Crib Supplemental Information to the Hanford Facility Contingency Plan, DOE/RL-93-75, BHI-00123, Rev. 2 (BHI 1996c)	Supplement to DOE/RL-93-75 (DOE-RL 1996a) and used to demonstrate compliance with the contingency plan requirements of the WAC.
216-A-36B Crib Supplemental Information to the Hanford Facility Contingency Plan, DOE/RL-93-75, BHI-00121, Rev. 2 (BHI 1996a)	Supplement to DOE/RL-93-75 (DOE-RL 1996a) and used to demonstrate compliance with the contingency plan requirements of the WAC.
216-A-10 Crib Supplemental Information to the Hanford Facility Contingency Plan (DOE/RL-93-75), BHI-00119, Rev. 2 (BHI 1996b)	Supplement to DOE/RL-93-75 (DOE-RL 1996a) and used to demonstrate compliance with contingency plan requirements of the WAC.
Radioactive Contamination in Liquid Wastes Discharged to Ground at Separations Facilities Through June 1958, HW-57649 (Baldridge 1958)	Summary of radioactive wastes discharged to major disposal sites in the 200 East Area through June 1958.
Index of CPD Crib Building Numbers Designs of CPD Radioactive Liquid Waste Disposal Sites, HW-55176 (GE 1958)	References to PUREX liquid waste disposal sites that include design sketches.
Tabulation of Radioactive Liquid Waste Disposal Facilities, HW-43121 (Clukey 1956)	Brief descriptions of liquid waste sites that include name, dimensions, coordinates, surface elevation, waste source, dates used, and drawing numbers.
Laboratory Studies of Hanford Waste Cribs, HW-63121 (Reisenauer 1959)	Brief descriptions of waste disposal cribs that include names, depth to water, size of soil column, and waste volume received per year.
Properties and Environmental Impact of Ammonia Scrubber Discharge Waste to the 216-A-36B Crib, WHC-EP-0100 (WHC 1988)	Characterization data of the discharge of waste materials from the ammonia scrubber to the 216-A-36B Crib.
Radioactive Contamination in Liquid Wastes Discharged to Ground at Separations Facilities Through June 1956, HW-44784 (Heid 1956a)	Summary of radioactive wastes discharged to major disposal sites in the 200 East Area through June 1956.
PUREX Plant Source Aggregate Area Management Study Report, DOE/RL-92-04 (DOE-RL 1993d)	Waste unit descriptions including cribs, french drains, septic tanks, and drain fields, trenches and ditches, ponds, catch tanks, settling tanks, diversion boxes, underground tank farms designed for high-level liquid wastes, and the lines and encasements that connect them. Waste sites are described separately.
Serviceability of Crib Affected by PUREX Startup, RHO-HS-EV-18 (Smith and Kasper 1983)	Evaluation of six existing cribs in the 200 Area for accepting startup waste from PUREX operations.

Table 1-5. Existing Documents and Data Sources for 200-PW-2 Operable Unit. (5 Pages)

Reference	Summary
REDOX Plant Source Aggregate Area Management Study Report, DOE/RL-91-60 (DOE-RL 1992a)	Waste unit descriptions including cribs, french drains, septic tanks, and drain fields, trenches and ditches, ponds, catch tanks, settling tanks, diversion boxes, underground tank farms designed for high-level liquid wastes, and the lines and encasements that connect them. Waste sites are described separately.
Semiworks Plant Source Aggregate Area Management Study Report, DOE/RL-92-18 (DOE-RL 1993e)	Well and operational history information for the 216-C-1 Crib. Waste unit descriptions including cribs, french drains, septic tanks, drain fields, trenches and ditches, ponds, catch tanks, settling tanks, diversion boxes, underground tank farms designed for high-level liquid wastes, and the lines and encasements that connect them. Waste sites are described separately.
U Plant Source Aggregate Area Management Study Report, DOE/RL-91-52 (DOE-RL 1992b)	Well and operational history information for the 216-U-8 and 216-U-12 Cribs. Waste unit descriptions including cribs, french drains, septic tanks, drain fields, trenches and ditches, ponds, catch tanks, settling tanks, diversion boxes, underground tank farms designed for high-level liquid wastes, and the lines and encasements that connect them. Waste sites are described separately.
Hazard Ranking System Evaluation of CERCLA Inactive Waste Sites at Hanford, PNL-6456, Vol. 2 (PNL 1988)	Historical data on individual CERCLA sites.
PUREX Plant Final Safety Analysis Report, Revisions 3, 4, and 5, SD-HS-SAR-001 (Manry and Prosk 1985)	Chronology of significant events that took place at PUREX.
Information on Hanford Site Cribs and Septic Systems, DOE/RL-88-19 (DOE-RL 1988)	Historical data for cribs and septic systems. Data for this report were obtained from WIDS and the Hanford Environmental Compliance Records database.
Isolation of Abandoned or Depleted Waste Disposal Sites, HW-57830 (Tabasinske 1958)	Historical data for known liquid waste sites that include number, type, use, status, references, and isolation measures.
Hanford Facility Dangerous Waste Part A Permit Application, DOE/RL-88-21 (DOE-RL 1993c)	Waste site information.
Radioactive Liquid Waste Disposal Facilities, HW-33305 (Clukey 1954)	Information describing physical characteristics of numerous waste sites.
Summary of Liquid Radioactive Wastes Discharged to the Ground -- 200 Areas July 1952 Through June 1954, HW-33591 (Heid and Paas 1954)	Summarizes radioactive contamination discharged to the ground from separation facilities. Detailed data for individual waste sites.
Radioactive Contamination in Liquid Wastes Discharged to Ground at Separations Facilities Through December 1956, HW-48518 (Heid 1957)	Summarizes radioactive contamination discharged to the ground from separation facilities through December 1956. Detailed data for individual waste sites.
Radioactive Contamination in Liquid Wastes Discharged to Ground Separation Facilities Through December 1957, HW-55593 (Bernard 1958)	Summarizes radioactive contamination discharged to the ground from separation facilities through December 1957. Detailed data for individual waste sites.

Table 1-5. Existing Documents and Data Sources for 200-PW-2 Operable Unit. (5 Pages)

Reference	Summary
Radioactive Contamination in Liquid Wastes Discharged to Ground at the Separations Facilities Through December 1959, HW-64375 (GE 1960)	Summarizes radioactive contamination discharged to the ground from separation facilities through December 1959. Detailed data for individual waste sites.
Radioactive Contamination in Liquid Wastes Discharged to Ground at Separations Facilities Through December 1958, HW-59359 (Baldridge 1959)	Summarizes radioactive contamination discharged to the ground from separation facilities through December 1958. Detailed data for individual waste sites.
Unconfined Underground Radioactive Waste and Contamination in the 200 Areas, HW-41535 (Heid 1956b)	Historical information on waste sites in the 200 Areas.
Focused Feasibility Study of the 200-UP-2 Operable Unit, DOE/RL-95-106 (DOE-RL 1995a)	Information on waste site conditions.
Uranium Recovery Technical Manual, HW-19140 (GE 1951b)	Process information on U Plant facilities, chemicals used or stored, and operations and maintenance information including process effluent sampling/analysis methods and theory behind the materials, chemicals, and equipment utilized during the URP campaign. Results of references include general designation of waste streams generated and conclusive evidence that the URP separation and the supplementary purification processes were strictly inorganic in chemical nature with the exception of tributyl phosphate diluted in normal hydrocarbon paraffin.
Waste Site Grouping for 200 Areas Soil Investigations, DOE/RL-96-81 (DOE-RL 1997b)	Summarizes site names, locations, type status, site and process descriptions, known and suspected contamination, preliminary contaminant distribution conceptual model (see Section 4.12 and Figure 4-14 in DOE-RL 1997b), site conditions that may affect COC fate and transport, COC mobility in Hanford Site soils, COC distribution and transport to groundwater, and hazards associated with COCs. Provides soil porosity information for each waste site.
200 Areas Disposal Sites for Radioactive Liquid, ARH-947 (Curren 1972)	Waste site and COC information.
An Introduction to the TBP and UO_3 Plants, HW-19400 (Gustavson 1950)	Process information on U Plant facilities, chemicals used or stored, and operations and maintenance information including process effluent sampling/analysis methods and theory behind the materials, chemicals, and equipment used during the URP campaign. Reference includes general designation of waste streams generated and conclusive evidence that the URP separation and the supplementary purification processes were strictly inorganic in chemical nature, with the exception of tributyl phosphate diluted in normal hydrocarbon paraffin.
REDOX Technical Manual, HW-18700-DEL (GE 1951a)	Process information on S Plant facilities, chemicals used or stored, and operations and maintenance information including process effluent sampling/analysis methods and theory behind the materials, chemicals, and equipment used during the REDOX process.

Table 1-5. Existing Documents and Data Sources for 200-PW-2 Operable Unit. (5 Pages)

Reference	Summary
PUREX Technical Manual, HW-31000-DEL (GE 1955)	Process information on PUREX Plant facilities, chemicals used or stored, and operations and maintenance information including process effluent sampling/analysis methods and theory behind the materials, chemicals, and equipment used during the PUREX process.
Iodine-129 Contamination: Nature, Extent, and Treatment Technologies, DOE/RL-95-89, Rev. 0 (DOE-RL 1996b)	Nature and extent of I-129 contamination in groundwater; process information resulting in iodine-129 contamination.
200-CW-1 Operable Unit Borehole/Test Pit Summary Report, BHI-01367 (BHI 2000)	Contains 200 East Area physical property testing data.
200 Areas Remedial Investigation/Feasibility Study Implementation Plan-Environmental Restoration Program, DOE/RL-98-28 (DOE-RL 1999)	Background waste site information and generic strategy for 200 Area waste site investigations.
Final Hanford Comprehensive Land –Use Plan Environmental Impact Statement, DOE/EIS-0222-F (DOE 1999)	Land-use plan for the Hanford Site.
Hanford Site Groundwater Monitoring for Fiscal Year 1999, PNNL-13116 (PNNL 2000)	Description of groundwater monitoring activities on the Hanford Site. Contains plume and water table maps.
RCRA Facility Investigation Report for the 200-PO-1 Operable Unit, DOE/RL-95-100 (DOE-RL 1997a)	Background information, waste site descriptions, and hydrogeology report.
Chemical Information on Tank Supernatants, Cs Adsorption from Tank Liquids onto Hanford Sediments, and Field Observations of Cs Migration from Past Tank Leaks, PNNL-11495 (PNNL 1998a)	Describes mobility of cesium-137 from tank waste in Hanford Site sediments.
Hanford Engineer Works Technical Manual, HW-10475 (Parts A, B, and C) (GE 1944)	Process information on B, T, and U Plant facilities, chemicals used or stored, and operations and maintenance information including process effluent sampling/analysis methods and theory behind the materials, chemicals, and equipment used during the bismuth phosphate campaign. Reference includes general designation of waste streams generated and conclusive evidence that the bismuth phosphate separation and the lanthanum fluoride purification process were strictly inorganic in chemical nature.
Hanford Tank Chemical and Radionuclide Inventories: HDW Model, LA-UR-96-3860, Rev. 4 (Agnew et al. 1997)	Scavenged and URP process waste and COC comparisons.
200 East Groundwater Aggregate Area Management Study Report, DOE/RL-92-19 (DOE-RL 1993a)	Hydrogeology report.
B Plant Process Condensate Stream-Specific Report, WHC-EP-0342, Addendum 17 (Peterson 1990)	Process information on B Plant facilities, chemicals used or stored, and operations and maintenance information, including process effluent sampling/analysis methods and results for the 216-B-12 Crib.

Table 1-5. Existing Documents and Data Sources for 200-PW-2 Operable Unit. (5 Pages)

Reference	Summary
PUREX Plant Process Condensate Stream-Specific Report, WHC-EP-0342, Addendum 12 (WHC 1990b)	Process information on PUREX Plant facilities, chemicals used or stored, and operations and maintenance information, including process effluent sampling/analysis methods and results for the 216-A-10 Crib.
UO_3 Plant Process Condensate Stream-Specific Report, WHC-EP-0342, Addendum 19 (Hendengren et al. 1990)	Process information on UO_3 Plant facilities, chemicals used or stored, and operations and maintenance information, including process effluent sampling/analysis methods and results for the 216-A-12 Crib.
PUREX Plant Ammonia Scrubber Condensate Stream-Specific Report, WHC-EP-0342, Addendum 14 (WHC 1990a)	Process information on PUREX Plant facilities, chemicals used or stored, and operations and maintenance information, including process effluent sampling/analysis methods and results for the 216-A-36B Crib.
B-Plant Phase III Flowsheets, ISO-00986	Process information on B Plant facilities, chemicals used or stored, and operations and maintenance information, including process effluent sampling/analysis methods and results for 216-B-12 Crib.
PNLATLAS/LG-ARCHV/200 EAST & WEST	Database for geophysical logging.
Hanford Site Atlas, BHI-01119, Rev. 1 (BHI 1998)	Site maps.
WIDS reports for 200-PW-2: 200-E-58 neutralization tank, 200-W-22 stabilized UPR, 200-W-23 UPR, 200-W-42 process pipeline, 216-A-1 Crib, 216-A-10 Crib, 216-A-18 Trench, 216-A-19 Trench, 216-A-20 Trench, 216-A-28 Crib, 216-A-3 Crib, 216-A-36A Crib, 216-A-36B Crib, 216-A-5 Crib, 216-B-12 Crib, 216-B-60 Crib, 216-C-1 Crib, 216-S-1&2 Crib, 216-S-7 Crib, 216-S-8 Trench, 216-U-1 and 216-U-2 Crib, 216-U-12 Crib, 216-U-5 Trench, 216-U-6 Trench, 216-U-8 Crib, 241-U-361 settling tank, 270-E-1 neutralization tank, 270-W neutralization tank, UPR-200-E-39, UPR-200-E-40, UPR-200-E-64, UPR-200-W-163, UPR-200-W-19, and UPR-200-W-36	Summarizes site names, locations, types, status, site and process descriptions, associated structures, cleanup activities, environmental monitoring description, access requirements, references, regulatory information, and waste information (e.g., type, category, physical state, description, and stabilizing activities).
Tank Characterization Database at http://twins.pnl.gov:8001/TCD/main.html (LHMC 1999)	Inactive miscellaneous underground storage tanks; search for tanks pertaining to 200-TW-1 and 200-TW-2 waste sites.
Site visit	Site visit
Construction drawings for 216-A-10	Contains drawings H-2-55576, H-2-55578, H-2-58131, and H-2-62875.
Construction drawings for 216-A-19	Contains drawings H-2-43029, H-2-56521, H-2-55900, and H-2-59129.
Construction drawings for 216-A-36B	Contains drawings H-2-59805, H-2-59129, and H-2-62875.
Construction drawings for 216-B-12	Contains drawings H-2-34524, H-2-43027, and H-2-43029.
Construction drawings for 216-U-8	Contains drawings H-2-332527, H-2-43028, H-2-43057, and H-2-72176.
Construction drawings for 216-U-12	Contains drawings H-2-31321, H-2-31322, H-2-32527, H-2-77174, and H-2-77175.

Table 1-6 represents the complete unconstrained set of COPCs that were, or could have been, discharged to the 200-PW-2 OU waste sites. The master COPC list was then evaluated against a set of exclusion rationale to determine a final list of project COCs. The COPCs that were excluded and the rationale for their exclusions are listed in Table 1-7.

Based on a review of process, operational, waste discharge, and sampling and analysis information from various sources (Table 1-5), the chemical behavior of the constituents was evaluated. Process knowledge indicates that the 200-PW-2 OU waste streams were predominantly liquid effluent discharges from the U/UO_3 Plant, PUREX Plant, REDOX Plant, WESF/221-Building, and Semiworks Facility. In general, the majority of the waste generated by operations associated with these waste sites can be described as a variety of liquid effluents, all containing large amounts of uranium. The pH of the waste ranges from acidic, neutral, and basic. The waste contains various constituents that include radionuclides, metals, inorganic chemicals, and semi-volatile and volatile organic chemicals.

Table 1-6. Sources of Contamination, COPCs, and Affected Media for the 200-PW-2 Operable Unit. (2 Pages)

Known or Suspected Source of Contamination (Process)	Type of Contamination from Each Source (General Contamination)	Affected Media
Tank waste discharges from U Plant, PUREX, REDOX, WESF/221-B Building, and the Semiworks Facility during uranium recovery, scavenging operations, REDOX and PUREX operations, and the experimental processes conducted at the Semiworks Facility.	Various acidic, neutral, and basic waste streams containing, mixed fission products, activation products, inorganic chemicals, metals, semi-volatile and volatile organic chemicals.	Shallow soils, deep zone soils associated with the waste sites, and potentially the groundwater beneath the waste sites.

Radioactive COPCs			
Americium-241	Curium-244	Plutonium-238	Tellurium-129m
Americium-242	Curium-245	Plutonium-239/240	Tellurium-129
Americium-243	Europium-152	Plutonium-241/242	Thorium-232
Antimony-123	Europium-154	Praseodymium-143	Tin-113
Antimony-125	Europium-155	Praseodymium-144	Tin-123m
Barium-137	Iodine-129	Promethium-147	Tin-123
Barium-137m	Iodine-131	Radium-226	Tin-125
Barium-140	Lanthanium-140	Radium-228	Tin-126
Cadmium-113m	Neodymium-147	Rhodium-106	Tritium
Carbon-14	Neptunium-237	Ruthenium-103	Uranium-232
Cerium-141	Neptunium-239	Ruthenium-106	Uranium-233/234
Cerium-144	Nickel-59	Samarium-149	Uranium-235/236
Cesium-134	Nickel-63	Samarium-151	Uranium-238
Cesium-135	Niobium-93m	Selenium-79	Yttrium-90
Cesium-137	Niobium-95	Strontium-89	Yttrium-91
Cobalt-60	Niobium-96	Strontium-90	Zirconium-93
Curium-242	Niobium-98	Technetium-99	Zirconium-95
Curium-243	Palladium-107		

Table 1-6. Sources of Contamination, COPCs, and Affected Media for the 200-PW-2 Operable Unit. (2 Pages)

Inorganic COPCs			
Aluminum	Chloride	Molybdenum	Sodium hydroxide
Aluminum fluoride	Chromic acid	Nickel	Sodium metabismuthate
Aluminum nitrate	Chromium	Nickel sulfate	Sodium nitrate
Aluminum nitrate nonahydrate (ANN)	Chromium nitrate	Nitrate	Sodium nitrite
Aluminum nitrate (mono basic)	Copper	Nitrite	Sodium oxalate
Aluminum silicate	Cyanide(s)	Nitric acid	Sodium silicate
Aluminum sulfate	Ferric ammonium sulfate	Ozone	Sodium sulfate
Ammonia	Ferric hydroxide	Peroxide	Sodium hydrogen sulfate
Ammonium cerium nitrate	Ferric nitrate	Phosphate	Sodium phosphate
Ammonium hydroxide	Ferrous ammonium sulfate	Phosphoric acid	Disodium phosphate
Ammonium iron fluoride	Ferro/ferric cyanide	Plutonium	Sodium pyrophosphate
Ammonium iron sulfate	Ferrous sulfamate	Plutonium fluoride	Sodium uranyl carbonate
Ammonium lanthanum nitrate	Fluoride	Plutonium dioxide	Disodium uranyl oxide
Ammonium oxalate	Hydrazine	Plutonium nitrate	Strontium (metal)
Ammonium fluoride/ammonium nitrate (AFAN)	Hydrochloric acid	Plutonium peroxide	Strontium carbonate
Ammonium fluosilicate	Hydrofluoric acid	Potassium	Strontium nitrate
Ammonium sulfate	Hydrogen	Potassium carbonate	Sulfamic acid
Anionic resins (sulfates)	Hydrogen peroxide	Potassium chloride Potassium dichromate	Sulfate
Antimony	Hydroxide	Potassium hydroxide	Sulfite
Arsenic	Hydroxylamine nitrate (HN)	Potassium fluoride	Sulfuric acid
Barium	Iron	Potassium nitrate	Tin
Beryllium	Iron sulfate	Potassium permanganate	Tungsten
Bismuth	Lanthanum	Ruthenium oxide	Uranium
Bismuth subnitrate/oxynitrate	Lanthanum fluoride	Silicon	Uranium dioxide
Bismuth orthophosphate	Lanthanum hydroxide	Silver	Uranium trioxide
Borate(s)	Lanthanum nitrate	Sodium	Uranyl nitrate
Cadmium	Lead	Sodium aluminate	Vanadium
Calcium	Lead oxide	Sodium bicarbonate	Zinc
Calcium carbonate (lime)	Magnesium	Sodium carbonate	Zinc nitrate
Calcium nitrate	Magnesium nitrate	Sodium chloride	Zinc phosphate
Cerium	Manganese	Sodium dichromate	Zirconium
Cerium phosphate	Manganese oxide	Sodium fluoride	Zirconium carbonate gel
Cesium nitrate	Manganese nitrate	Sodium hexametaphosphate (Calgon)	Zirconyl nitrate
Cesium phosphate	Mercury		
Organic Chemical COPCs			
Acetone	Dibutyl phosphate	Normal paraffin hydocarbons	Tributyl phosphate
AMSCO	Ethylene diamine tetra-acetate (EDTA)	Oxalic acid	Trisodium nitrilo triacetate (NTA)
Butanol	Hexone	Phosphotungstic acid (PTA)	Trisodium hydroxyethyl ethylene –diamine triacetate (HEDTA)
2-butanone (methyl ethyl ketone)	Kerosene	Polychlorinated biphenyls	Xylene
Benzyl alcohol	Mono-2-ethylhexyl phosphoric acid	Super gel hyflo	
Citric acid	Monobutyl phosphate	Tartaric acid	
di(2-ethylhexyl) phosphoric acid		Tetrahydrofuran	
		Toluene	

The first step in the evaluation process involved extracting known toxic materials from the master COPC list for placement on the final COC list. Inorganic salts represent a large group of constituents in the waste sites being evaluated. Because laboratory analyses are generally not compound-specific, the inorganic salts were excluded from further consideration. Instead, the readily detected anions (e.g., fluorides and nitrates) associated with the inorganic salts serve as the target constituents for those compounds. This logic recognizes the small volumes of wastes released into large-volume aqueous discharges.

The analytical approach employed for this project generally targets the significant risk drivers that are representative of the waste constituents present. The general suite-type analytical

techniques yield results on many metals and organic compounds, providing a cost-effective approach for the known toxic materials that could be present.

The COPCs in the following categories were dropped from further consideration:

- Short-lived radionuclides with half-lives less than 3 years
- Radionuclides that constitute less than 1% of the fission product inventory and for which historical sampling indicates nondetection
- Naturally occurring isotopes that were not created as a result of Hanford Site operations
- Constituents with atomic mass numbers greater than 242 that represent less than 1% of the actinide activities
- Progeny radionuclides that build insignificant activities within 50 years and/or for which parent/progeny relationships exist that permit progeny estimation
- Constituents that would be neutralized and/or decomposed by facility processes
- Chemicals in a gaseous state that cannot accumulate in soil media
- Chemicals used in minor quantities relative to the bulk production chemicals consumed in the normal processes; these chemicals are not likely to be present in toxic or high concentrations
- Chemicals that are not persistent in the environment due to volatilization, biological degradation or other natural mitigating features
- Chemicals that are not persistent in the vadose zone due to high mobility and previous confirmatory sampling/analysis activities.

Table 1-7. 200-PW-2 Operable Unit COPC Exclusions and Justifications. (5 Pages)

COPCs	Rationale for Exclusion
Radionuclides	
Americium-242	Constituent with atomic mass number greater than or equal to 242 that represents << 1% of the actinide activity (based on ORIGIN2 modeling of Hanford reactor production).
Americium-243	Constituent with atomic mass number greater than or equal to 242 that represents << 1% of the actinide activity (based on ORIGIN2 modeling of Hanford reactor production).
Antimony-123	Stable.
Antimony-125	Short-lived radionuclide (half-life <3 years).
Barium-137	Stable.
Barium-137m	Short-lived daughter of Cs-137 (which is a final COPC).
Barium-140	Short-lived radionuclide (half-life <3 years).
Cadmium-113m	Less than 1% of Cs-137 activity. Insignificant contribution to dose.

Table 1-7. 200-PW-2 Operable Unit COPC Exclusions and Justifications. (5 Pages)

COPCs	Rationale for Exclusion
Cerium-141	Short-lived radionuclide (half-life <3 years).
Cerium-144	Short-lived radionuclide (half-life <3 years).
Cesium-134	Short-lived radionuclide (half-life <3 years).
Cesium-135	Constituent generated at less than 5E-5 times Cs-137 activity.
Curium-242	Constituent with atomic mass number greater than or equal to 242 that represents << 1% of the actinide activity (based on ORIGIN2 modeling of Hanford reactor production).
Curium-243	Constituent with atomic mass number greater than or equal to 242 that represents << 1% of the actinide activity (based on ORIGIN2 modeling of Hanford reactor production).
Curium-244	Constituent with atomic mass number greater than or equal to 242 that represents less than 1% of the actinide activity. May be reported via americium isotopic analysis.
Curium-245	Constituent with atomic mass number greater than or equal to 242 that represents << 1% of the actinide activity (based on ORIGIN2 modeling of Hanford reactor production).
Iodine-129	Constituent generated at less than 5E-5 times Cs-137 activity, historical tank and vadose sampling indicates nondetection; highly mobile constituent found mainly in groundwater.
Iodine-131	Volatile gas emission; short-lived radionuclide (half-life <3 years).
Lanthanum-140	Short-lived radionuclide (half-life <3 years).
Neodymium-147	Short-lived radionuclide (half-life <3 years).
Neptunium-239	Short-lived radionuclide (half-life <3 years).
Nickel-59	Activity will be <5% of Ni-63 activity and may be estimated from that isotope.
Niobium-93m	Constituent generated at less than 5E-5 times Cs-137 activity.
Niobium-95	Short-lived radionuclide (half-life <3 years).
Niobium-96	Short-lived radionuclide (half-life <3 years).
Niobium-98	Short-lived radionuclide (half-life <3 years).
Palladium-107	Constituent generated at less than 5E-5 times Cs-137 activity.
Plutonium-241	Not detected by normal Pu analysis, can infer from Am/Pu results.
Plutonium-242	Constituent with atomic mass number greater than or equal to 242 that represents << 1% of the actinide activity (based on ORIGIN2 modeling of Hanford reactor production).
Praseodymium-143	Short-lived radionuclide (half-life <3 years).
Praseodymium-144	Short-lived radionuclide (half-life <3 years).
Promethium-147	Short-lived radionuclide (half-life <3 years).
Rhodium-106	Short-lived radionuclide (half-life <3 years).
Ruthenium-103	Short-lived radionuclide (half-life <3 years).
Ruthenium-106	Short-lived radionuclide (half-life <3 years).
Samarium-149	Stable.
Samarium-151	Less than 1% of Cs-137 activity. Insignificant contribution to dose.
Selenium-79	Constituent generated at less than 5E-5 times Cs-137 activity.
Strontium-89	Short-lived radionuclide (half-life <3 years).
Tellurium-129m	Short-lived radionuclide (half-life <3 years).
Tellurium-129	Short-lived radionuclide (half-life <3 years).
Tin-113	Short-lived radionuclide (half-life <3 years).
Tin-123m	Short-lived radionuclide (half-life <3 years).
Tin-123	Short-lived radionuclide (half-life <3 years).
Tin-125	Short-lived radionuclide (half-life <3 years).
Tin-126	Constituent generated at less than 5E-5 times Cs-137 activity (GEA will be reported if detected).
Uranium-232	<2 times E-03 times U-238 activity.
Uranium-233	Measurement cannot resolve U-233 + U-234 isotopes, reported as U-234 or U-233/234.
Uranium-236	Measurement cannot resolve U-235 + U-236 isotopes, reported as U-235.
Yttrium-90	Short-lived daughter of Sr-90 (which is a final COPC).

Table 1-7. 200-PW-2 Operable Unit COPC Exclusions and Justifications. (5 Pages)

COPCs	Rationale for Exclusion
Yttrium-91	Short-lived radionuclide (half-life <3 years).
Zirconium-93	Constituent generated at less than 5E-5 times Cs-137 activity.
Zirconium-95	Short-lived radionuclide (half-life <3 years).
Inorganics	
Aluminum	This inorganic substance is unlikely to be present in toxic concentrations. Routine analyte reported by ICP analysis.
Bismuth	This inorganic substance is unlikely to be present in toxic concentrations.
Borate	This inorganic substance is unlikely to be present in toxic concentrations.
Calcium	This inorganic substance is unlikely to be present in toxic concentrations. Routine analyte reported by ICP analysis.
Carbonate(axb)	This inorganic substance is unlikely to be present in toxic concentrations.
Cerium	This inorganic substance is unlikely to be present in toxic or high concentrations due minimal use in Hanford 200 Area processes.
Cesium	This inorganic substance is unlikely to be present in toxic or high concentrations due minimal use in Hanford 200 Area processes.
Hydrazine	Limited use of chemical based on process knowledge; unlikely to be present in toxic concentrations (GE 1955).
Hydrogen	Gas.
Hydroxide	Assessed via pH determination.
Hydroxylamine (HN)	Limited use of chemical based on process knowledge; unlikely to be present in toxic concentrations (GE 1955).
Iron	This inorganic substance is unlikely to be present in toxic concentrations. Routine analyte reported by ICP analysis.
Lanthanum	This inorganic substance is unlikely to be present in toxic concentrations.
Magnesium	This inorganic substance is unlikely to be present in toxic concentrations. Routine analyte reported by ICP analysis.
Manganese	This inorganic substance is unlikely to be present in toxic concentrations. Routine analyte reported by ICP analysis.
Molybdenum	This inorganic substance is unlikely to be present in toxic concentrations. Routine analyte reported by ICP analysis.
Ozone	Gas.
Peroxide	Has degraded to oxygen gas.
Potassium	This inorganic substance is unlikely to be present in toxic concentrations. Routine analyte reported by ICP analysis.
Silicon	This inorganic substance is unlikely to be present in toxic or high concentrations due minimal use in Hanford 200 Area processes.
Sodium	This inorganic substance is unlikely to be present in toxic concentrations. Routine analyte reported by ICP analysis.
Strontium	This inorganic substance is unlikely to be present in toxic or high concentrations due minimal use in Hanford 200 Area processes.
Sulfamates	Has degraded to sulfates.
Sulfite	Used in minimal quantities at Hanford. Reactive material with minimal lifetime in Hanford environment. Degraded to sulfates.
Tin	This inorganic substance is unlikely to be present in toxic concentrations.
Tungsten	This inorganic substance is unlikely to be present in toxic or high concentrations due minimal use in Hanford 200 Area processes.
Vanadium	This inorganic substance is unlikely to be present in toxic concentrations. Routine analyte reported by ICP analysis.
Zinc	This inorganic substance is unlikely to be present in toxic concentrations. Routine analyte reported by ICP analysis.

Table 1-7. 200-PW-2 Operable Unit COPC Exclusions and Justifications. (5 Pages)

COPCs	Rationale for Exclusion
Zirconium	This inorganic substance is unlikely to be present in toxic concentrations.
Organics	
Acetone	Very soluble, likely to have migrated or vaporized if exposed; reasonably biodegradable; sample collected from PDD PUREX stream indicated that acetone was detected at or below detection limits (WHC 1990a, 1990b; Hendengren et al. 1990).
Butanol	Very soluble, likely to have migrated or vaporized if exposed; reasonably biodegradable; PDD sample results indicate that butanol was detected at or below nominal reporting limits (WHC 1990a, 1990b; Hendengren et al. 1990).
2-butanone (methyl ethyl ketone)	Very soluble, likely to have migrated or vaporized if exposed; reasonably biodegradable; PDD sample results indicate that 2-butanone was detected at or below nominal reporting limits (WHC 1990a, 1990b; Hendengren et al. 1990).
Benzyl alcohol	Very soluble, likely to have migrated or vaporized if exposed; reasonably biodegradable; PDD sample results indicate that benzyl alcohol was detected at or below nominal reporting limits (WHC 1990a, 1990b; Hendengren et al. 1990).
Citric acid	No direct standard analytical technique available. Has dissolved to a complexing agent that could have affected the mobility of certain COCs. Unexpected mobility of COCs will indicate the presence of complexents.
di(2-ethylhexyl) phosphoric acid	No direct standard analytical technique available. Has dissolved to a complexing agent that could have affected the mobility of certain COCs. Unexpected mobility of COCs will indicate the presence of complexents.
Dibutyl phosphate	No direct standard analytical technique available. This compound is a degradation product of tributyl phosphate and is unlikely to be present in toxic or high concentrations.
Ethylene-diamine tetraacetic acid (EDTA)	No direct standard analytical technique available. Has dissolved to a complexing agent that could have affected the mobility of certain COCs. Unexpected mobility of COCs will indicate the presence of complexents.
Mono-2-ethylhexyl phosphoric acid	No direct standard analytical technique available. Has dissolved to a complexing agent that could have affected the mobility of certain COCs. Unexpected mobility of COCs will indicate the presence of complexents.
Monobutyl phosphate	No direct standard analytical technique available. This compound is a degradation product of tributyl phosphate and is unlikely to be present in toxic or high concentrations
Oxalic acid	No direct standard analytical technique available. Has dissolved to a complexing agent that could have affected the mobility of certain COCs. Unexpected mobility of COCs will indicate the presence of complexents.
Phosphotungstic acid (PTA)	No direct standard analytical technique available. Has dissolved to a complexing agent that could have affected the mobility of certain COCs. This compound is unlikely to be present in toxic or high concentrations.
PCBs	During the sampling and analysis effort of 200-UP-2 OU, it is documented in the limited field investigation (DOE-RL 1995b) that PCB Aroclors 1254 and 1260 were detected only at the 216-U-10 Pond and not at any of the waste sites within 200-PW-2 OU (216-U-1&2, 216-U-8, and 216-U-12 Cribs). All three of the near-surface samples were detected at levels less than 1 mg/kg. None of the samples exceeded MTCA Method B values (0.50 mg/kg). None of the samples exceeded MTCA Method C values, all three samples were near detection limits, and one sample was qualified as an estimated value (Table B-4B of DOE-RL 1995b).
Super gel hyflo	A chromatography medium that was utilized in determining if samples collected from various steps of the bismuth phosphate and URP processes had successfully reacted, separated, etc. This organic substance is unlikely to be present in toxic concentrations. No analytical technique.
Tartaric acid	No direct standard analytical technique available. Has dissolved to a complexing agent that could have affected the mobility of certain COCs. Unexpected mobility of COCs will indicate the presence of complexents.

Table 1-7. 200-PW-2 Operable Unit COPC Exclusions and Justifications. (5 Pages)

COPCs	Rationale for Exclusion
Tetrahydrofuran	No direct standard analytical technique available. Has dissolved to a complexing agent that could have affected the mobility of certain COCs. This compound is unlikely to be present in toxic or high concentrations.
Toluene	Very soluble, likely to have migrated or vaporized if exposed; reasonably biodegradable; PDD sample results indicate that toluene was detected at or below nominal reporting limits (WHC 1990a, 1990b; Hendengren et al. 1990).
Trisodium nitrilo triacetate (NTA)	No direct standard analytical technique available. Has dissolved to a complexing agent that could have affected the mobility of certain COCs. Unexpected mobility of COCs will indicate the presence of complexents.
Trisodium hydroxyethyl Ethylene-diamine triaceatate (HEDTA)	No direct standard analytical technique available. Has dissolved to a complexing agent that could have affected the mobility of certain COCs. Unexpected mobility of COCs will indicate the presence of complexents.
Xylene	Very soluble, likely to have migrated or vaporized if exposed; reasonably biodegradable; PDD sample results indicate that xylene was detected at or below nominal reporting limits (WHC 1990a, 1990b; Hendengren et al. 1990).

GEA = gamma energy analysis
ICP = inductively coupled plasma

Table 1-8 includes the final lists of COCs for the 200-PW-2 OU and the rationale for inclusion for each of the COCs.

Table 1-8. 200-PW-2 Operable Unit Final COC List. (3 Pages)

Final COCs	Rationale for Inclusion
Radioactive Constituents	
Americium-241	Reactor product and listed via tank farm integration (Agnew et al. 1997, Borsheim and Simpson 1991).
Carbon-14	Fission/activation product and listed via tank farm integration (Agnew et al. 1997, Borsheim and Simpson 1991).
Cesium-137	Known fission product (GE 1944, Sections A, B, and C; Borsheim and Simpson 1991).
Cobalt-60	Known activation product (GE 1944, Sections A, B, and C; Borsheim and Simpson 1991; Jacques and Kent 1991).
Europium-152	Known fission product (GE 1944, Sections A, B, and C; Diediker 1999).
Europium-154	Known fission product (GE 1944, Sections A, B, and C; Diediker 1999).
Europium-155	Known fission product (GE 1944, Sections A, B, and C; Borsheim and Simpson 1991).
Hydrogen-3 (tritium)	Fission/activation product and listed via tank farm integration (Agnew et al. 1997, Borsheim and Simpson 1991).
Neptunium-237	Reactor product and listed via tank farm integration (Agnew et al. 1997, Borsheim and Simpson 1991).
Nickel-63	Activation product and listed via tank farm integration (Agnew et al. 1997, Borsheim and Simpson 1991).
Plutonium-238	Reactor product (GE 1944, Sections A, B, and C).
Plutonium-239/240	Reactor product (GE 1944, Sections A, B, and C).

Table 1-8. 200-PW-2 Operable Unit Final COC List. (3 Pages)

Final COCs	Rationale for Inclusion
Radium-226	Known production from fission reaction and listed via tank farm integration (Agnew et al. 1997, Borsheim and Simpson 1991).
Radium-228	Known production from fission reaction and listed via tank farm integration (Agnew et al. 1997, Borsheim and Simpson 1991).
Strontium-90	Known fission product (GE 1944, Sections A, B, and C; Borsheim and Simpson 1991).
Technetium-99	Known fission product (GE 1944, Sections A, B, and C; Jacques and Kent 1991).
Thorium-232	Reactor feed (GE 1944, Sections A, B, and C; Diediker 1999).
Uranium-234	Reactor feed (GE 1944, Sections A, B, and C).
Uranium-235	Reactor feed (GE 1944, Sections A, B, and C).
Uranium-238	Reactor feed (GE 1944, Sections A, B, and C).
Chemical Constituents – Metals	
Antimony	Metal byproduct from uranium fuel rod (GE 1951b).
Arsenic	RCRA treatment, storage, and disposal unit analyte.
Barium	Metal byproduct from uranium fuel rod (GE 1951b).
Beryllium	Metal used in braze to seal end of fuel rod (GE 1951b).
Cadmium	Metal used in lead-dipped cladding and thus cladding waste stream (1952 to 1956) (GE 1944, Section A).
Chromium	Due to sodium/potassium dichromate added during first- and second-cycle decontamination and concentration operations of bismuth phosphate process (GE 1944, Section C; Anderson 1990).
Chromium (VI)	Due to sodium/potassium dichromate added during first- and second-cycle decontamination and concentration operations of bismuth phosphate process (GE 1944, Section C; Anderson 1990).
Copper	Metal used in triple-dip process of cladding and thus cladding waste stream (1944 to 1952) (GE 1944, Section A).
Lead	Metal used in lead-dipped cladding and thus cladding waste stream (1952 to 1956) (GE 1944, Section A) lead oxide was added as an oxidizing agent to the first- and second-cycle decontamination operations of bismuth phosphate process (GE 1944, Section C).
Mercury	Several uses in bismuth phosphate campaign including addition to cladding and metal waste streams to prevent gaseous generations and miscellaneous laboratory uses. Listed by the basis of knowledge gained by interviews and via tank farm integration (Agnew et al. 1997).
Nickel	Experimental additions of nickel sulfate added during the bismuth phosphate process to serve as a scavenging agent. Listed as a result of tank farm integration (Agnew et al. 1997, Borsheim and Simpson 1991) and extensive use (1954 to 1958) as nickel ferro/ferric cyanide during scavenging and recovery processes (Borsheim and Simpson 1991).
Selenium	Several uses in bismuth phosphate campaign including filtering of gases generated in the 1950s and miscellaneous laboratory uses. Listed by the basis of knowledge gained by previous sampling efforts in the 200 Areas.
Silver	Several uses in bismuth phosphate campaign, including filtering of gas generated in the 1950s and miscellaneous laboratory uses. Listed by the basis of knowledge gained by interviews.

Table 1-8. 200-PW-2 Operable Unit Final COC List. (3 Pages)

Final COCs	Rationale for Inclusion
Chemical Constituents -- General Inorganics	
Ammonia/ammonium	Several compounds contained ammonium the most widely used included ammonium silica fluoride which was used as a cleaning and decontamination compound based on ability to dissolve metals and fission products (GE 1944, Section C; Borsheim and Simpson 1991; HEW 1945).
Chloride	Several compounds contained chloride the most widely used included ferrous chloride, which was used as a carrier and potassium/sodium chloride used as salting agents during the bismuth phosphate process (GE 1944, Section C; Borsheim and Simpson 1991; HEW 1945).
Cyanide	Extensive use (1954 to 1958) as nickel ferro/ferric cyanide during scavenging and recovery processes listed as a result of tank farm integration (Agnew et al. 1997, Borsheim and Simpson 1991).
Fluoride	Several compounds contained fluoride the most widely used included lanthanum fluoride, which was used during the concentration operations of the bismuth phosphate process, and ammonium silica fluoride, which was used as a cleaning and decontamination compound based on the ability to dissolve metals and fission products (GE 1944, Section C; Borsheim and Simpson 1991; HEW 1945).
Nitrate/nitrite	Several compounds contained nitrates/nitrites the most widely used included sodium nitrite, a salting agent during the cladding removal, nitric acid, used throughout the bismuth phosphate and uranium recovery processes, and bismuth subnitrate, which was used to create the bismuth phosphate/ plutonium solid during the first- and second-cycle decontamination process (GE 1944, Section C; Borsheim and Simpson 1991; HEW 1945).
Phosphate	Several compounds contained phosphate. The most widely used included phosphoric acid, which was used throughout bismuth phosphate process (GE 1944, Section C; HEW 1945).
Sulfate	Several compounds contained sulfate the most widely used included sulfuric acid, which was used in the dissolving of the fuel rod during the bismuth phosphate process (GE 1944, Section C; Borsheim and Simpson 1991; HEW 1945). Many other sulfate complexes were used as carriers for various metals.
Semi-Volatile Organics	
AMSCO[a]	Extensive use (1953 to 1957) in solvent extraction operation as the dilutant for tributyl phosphate in the uranium recovery processes (Borsheim and Simpson 1991).
Dodecane[a]	Use (1953 to 1957) in solvent extraction operation as the dilutant for tributyl phosphate in the uranium recovery processes (Borsheim and Simpson 1991).
Normal paraffin hydrocarbons[a]	Extensive use (1953 to 1957) in solvent extraction operation as the dilutant for tributyl phosphate in the uranium recovery processes (Borsheim and Simpson 1991).
Tributyl phosphate and derivatives (mono, di)	Extensive use (1953 to 1957) in solvent extraction in the uranium recovery and PUREX processes (Borsheim and Simpson 1991, GE 1955).
Volatile Organics	
Hexone[b]	Used as solvent for solvent extraction of uranium and plutonium from fission products. Present in process drainage and possibly in process condensates (GE 1951b).

[a] Analyzed as kerosene total petroleum hydrocarbons.
[b] Only present at waste sites (216-S-1&2 and 216-S-7 Cribs and 216-S-8 Trench) via REDOX process condensate and process cell drainage waste streams only.

Table 1-9 defines the ARARs and preliminary remediation goals (PRGs) for each of the COCs.

Table 1-9. List of Preliminary ARARs and PRGs.

COCs	Preliminary ARARs	PRGs
Radionuclides Inside the 200 Area Land-Use Boundary [a]		
Shallow zone (0 to 4.6 m [0 to 15 ft] bgs)	100 mrem/yr above background via industrial land-use scenario while under DOE control; 15 mrem/yr above background at the end of the exclusive-use period if DOE control is relinquished; 4 mrem/yr above background to groundwater; or no additional groundwater degradation.[b]	Contaminant-specific; RESRAD modeling[c]
Deep zone (>4.6 m [>15 ft] bgs)	4 mrem/yr above background to groundwater, or no additional groundwater degradation.[b]	MCLs, state and Federal ambient water quality control criteria; alternatively, site-specific modeling
Nonradiological Constituents Inside the 200 Area Land-Use Boundary		
Shallow zone (0 to 4.6 m [0 to 15 ft] bgs)	MTCA Method C industrial or 100 times groundwater, whichever is lower	Chemical-specific
Deep zone (>4.6 m [>15 ft] bgs)	100 times groundwater (per MTCA)	Alternatively, site-specific modeling

[a] Based on *Final Hanford Comprehensive Land Use Plan Environmental Impact Statement* (DOE 1999) (see Figure 1-1)
[b] Radionuclide standards are not final and will be agreed upon in the ROD. A radionuclide standard of 25 mrem/yr above background was adopted by the Washington State Department of Health (WDOH) in February 2000.
[c] The RESidual RADioactivity dose model (RESRAD) use has been used for similar waste sites and will be used as a minimum for direct exposure. If more appropriate models are developed, they will be evaluated for use.
bgs = below ground surface
MCL = maximum contamination level

Table 1-10 lists the general exposure scenarios.

Table 1-10. General Exposure Scenarios.

Scenario No.	General Exposure Scenario Description
1	Industrial land-use scenario (inside the 200 Area land-use boundary)[a]: The source of contamination in the 200-PW-2 OU is the liquid effluent disposed to the waste sites. The release mechanism is direct radiation exposure to occupational workers in the vicinity of the waste sites (although shielded by stabilizing cover). Ingestion and inhalation of surface or subsurface soils in an occupational scenario does not represent a substantial exposure due to waste site surface stabilization and the limited soil ingestion and inhalation anticipated during excavation activities in an industrial setting (use of dust control measures limits exposures). Downward migration of mobile constituents into the groundwater would not affect occupational workers because their drinking water source would not be the underlying aquifers. However, the protection of groundwater is a requirement and must be addressed by evaluating potential future impacts. The exposure time is divided into time spent inside and outside an industrial facility: • Building occupancy: 8 hours/day x 0.6 (building occupancy factor), 5 days/week, 50 weeks/yr, for 20 years (of a 75-year lifetime). • Outdoor exposure: 8 hours/day x 0.4 (outdoor exposure factor), 5 days/week, 50 weeks/yr, for 20 years (of a 75-year lifetime). In addition, the building occupancy exposure includes a factor of 0.4 to reduce the ingested dust component due to building ventilation system filtration. Biota that may be exposed to contaminants in this OU will be addressed through a more Hanford Site-wide evaluation. Remedial actions to address human health concerns will also serve to protect biota.

[a] The *Final Hanford Comprehensive Land Use Plan Environmental Impact Statement* (DOE 1999) (see Figure 1-1) identifies the actual land use within the 200 Area land-use boundary as industrial (exclusive) and would center mainly around waste management activities.

Table 1-11 provides the regulatory milestones and regulatory drivers associated with this project.

Table 1-11. Regulatory Milestones.

Milestone	Due Date	Regulatory Driver
M-13-25	December 31, 2000	Tri-Party Agreement milestone to submit Draft A work plan for 200-PW-2 OU
M-20-33	October 31, 2003	Tri-Party Agreement milestone to submit 216-A-10 Crib/216-A-36B Crib closure/post-closure plan to Ecology

The project milestones and their drivers are listed in Table 1-12.

Table 1-12. Project Milestones.

Milestone	Due Date	Driver
Internal DQO workshop	July 26, 2000	DQO schedule
External RL/regulator briefing	August 8, 2000	
Issue DQO summary report	September 6, 2000	DQO process documentation

Table 1-13 combines the relevant background information into a concise statement of the problem to be resolved.

Table 1-13. Preliminary Conceptual Contaminant Distribution Model Discussion and Concise Statement of the Problem. (2 Pages)

<u>Preliminary Conceptual Contaminant Distribution Model[a]:</u>

The liquid effluents associated with the uranium and plutonium recovery processes at U Plant, PUREX Plant, REDOX Plant, WESF/221-B Building, and Semiworks Facility were discharged to the 200-PW-2 OU waste sites. The effluents from these various chemical operations contained uranium, plutonium, fission products, nitrates, metals, and semi-volatile organic and volatile organic chemicals. Immobile contaminants accumulated in the soils below the release point over time, while the mobile contaminants may have reached groundwater. Geophysical logging of boreholes in the vicinity of the waste sites, along with sampling data from boreholes near several of the representative sites, provided the basis for the preliminary conceptual contaminant distribution model.

Several of cribs in the OU were sampled as part of the 200-UP-2 RI conducted in 1994 through 1995. Data from this investigation indicated a zone of higher contamination extending up to 30 m (100 ft) below the bottom of the cribs and trenches. Contamination continued below this zone but generally decreased with depth. More mobile contaminants were distributed throughout the soil column and are present at residual concentrations. In at least one instance at the 216-U-8 Crib there is evidence that elevated levels of contamination are present, associated with the caliche layer that exists at a depth of 57 m (187 ft).

Volatile organics were not a major part of the processes associated with 200-PW-2 OU waste sites. With the exception of tributyl phosphate, normal paraffin hydrocarbons, and perhaps hexone (specifically at only 216-S-1&2, 216-S-7, and 216-S-8), no other volatile organics are expected in the vadose zone. Because of the volume of liquid and contaminants received by the 200-PW-2 OU waste sites, groundwater impacts are generally assumed. Groundwater monitoring has indicated chemical and radionuclide constituents in the groundwater beneath the waste sites; however, contributions from individual waste sites have not been fully evaluated. While significant data exist for the 216-U-8 and 216-U-12 Cribs, which are representative of sites in the OU, limited chemical and radiological data are available for the other 200-PW-2 OU sites.

Figures 1-8 through 1-14 graphically present the overall conceptual exposure model for the OU and the preliminary conceptual contaminant distribution models for each of the representative waste sites. Each of these waste sites is analogous to other sites in the OU.

Table 1-13. Preliminary Conceptual Contaminant Distribution Model Discussion and Concise Statement of the Problem. (2 Pages)

DQO Approach: The DQO process for the 200-PW-2 OU is being performed to determine if representative sites in this OU have been contaminated to levels that require remedial action. The outcome of the characterization being developed in this DQO process for the representative sites will be applied to the other analogous sites. A SAP will be developed after completion of the DQO process, which specifies the sampling and analyses to be performed for characterization of the six representative sites. All of the waste sites associated with this OU are located within the 200 Area land-use boundary line and will be evaluated on the basis of future industrial uses. **Problem Statement:** The problem is to determine contaminant concentrations and physical parameters in the representative sites to support evaluation of remedial alternatives and remedial decision making in the FS and to verify or refine the conceptual contaminant distribution models.

[a] The preliminary conceptual contaminant distribution model will become the conceptual contaminant distribution model after acceptance of this DQO summary report and will then be applied to the project work plan.

Figure 1-8. Conceptual Exposure Model for the 200-PW-2 Operable Unit.

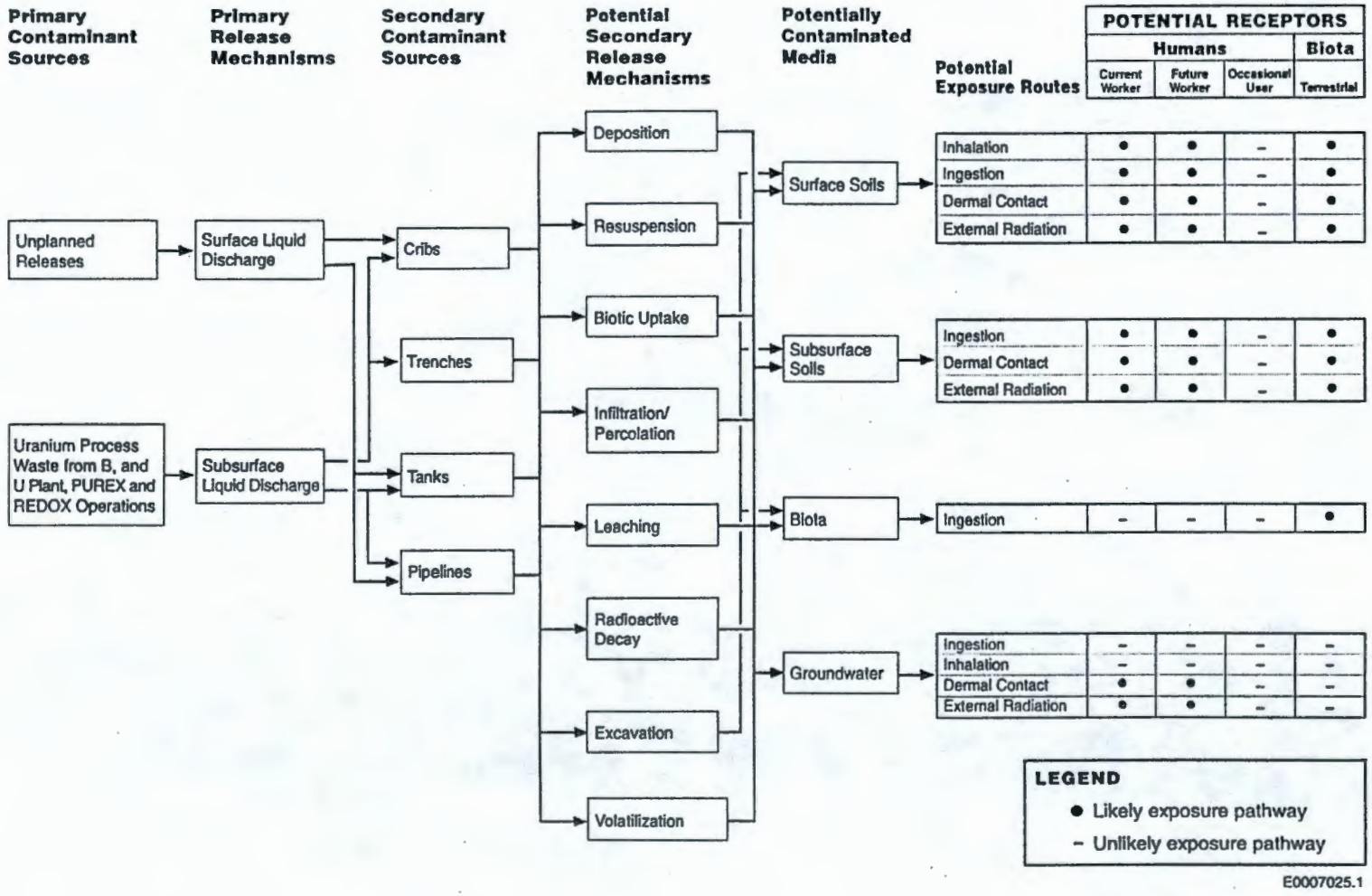
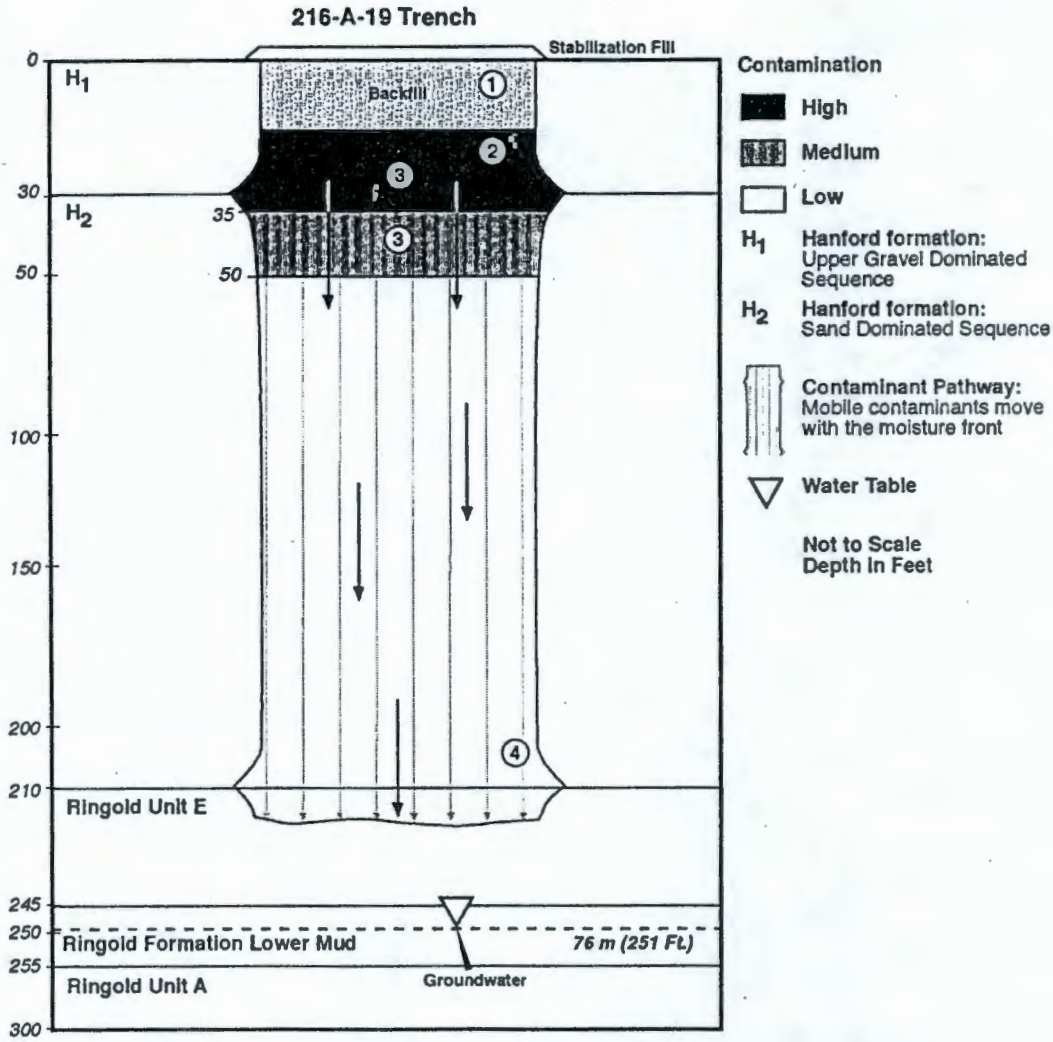


Figure 1-9. Preliminary Conceptual Contaminant Distribution Model for the 216-A-19 Trench.



① Uranium rich process wastes were discharged to the 216-A-19 Trench between November 1955 and January 1956. The open trench received a total volume of 1.1×10^6 liters (291,000 gallons) of wastewater via a temporary overland pipe. The effluent contained uranium, cesium-137, plutonium, strontium-90, tributyl phosphate, normal paraffin hydrocarbon and nitrate. The trench was backfilled with native material after operations ceased. The site was stabilized with an additional 0.6 m (2 ft) of clean fill in 1990.

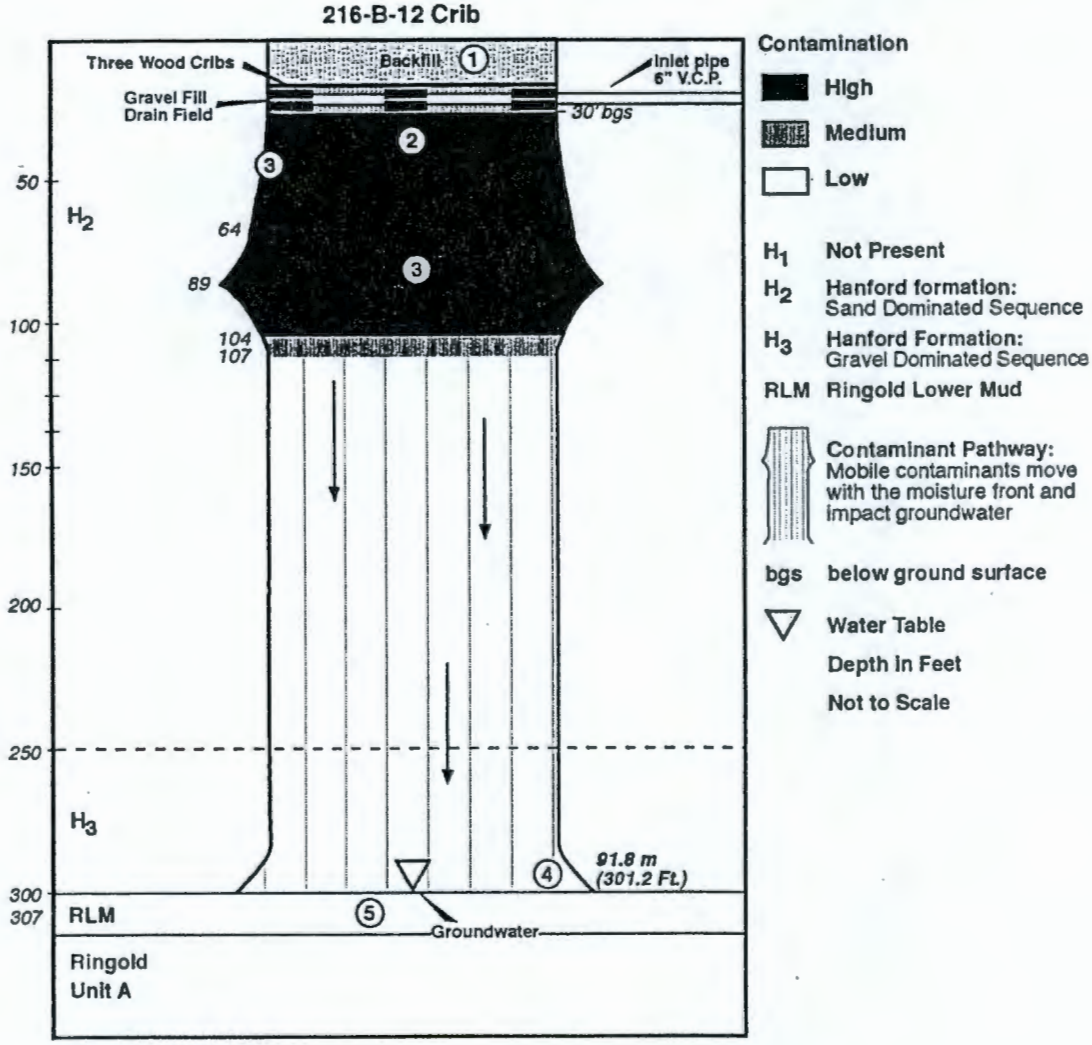
② Effluent and contaminants were released into H1. The wetting front and contaminants move vertically down beneath the crib. There is little or no lateral spreading as evident by the lack of contamination in borehole 299-E25-10 which is located 18 m (60 ft) west of the trench.

③ Contaminants that are immobile, such as cesium-137, sorb to soils near the bottom of the trench. The highest concentrations are expected near bottom of the trench. Contaminants that are moderately mobile, such as strontium-90 and uranium are present deeper in the vadose zone. The most mobile contaminants such as nitrate move with the moisture front. Contaminant data has not been collected within the waste site boundary.

④ Wastewater and contaminants may not have impacted groundwater as the effluent volume discharge to the soil column {1,100 m^3 (38,846 ft^3)} does not exceed the soil pore volume {1,232 m^3 (43,508 ft^3)}.

E0006137.2

Figure 1-10. Preliminary Conceptual Contaminant Distribution Model for the 216-B-12 Crib.



① Uranium rich process wastes were discharged to the 216-B-12 Crib between 1952 and 1973. The crib received a total volume of $5.2X10^6$ L ($1.4X10^6$ gal) of wastewater. The effluent contained uranium, cesium-137, plutonium, strontium-90, tributyl phosphate and ammonium nitrate. The crib collapsed in 1952 and was backfilled to grade. The crib was stabilized with at least 0.6 m (2 ft) of soil in 1973 and again in 1993.

② Effluent and contaminants were released into H2. The wetting front and contaminants move vertically down beneath the crib. There is moderate lateral spreading as evident by contamination in borehole 299-E28-16 which is located 15.2 m (50 ft) south of the crib.

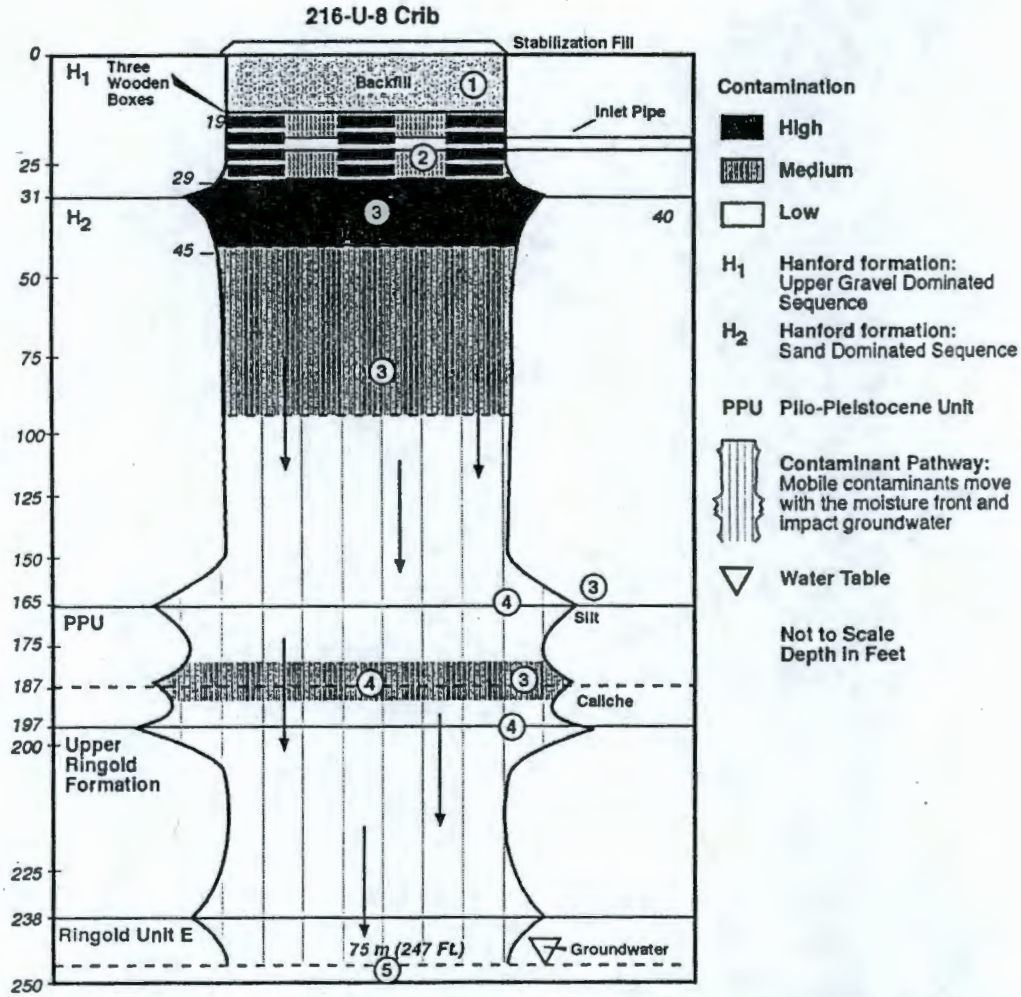
③ The zone of greatest contamination is detected near the bottom of the crib to a depth 31.7 m (104 ft). Contaminants that are immobile, such as cesium-137, sorb to soils near the bottom of the crib. Contaminants that are moderately mobile are present deeper in the vadose zone. The most mobile contaminants move with the moisture front and are present in trace amounts throughout the vadose zone.

④ If additional lateral spreading occurs within the vadose zone, it is likely to be associated with the Ringold lower mud unit.

⑤ Wastewater and mobile contaminants impact groundwater as the effluent volume discharged to the soil column {520,000 m^3 ($1.8X10^7 ft^3$)} is greater than the soil pore volume {18,300 m^3 (645,258 ft^3)}. Uranium, iodine-129, and nitrate are found in the groundwater in the vicinity of the crib.

E0007007.1

Figure 1-11. Preliminary Conceptual Contaminant Distribution Model for the 216-U-8 Crib.



① Uranium rich process wastes were discharged to the 216-U-8 Crib between 1952 and 1960. The wooden crib structure received a total volume of $3.7X10^9$ liters ($1.0X10^6$ gallons) of wastewater. The effluent contained uranium, cesium-137, plutonium, strontium-90, tributyl phosphate, normal paraffin hydrocarbon and nitric acid. The crib was stabilized with 0.3-0.6 m (1-2 ft) of clean fill in 1994. The pipeline leading to the crib was known to have leaked contamination into near-surface soils.

② Effluent and contaminants were releesed to the environment at the bottom of the wooden structure near the contact between H1 and H2. The wetting front and contaminants move vertically down beneath the crib. There is little or no lateral spreading. (Low levels (<1 pCi/g) of cesium-137 contamination were intermittently detected in borehole 299-W19-2 approximately 15.2 m (50 ft) east of the waste site).

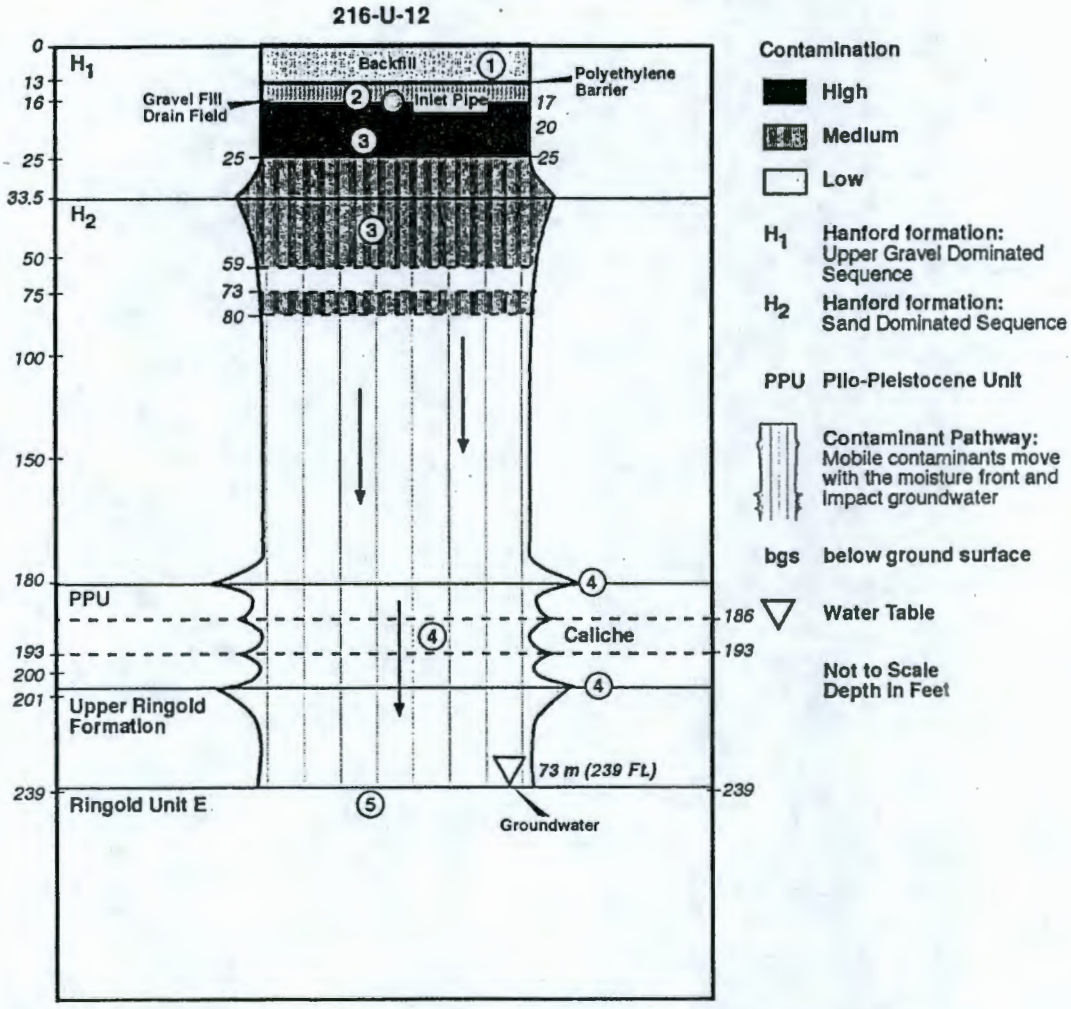
③ The zone of greatest contamination is detected from the bottom of the crib to a depth of 12.8 m (42 ft). Contaminants that are immobile, such as cesium-137, sorb to soils near the bottom of the trench. Cesium-137 concentrations are highest at depths less than 12.8 (42 ft); it decreases with depth to 30.5 m (100 ft) where it becomes undetectable. Contaminants that are moderately mobile, such as strontium-90 and uranium are present deeper in the vadose zone. Uranium-238 concentrations were highest at the base of the crib and at a depth of 56.4 m (185 ft). Strontium-90 was detected in the vadose zone to a depth of at least 61 m (199 ft). The maximum concentration was detected at the interface between H2 and the PPU at 50.3 m (165ft). The most mobile contaminants such as nitrate move with the moisture front and are present in trace amounts in the vadose zone.

④ If significant lateral spreading occurs within the vadose zone, it is associated with the upper Ringold Formation, and the Plio-Pleistocene Unit.

⑤ Wastewater and mobile contaminants impact groundwater as the effluent volume discharged to the soil column {380,000 m^3 ($1.34X10^7$ ft^3)} is greater than the soil pore volume {11,100 m^3 ($3.9X10^5$ ft^3)} as evident by the uranium, tritium and nitrate in downgradient well 299-W19-2.

E0006137.3

Figure 1-12. Preliminary Conceptual Contaminant Distribution Model for the 216-U-12 Crib.



① Uranium rich process wastes were discharged to the 216-U-12 Crib between 1960 and 1988. The gravel drain field received a total volume of $1.5X10^8$ liters ($4.00X10^7$ gallons) of wastewater. The effluent contained uranium, cesium-137, plutonium, strontium-90, tritium, americium-241, thorium, and nitric acid.

② Effluent and contaminants were released to the environment from a buried pipe approximately 5.2 m (17 ft) bgs within H1. The wetting front and contaminants move vertically down beneath the crib. There is little or no lateral spreading. Uranium isotopes were detected 3.8 to 7.0 m (12.5 to 23 ft) bgs adjacent to the crib in borehole 299-W22-78. A maximum of 66 pCi/g was detected with the RLS at the bottom of the crib at 5.8 m (19 ft) bgs. Isotopic uranium detected in soil chemistry samples adjacent to the crib was typically < 1.1 pCi/g.

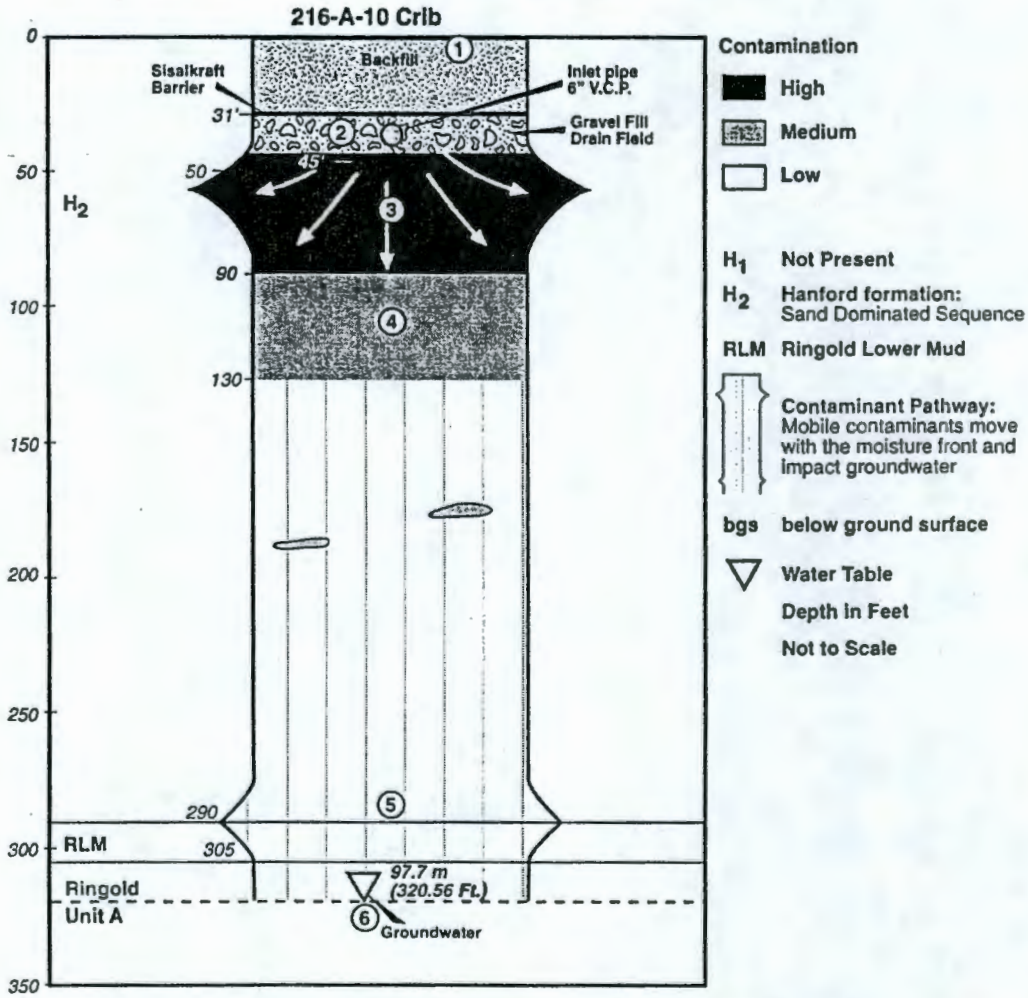
③ The zone of greatest contamination is detected near the discharge pipe to a depth of 12.8 m (42 ft). Contaminants that are immobile, such as cesium-137, sorb to soils near the bottom of the crib. Cesium-137 concentrations are highest to a depth of 7 m (23 ft); it decreases with depth to 18 m (59 ft) where it becomes undetectable. Contaminants that are moderately mobile, such as uranium, are present deeper in the vadose zone. Uranium-238 concentrations were highest (500 pCi/g) at a depth of 23 m (76 ft). The most mobile contaminants such as nitrate move with the moisture front and are present in trace amounts in the vadose zone.

④ If significant lateral spreading occurs within the vadose zone, it is associated with the Plio-Pleistocene Unit and upper Ringold Formation.

⑤ Wastewater and mobile contaminants impact groundwater as the effluent volume discharged to the soil column (150,000 m^3 ($5.3X10^6$ ft^3)) is greater than the soil pore volume. (1,400 m^3 ($4.9X10^4$ ft^3)) as evident by the tritium, technetium-99, and nitrate in the groundwater.

E0006137.1

Figure 1-13. Preliminary Conceptual Contaminant Distribution Model for the 216-A-10 Crib.



① Uranium rich process wastes (ph≤1 to 2.5) were discharged to the 216-A-10 Crib between 1961 and 1986. The crib received a total of 3.21×10^9 L (8.5×10^8 gal) of waste water.

② Effluent and contaminants were released to the environment from a vitrified clay pipe approximately 31' bgs with a gravel fill drain field.

③ The wetting front and contaminants move vertically down beneath the crib. There is moderate lateral spreading.

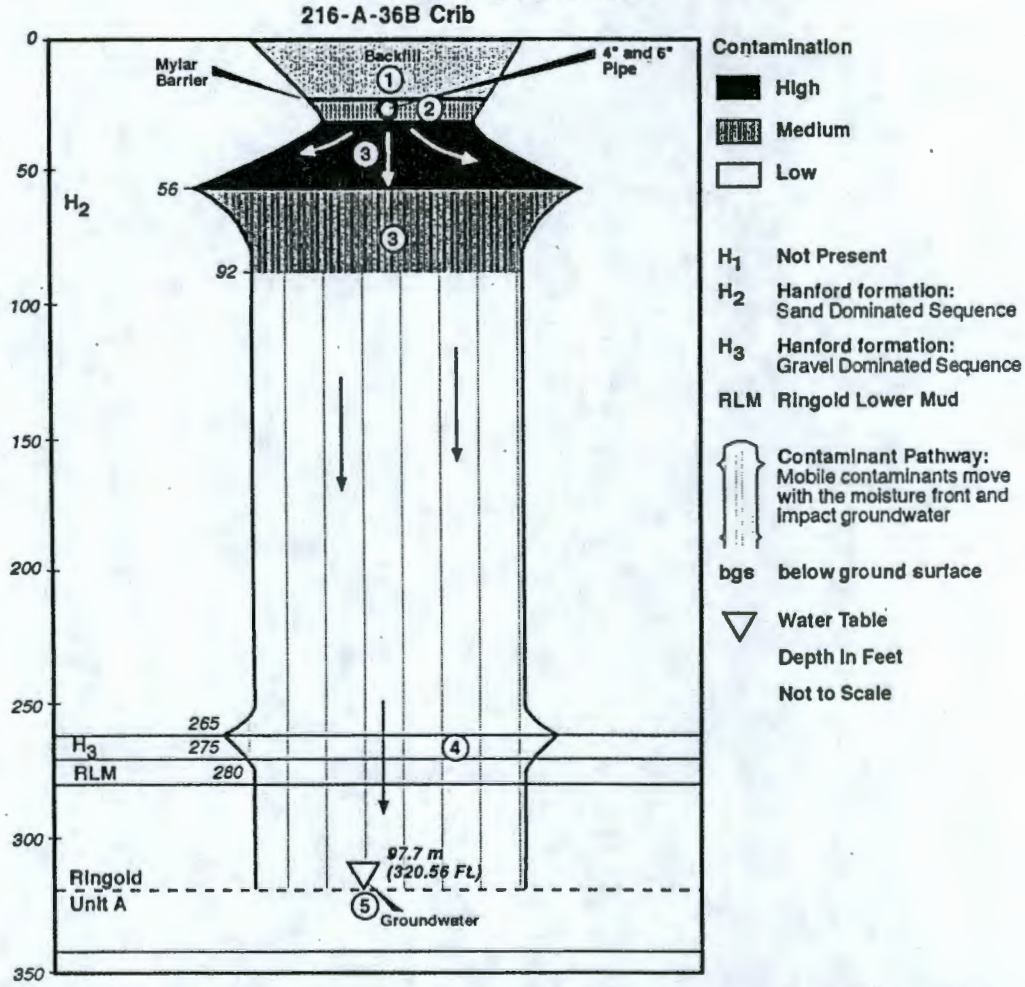
④ Contaminants with large distribution coefficients, such as cesium-137, sorb to soils in the highest concentration within 45 ft. of the bottom of the crib. Contaminant concentrations generally decrease with depth. Contaminants with moderate distribution coefficients such as cobalt-60 and europium-154 are present throughout the vadose. Concentrations are highest greater than 135 ft. below ground surface and generally increase with depth. Uranium has a very small contaminant distribution coefficient and is also distributed throughout the vadose zone. The highest concentrations are generally associated with the bottom of the crib and also generally decrease with depth. Contaminant with contaminant distribution coefficients of 0 move with the moisture front and are present in trace amounts throughout the vadose zone.

⑤ If spreading occurs within the vadose zone it is associated with the fine grained lenses in the H_2 and the Ringold Formation Lower Mud Unit.

⑥ Wastewater and contaminants with moderate to very low contaminant distribution coefficient impact groundwater.

E0007007.2

Figure 1-14. Preliminary Conceptual Contaminant Distribution Model for the 216-A-36B Crib.



① Uranium rich process and ammonia scrubber wastes were discharged to the 216-A-36A/B Cribs between 1966 and 1987. The gravel drain field received a total volume of $3.17X10^8$ liters ($8.37X10^7$ gallons) of wastewater through a 15 cm (6 in. pipe) buried 7.0m (23 ft.) bgs. The low salt, neutral to basic effluent contained uranium, cesium-137, plutonium, strontium-90, iodine-129, tritium, tributyl phosphate, normal paraffin hydrocarbon, nitrate, sodium dichromate and ammonia. Due to the high inventory of short lived beta emitters (147,000 Ci) discharged to 216-A-36A, the crib was isolated by grouting 10 cm (4 in.) pipe inside of the original 15 cm (6 in.) pipe. The 10 cm (4 in.) pipe was extended to 216-A-36B and perforated. Contamination from 216-A-36A may impact soils on the northern end of the 216-A-36B crib.

② Effluent and contaminants were released to the environment at the bottom of the crib within H2. The wetting front and contaminants move vertically down beneath the crib. There may be significant lateral spreading as indicated by the elevated hydrogen ion (pH 9-10) and ammonium concentrations (max 353 ppm) 30.5m (100 ft) bgs in boreholes 299-E17-14, 299-E17-15 and 299-E17-16 which are located approximately 30.5 m (100 ft) east of the waste site.

③ The zone of greatest contamination is detected from the bottom of the crib at a depth of 17.0 m (56 ft). Contaminants that are immobile, such as cesium-137, sorb to soils near the bottom of the trench. Cesium-137 concentrations are highest ($1.6X10^6$ pCi/g) at a depth of 12.8 (30 ft); concentrations decrease with depth to 18.6 m (61 ft). Maximum concentrations of americum-241 (18,200 pCi/g) and cobalt-60 (1,025 pCi/g) were also detected in this zone. Contaminants that are moderately mobile, and uranium are present deeper in the vadose zone. Uranium-235 concentrations were highest (1,225 pCi/g) at the base of the crib. The most mobile contaminants such as nitrate move with the moisture front and are present in trace amounts in the vadose zone.

④ Lateral spreading may also occur within the vadose zone associated with the Ringold Lower Mud Unit.

⑤ Wastewater and mobile contaminants impact groundwater as the effluent volume discharged to the soil column (318,080 m^3 ($1.1X10^7$ ft^3)) is greater than the soil pore volume (16,327 m^3 ($5.7X10^5$ ft^3)) as evident by iodine-29, tritium, and nitrate in the groundwater.

E0007007.3

2.0 STEP 2 -- IDENTIFY THE DECISION

The purpose of DQO Step 2 is to define the principal study questions (PSQs) that need to be resolved to address the problems identified in DQO Step 1 and the alternative actions (AAs) that would result from resolution of the PSQs. The PSQs and AAs are then combined into decision statements that express a choice among AAs. Table 2-1 presents the task-specific PSQs, AAs, and resulting decision statements. This table also provides a qualitative assessment of the severity of the consequences of taking an AA if it is incorrect. This assessment takes into consideration human health and the environment (i.e., flora/fauna) and political, economic, and legal ramifications. The severity of the consequences is expressed as low, moderate, or severe.

Table 2-1. Summary of DQO Step 2 Information. (2 Pages)

PSQ-AA #	Alternative Action	Consequences of Erroneous Actions	Severity of Consequences
PSQ #1—Do the radionuclide concentrations in vadose soils in the 200-PW-2 OU representative waste sites exceed the annual radiological exposure limits for human health protection under an industrial exposure scenario?[a]			
1-1	If the radionuclide concentrations in the vadose soils do not exceed the industrial exposure limits, evaluate the site for closure with no remedial action in a FS.	The site may inappropriately be closed without remedial action, increasing risks of potential exposure to workers and the environment.	Low; additional samples will be collected in the confirmatory sampling phase to support no action closures.
1-2	If the radionuclide concentrations in the vadose soils exceed the industrial exposure limits, evaluate the need for remedial action alternatives or evaluate a streamlined approach to site closure (e.g., add to an existing ROD) in a FS.	The site may be inappropriately remediated resulting in unnecessary expenditure of funds.	Low for risk; no risk to human health or environment. Low to moderate for cost depending on remedial action.
Decision Statement #1 – Determine if the vadose zone radionuclide concentrations in the 200-PW-2 OU representative waste sites exceed the radiological exposure limits for human health protection under an industrial exposure scenario requiring evaluation in a FS.			

Table 2-1. Summary of DQO Step 2 Information. (2 Pages)

PSQ-AA #	Alternative Action	Consequences of Erroneous Actions	Severity of Consequences
PSQ #2 – Do the concentrations of nonradiological constituents in the vadose soils in the 200-PW-2 OU representative waste sites exceed the nonradiological exposure limits for human health protection under an industrial exposure scenario?[a]			
2-1	If the nonradiological constituent concentrations in the vadose soils do not exceed the industrial exposure limits, evaluate the site for closure with no remedial action in a FS.	The site may inappropriately be closed without remedial action, increasing risks of potential exposure to workers and the environment.	Low; additional samples will be collected in the confirmatory sampling phase to support no action closures.
2-2	If the nonradiological constituent concentrations in the vadose soils exceed the industrial exposure limits, evaluate the need for remedial action alternatives or evaluate a streamlined approach to site closure (e.g., add to an existing ROD) in a FS.	The site may be inappropriately remediated resulting in unnecessary expenditure of funds.	Low for risk; no risk to human health or environment. Low to moderate for cost depending on remedial action.
Decision Statement #2 – Determine if vadose zone nonradiological constituent concentrations in the 200-PW-2 OU representative waste sites exceed the nonradiological constituent exposure limits for human health protection under an industrial exposure scenario requiring evaluation in a FS.			
PSQ #3 – Do the 200-PW-2 OU conceptual contaminant distribution models properly reflect the physical characteristics and distribution of contaminants in the waste sites?			
3-1	If the conceptual contaminant distribution models reflect the actual distribution of contaminants and physical characteristics, use the models for remedial alternative selection and remedial action planning.	Inappropriate or inadequate remedial alternatives could be planned in the FS and implemented during the remedial action phase.	Low to moderate; additional sampling in confirmatory phase will limit consequences.
3-2	If the conceptual contaminant distribution models do not accurately reflect the distribution of contaminants and physical characteristics, revise the models prior to remedial alternative selection and remedial action planning.	The site may be inappropriately remediated resulting in unnecessary expenditure of funds.	Low; no risk to human health or the environment
Decision Statement #3 – Determine if the 200-PW-2 OU conceptual contaminant distribution models represent the contaminant distribution conditions and physical characteristics in each waste site or if the models need to be refined.			

[a] Refer to Table 1-9 for scenario-specific ARARs and PRGs.

3.0 STEP 3 -- IDENTIFY THE INPUTS TO THE DECISION

The purpose of DQO Step 3 is to identify the types of data needed to resolve each of the decision statements identified in DQO Step 2. The data may already exist or may be derived from computational or surveying/sampling and analysis methods. Analytical performance requirements (e.g., practical quantitation limit [PQL], precision, and accuracy) are also provided in this step for any new data that need to be collected.

3.1 INFORMATION REQUIRED TO RESOLVE DECISION STATEMENTS

Table 3-1 specifies the information (data) required to resolve each of the decision statements identified in Table 2-1 and identifies whether the data already exist. For the data that are identified as existing, the source references for the data have been provided with a qualitative assessment as to whether or not the data are of sufficient quality to resolve the corresponding decision statement.

Table 3-1. Required Information and Reference Sources. (3 Pages)

PSQ #	Required Information Category	Do Data Exist ? Y//N	Reference Source	Are Available Data of Sufficient Quality and Quantity to Support RI/FS Process? (Y/N)						Are Additional Data Required to Support RI/FS Process? (Y/N)					
				A-10	A-19	A-36B	B-12	U-12	U-8	A-10	A-19	A-36B	B-12	U-12	U-8
1 and 3	Soil radiological data	Y	*Limited Field Investigation for the 200-UP-2 Operable Unit*, DOE/RL-95-13 (DOE-RL 1995b). Summarizes the data collection and analysis activities conducted during the limited field investigation and presents the associated qualitative risk assessment.	a	a	a	a	N	Y	c	c	c	c	N[b]	N
			Focused Feasibility Study of the 200-UP-2 Operable Unit, DOE/RL-95-106 (DOE-RL 1995a). Information on waste site conditions and remedial alternatives evaluated.	a	a	a	a	N	Y	c	c	c	c	N[b]	N
			B Plant Source Aggregate Area Management Study Report, DOE/RL-92-05, Rev. 0 (DOE-RL 1993b). Provides summary of existing data for sites associated with B Plant.	a	a	a	N	a	a	c	c	c	Y	c	c
			Evaluation of Scintillation Probe Profiles from 200 Area Crib Monitoring Wells, ARH-ST-156 (Fecht et al. 1977). Provides scintillation logs with gross gamma readings for boreholes in the vicinity of the waste sites.	N	N	N	N	N	N	Y	Y	Y	Y	N	N
			PUREX Plant Source Aggregate Area Management Study Report, DOE/RL-92-04 (DOE-RL 1993d).	N	N	N	a	a	a	Y	Y	Y	c	c	c
			PNLATLAS database, which provides borehole geophysical logging data for gamma-emitting radionuclides.	N	N	N	N	N	Y	Y	Y	Y	Y	N[b]	N
2 and 3	Soil non-radiological sample data	Y	*Limited Field Investigation for the 200-UP-2 Operable Unit*, DOE/RL-95-13 (DOE-RL 1995b).	a	a	a	a	N	Y	d	d	d	d	N[b]	N
N/A	GW data	Y	Refer to footnote e.	Groundwater data cannot be used to validate a vadose zone preliminary conceptual contaminant distribution model.											

Table 3-1. Required Information and Reference Sources. (3 Pages)

PSQ #	Required Information Category	Do Data Exist ? Y//N	Reference Source	Are Available Data of Sufficient Quality and Quantity to Support RI/FS Process? (Y/N)						Are Additional Data Required to Support RI/FS Process? (Y/N)					
				A-10	A-19	A-36B	B-12	U-12	U-8	A-10	A-19	A-36B	B-12	U-12	U-8
All	Physical properties moisture content, particle size distribution and lithology	Y	*Borehole Summary Report for the 200-UP-2 Operable Unit, 200 West Area*, BHI-00034, Rev. 1 (BHI 1995).	[a]	[a]	[a]	[a]	N	Y	[c]	[c]	[c]	[c]	N[b]	N
			Hydrogeologic Model for the 200-East Groundwater Aggregate Area, WHC-SD-EN-TI-019, Rev. 0 (WHC 1992b). Presents site-specific data for 200 East Area that can be used to calculate soil density, hydraulic conductivity, and porosity.	N	N	N	N	[a]	[a]	Y	Y	Y	Y	[c]	[c]
			Hydrogeologic Model for the 200-West Groundwater Aggregate Area, WHC-SD-EN-TI-014, Rev. 0 (WHC 1992b). Presents site-specific data for 200 West Area that can be used to calculate soil density, hydraulic conductivity, and porosity.	[a]	[a]	[a]	[a]	Y	Y	[c]	[c]	[c]	[c]	N	N

Table 3-1. Required Information and Reference Sources. (3 Pages)

PSQ #	Required Information Category	Do Data Exist ? Y//N	Reference Source	Are Available Data of Sufficient Quality and Quantity to Support RI/FS Process? (Y/N)						Are Additional Data Required to Support RI/FS Process? (Y/N)					
				A-10	A-19	A-36B	B-12	U-12	U-8	A-10	A-19	A-36B	B-12	U-12	U-8
All	Distribution coefficients	Y	*Composite Analysis for Low-Level Waste Disposal in the 200 Area Plateau of the Hanford Site*, PNNL-11800 (PNNL 1998b). Provides 200 Area distribution coefficients for various waste stream types and Hanford soils.	Y	Y	Y	Y	Y	Y	N	N	N	N	N	N
			Geochemical Data Package for the Hanford Immobilized Low-Activity Tank Waste Performance Assessment (ILAW PA), PNNL-13037, Rev. 1 (Kaplan and Serne 2000). Provides 200 Area distribution coefficients for various waste stream types and Hanford soils.	Y	Y	Y	Y	Y	Y	N	N	N	N	N	N
All	RESRAD input data	Y	*Manual for Implementing Residual Radioactive Material Guidelines Using RESRAD, Version 5.0*, ANL-EAD-LD-2 (ANL 1993). Input parameters are defined in this manual that can be determined based on existing information or RESRAD defaults.	N/A	N/A	N/A	N/A	N/A	N/A	N	N	N	N	N	N

[a] Reference source does not pertain to this waste site; no site-specific information included for the site.
[b] Contaminant data from 216-U-8 is considered analogous to this site and appropriate for RI/FS decision making because the 216-U-8 and 216-U-12 Cribs received the same waste stream.
[c] Decision on additional data is irrelevant for the document as no site-specific information is included for the site.
[d] Nonradiological soil sample data has not been collected. Therefore additional data is required to support the RI/FS process.
[e] Groundwater has been impacted in the past by waste sites in this OU, and mobile contaminants were disposed at the sites within this waste group. However, evaluation of groundwater contamination and remediation is not included in the scope of the work plan.

GW = groundwater
N/A = not applicable

3.2 BASIS FOR SETTING THE PRELIMINARY ACTION LEVEL

The preliminary action level is the threshold value that provides the criterion for choosing between AAs. Table 3-2 identifies the basis (i.e., regulatory threshold or risk-based) for establishing the preliminary action level for each of the COCs. The numerical value for the action level is defined in DQO Step 5.

Table 3-2. Basis for Setting Preliminary Action Level.

DS #	COCs	Basis for Setting Preliminary Action Level
1	Radiological COCs	Radiological lookup values for shallow zone soils based on RESRAD analyses for the applicable scenarios. Deep zone lookup values TBD.
2	Nonradiological COCs	MTCA Method C cleanup levels with contaminant-specific variations.
3	Radiological and nonradiological COCs	Preliminary action levels do not apply for preliminary conceptual contaminant distribution model evaluation. This is a judgmental assessment.

DS = decision statement
N/A = not applicable
TBD = to be determined in a vadose zone transport model co-selection process.

3.3 COMPUTATIONAL AND SURVEY/ANALYTICAL METHODS

Table 3-3 identifies the decision statements where existing data either do not exist or are of insufficient quality to resolve the decision statements. For these decision statements, Table 3-3 presents computational and/or surveying/sampling methods that could be used to obtain the required data.

Table 3-3. Information Required to Resolve the Decision Statements.[a]

DS #	Remedial Investigation Variable	Required Data	Computational Methods	Survey/Analytical Methods
1 and 3	Concentrations of radiological COCs in vadose zone soils	Alpha, beta, and gamma COC concentrations in soils for evaluation against ARARs an PRGs. Location data (depth and lateral extent of COCs within waste site boundaries).	RESRAD – analytical modeling method for human health dose assessment. TBD – analytical modeling through vadose zone to groundwater.	Field screening with radiological detection equipment. Geophysical borehole logging with downhole radiological detectors. Soil sampling and laboratory analysis.
2 and 3	Concentrations of nonradiological COCs in vadose zone soils	Nonradiological (e.g., inorganic metals and anions, and SVOCs) COC concentrations in soils for evaluation against ARARs and PRGs. Location data (depth and lateral extent of COCs within waste site boundaries).	Risk assessment. TBD -- analytical modeling through vadose zone to groundwater.	Soil sampling and laboratory analysis.
All	Physical properties in vadose zone soils	Moisture content, bulk density, particle size distribution	Direct comparison to existing models to determine conductivity.	Soil sampling and laboratory analysis.

[a] See Table 3-5 for additional information.
SVOC = semi-volatile organic compound
TBD = to be determined

Table 3-4 presents details on the computational methods identified in Table 3-3. These details include the source and/or author of the computational method and information on how the method could be applied to this study.

Table 3-4. Details on Identified Computational Methods.

DS #	Computational Method	Source/ Author	Application to Study	Satisfy Input Req't?
1	RESRAD	Argonne National Laboratory	RESRAD will be used to estimate direct human radiation exposure to account for radioactive decay.	Yes
1 and 2	TBD	TBD	Estimates direct human radiation exposures and the migration of all contaminants (radiological and nonradiological) to groundwater for indirect exposure estimates. If mobile contaminants are present, then a vadose zone transport model will be needed and typically requires site-specific geohydrologic soil properties such as hydraulic conductivity, moisture, etc.	TBD

TBD = to be determined in a vadose zone transport model co-selection process.

Table 3-5 identifies each of the survey and/or analytical methods that may be used to provide the required information needed to resolve each of the decision statements. The possible limitations associated with each of these methods are also provided.

Table 3-5. Potentially Appropriate Survey and/or Analytical Methods. (3 Pages)

Media	Remediation Variable	Potentially Appropriate Survey/ Analytical Method	Possible Limitations
Field Screening			
Fine-grained materials, structures	Site location; underground structures or interferences	GPR	GPR is a radar-reflection surface geophysical survey technique that detects contrasts in di-electric constants in the below-grade environments from the surface. Requires subjective interpretation of the reflected signals. Lack of reflective below-grade surfaces or the presence of interfering matrices can complicate or invalidate the findings. The presence of nearby buildings and utilities can interfere with reflected signals. Fines (e.g., clay and heavy fly ash) can act as a reflector to the radar signal.
		EMI	EMI is a surface geophysical survey technique that measures electrical conductivity in below-grade soils based on detected changes in electrical fields. The results of EMI are generally used to support the interpretation of GPR surveys. Nearby buildings and utilities can cause interferences.

Table 3-5. Potentially Appropriate Survey and/or Analytical Methods. (3 Pages)

Media	Remediation Variable	Potentially Appropriate Survey/ Analytical Method	Possible Limitations
Vadose zone soils	Gross and isotopic gamma emissions	Cone penetrometer; NaI detector logging	A closed-end rod is pushed into the soil to the desired depth. A small-diameter NaI detector (or other suitable detector) is used to log the gross gamma response with depth. The cone penetrometer is not effective in cobbly or rocky soils.
	Gross and isotopic gamma emissions	Direct push; NaI detector logging	A small-diameter casing is pushed into the soil to the desired depth. A small-diameter NaI detector (or other suitable detector) is used to log the gamma response with depth. Direct-push methods (e.g., Geoprobe™) may be ineffective in cobbly or rocky soils.
	Gamma emissions from fission products, Am-241, Pu-239, and Np-237	Borehole SGL with HPGe detector	Gamma-ray logging provides the concentration profiles of gamma-emitting radionuclides such as Am-241, Pu-239, and many fission products in a borehole environment. It is considered by some to be more accurate than sampling and laboratory assay because the assay is performed in situ with less disturbance of the sample, there is higher vertical spatial resolution, and the sample size is much larger. This method may also be more economical than traditional sampling and analysis. This method does not assess radionuclides or daughter products that do not emit gamma rays. The gamma energies from these isotopes are at the low end of the spectrum, which results in high numerical minimum detectable activities and possible matrix effects from other isotopes. This technique requires the use of a single casing (installed by drilling or driving) in contact with the soil formation.
	Neutron emissions from plutonium	Borehole passive neutron logging	Passive neutron logging provides indication of the presence of neutron-emitting isotopes. Because of the very low incidence of spontaneous Pu fission and alpha-N reactions, the passive neutron profile is orders of magnitude lower than the gamma emissions.
	Active neutron emissions from transuranics	Borehole passive/active neutron-logging methods	This technique uses source materials or generators to release neutrons into the soil formation. Passive detectors measure the response to the neutron flux as a means of detecting specific transuranic constituents. Although neutron activation methods have been developed, they are not expected to be useful for this initial characterization effort. At present, these techniques are too expensive and time consuming, and logistical problems are associated with the handling of intense sources or generators.
	Vertical moisture profile	Borehole neutron-neutron moisture logging	N-N moisture logs can be used to determine current moisture content profiles of the subsurface through new or existing boreholes. The moisture profiles are often directly correlated to contaminant concentrations, sediment grain size, composition, or subsurface structural features. For this project, the moisture profile may be useful for helping determine the location of contamination and/or the location of the ditch and establish geologic conditions to support contaminant fate and transport modeling. It may also be correlated to reflections identified in ground-probing radar surveys.

Table 3-5. Potentially Appropriate Survey and/or Analytical Methods. (3 Pages)

Media	Remediation Variable	Potentially Appropriate Survey/ Analytical Method	Possible Limitations
Laboratory Samples			
Vadose zone soils	All COCs and physical properties	Laboratory analysis	Highly contaminated samples require use of onsite laboratories, with associated impacts (e.g., high cost, reduced analyte lists, matrix effects, degraded detection limits, and long turnaround times). Lower contamination levels allow use of offsite laboratories, avoiding these limitations. Physical property analysis will include bulk density, moisture content, and particle size distribution.

™ Geoprobe is a registered trademark of Geoprobe Systems, Salinas, Kansas.
EMI = electromagnetic imaging
GPR = ground-penetrating radar
HPGe = high-purity germanium
NaI = sodium iodide
SGL = spectral gamma logging

3.4 ANALYTICAL PERFORMANCE REQUIREMENTS

Table 3-6 defines the analytical performance requirements for the data that need to be collected to resolve each of the decision statements. These performance requirements include the PQL and the precision and accuracy requirements for each of the COCs.

Table 3-6. Analytical Performance Requirements – Shallow and Deep Zone Soils. (3 Pages)

COCs	CAS #	Preliminary Action Level[a]			Name/Analytical Technology	Target Required Quantitation Limits				Precision Water	Accuracy Water	Precision Soil	Accuracy Soil
		RR[b] (pCi/g)	C/I[b] (pCi/g)	GW Protection[b,c] (pCi/g)		Water[d] Low Activity (pCi/L)	Water[d] High Activity (pCi/L)	Soil-Other Low Activity (pCi/g)	Soil-Other High Activity (pCi/g)				
Americium-241	14596-10-2	31	210	TBD	Americium isotopic – AEA	1	400	1	4,000	±20%	70-130%	±35%	70-130%
Carbon-14	14762-75-5	5.2[e]	33,100	TBD	Carbon-14 - liquid scintillation	200	N/A	50	N/A	±20%	70-130%	±35%	70-130%
Cesium-137	10045-97-3	6.2	25	TBD	GEA	15	200	0.1	2,000	±20%	70-130%	±35%	70-130%
Cobalt-60	10198-40-0	1.4	5.2	TBD	GEA	25	200	0.05	2,000	±20%	70-130%	±35%	70-130%
Europium-152	14683-23-9	3.3	12	TBD	GEA	50	200	0.1	2,000	±20%	70-130%	±35%	70-130%
Europium-154	15585-10-1	3	11	TBD	GEA	50	200	0.1	2,000	±20%	70-130%	±35%	70-130%
Europium-155	14391-16-3	125	449	TBD	GEA	50	200	0.1	2,000	±20%	70-130%	±35%	70-130%
Hydrogen-3	10028-17-8	359[e]	14,200	TBD	Tritium – liquid scintillation	400	400	400	400	±20%	70-130%	±35%	70-130%
Neptunium-237	13994-20-2	2.5	62.2	TBD	Neptunium-237 - AEA	1	N/A	1	8,000	±20%	70-130%	±35%	70-130%
Nickel-63	13981-37-8	4,026	3,008,000	TBD	Nickel-63 - liquid scintillation	15	N/A	30	N/A	±20%	70-130%	±35%	70-130%
Plutonium-238	13981-16-3	37	483	TBD	Plutonium isotopic – AEA	1	130	1	1,300	±20%	70-130%	±35%	70-130%
Plutonium-239/240	Pu-239/240	34	243	TBD	Plutonium isotopic – AEA	1	130	1	1,300	±20%	70-130%	±35%	70-130%
Radium-226	13982-63-3	1.1	7.4	TBD	GEA	50	N/A	0.1	2000	±20%	70-130%	±35%	70-130%
Radium-228	15262-20-1	1.7	8.5	TBD	GEA	50	N/A	0.2	2000	±20%	70-130%	±35%	70-130%
Strontium-90	Rad-Sr	4.5	2,500	TBD	Total radioactive strontium - GPC	2	80	1	800	±20%	70-130%	±35%	70-130%
Technetium-99	14133-76-7	5.7[e]	410,000	TBD	Technetium-99 - liquid scintillation	15	400	15	4,000	±20%	70-130%	±35%	70-130%
Thorium-232	TH-232	1	5.1	TBD	Thorium isotopic - AEA (pCi) ICPMS (mg)	1	0.002 mg/L	1	0.02 mg/kg	±20%	70-130%	±35%	70-130%
Uranium-234	13966-29-5	160	1,200	TBD	Uranium isotopic - AEA (pCi) ICPMS (mg)	1	0.002 mg/L	1	0.02 mg/kg	±20%	70-130%	±35%	70-130%
Uranium-235	15117-96-1	26	100	TBD	Uranium isotopic - AEA (pCi) ICPMS (mg)	1	0.002 mg/L	1	0.02 mg/kg	±20%	70-130%	±35%	70-130%
Uranium-238	U-238	85	420	TBD	Uranium isotopic - AEA (pCi) ICPMS (mg)	1	0.002 mg/L	1	0.02 mg/kg	±20%	70-130%	±35%	70-130%

Table 3-6. Analytical Performance Requirements – Shallow and Deep Zone Soils. (3 Pages)

COCs	CAS #	Preliminary Action Level[a]			Name/Analytical Technology	Target Required Quantitation Limits				Precision Water	Accuracy Water	Precision Soil	Accuracy Soil
		Method B[f] (mg/kg)	Method C[g] (mg/kg)	GW Protection[h] (mg/kg)		Water[d] Low Conc. (mg/L)	Water[d] High Conc. (mg/L)	Soil-Other Low Conc. (mg/kg)	Soil-Other High Conc. (mg/kg)				
Metals													
Antimony	7440-36-0	32	1750	0.6	Metals - 6010 - ICP	0.06	0.12	6	12	i	i	i	i
Antimony	7440-36-0	32	1750	0.6	Metals – 6010[k]– ICP (trace)	0.01	NA	1	NA	i	i	i	i
Arsenic	7440-38-2	1.67	219	0.00583	Metals - 6010 - ICP	0.1	0.2	10	20	i	i	i	i
Arsenic	7440-38-2	1.67	219	0.00583	Metals - 6010 – ICP (trace)	0.01	NA	1	NA	i	i	i	i
Barium	7440-39-3	5600	245,000	200	Metals - 6010 - ICP	0.2	0.2	20	20	i	i	i	i
Barium	7440-39-3	5600	245,000	200	Metals - 6010 – ICP (trace)	0.005	NA	0.5	NA	i	i	i	i
Beryllium	7440-41-7	0.233	30.5	0.00203	Metals - 6010 - ICP	0.005	0.01	0.5	1	i	i	i	i
Cadmium	7440-43-9	80	3,500	0.5[j]	Metals - 6010 - ICP	0.005	0.01	0.5	1	i	i	i	i
Cadmium	7440-43-9	80	3,500	0.5[j]	Metals - 6010 – ICP (trace)	0.005	N/A	0.5	N/A	i	i	i	i
Chromium (total)	7440-47-3	80,000[l]	Unlimited[l]	10[j]	Metals - 6010 - ICP	0.01	0.01	1	2	i	i	i	i
Chromium (total)	7440-47-3	80,000[l]	Unlimited[l]	10[j]	Metals - 6010 – ICP (trace)	0.01	N/A	1	N/A	i	i	i	i
Chromium VI	18540-29-9	400	17,500	8	Chromium (hex) - 7196 - colorimetric	0.01	4	0.5	200	i	i	i	i
Copper	7440-50-8	2,960	130,000	59.2	Metals - 6010 - ICP	0.025	0.025	2.5	2.5	i	i	i	i
Lead	7439-92-1	353[m]	1,000[n]	1.5[o]	Metals - 6010 - ICP	0.1	0.2	10	20	i	i	i	i
Lead	7439-92-1	353[m]	1,000[n]	1.5[o]	Metals - 6010 - ICP (trace)	0.01	N/A	1	N/A	i	i	i	i
Mercury	7439-97-6	24	1,050	0.2[j]	Mercury - 7470 - CVAA	0.0005	0.005	N/A	N/A	i	i	i	i
Mercury	7439-97-6	24	1,050	0.2[j]	Mercury - 7471 - CVAA	N/A	N/A	0.2	0.2	i	i	i	i
Nickel	7440-02-0	1,600[p]	70,000[p]	32	Metals - 6010 - ICP	0.04	0.04	4	4	i	i	i	i
Selenium	7782-49-2	400	17,500	5[q]	Metals - 6010 - ICP	0.1	0.2	10	20	r	r	r	r
Silver	7440-22-4	400	17,500	8	Metals - 6010 - ICP	0.02	0.02	2	2	i	i	i	i
Silver	7440-22-4	400	17,500	8	Metals - 6010 - ICP (trace)	0.005	N/A	0.5	N/A	i	i	i	i
Uranium (total)	7440-61-1	240[p]	10,500[p]	2[q]	Uranium total - kinetic phosphorescence analysis	0.0001	0.02	1	0.2	±20%	70-130%	±35%	70-130%
Inorganics													
Ammonia/ ammonium	7664-41-7	Unlimited	Unlimited	27,200	Ammonia - 350.N[r]	0.05	800	0.5	8,000	i	i	i	i
Chloride	16887-00-6	25,000[h]	25,000[h]	25,000[h]	Anions - 300.0 - IC	0.2	5	2	5	i	i	i	i
Cyanide	57-12-5	1,600	70,000	20[j]	Total cyanide - 9010 - colorimetric	0.005	0.005	0.5	0.5	i	i	i	i
Fluoride	16984-48-8	4,800	210,000	96	Anions - 300.0 - IC	0.5	5	5	5	i	i	i	i

Table 3-6. Analytical Performance Requirements – Shallow and Deep Zone Soils. (3 Pages)

COCs	CAS #	Preliminary Action Level[a]			Name/Analytical Technology	Target Required Quantitation Limits				Precision Water	Accuracy Water	Precision Soil	Accuracy Soil
		Method B[f] (mg/kg)	Method C[g] (mg/kg)	GW Protection[h] (mg/kg)		Water[d] Low Conc. (mg/L)	Water[d] High Conc. (mg/L)	Soil-Other Low Conc. (mg/kg)	Soil-Other High Conc. (mg/kg)				
Nitrate	14797-55-8	128,000	Unlimited	4,400	Anions - 300.0 - IC	0.25	10	2.5	40	i	i	i	i
Nitrite	14797-65-0	8,000	350,000	160	Anions - 300.0 - IC	0.25	15	2.5	20	i	i	i	i
Nitrate/Nitrite	NO_3/NO_2-N	128,000	Unlimited	4,400	NO_3/NO_2 - 350.N[r]	0.075	5	0.75	10	i	i	i	i
Phosphate	14265-44-2	N/A	N/A	None	Anions - 300.0 - IC	0.5	15	5	40	i	i	i	i
Sulfate	14808-79-8	25,000[h]	25,000[h]	25,000[h]	Anions - 300.0 - IC	0.5	15	5	40	i	i	i	i
Organics													
Kerosene (normal paraffin hydrocarbons)	8008-20-6	200[n]	200[n]	200[n]	Nonhalogenated VOA - 8015M - GC modified for hydrocarbons	0.5	0.5	5	5	i	i	i	i
Tributyl phosphate	126-73-8	None	None	None	Semi-volatiles - 8270 – GCMS	0.1	0.5	3.3	5	i	i	i	i
Total organic carbon	TOC	N/A	N/A	None	TOC - 9060-combustion	1	1	100	100	±20%	70-130%	±35%	70-130%

[a]The preliminary action level is the regulatory or risk-based value used to determine appropriate analytical requirements (e.g., detection limits). Remedial action levels will be proposed in the FS, finalized in the ROD, and will drive remediation of the sites.
[b]RR = rural residential, C/I = commercial industrial, GW = groundwater protection radionuclide values from the Washington State Department of Health's (WDOH's) *Hanford Guidance for Radiological Cleanup* (WDOH 1983). Radionuclide values are calculated using parameters from WDOH guidance. RR and C/I values show a possible range of lookup values for comparison with analytical detection limits.
[c]The "100 times groundwater" rule does not apply to residual radionuclide contaminants. For radionuclides, groundwater protection is demonstrated through technical evaluation using RESRAD (DOE-RL 2000).
[d]Water values for sampling quality control (e.g., equipment blanks/rinses) or drainable liquid (if recovered).
[e]If quantitation to action level lower than nominal reliable detection level is required, prior notification/concurrence with the laboratory will be required to address special low-level detection limits.
[f]MTCA Method B soil values for direct exposure.
[g]MTCA Method C industrial soil values for direct exposure.
[h]MTCA Method B soil values for groundwater protection.
[i]Precision and accuracy requirements as identified and defined in the referenced EPA procedures.
[j]Based on *Federal Primary Drinking Water Standards* (40 CFR 141), which is more restrictive than MTCA.
[k]All four-digit numbers refer to *Test Methods for Evaluating Solid Waste: Physical/Chemical Methods* (EPA 1986).
[l]Value based on chromium (III) MTCA soil concentrations.
[m]Based on EPA's *Integrated Exposure Uptake Biokenetic Model for Lead In Children* (EPA 1994c).
[n]This value is based on MTCA Method A values.
[o]This value is based on 100 times the *National Primary Drinking Water Regulations* action level.
[p]Value based on nickel or uranium soluble salts value.
[q]Based on a proposed drinking water standard.
[r]From *Methods of Analysis of Water and Waste* (EPA 1983).

AEA = alpha energy analysis
CVAA = cold vapor atomic absorption
GC = gas chromatograph
GCMS = gas chromatograph/mass spectrometry
GPC = gas proportional counter
IC = ion chromatography
ICPMS = inductively coupled plasma mass spectrometer
N/A = not applicable
TBD = to be determined
TOC = total organic carbon
VOA = volatile organic analysis

4.0 STEP 4 -- DEFINE THE BOUNDARIES OF THE STUDY

4.1 OBJECTIVE

The primary objective of DQO Step 4 is for the DQO team to identify the spatial, temporal, and practical constraints on the sampling design and to consider the consequences. This objective (in terms of the spatial, temporal, and practical constraints) ensures that the sampling design results in the collection of data that accurately reflect the true condition of the site and/or populations being studied.

4.2 WORKSHEETS FOR STEP 4 -- DEFINE THE BOUNDARIES OF THE STUDY

Table 4-1 defines the population of interest to clarify what the samples are intended to represent. The characteristics that define the population of interest are also identified.

Table 4-1. Characteristics that Define the Population of Interest.

DS #	Population of Interest	Characteristics
Cribs and Trenches		
All	Vadose zone soils beneath each of the individual representative waste sites and TSDs	Concentrations of radionuclides, metals, and limited organic constituents; physical properties including moisture content, bulk density, and grain size distribution

Table 4-2 defines the spatial boundaries of the decision and the domain or geographic area (or volume) within which all decisions must apply (in some cases, this may be defined by the OU). The domain is a region distinctly marked by some physical features (i.e., volume, length, width, and boundary).

Table 4-2. Geographic Boundaries of the Investigation.

DS #	Geographic Boundaries of the Investigation
All	The geographic boundaries for the investigation are the boundaries of the individual representative waste sites.

When appropriate, the population is divided into strata that have relatively homogeneous characteristics. The DQO team must systematically evaluate process knowledge, historical data, and plant configurations to present evidence of a logic that supports alignment of the population

into strata with homogeneous characteristics. Table 4-3 identifies the strata with homogeneous characteristics.

Table 4-3. Zones with Homogeneous Characteristics.

DS #	Population of Interest	Zone	Homogeneous Characteristic Logic
Cribs			
All	Vadose zone soils beneath the representative waste sites	Clean or very low concentration stabilizing fill over waste site	Generally not expected to be contaminated. Have been stabilized with clean fill. Fill will be field-screened for contamination at all sites during characterization activities.
		Highest contaminant concentration layer[a]	The particulates and high distribution coefficient contaminants were sorbed and/or filtered out of the liquid flow via the soils at the bottom of the excavated crib/trench. This zone is expected to contain the highest concentrations of contaminants and to have decreasing concentrations with depth. May also contain residual concentrations of mobile constituents.
		Moderate to low contaminant concentration layer[a]	A moderate concentration layer was formed immediately beneath the expected high concentration layer. In this zone, finer particulates and moderate distribution coefficient contaminants from the liquid waste streams were filtered and sorbed. High volumes of disposed liquids may have carried some immobile constituents into this zone, and residual concentrations of mobile constituents may also be present. This zone is expected to have decreasing concentrations with depth as more immobile constituents filter and sorb out with the passing of the wetting front.[b]
		Low contaminant concentration layer[a]	This zone is expected to contain low concentrations of mobile contaminants from the source to the groundwater table. Concentrations are expected to remain fairly constant through the impacted zone because the majority of the contaminants have been flushed through the system, leaving residual concentrations.

[a] The thickness is not specified.
[b] The wetted front may have reached groundwater for crib sites. It is not known if groundwater was impacted by the discharges in the trench sites.

The temporal boundaries of the decision are defined in Table 4-4.

Table 4-4. Temporal Boundaries of the Investigation.

DS #	Timeframe	When to Collect Data
Field Screening		
All	0 to 5 years[a] after issuance of the SAP	Avoid extreme hot/cold months due to impacts on worker efficiency and equipment effectiveness. Inclement weather may impact sample quality.
Laboratory Samples		
All	0 to 5 years[a] after issuance of the SAP	Avoid extreme hot/cold months and inclement weather that have potential to impact sample integrity and soil sampling operations.

[a] Timeframe is approximate and may be impacted by changing priorities, budgets, and approval of the work plan.

4.3 SCALE OF DECISION MAKING

Table 4-5 defines the scale of decision making for each decision statement. The scale of decision making is defined as the smallest, most appropriate subsets of the population (sub-population) for which decisions will be made based on the spatial or temporal boundaries of the area under investigation.

Table 4-5. Scale of Decision Making.

DS #	Population of Interest	Geographic Boundary	Temporal Boundary		Spatial Scale of Decision Making
			Timeframe[a]	When to Collect Data	
All	Vadose zone soils beneath each of the individual representative waste sites and TSDs	Boundaries of the individual representative waste sites: 216-A-19 Crib 216-B-12 Crib, 216-U-8 Crib, 216-U-12 Crib, 216-A-10 Crib, 216-A-36B Crib	0 to 5 years after issuance of SAP	Avoid extreme hot/cold months and inclement weather that have potential to impact sample integrity and soil sampling operations.	Vadose soils

[a] Timeframe is approximate and may be impacted by changing priorities, budgets, and approval of the work plan.

The zones of homogeneous characteristics in Table 4-3 identify various strata within the representative waste site. However, the scale of decision making for this DQO process is the vadose zone soils within the geographic boundaries of the individual waste sites over the next 0 to 5 years. The homogeneous characteristics in Table 4-3 are not significant factors in remedial decision making. The remedial decisions will focus on contaminant concentrations and depth. The depth intervals of concern are identified in Table 1- 9.

4.4 PRACTICAL CONSTRAINTS

Table 4-6 identifies all of the practical constraints that may impact the data collection effort. These constraints include physical barriers, difficult sample matrices, high radiation areas, or any other condition that will need to be taken into consideration in the design and scheduling of the sampling program.

Table 4-6. Practical Constraints on Data Collection.

Boreholes may not obtain sufficient volumes of sample media if the sampled zone is 0.6-m (2-ft) thick or less. Advancement of borehole casing may smear contamination downhole.
The soils in the vadose zone are expected to be typical Hanford Site soils. These soils should be easily recognizable and should not pose unusual sampling problems.
Other Constraints:
Health and safety constraints may be imposed during characterization sampling to ensure that as low as reasonably achievable issues are properly addressed when sampling radiologically contaminated soils.
Laboratory constraints are expected when analyzing soil samples with high contaminant concentrations. Soil samples in this category would be analyzed in an onsite laboratory. Impacts are expected in cost, degradation of detection limits, and possible reduction in the analyte lists. Extreme weather conditions may also limit or shut down field screening operations.

5.0 STEP 5 -- DEVELOP A DECISION RULE

The purpose of DQO Step 5 is initially to define the statistical parameter of interest (i.e., maximum, mean, or 95% upper confidence level [UCL]) that will be used for comparison against the action level. The statistical parameter of interest specifies the characteristic or attribute that a decision maker would like to know about the population. The preliminary action level for each of the COCs is also identified in DQO Step 5. When this is established, a decision rule is developed for each decision statement in the form of an "IF...THEN..." statement that incorporates the parameter of interest, the scale of decision making, the preliminary action level, and the AAs that would result from resolution of the decision. Note that the scale of decision making and AAs were identified earlier in DQO Steps 4 and 2, respectively.

5.1 INPUTS NEEDED TO DEVELOP DECISION RULES

Tables 5-1, 5-2, and 5-3 present the information needed to formulate the decision rules in Section 5.2. This information includes the decision statements and AAs identified in DQO Step 2, the scale of decision making identified in DQO Step 4, and the statistical parameters of interest and preliminary action levels for each of the COCs.

Table 5-1. Decision Statements.

DS #	Decision Statement
1	Determine if the vadose zone radionuclide concentrations in the 200-PW-2 OU representative waste sites exceed the radiological exposure limits for human health protection under an industrial exposure scenario, requiring evaluation in a FS.
2	Determine if vadose zone nonradiological constituent concentrations in the 200-PW-2 OU representative waste sites exceed the nonradiological constituent exposure limits for human health protection under an industrial exposure scenario, requiring evaluation in a FS.
3	Determine if the 200-PW-2 OU conceptual contaminant distribution models represent the contaminant distribution conditions and physical characteristics in each waste site or if the models need to be refined.

Table 5-2. Inputs Needed to Develop Decision Rules.

DS #	COCs	Parameter of Interest	Statistic	Scale of Decision Making	Preliminary Action Levels
1	Radionuclides	Population maximum	Maximum detected values	Vadose soils	RESRAD lookup values and TBD through other modeling; radionuclide concentrations equating to a dose limit of 100 mrem/yr
2	Nonradiological constituents				MTCA and other regulatory levels (identified in Table 3-6)
3	Radiological and nonradiological constituents and physical properties				N/A

N/A = not applicable
TBD = to be determined

The AAs identified in DQO Step 2 are summarized in Table 5-3.

Table 5-3. Alternative Actions.

PSQ #	AA #	Alternative Actions
1	1	If the radionuclide concentrations in the vadose soils do not exceed the industrial exposure limits, evaluate the site for closure with no remedial action in a FS.
	2	If the radionuclide concentrations in the vadose soils exceed the industrial exposure limits, evaluate the need for remedial action alternatives or evaluate a streamlined approach to site closure (e.g., add to an existing ROD) in a FS.
2	1	If the nonradiological constituent concentrations in the vadose soils do not exceed the industrial exposure limits, evaluate the site for closure with no remedial action in a FS.
	2	If the nonradiological constituent concentrations in the vadose soils exceed the industrial exposure limits, evaluate the need for remedial action alternatives or evaluate a streamlined approach to site closure (e.g., add to an existing ROD) in a FS.
3	1	If the conceptual contaminant distribution models reflect the actual distribution of contaminants and physical characteristics, use the models for remedial alternative selection and remedial action planning.
	2	If the conceptual contaminant distribution models do not accurately reflect the distribution of contaminants and physical characteristics, revise the models prior to remedial alternative selection and remedial action planning.

5.2 DECISION RULES

The output of DQO Step 5 and the previous DQO steps are combined into "IF...THEN" decision rules that incorporate the parameter of interest, the scale of decision making, the action level, and

the actions that would result from resolution of the decision. The decision rules are listed in Table 5-4.

Table 5-4. Decision Rules.

DR #	Decision Rule
1 & 2	If the analytical results of the vadose zone soil samples within the geographic boundaries of the individual 200-PW-2 OU representative and TSD waste sites over the next 5 years meet all of the following conditions: • The RESRAD analysis of maximum detected soil sampling results for the radiological COCs in the 200-PW-2 OU representative waste site vadose soils do not exceed the annual exposure limits for human health protection. • The fate and transport analysis (TBD) of the maximum detected soil sampling results for the radiological COCs in the 200-PW-2 OU representative waste site vadose soils do not exceed the annual exposure limits for protection of groundwater. • The analytical results of the 200-PW-2 OU representative waste sites indicate that maximum detected values do not exceed the respective nonradiological COC preliminary action levels for direct exposure. • The analytical results of the 200-PW-2 OU representative waste site vadose soils indicate that the maximum detected values do not exceed the respective nonradiological COC preliminary action levels for protection of groundwater. Then evaluate for site closure with no remedial action. If any of these conditions are not met, then evaluate the need for conventional remedial action alternatives within a FS/closure plan, or evaluate a streamlined approach to site closure to be applied administratively via an existing ROD.
3	If the maximum detected values indicate that the contamination distribution and physical characteristics in the 200-PW-2 OU waste sites do not differ significantly from the preliminary conceptual contaminant distribution model, then the preliminary conceptual contaminant distribution model will not be revised prior to use for remedial decision making or remedial action planning. If the maximum detected values indicate that the contamination distribution and physical properties in the 200-PW-2 OU waste sites differ significantly from the preliminary conceptual contaminant distribution model, then the preliminary conceptual contaminant distribution model will be revised prior to use for remedial decision making or remedial action planning.

[a] The use of the term "remedial action" is used collectively to refer to one of the alternatives described in the project objectives discussion. The selection of the appropriate AA is beyond the scope of this DQO summary report.
DR = decision rule
TBD = to be determined

6.0 STEP 6 -- SPECIFY TOLERABLE LIMITS ON DECISION ERRORS

Because analytical data can only estimate the true condition of the site under investigation, decisions that are made based on measurement data could potentially be in error (i.e., decision error). For this reason, the primary objective of DQO Step 6 is to determine which decision statements (if any) require a statistically based sample design. For those decision statements requiring a statistically based sample design, DQO Step 6 defines tolerable limits on the probability of making a decision error.

6.1 STATISTICAL VERSUS NON-STATISTICAL SAMPLING DESIGN

Table 6-1 provides a summary of the information used to support the selection between a statistical versus a non-statistical sampling design for each decision statement. The factors that were taken into consideration in making this selection included the timeframe over which each of the decision statements applies, the qualitative consequences of an inadequate sampling design, and the accessibility of the site if resampling is required.

Table 6-1. Statistical Versus Non-Statistical Sampling Design.

DS #	Timeframe (Years)	Qualitative Consequences of Inadequate Sampling Design (Low/ Moderate/Severe)	Resampling Access After RI (Accessible/ Inaccessible)	Proposed Sampling Design (Statistical/ Non-Statistical)
All	0 to 5	Low	Accessible	Non-statistical

6.2 NON-STATISTICAL DESIGNS

A biased (or focused) sampling approach, which targets the maximum potential contamination within a waste site, is considered appropriate for the waste sites in the 200-PW-2 OU. Contaminant distributions are expected to follow relatively predictable patterns based on process knowledge and existing environmental data.

The "gray region" and tolerable limits on decision error will not be developed in this DQO process because they only apply to statistical sampling designs. The nature of the waste sites to be investigated in the RI supports the use of focused sampling, as identified in *Washington State Department of Ecology Toxics Cleanup Program Guidance on Sampling and Data Analysis Methods* (Ecology 1995). This guidance document defines "focused sampling" as selective

sampling of areas where potential or suspected soil contamination can reliably be expected to be found if a release of a hazardous substance has occurred. The relatively small crib structures to be investigated released contaminants in a point-source fashion. Contaminants released through a small crib would likely impact the soil immediately beneath the crib with minimal lateral spread; therefore, the focused RI sampling in cribs ensures collection of the area of greatest impact associated with the discharge. In comparison, trench structures, which are longer by design, may require additional efforts to determine the worst-case location for the borehole. This will also provide additional data on gamma-emitting radionuclides to support the focused sampling regime.

7.0 STEP 7 -- OPTIMIZE THE DESIGN

7.1 PURPOSE

The purpose of DQO Step 7 is to identify the most resource-effective design for generating data to support decisions while maintaining the desired degree of precision and accuracy. When determining an optimal design, the following activities should be performed:

- Review the DQO outputs from the previous DQO steps and the existing environmental data.
- Develop general data collection design alternatives.
- Select the sampling design (e.g., techniques, locations, or numbers/volumes) that most cost effectively satisfies the project's goals.
- Document the operational details and theoretical assumptions of the selected design.

7.2 WORKSHEETS FOR STEP 7 -- OPTIMIZE THE DESIGN

Table 7-1 identifies information in relation to determining the data collection design.

Table 7-1. Determine Data Collection Design.

Decision	Statistical	Non-Statistical	Rationale
All	N/A	Non-statistical sampling design	Judgmental data collection design is applicable to investigation as preliminary data suggest that the highest levels of contamination are located relative to release points or the bottom of waste sites. The relative size of waste sites presents a point-source-type disposal, focusing the area of investigation to the distribution of contaminants with depth. Consequences of erroneous decisions are not severe. Characterization sampling results will be verified by confirmatory sampling of analogous sites during the confirmatory and remedial design phase.

N/A = not applicable

Table 7-2 is used to develop general data collection design alternatives. If the data collection design for a given decision will be non-statistical, determine what type of non-statistical design is appropriate (i.e., haphazard or judgmental).

Table 7-2. Determine Non-Statistical Sampling Design.

DR #	Haphazard	Judgmental
All	None	Professional judgmental sampling design is indicated.

The data collection design alternatives for this project are described in Table 7-3.

Table 7-3. Methods for Collection of Data at Depth. (2 Pages)

Method	Description
Cone penetrometer or direct-push sampling	A closed-end rod is pushed into the soil to the desired depth, where a removable tip is displaced and a small volume of soil is retrieved. Due to the small volume of soil retrieved, multiple samples would be required to meet sample volume requirements for a large analyte list. The cone penetrometer and other direct-push methods are easily stopped by cobbles, rocks, or other features in the soil column. The resulting hole can be geophysically logged, providing information on gamma-emitting radionuclides and moisture content.
Auger drilling and sampling	Grab samples may be collected from the auger fitting during drilling, or split tube samples may be collected with the aid of hollow-stem auger "flights." To achieve laboratory analysis sample volume needs for large analytical lists, a 0.6-m (2-ft) core sample from a 13-cm (5-in.)-diameter sampler is typically needed. Running a sample tube down the hollow center of the flight retrieves split tube samples. This method is not well suited to drilling in soils contaminated with alpha-emitting radionuclides because of contamination control limitations. The auger split-spoon samples are typically 6 cm (2.5 in.) in diameter.
Cable tool drilling and sampling	This slow drilling method is particularly useful in highly contaminated areas because potential contamination releases can be more easily controlled. This drilling method allows collection of grab samples from the drive barrel or split-spoon. To achieve adequate laboratory analysis sample volumes for large analytical lists, a 0.6-m (2-ft)-long core sample from a 13-cm (5-in.)-diameter sampler is typically needed. DOE-owned, controlled cable tool rigs are available onsite for use in highly contaminated areas. In alpha-contaminated soils, significant contamination controls are required.
Diesel hammer drilling	The diesel hammer is a dual-string, reverse-air circulation drilling method. The potential impacts of this drilling method include degraded sample quality and increased contaminant release potential. Because of the introduction of air to the sample media, affects on analytical results for volatile organics and increased potential for dust result from this technique.
Sonic drilling and sampling	Sonic drilling can quickly advance either well casings or sample tubes. Samples are retrieved similar to split-spoon sample collection during a cable tool operation. To achieve adequate laboratory analysis sample volumes, a 0.6-m (2-ft)-long core sample is typically needed from a 13-cm (5-in.)-diameter sampler. Sonic drilling is much faster than cable tool drilling, but the technique generates a significant amount of heat, which can alter samples (e.g., liberate volatile organics from the sampled soils) and the surrounding formation. In alpha contaminated soils, significant contamination controls are required and may be difficult to implement because of the nature of the equipment and operations.

Table 7-3. Methods for Collection of Data at Depth. (2 Pages)

Method	Description
Air rotary drilling and sampling	Air rotary drilling is much faster than other drilling techniques. Grab samples and split-spoon samples may be taken using this method. In addition, most rotary drill rigs can be configured to collect core samples. To achieve adequate laboratory analysis sample volumes, a 0.6-m (2-ft)-long core sample is typically needed from a 13-cm (5-in.)-diameter sampler. This technique may introduce air into the soil, potentially altering the sample quality and formation moisture levels.

The design options are evaluated based on cost and ability to meet the DQO constraints. The results of the trade-off analyses should lead to one of two outcomes: (1) the selection of a design that most efficiently meets all of the DQO constraints, or (2) the modification of one or more outputs from DQO Steps 1 through 6 and the selection of a design that meets the new constraints.

The key features of the selected design are then documented, including (for example) the following:

- Maps outlining sample locations, strata, and inaccessible areas
- Directions for selecting sample locations, if the selection is not necessary or appropriate at this time
- Order in which samples should be collected (if important)
- Stopping rules
- Special sample collection methods
- Special analytical methods.

7.3 SAMPLING OBJECTIVES

In DQO Step 3 it was concluded that the historical characterization data available for the 216-U-8 Crib met the data quality needs for the RI/FS process. In addition, the data collected previously at the 216-U-8 Crib are considered to be sufficient for the analogous site (i.e., the 216-U-12 Crib); therefore, additional data collection is not required at the 216-U-12 Crib. The PSQs identified in Table 2-1 result in the following characterization objectives:

- Determine if the concentrations of chemical and radiological constituents in the 216-A-10 Crib, 216-A-19 Trench, 216-A-36B Crib, and 216-B-12 Crib exceed the exposure limits for human health protection.

- Evaluate soil sample results, geophysical logs of boreholes, and physical property analyses to determine whether conceptual contaminant distribution models need refinement.

7.4 SAMPLING DESIGN

7.4.1 Summary of Sampling Activities

A summary of the sampling activities is presented in Table 7-4.

Table 7-4. Key Features of the 200-PW-2 Sampling Design. (7 Pages)

Sample Collection Methodology	Key Features of Design	Basis for Sampling Design
216-A-19 Trench		
Surface geophysical surveys (GPR and EMI)	Perform GPR and/or EMI over the general trench area. Contingency – If GPR/EMI cannot ascertain the location of the trench then geophysical logging of a small diameter Geoprobe casing may be used to locate radiological contamination for placement of a borehole.	Geophysics techniques are expected to distinctly identify the trench and subsurface features to distinguish the 216-A-19 Trench from the 216-A-20 Trench.
Borehole characterization	Install one vadose borehole near the center of the trench. The location will be based upon interpretation of the surface or downhole geophysical results. The borehole will be drilled to the water table. Begin with a sample at 14.5-17 ft bgs in the backfill. At the bottom of the trench collect samples every 5 ft in the zone of expected highest contamination (17.5–20 ft, 22.5-25 ft, and 27.5-30 ft). The sample at 27.5-30 ft also represents a change in lithology from H1 to H2 sequences. At the transition from high to medium contamination zones (32.5-35 ft) and at the transition from medium to low contamination zones (47.5-50 ft) take additional samples.	The center of the trench was selected since there is no apparent "head end". Install a borehole for soil sampling and to support geophysical logging with spectral gamma and neutron moisture tools. Soil samples will be used to determine COC concentrations beneath the trench and in the vadose zone. Sampling provides data for remedial action decision making, to verify the preliminary conceptual contaminant distribution model, and to support numerical modeling.

Table 7-4. Key Features of the 200-PW-2 Sampling Design. (7 Pages)

Sample Collection Methodology	Key Features of Design	Basis for Sampling Design
Borehole characterization (con't)	Within the zone of expected lower contamination the sample interval is increased to 50 ft and one sample is taken at 97.5-100 ft. Below 100 ft bgs the sample interval is increased to approximately 100 ft, or samples are taken at anticipated changes in lithology at the base of the H2 sequence (207.5-210 ft), the base of the Ringold Unit E (242.5-245 ft), and at the top of the water table (248.5-251 ft) in the Ringold Lower Mud. (Field screening will be used in conjunction with the guidance provided above to determine actual sample depths.)	The soil sample at 14.5-17 ft bgs is critical. Samples at five ft intervals from the base of the trench to 35 ft are required to support the conceptual model expectation that contamination levels are predicted to drop off rapidly with increasing depth. Changes in contamination levels with depth are expected to decrease thereby allowing the sampling interval to increase with depth.
	Collect bulk density and grain-size distribution samples at major changes in lithology. Collect moisture samples with the other physical property samples.	Soil physical properties (e.g., moisture content, grain-size distribution, and bulk density) will be used to support contaminant transport modeling, if needed.
	Perform spectral logging for the entire length of the borehole.	SGL provides a continuous gamma-emitting radiological contaminant distribution profile with depth that will be used as supplemental information to soil samples. All of this information will be used to refine the preliminary conceptual contaminant distribution model.
	Perform neutron moisture logging for the entire length of the borehole.	Collect soil moisture data to determine the residual amount of moisture in the vadose zone, and to support numerical modeling efforts, if needed.
216-B-12 Crib		
Borehole characterization	Perform spectral logging down existing boreholes within the crib: • 299-E28-64 • 299-E28-65 • 299-E28-66.	SGL will be used to develop gamma contamination profiles beneath the crib. This information will also be used to specify the location of the new borehole (i.e., in the area of greatest contamination) and to guide borehole soil sample location depths.

Table 7-4. Key Features of the 200-PW-2 Sampling Design. (7 Pages)

Sample Collection Methodology	Key Features of Design	Basis for Sampling Design
Borehole characterization (con't)	Contingency approach for borehole placement – If SGL results are not conclusive one borehole will be placed near the front of the crib between the first and second wooden box structures. The borehole will be drilled to the water table.	Drill the borehole to support soil sampling and geophysical logging with spectral gamma and neutron moisture tools.
	Begin with a sample at 14.5-17 ft bgs in the backfill. At the base of the crib collect samples at approximately 10 ft intervals within the zone of highest contamination (30-32.5 ft, 40-42.5 ft, and 50-52.5 ft). At the transition from high to medium contamination zones (62.5-65 ft) and at the transition from medium to low contamination zones (94.5-97 ft) take additional samples. Within the zone of expected lower contamination the sample interval is increased to every 100 ft and one sample is taken at 197.5-200 ft. Below this depth samples are taken at a change in lithology at the bottom of the H2 sequence (247.5-250 ft) and at the top of the water table (294.5-297 ft). (Field screening will be used in conjunction with the guidance provided above to determine actual sample depths.)	Soil samples will be used to determine COC concentrations beneath the crib and in the vadose zone. Sampling provides data for remedial action decision making, to verify the preliminary conceptual contaminant distribution model, and to support numerical modeling The soil sample at 14.5-17 ft bgs is critical. Samples at 10 ft intervals from the base of the crib to approximately 65 ft are required to support the conceptual model expectation that contamination levels are predicted to drop off rapidly with increasing depth. Changes in contamination levels with depth are expected to decrease thereby allowing the sampling interval to increase with depth.
	Collect bulk density and grain-size distribution samples at major changes in lithology. Collect moisture samples with the other physical property samples.	Soil physical properties (e.g., moisture content, grain-size distribution, and bulk density) will be used to support contaminant transport modeling, if needed.
	Perform spectral logging for the entire length of the borehole.	SGL provides a continuous gamma-emitting radiological contaminant distribution profile with depth that will be used as supplemental information to soil samples. All of this information will be used to refine the preliminary conceptual contaminant distribution model.
	Perform neutron moisture logging for the entire length of the borehole.	Collect soil moisture data to determine the residual amount of moisture in the vadose zone, and to support numerical modeling efforts, if needed.

Table 7-4. Key Features of the 200-PW-2 Sampling Design. (7 Pages)

Sample Collection Methodology	Key Features of Design	Basis for Sampling Design
Borehole spectral logging in existing wells	Perform borehole spectral logging in accessible boreholes and groundwater wells near the crib. BHI well status records indicate that the following wells may be accessible and are appropriately configured for geophysical logging: • 299-E28-71 • 299-E28-76 • 299-E28-16.	These wells represent data collection points within 7.6 m (25 ft) of the waste site. Logging of these wells will provide additional current site-specific information on contaminant distribution, both laterally and vertically for comparison to previous surveys.
216-U-8 Crib		
Existing data collected as part of the 200-UP-2 LFI are sufficient to support the RI/FS decision process. SGL will be performed down existing boreholes (299-W19-70 and 299-W19-71) for comparison to pre-existing data and to assess changes in gamma-emitting contamination. Neutron moisture logging will also be conducted to collect soil moisture data in support of numerical modeling, if needed.		
216-U-12 Crib		
The 216-U-8 Crib waste is analogous to that found in the 216-U-12 Crib. Sufficient data collected as part of the 200-UP-2 LFI have already been collected at the 216-U-8 Crib to support the RI/FS decision process. SGL will be performed down an existing borehole (299-W22-75) for comparison to pre-existing data and to assess changes in gamma-emitting contamination. Neutron moisture logging will also be conducted to collect soil moisture data in support of numerical modeling, if needed.		
216-A-10 Crib		
Borehole spectral gamma logging (SGL) along the length of the crib	Perform borehole spectral logging, or comparable method, in up to six locations along the length of the crib. Drive casings, a cone penetrometer, or geoprobe boring to a maximum depth of approximately 30.5 m (100 ft) bgs will be utilized.	SGL, or comparable method, will be used to determine the distribution of gamma radiation along the length of the crib (96.3 m [316 ft]) and to a maximum depth of 16.8 m (55 ft) beneath the bottom of the crib. The data will be used to locate the borehole in the area of greatest contamination, and guide subsequent borehole soil sampling. The first drive casing will be placed approximately midway along the length of the crib and to a maximum depth of 30.5 m (100 ft). Other casings will be driven at each end of the central pipeline and along the east side of the central pipeline midway between it and the newer pipeline to the east.
Borehole characterization	Install one vadose borehole within the crib boundaries at the hot spot location indicated by SGL, avoiding subsurface structures. The borehole will be drilled to the water table.	Drill a borehole to allow soil sampling with depth and to support geophysical logging with spectral gamma and neutron moisture tools.

Table 7-4. Key Features of the 200-PW-2 Sampling Design. (7 Pages)

Sample Collection Methodology	Key Features of Design	Basis for Sampling Design
Borehole characterization (con't)	Begin with a sample at 14.5-17 ft bgs in the backfill. At the base of the crib collect samples at approximately 10 ft intervals within the zone of highest contamination (45-47.5 ft, 52.5-55 ft, 62.5-65 ft, and 72.5-75 ft). At the transition from high to medium contamination zones (87.5-90 ft) and at the transition from medium to low contamination zones (127.5-130 ft) take additional samples. Within the zone of expected lower contamination the sample interval is increased and one sample is taken at 197.5-200 ft. Below this depth samples are taken at anticipated changes in lithology at the base of the H2 sequence (287.5-290 ft), in the Ringold Lower Mud (292-294.5 ft), and at the top of the water table (318.5-321 ft) in the Ringold Unit A sequence. (Field screening will be used in conjunction with the guidance provided above to determine actual sample depths.)	Soil samples will be used to determine type and concentration of COCs beneath the crib in the vadose zone. Sampling provides data for remedial action decision making, to confirm the preliminary conceptual contaminant distribution model, and to support numerical modeling. The soil sample at 14.5-17 ft bgs is critical. Samples at approximately 10 ft intervals from the base of the crib to 90 ft are required to support the conceptual model expectation that contamination levels are predicted to drop off rapidly with increasing depth. Changes in contamination levels with depth are expected to decrease thereby allowing the sampling interval to increase with depth.
	Collect bulk density and grain-size distribution samples at major changes in lithology. Collect moisture samples with the other physical property samples.	Soil physical properties (e.g., moisture content, grain-size distribution, and bulk density) will be used to support contaminant transport modeling, if needed.
	Perform spectral logging for the entire length of the borehole.	SGL provides a continuous gamma-emitting radiological contaminant distribution profile with depth that will be used as supplemental information to soil samples. All of this information will be used to refine the preliminary conceptual contaminant distribution model.
	Perform neutron moisture logging for the entire length of the borehole.	Collect soil moisture data to determine the residual amount of moisture in the vadose zone, and to support numerical modeling efforts, if needed.
Borehole spectral logging in existing wells	Perform borehole spectral logging in accessible boreholes and groundwater wells near the crib. BHI well status records indicate that the following wells may be accessible and are appropriately configured for geophysical logging: • 299-E17-1 • 299-E-24-2 • 299-E24-59 • 299-E-24-60.	These wells represent data collection points within 30.5 m (100 ft) of the waste site. Logging of these wells will provide additional current site-specific information on contaminant distribution, both laterally and vertically for comparison to previous surveys.

Table 7-4. Key Features of the 200-PW-2 Sampling Design. (7 Pages)

Sample Collection Methodology	Key Features of Design	Basis for Sampling Design
216-A-36B Crib		
Borehole characterization	Drill one borehole to groundwater at the north end of the crib, as close as possible to the 216-A-36A Crib.	Drill a borehole to allow sampling with depth and to support geophysical logging with spectral gamma and neutron moisture tools. The location of the borehole at the north end is where contamination is expected to be the greatest and maximizes the effects that contaminants from the adjacent 216-A-36A Crib will have on the vadose zone.
	Begin with a sample at 14.5-17 ft bgs in the backfill. At the base of the crib collect a sample (24-26.5 ft). In the zone of highest contamination take a sample at 30-32.5 ft and then increase the sampling interval to approximately 10 ft and take samples at 40-42.5 ft and 53.5-56 ft. (The 53.5-56 ft sample also corresponds to the anticipated change from high to medium zones of contamination.) The next sample at 89.5-92 ft corresponds to the transition from medium to low zones of contamination. In the low contamination zone the sampling frequency is increased to 100 ft and the next sample is taken at 197.5-200 ft. Below this depth samples are taken at anticipated changes in lithology at the base of the H2 sequence (287.5-290 ft), in the Ringold Lower Mud (292-294.5 ft), and at the top of the water table (318.5-321 ft) in the Ringold Unit A sequence. (Field screening will be used in conjunction with the guidance provided above to determine actual sample depths.)	Soil samples will be used to determine COC concentrations beneath the crib and in the vadose zone. Sampling provides data for remedial action decision making, to verify the preliminary conceptual contaminant distribution mode, and to support numerical modeling. The soil sample at 14.5-17 ft bgs is critical. Samples at approximate 10 ft intervals from the base of the crib to about 56 ft are required to support the conceptual model expectation that contamination levels are predicted to drop off rapidly with increasing depth. Changes in contamination levels with depth are expected to decrease thereby allowing the sampling interval to increase with depth.
	Collect bulk density and grain-size distribution samples at major changes in lithology. Collect moisture samples with the other physical property samples.	Soil physical properties (e.g., moisture content, grain-size distribution, and bulk density) will be used to support contaminant transport modeling, if needed.
	Perform spectral logging for the entire length of the borehole.	SGL provides a continuous gamma-emitting radiological contaminant distribution profile with depth that will be used as supplemental information to soil samples. All of this information will be used to refine the preliminary conceptual contaminant distribution model.
	Perform neutron moisture logging for the entire length of the borehole.	Collect soil moisture data to determine the residual amount of moisture in the vadose zone, and to support numerical modeling efforts, if needed.

Table 7-4. Key Features of the 200-PW-2 Sampling Design. (7 Pages)

Sample Collection Methodology	Key Features of Design	Basis for Sampling Design
Borehole spectral logging in existing wells	Perform borehole spectral logging in accessible boreholes and groundwater wells near the crib. BHI well status records indicate that the following wells may be accessible are appropriately configured for geophysical logging: • 299-E17-5 • 299-E17-11 • 299-E17-51.	These wells represent data collection points within 7.6 m (25 ft) of the waste site or are within the waste site boundary. Logging of these wells will provide additional current site-specific information on contaminant distribution, both laterally and vertically for comparison to previous surveys.

7.5 POTENTIAL SAMPLE DESIGN LIMITATIONS

- Drilling impediments (e.g., boulders) may be encountered and/or insufficient sample volumes may be retrieved from the split-spoon samplers. The list of analytes will be prioritized in the SAP to account for insufficient sample volume.

- The 216-B-12 Crib has the potential for cave-in. Safety considerations associated with borehole installation may require additional equipment (e.g., a bridge structure or relocation of the borehole to a safer zone not directly through the crib structure), which may impact the sampling location and quality.

- Because the potential exists for significant concentrations of radiological COCs, samples may need to be analyzed in an onsite laboratory. In this case, expected impacts include high analytical costs, degradation of detection limits, reduced analyte lists, and long turnaround times. Sample volumes may be reduced if the radiation levels are high for the samples.

- Geophysical logging of existing boreholes is dependent on accessibility and configuration of the boreholes. If the specified boreholes are not properly configured or available for logging, other boreholes may be considered or the logging program may be reduced.

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