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Section 2 of 4

Document Information			
Document #	DOE/RL-2004-85	REV	DFTA
Title	FEASIBILITY STUDY FOR THE 200-PW-2 URANIUM RICH PROCESS WASTE GROUP & 200-PW-4 GENERAL PROCESS CONDENSATE WASTE GROUP OU [DRAFT A]		
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8.0 CONCLUSIONS AND PATH FORWARD

This chapter summarizes the results of FS evaluations, presents the path forward for the 200-PW-2 and 200-PW-4 OU waste sites, and identifies the preferred alternatives for remediation of the waste sites.

8.1 FEASIBILITY STUDY SUMMARY

The five remedial alternatives evaluated for the 200-PW-2 and 200-PW-4 OU waste sites are as follows:

- Alternative 1 – No Action
- Alternative 2 – Maintain Existing Soil Cover, Monitored Natural Attenuation, and Institutional Controls
- Alternative 3 – Removal, Treatment, and Disposal
- Alternative 4 – Engineered Surface Barrier
- Alternative 5 – Partial Removal, Treatment, and Disposal with Engineered Surface Barrier.

Tables 8-1 through 8-6 identify the preferred remediation alternative for each representative site and associated analogous waste sites within the 200-PW-2 and 200-PW-4 OUs. These tables also provide summary justification for the preferred alternative selection based on the assumptions and the detailed and comparative analyses presented in Chapters 6.0 and 7.0 of this FS.

Only 7 out of 38 waste sites within these 2 OUs have been characterized. Additionally, the structural configuration of the representative sites, as compared to some analogous sites, may be significantly different (e.g., cribs to tanks, trenches to UPR sites). For these reasons, the preferred remediation alternative for a representative site may not necessarily be the preferred alternative for its analogous site. Thus, if an analogous site has an option between two alternatives that comply with the CERCLA threshold and balancing criteria (equally), the lower cost option is selected.

8.1.1 Representative Site 207-A South Retention Basin and its Analogous Waste Sites

The 207-A South Retention Basin, located administratively within the 200-PW-4 OU, is the representative site for the following waste site:

- 200-W-22 Site Group.

The 207-A South Retention Basin does not exceed any PRGs. The preferred remedy for this representative site is Alternative 1 – No Action, because this alternative meets all RAOs and is the most cost-effective.

For the 200-W-22 waste site, the preferred remedy is Alternative 3 – Removal, Treatment, and Disposal for the UPRs associated with the waste site and subgrade structures. Alternative 3 removes all contaminants necessary to meet PRGs and is protective of human health, the environment, and groundwater; is implementable with minimal worker risk; and provides the best long-term effectiveness for the cost.

Table 8-1 provides a summary of the analysis of alternatives supporting the selection of the preferred alternatives for this group of waste sites.

8.1.2 Representative Site 216-A-10 Crib and its Analogous Waste Sites

The 216-A-10 Crib, located administratively within the 200-PW-2 OU, is the representative site for the following analogous waste sites:

- 216-A-5 Crib
- 216-A-45 Crib
- 216-C-1 Crib
- 200-E-58 Neutralization Tank.

Currently, the 216-A-10 Crib exceeds groundwater protection PRGs because elevated concentrations are found throughout the soil column to approximately 19 m (63 ft) belowground surface (bgs). The preferred remedy for this representative site is Alternative 4 – Engineered Surface Barrier, because this alternative is protective of human health, the environment, and groundwater; complies with ARARs; is implementable with minimal worker risk; and is cost-effective.

For the 216-A-5 and 216-A-45 Cribs, the preferred remedy is Alternative 4 – Engineered Surface Barrier. Alternative 4 is protective of human health, the environment, and groundwater; complies with ARARs; is implementable with minimal worker risk; and is cost-effective.

For the 216-C-1 Crib, the preferred remedy is Alternative 3 – Removal, Treatment, and Disposal. Alternative 3 removes all contaminants exceeding PRGs and is cost-effective.

For the 200-E-58 Neutralization Tank, the preferred remedy is Alternative 3 – Removal, Treatment, and Disposal. Alternative 3 removes all contaminants necessary to meet PRGs and therefore is protective of human health, the environment, and groundwater; is implementable with minimal worker risk; and is cost-effective.

Table 8-2 provides a summary of the analysis of alternatives supporting the selection of the preferred alternatives for this group of waste sites.

8.1.3 Representative Site 216-A-19 Trench and its Analogous Waste Sites

The 216-A-19 Trench, located administratively within the 200-PW-2 OU, is the representative site for the following analogous waste sites:

- 216-A-1 Crib
- 216-A-3 Crib
- 216-A-18 Trench
- 216-A-20 Trench
- 216-A-22 French Drain
- UPR-200-E-17
- 216-A-28 Crib
- 216-A-34 Ditch
- 216-S-8 Trench
- UPR-200-E-145.

Currently, the 216-A-19 Trench exceeds groundwater protection and ecological wildlife PRGs for total uranium and groundwater protection PRGs for nitrates. The preferred remedy for this representative site is Alternative 3 – Removal, Treatment, and Disposal, because excavation to approximately 11 m (36 ft) should be sufficient to remove contamination having potential to adversely affect human health and/or the groundwater. This alternative is protective of human health, the environment, and groundwater; complies with ARARs; is implementable with minimal worker risk; and is cost-effective.

For the 216-A-1, 216-A-3, 216-A-20, 216-A-22, UPR-200-E-17, 216-A-28, and UPR-200-E-145 analogous waste sites, the preferred remedy also is Alternative 3 – Removal, Treatment, and Disposal. Alternative 3 removes all contaminants necessary to meet PRGs and therefore is protective of human health, the environment, and groundwater; is implementable with minimal worker risk; and is cost-effective. Alternative 3 is recommended for the 216-A-28 Crib despite its cost being significantly greater than other alternatives, because of its large quantity of uranium (682 kg according to RPP-26744, *Soil Inventory Model*) that eventually could reach groundwater if Alternative 4 or 5 were employed.

For the 216-A-34 Ditch, the preferred remedy is Alternative 2, Maintain Existing Soil Cover, Monitored Natural Attenuation, and Institutional Controls. This waste site has no reportable contaminant inventory. Any contamination is expected to minor, which would decay to acceptable levels within a few decades.

For the 216-A-18 Trench, the preferred remedy is Alternative 3, despite its cost being substantially greater. This waste contains a large quantity of uranium (682 kg per RPP-26744), which could eventually reach groundwater.

For the 216-S-8 Trench, the preferred remedy is Alternative 2 – Maintain Existing Soil Cover, Monitored Natural Attenuation, and Institutional Controls. Recent inventory estimate (RPP-26744) indicates minimal uranium and fission product inventories. Only nitrate poses a potential threat to groundwater. This alternative is cost-effective and provides assurance that groundwater will be protected, if necessary.

Table 8-3 provides a summary of the analysis of alternatives supporting the selection of the preferred alternatives for this group of waste sites.

8.1.4 Representative Site 216-A-36B Crib and its Analogous Waste Sites

The 216-A-36B Crib, located administratively within the 200-PW-2 OU, is the representative site for the following waste sites:

- 216-A-36A Crib
- UPR-200-E-39.

Currently, the 216-A-36B Crib exceeds total uranium, nitrates, and Tc-99 groundwater protection PRGs because elevated concentrations are found throughout the soil column to approximately 92 m (303 ft) bgs. The preferred remedy for this representative site is Alternative 5 – Partial Removal, Treatment, and Disposal with Engineered Barrier. The excavation portion of this alternative would remove high concentrations of Cs-137, Pu, and Am-241, which represent a potential intruder risk, and much of the uranium, which is a potential groundwater threat. This alternative is protective of human health, the environment, and groundwater; complies with ARARs; is implementable with minimal worker risk; and is cost-effective.

For the 216-A-36A Crib, the preferred remedy also is Alternative 5 – Partial Removal, Treatment, and Disposal with Engineered Surface Barrier. Alternative 5 is protective of human health, the environment, and groundwater; complies with ARARs; is implementable with minimal worker risk; and is cost-effective.

For the UPR-200-E-39 waste site, the preferred remedy is Alternative 3 – Removal, Treatment, and Disposal. Even if the Plutonium-Uranium Extraction (PUREX) zone closure remedy provides an engineered barrier for the 202-A Building and this waste site is incorporated under that barrier, Alternative 3 would be most protective. Alternative 3 removes all contaminants necessary to meet PRGs and therefore is protective of human health, groundwater, and the environment; is implementable at the waste site; and is the next lowest-cost alternative.

Table 8-4 provides a summary of the analysis of alternatives supporting the selection of the preferred alternatives for this group of waste sites.

8.1.5 Waste Site 216-A-37-1 Crib

The 216-A-37-1 Crib, located administratively within the 200-PW-4 OU, currently is not a representative site for any analogous waste sites. This site is a RCRA TSD unit and was characterized to facilitate RCRA closure/postclosure.

Currently, the 216-A-37-1 Crib exceeds groundwater protection PRGs because elevated concentrations of nitrates are found throughout the soil column to approximately 8 m (25 ft) bgs. The preferred remedy for this representative site is Alternative 2 – Maintain Existing Soil Cover, Monitored Natural Attenuation, and Institutional Controls. The only contaminant of significance at this waste site is nitrate at concentrations not expected to adversely impact groundwater. This alternative is protective of human health, the environment, and groundwater; complies with ARARs; is implementable with minimal worker risk; and is cost-effective.

Table 8-5 provides a summary of the analysis of alternatives supporting the selection of the preferred alternative for this waste site.

8.1.6 Representative Site 216-B-12 Crib and its Analogous Waste Sites

The 216-B-12 Crib, located administratively within the 200-PW-2 OU, is the representative site for the following waste sites:

- 216-B-60 Crib
- 216-C-3 Crib
- 216-C-5 Crib
- 216-C-7 Crib
- 216-C-10 Crib
- 209-E-WS-3 Valve Pit and Hold-Up Tank
- 270-E-1 Neutralization Tank
- UPR-200-E-64.

Currently, the 216-B-12 Crib exceeds groundwater protection PRGs for nitrates and total uranium because elevated concentrations are found throughout the soil column to approximately 59 m (192 ft) bgs. The preferred remedy for this representative site is Alternative 4 – Engineered Surface Barrier, because this alternative is protective of human health, the environment, and groundwater; complies with ARARs; is implementable with minimal worker risk; and is cost-effective.

For the 216-C-3, 216-C-5, 216-C-7, 216-C-10, 209-E-WS-3, and 270-E-1 waste sites, the preferred remedy is Alternative 3 – Removal, Treatment, and Disposal. Alternative 3 removes all contaminants necessary to meet PRGs and therefore is protective of human health, the environment, and groundwater; is implementable with minimal worker risk; and is cost-effective.

For the 216-B-60 Crib, the preferred remedy is Alternative 2 – Maintain Existing Soil Cover, Monitored Natural Attenuation, and Institutional Controls. This deep (~12.2 m [~40 ft]) waste site is beneath the 225-B Facility (Waste Encapsulation and Storage Facility) and its inventory is believed to be mostly solid material that is confined to the waste site structure. Furthermore, the most recent inventory estimate indicates minimal contaminant presence (RPP-26744).

For the UPR-200-E-64 waste site, where speck contamination has been spread by ants and wind, the preferred alternative is Alternative 2 – Maintain Existing Soil Cover, Monitored Natural Attenuation, and Institutional Controls. This 8,100 m^2 (2-a) site is contaminated with low concentrations of Cs-137 and Sr-90 that are expected to decay to acceptable levels in a few decades. Excavation of the 270-E-1 Neutralization Tank, as recommended above, will remove the source of contamination for the UPR-200-E-64 waste site.

Table 8-6 provides a summary of the analysis of alternatives supporting the selection of the preferred alternatives for this group of waste sites.

8.1.7 Representative Site 216-S-7 Crib and its Analogous Waste Sites

The 216-S-7 Crib, located administratively within the 200-PW-2 OU, is the representative site for the following waste sites:

- 216-S-1&2 Cribs
- UPR-200-W-36
- 216-S-4 French Drain
- 216-S-22 Crib
- 216-S-23 Crib
- 216-T-20 Trench.

Currently, the 216-S-7 Crib exceeds groundwater protection PRGs for nitrates and total uranium because elevated concentrations are found throughout the soil column to approximately 69 m (226 ft) bgs. The preferred remedy for this representative site is Alternative 5 – Partial Removal, Treatment, and Disposal with Engineered Barrier. This alternative is protective of human health, the environment, and groundwater; complies with ARARs; is implementable with minimal worker risk; and is cost-effective.

For the 216-S-1&2 Cribs and associated UPR-200-W-36 waste sites, the preferred remedy is Alternative 4 – Engineered Surface Barrier. Alternative 4 is protective of human health, the environment, and groundwater; complies with ARARs; and is implementable with minimal worker risk. Although Alternative 5 is more costly than Alternative 4, excavation of near-surface (7.6 m [25 ft] bgs) concentrations of plutonium, americium, and uranium will mitigate future intruder and groundwater risks.

For the 216-S-4, 216-S-22, and 216-T-20 waste sites, the preferred remedy is Alternative 3 – Removal, Treatment, and Disposal. Alternative 3 removes all contaminants necessary to meet PRGs and therefore is protective of human health, the environment, and groundwater; is implementable at the waste site; and is the next lowest-cost alternative.

For the 216-S-23 Crib, the preferred remedy is Alternative 2 – Maintain Existing Soil Cover, Monitored Natural Attenuation, and Institutional Controls. This relatively deep (8.5 m [28 ft]) waste site is predicted to possess only minor inventory that should decay to acceptable levels in a few decades.

Table 8-7 provides a summary of the analysis of alternatives supporting the selection of the preferred alternatives for this group of waste sites.

8.2 CLOSURE OF RCRA TSD UNITS

The RCRA TSD units within the consolidated 200-PW-2 and 200-PW-4 OUs include the 216-A-10 Crib (200-PW-2), the 216-A-36B Crib (200-PW-2), the 207-A South Retention Basin (200-PW-4) and the 216-A-37-1 Crib (200-PW-4). These units are described in Chapter 2.0. These TSD units will undergo closure following the requirements of the Tri-Party Agreement (Ecology et al. 1989); WA7890008967; and *Washington Administrative Code* (WAC) 173-303-610.

Tri-Party Agreement Milestone M-20-33 requires submittal of closure plans for the following units by April 30, 2006. The closure strategy for each of these TSD units is as follows:

- **216-A-10 Crib.** This crib operated for disposal of mixed waste effluent from PUREX operations to the soil column. Based on the date of Ecology mixed-waste authority, this unit will undergo administrative closure in accordance with DOE/RL-2006-37, *Closure Plan for the 216-A-10 Crib.* A RCRA final status groundwater monitoring plan will not be required for this unit.

- **216-A-36B Crib.** This crib operated for disposal of mixed waste effluent generated during PUREX operations and received mixed waste containing RCRA-regulated constituents. Based on analytical data obtained during the RI and provided in the RI report (DOE/RL-2004-25), this unit qualifies for clean closure in accordance with WAC 173-303-610(2) without further physical closure activities. A plan for clean closure of this unit is provided in DOE/RL-2005-90, *Closure Plan for the 216-A-36B Crib.* A RCRA final status groundwater monitoring plan will not be required for this unit.

- **207-A South Retention Basin.** The 207-A South Retention Basin stored mixed waste effluent from the 242-A Evaporator while awaiting effluent sampling to allow its disposal to the 216-A-37-1 Crib. The effluent contained RCRA-regulated constituents. As a storage unit that is not anticipated to have contaminated soil, this unit will be clean closed. The plan for clean closure of this unit is provided in DOE/RL-2005-89, *Closure Plan for the 207-A South Retention Basin.* A RCRA final status groundwater monitoring plan will not be required for this unit.

- **216-A-37-1 Crib.** This crib operated until April 12, 1989, for disposal of mixed waste effluent generated during PUREX operations containing RCRA-regulated constituents. Based on analytical data obtained during the RI and provided in the RI report (DOE/RL-2004-25), this unit qualifies for clean closure in accordance with WAC 173-303-610(2) without further physical closure activities. A plan for clean closure of this unit is provided in DOE/RL-2005-88, *Closure Plan for the 2160A-37-1 Crib.* A RCRA final status groundwater monitoring plan will not be required for this unit.

- For the 216-A-10 Crib and 216-A-36B Crib, the recommended remedial alternative includes an engineered surface barrier. However, this barrier will not be a requirement of RCRA closure and therefore does not need to meet the RCRA requirement for construction of a cap.

8.3 PATH FORWARD

This section identifies the path forward for completion of remedy selection for the 200-PW-2 and 200-PW-4 OU waste sites.

Additional fate and transport modeling will be performed to refine groundwater protection PRGs. Because the initial PRG values are believed to be conservative, there is a potential for the remedy selection to change, particularly if PRGs increase significantly.

8.3.1 Proposed Plan, Record of Decision, Closure Plans, and Permit Modification

A proposed plan has been prepared to document the preferred alternatives for the 200-PW-2 and 200-PW-4 OU waste sites (DOE/RL 2004-86, *Proposed Plan for the 200-PW-2 Uranium-Rich Process Waste Group and 200-PW-4 General Process Condensate Waste Group Operable Units)*. The proposed plan details the closure options and documents that the waste sites will be remediated in accordance with the ROD, developed following issuance of the proposed plan.

RCRA TSD units will be closed as described in Section 8.2. The closure plans for these TSD units will be approved by incorporation of the plans into WA7890008967 through a permit modification.

8.3.2 Post-Record of Decision Sampling

The representative sites in the 200-PW-2 and 200-PW-4 OUs were evaluated in this FS based on data generated through an RI. The analogous sites for these OU waste sites were evaluated based on data generated for the representative sites, or on site-specific data. DOE/RL-98-28, *200 Areas Remedial Investigation/Feasibility Study Implementation Plan – Environmental Restoration Program*, defines this strategy as a means to streamline RIs and focus the CERCLA process to obtain a decision.

As identified in DOE/RL-98-28, additional sampling phases conducted pre- and post-ROD are meant to augment the RI data, confirm the alternative selection, support the design, and provide information for final site closeout. Post-ROD sampling will be determined through data quality objectives identification and a sampling and analysis plan that will be developed to direct the sampling needed at the analogous sites. This sampling will be used to confirm that the correct alternative has been selected and to provide design data.

Confirmatory sampling is conducted to confirm that the representative site distribution model used to evaluate the analogous site is appropriate to the site conditions and to confirm that the appropriate remedial alternative was selected. Design sampling is conducted to obtain data necessary to design the remedial alternative and refine the cost estimated for the FS. Verification sampling is conducted to verify that the remedial goals have been met by the implementation of the remedial alternative.

Table 8-8 presents the confirmatory, design, and verification sampling phases and presents assumed data needs for each sampling phase for the representative sites and for analogous sites that are similar (or equal) to the representative sites, are less contaminated (or have lower risk) than the representative sites, or are more contaminated (or have higher risk) than the representative sites (see Chapter 2.0 for additional details). This table builds off the decision logic presented in Figure 2-14 and Table 2-2 and provides a basis for initiating the data quality objectives process for the confirmatory sampling and design sampling phases.

Some of the analogous sites likely will undergo a remove and dispose alternative; these sites will use the observational approach (confirmatory sampling) during removal. Sites slated for engineered barriers will need additional data (confirmatory and design sampling) to confirm the lateral extent and to support barrier design. Sites slated for no action or continuation of existing conditions augmented by institutional controls also may need verification sampling, depending on the amount, type, and quality of data available to support these decisions. CERCLA operations and maintenance sampling could include the monitoring of natural attenuation and performance monitoring of the engineered barrier.

8.3.3 Plug-in Approach for the 200-PW-2 and 200-PW-4 Operable Unit Waste Sites

The plug-in approach is a process that helps make remedial action decisions for additional waste sites using existing CERCLA evaluations. In the future, the plug-in approach is proposed for any similar waste sites already defined within the 200-PW-2 and 200-PW-4 OUs and for newly discovered waste sites that have a similar conceptual site model to waste sites already addressed in this FS. The plug-in approach will be used on the analogous sites considered in this FS after additional data are collected in the confirmatory and design sampling phases.

The plug-in approach benefits the goal of remediating waste sites within the OUs in conjunction with the analogous site approach. The traditional CERCLA approach for remedy selection would require the development of multiple proposed plans and RODs that, for similar sites, would be nearly identical to the FSs, proposed plans, and RODs already developed and proven to be successful. The plug-in approach allows remedial actions to begin much more quickly at a waste site, without the need for redundant remedy selection processes.

8.3.3.1 Required Elements of the Plug-in Approach

The plug-in approach requires three main elements to establish its use as a cost-effective tool for remediation.

- Multiple sites must exist that share common physical and contaminant characteristics, referred to as the conceptual site model.
- A remedial alternative or standard remedy must exist that has been shown to be protective and cost-effective for sites that share the common conceptual site model.
- Sites sharing a common conceptual site model must require remedial action because of contaminant concentrations that pose risk to human health and the environment.

To use the plug-in approach for a waste site not evaluated in the FS, the site must fit the defined conceptual model and must be shown to require remedial action. The site then can be "plugged in" to the standard remedy.

The following information describes how the plug-in approach is proposed for remedy selection.

8.3.3.2 Applying the Plug-in Approach for Remedy Selection

Post-ROD sampling will be determined through data quality objectives identification and a sampling and analysis plan that will be developed to direct the sampling needed at the analogous sites. This sampling will be used to confirm that the correct alternative has been selected and to provide design data.

8.3.3.2.1 Establishing the Conceptual Site Model

Conceptual site models have been defined based on the site characteristics contained in the FS. These characteristics include the following:

- Type of contaminant inventory
- Concentrations of contaminants in environmental media
- Types of contaminated environmental media (soil) or material (e.g., concrete, metal, wood)
- Extent of contamination within the environment (i.e., the depth of discharge, the expected contaminant distributions, and the potential for hydrologic and contaminant impacts to groundwater).

Based on the representative sites evaluated in the FS, the following initial five conceptual site models were developed.

- Waste sites where no hazardous material was disposed at the waste site or where, with confirmatory sampling, contaminants disposed of currently meet the RAOs. Standard remedy is defined as Alternative 1 – No Action.
- Waste sites where limited contamination exists at the waste sites, an existing soil cover is in place and of sufficient thickness to provide protection, contaminants are expected to meet the RAOs during the institutional control period (150 years), and groundwater PRGs are not exceeded. Contaminated environmental media include soil, solid waste, debris, and materials (e.g., timbers and vent pipes) associated with the waste sites. The standard remedy is defined as Alternative 2 – Maintain Existing Soil Cover, Monitored Natural Attenuation, and Institutional Controls.
- Waste sites where contaminants exceed the RAOs and removal, treatment, and disposal of contamination can be readily implementable and is cost-effective. Typically, these contaminants exceed the human health and ecological PRGs; however, groundwater PRGs are not exceeded at depths that make excavation impracticable. Contaminated

environmental media include soil, solid waste, debris, and materials (e.g., timbers and vent pipes) associated with the waste sites. The standard remedy is defined as Alternative 3 – Removal, Treatment, and Disposal.

- Waste sites where contaminants exceed the RAOs, where contaminants are at concentrations that pose a significant worker risk, and where contaminants having potential to adversely affect groundwater are at significant depth. Contaminated environmental media include soil, solid waste, debris, and materials (e.g., timbers and vent pipes) associated with the waste sites. The standard remedy is defined as Alternative 4 – Engineered Surface Barrier.

- Waste sites where readily accessible contaminants exceed the human-health RAOs or represent a significant potential intruder threat, and where the contaminants having potential to adversely affect groundwater are at significant depth. This is not applicable to sites where contaminants are in the shallow layer with no deep component or where contamination is deep with no shallow component. Contaminated environmental media include soil, solid waste, debris, and materials (e.g., timbers and vent pipes) associated with the waste sites. The standard remedy is defined as Alternative 5 – Partial Removal, Treatment, and Disposal with Engineered Surface Barrier.

8.3.3.2.2 Establishing the Need for Remedial Action

Waste sites that share a common conceptual site model will "plug-in" to the standard remedy if they are determined to require remedial action due to a risk to human health and the environment (based on the previously defined RAOs and associated PRGs). Some of the waste sites in the 200-PW-2 OU and 200-PW-4 OU likely will require confirmatory sampling to validate the conceptual site model and the identified preferred remedy. The preferred remedy will be implemented following confirmation of the conceptual site model. Should the confirmatory sampling indicate variations in the defined conceptual site model, this plug-in approach will be used to define the appropriate remedy.

8.4 PUBLIC INVOLVEMENT IN THE PLUG-IN APPROACH

To ensure that the public is meaningfully involved in the application of the plug-in approach, the DOE, EPA, and Ecology will publish explanations of significant differences at the following points in the plug-in process:

- When newly discovered waste sites are proven through analysis to be above remediation goals and can plug in to the standard remedy

- When confirmatory sampling identified for the waste sites discussed herein indicates variations in the defined conceptual site model such that the preferred remedy is no longer protective.

Table 8-1. Preferred Alternative for the Representative Site 207-A South Retention Basin and its Analogous Waste Site[e] (costs in $1,000). (2 Pages)

Comparison of Alternatives - Representative Site 207-A South Retention Basin and Associated Analogous Site					
Criteria for Representative and Analogous Waste Sites	Alternatives				
	① No Action	② MESC, MNA, IC[a]	③ RTD[b]	④ Barrier	⑤ RTD/ Barrier[d]
Representative Site 207-A South Retention Basin	☑				
Threshold Criteria					
Overall protection	☑	☑	☑	☑	N/A
Compliance with ARARs	☑	☑	☑	☑	N/A
Balancing Criteria					
Long-term effectiveness	Best	Best	Best	Best	N/A
Short-term effectiveness	Best	Moderate	Moderate	Moderate	N/A
Reduction in TMV[c]	Least	Least	Least	Least	N/A
Implementability	Best	Moderate	Moderate	Moderate	N/A
Cost (in thousands)					
Capital costs	$0	$35	$724	$738	N/A
Operating and maintenance costs	$0	$4,000	$0	$3,996	N/A
Non-discounted costs	$0	$4,031	$724	$4,733	N/A
Total present worth	$0	$868	$724	$1,571	N/A
Analogous Site 200-W-22 Site Group, Including Subgrade Structures			☑		
Threshold Criteria					
Overall protection	☐	☑	☑	☑	N/A
Compliance with ARARs	☐	☑	☑	☑	N/A
Balancing Criteria					
Long-term effectiveness	Least	Best	Best	Best	N/A
Short-term effectiveness	Least	Best	Best	Moderate	N/A
Reduction in TMV	Least	Least	Least	Least	N/A
Implementability	Best	Best	Moderate	Moderate	N/A
Cost (in thousands)					
Capital costs	$0	$35	$2,070	$1,829	N/A
Operating and maintenance costs	$0	$888	$0	$7,362	N/A
Non-discounted costs	$0	$4,923	$2,070	$9,191	N/A
Total present worth	$0	$1,057	$2,070	$3,378	N/A

Table 8-1. Preferred Alternative for the Representative Site 207-A South Retention Basin and its Analogous Waste Site[e] (costs in $1,000). (2 Pages)

Comparison of Alternatives - Representative Site 207-A South Retention Basin and Associated Analogous Site	
	Alternatives

[a]Maintain existing soil cover, monitored natural attenuation, and institutional controls.
[b]Removal, treatment, and disposal.
[c]Toxicity, mobility, or volume through treatment.
[d]Partial removal, treatment, and disposal with barrier.
[e]The choice of the preferred alternative is based on information at the writing of this feasibility study. The preferred alternative may be revised based on future characterization activities at the analogous sites.

☒ = Indicates the preferred alternative (e).
☑ = Yes, meets threshold criterion.
☐ = No, does not meet threshold criterion.

ARAR = applicable or relevant and appropriate requirement.
IC = institutional controls.
MESC = maintain existing soil cover.
MNA = monitored natural attenuation.
N/A = not applicable.
RTD = removal, treatment, and disposal.
TMV = toxicity, mobility, or volume through treatment.

Table 8-2. Preferred Alternative for the Representative Site 216-A-10 Crib and its Analogous Waste Sites[e] (costs in $1,000). (3 Pages)

Comparison of Alternatives - Representative Site 216-A-10 Crib and Associated Analogous Sites					
	Alternatives				
Criteria for Representative and Analogous Waste Sites	① No Action	② MESC, MNA, IC[a]	③ RTD[b]	④ Barrier	⑤ RTD/ Barrier[d]
Representative Site 216-A-10 Crib				☑	
Threshold Criteria					
Overall protection	☐	☐	☑	☑	☑
Compliance with ARARs	☐	☐	☑	☑	☑
Balancing Criteria					
Long-term effectiveness	Least	Least	Best	Moderate	Moderate
Short-term effectiveness	Best	Moderate	Least	Moderate	Moderate
Reduction in TMV[c]	Least	Least	Least	Least	Least
Implementability	Best	Best	Moderate	Moderate	Moderate
Cost (in thousands)					
Capital costs	$0	$35	$11,215	$747	$9,111
Operating and maintenance costs	$0	$3,984	$0	$4,149	$4,168
Non-discounted costs	$0	$4,020	$11,215	$4,896	$13,279
Total present worth	$0	$866	$11,215	$1,613	$9,980
Analogous Site 216-A-5 Crib				☑	
Threshold Criteria					
Overall protection	☐	☐	☑	☑	☑
Compliance with ARARs	☐	☐	☑	☑	☑
Balancing Criteria					
Long-term effectiveness	Least	Least	Best	Moderate	Moderate
Short-term effectiveness	Best	Moderate	Least	Moderate	Moderate
Reduction in TMV[c]	Least	Least	Least	Least	Least
Implementability	Best	Best	Moderate	Moderate	Moderate
Cost (in thousands)					
Capital costs	$0	$35	$2,714	$483	$2,228
Operating and maintenance costs	$0	$3,984	$0	$3,984	$4,004
Non-discounted costs	$0	$4,020	$2,714	$4,468	$6,232
Total present worth	$0	$866	$2,714	$1,314	$3,062
Analogous Site 216-A-45 Crib				☑	
Threshold Criteria					
Overall protection	☐	☐	☑	☑	☑
Compliance with ARARs	☐	☐	☑	☑	☑
Balancing Criteria					
Long-term effectiveness	Least	Least	Best	Best	Moderate
Short-term effectiveness	Best	Moderate	Least	Moderate	Moderate
Reduction in TMV[c]	Least	Least	Least	Least	Least
Implementability	Best	Best	Moderate	Moderate	Moderate

Table 8-2. Preferred Alternative for the Representative Site 216-A-10 Crib and its Analogous Waste Sites[c] (costs in $1,000). (3 Pages)

Comparison of Alternatives - Representative Site 216-A-10 Crib and Associated Analogous Sites					
	Alternatives				
Criteria for Representative and Analogous Waste Sites	① No Action	② MESC, MNA, IC[a]	③ RTD[b]	④ Barrier	⑤ RTD/ Barrier[d]
Cost (in thousands)					
Capital costs	$0	$35	$15,810	$850	$9,131
Operating and maintenance costs	$0	$3,984	$0	$4,686	$4,004
Non-discounted costs	$0	$4,020	$15,810	$5,535	$13,135
Total present worth	$0	$866	$15,810	$1,830	$9,965
Analogous Site 216-C-1 Crib			☑		
Threshold Criteria					
Overall protection	☐	☐	☑	☑	☑
Compliance with ARARs	☐	☐	☑	☑	☑
Balancing Criteria					
Long-term effectiveness	Least	Least	Best	Moderate	Moderate
Short-term effectiveness	Best	Moderate	Least	Moderate	Least
Reduction in TMV[c]	Least	Least	Least	Least	Least
Implementability	Best	Best	Moderate	Moderate	Moderate
Cost (in thousands)					
Capital costs	$0	$35	$1,677	$460	$1,190
Operating and maintenance costs	$0	$4,042	$0	$4,042	$4,042
Non-discounted costs	$0	$4,078	$1,677	$4,502	$5,232
Total present worth	$0	$877	$1,677	$1,301	$2,031
Analogous Site 200-E-58 Neutralization Tank			☑		
Threshold Criteria					
Overall protection	☐	☐	☑	☑	N/A
Compliance with ARARs	☐	☐	☑	☑	N/A
Balancing Criteria					
Long-term effectiveness	Least	Moderate	Best	Moderate	N/A
Short-term effectiveness	Best	Moderate	Least	Moderate	N/A
Reduction in TMV	Least	Least	Least	Least	N/A
Implementability	Best	Moderate	Moderate	Moderate	N/A
Cost (in thousands)					
Capital costs	$0	$35	$812	$463	N/A
Operating and maintenance costs	$0	$3,984	$0	$3,984	N/A
Non-discounted costs	$0	$4,020	$812	$4,447	N/A
Total present worth	$0	$866	$812	$1,294	N/A

Table 8-2. Preferred Alternative for the Representative Site 216-A-10 Crib and its Analogous Waste Sites[e] (costs in $1,000). (3 Pages)

Comparison of Alternatives - Representative Site 216-A-10 Crib and Associated Analogous Sites					
Criteria for Representative and Analogous Waste Sites	Alternatives				
	① No Action	② MESC, MNA, IC[a]	③ RTD[b]	④ Barrier	⑤ RTD/ Barrier[d]

[a]Maintain existing soil cover, monitored natural attenuation, and institutional controls.
[b]Removal, treatment, and disposal.
[c]Toxicity, mobility, or volume through treatment.
[d]Partial removal, treatment, and disposal with barrier.
[e]The choice of the preferred alternative is based on information at the writing of this feasibility study. The preferred alternative may be revised based on future characterization activities at the analogous sites.

☑ = Indicates the preferred alternative (e).
☑ = Yes, meets threshold criterion.
☐ = No, does not meet threshold criterion.

ARAR = applicable or relevant and appropriate requirement.
IC = institutional controls.
MESC = maintain existing soil cover.
MNA = monitored natural attenuation.
N/A = not applicable.
RTD = removal, treatment, and disposal.
TMV = toxicity, mobility, or volume through treatment.

Table 8-3. Preferred Alternatives for the Representative Site 216-A-19 Trench and its Analogous Waste Sites[e] (costs in $1,000). (4 Pages)

Comparison of Alternatives - Representative Site 216-A-19 Trench and Associated Analogous Sites					
	Alternatives				
Criteria for Representative and Analogous Waste Sites	① No Action	② MESC, MNA, IC[a]	③ RTD[b]	④ Barriers	⑤ RTD/ Barrier[d]
Representative Site 216-A-19 Trench			☑		
Threshold Criteria					
Overall protection	☐	☐	☑	☑	☑
Compliance with ARARs	☐	☐	☑	☑	☑
Balancing Criteria					
Long-term effectiveness	Least	Least	Best	Moderate	Moderate
Short-term effectiveness	Moderate	Best	Least	Moderate	Moderate
Reduction in TMV[c]	Least	Least	Least	Least	Least
Implementability	Best	Best	Moderate	Moderate	Moderate
Cost (in thousands)					
Capital costs	$0	$35	$3,368	$469	$1,566
Operating and maintenance costs	$0	$3,996	$0	$3,996	$3,996
Non-discounted costs	$0	$4,031	$3,368	$4,465	$5,561
Total present worth	$0	$868	$3,368	$1,302	$2,399
Analogous Site 216-A-1 Crib			☑		
Threshold Criteria					
Overall protection	☐	☐	☑	☑	☑
Compliance with ARARs	☐	☐	☑	☑	☑
Balancing Criteria					
Long-term effectiveness	Least	Least	Best	Moderate	Moderate
Short-term effectiveness	Moderate	Best	Least	Moderate	Moderate
Reduction in TMV	Least	Least	Least	Least	Least
Implementability	Best	Moderate	Moderate	Moderate	Moderate
Cost (in thousands)					
Capital costs	$0	$35	$2,265	$476	$1,361
Operating and maintenance costs	$0	$3,996	$0	$3,996	$3.996
Non-discounted costs	$0	$4,031	$2,265	$4,472	$5,357
Total present worth	$0	$868	$2,265	$1,309	$2,194
Analogous Site 216-A-3 Crib			☑		
Threshold Criteria					
Overall protection	☐	☐	☑	☑	☑
Compliance with ARARs	☐	☐	☑	☑	☑
Balancing Criteria					
Long-term effectiveness	Least	Least	Best	Moderate	Moderate
Short-term effectiveness	Moderate	Moderate	Least	Moderate	Moderate
Reduction in TMV	Least	Least	Least	Least	Least
Implementability	Best	Best	Moderate	Moderate	Moderate

Table 8-3. Preferred Alternatives for the Representative Site 216-A-19 Trench and its Analogous Waste Sites[e] (costs in $1,000). (4 Pages)

Comparison of Alternatives - Representative Site 216-A-19 Trench and Associated Analogous Sites					
Criteria for Representative and Analogous Waste Sites	Alternatives				
	① No Action	② MESC, MNA, IC[a]	③ RTD[b]	④ Barriers	⑤ RTD/ Barrier[d]
Cost (in thousands)					
Capital costs	$0	$35	$2,394	$461	$1,283
Operating and maintenance costs	$0	$3,984	$0	$3,984	$3,984
Non-discounted costs	$0	$4,020	$2,394	$4,446	$5,268
Total present worth	$0	$866	$2,394	$1,292	$2,114
Analogous Site 216-A-18 Trench			☑		
Threshold Criteria					
Overall protection	☐	☐	☑	☑	☑
Compliance with ARARs	☐	☐	☑	☑	☑
Balancing Criteria					
Long-term effectiveness	Least	Least	Best	Moderate	Moderate
Short-term effectiveness	Best	Best	Least	Moderate	Least
Reduction in TMV	Least	Least	Least	Least	Least
Implementability	Best	Best	Moderate	Moderate	Least
Cost (in thousands)					
Capital costs	$0	$35	$7,336	$587	$3,132
Operating and maintenance costs	$0	$3,994	$0	$3,996	$3,996
Non-discounted costs	$0	$4,031	$7,336	$4,582	$7,127
Total present worth	$0	$868	$7,336	$1,420	$3,964
Analogous Site 216-A-20 Trench (Includes Overflow Area)			☑		
Threshold Criteria					
Overall protection	☐	☐	☑	☑	☑
Compliance with ARARs	☐	☐	☑	☑	☑
Balancing Criteria					
Long-term effectiveness	Least	Least	Best	Best	Best
Short-term effectiveness	Moderate	Moderate	Least	Moderate	Moderate
Reduction in TMV	Least	Least	Least	Least	Least
Implementability	Best	Best	Moderate	Moderate	Moderate
Cost (in thousands)					
Capital costs	$0	$35	$2,404	$815	$1,661
Operating and maintenance costs	$0	$3,996	$0	$4,512	$4,512
Non-discounted costs	$0	$4,031	$2,404	$5,327	$6,173
Total present worth	$0	$868	$2,404	$1,758	$2,604
Analogous Site 216-A-22 French Drain and UPR-200-E-17			☑		
Threshold Criteria					
Overall protection	☐	☐	☑	☑	☑
Compliance with ARARs	☐	☐	☑	☑	☑
Balancing Criteria					
Long-term effectiveness	Least	Least	Best	Moderate	Moderate
Short-term effectiveness	Moderate	Moderate	Least	Moderate	Moderate

Table 8-3. Preferred Alternatives for the Representative Site 216-A-19 Trench and its Analogous Waste Sites[c] (costs in $1,000). (4 Pages)

Comparison of Alternatives - Representative Site 216-A-19 Trench and Associated Analogous Sites					
Criteria for Representative and Analogous Waste Sites	Alternatives				
	① No Action	② MESC, MNA, IC[a]	③ RTD[b]	④ Barriers	⑤ RTD/ Barrier[d]
Reduction in TMV	Least	Least	Least	Least	Least
Implementability	Best	Best	Moderate	Moderate	Moderate
Cost (in thousands)					
Capital costs	$0	$35	$1,722	$434	$1,031
Operating and maintenance costs	$0	$3,984	$0	$3,984	$3,984
Non-discounted costs	$0	$4,020	$1,722	$4,419	$5,016
Total present worth	$0	$866	$1,722	$1,265	$1,862
Analogous Site 216-A-28 Crib			☑		
Threshold Criteria					
Overall protection	☐	☐	☑	☑	☑
Compliance with ARARs	☐	☐	☑	☑	☑
Balancing Criteria					
Long-term effectiveness	Least	Least	Best	Moderate	Moderate
Short-term effectiveness	Moderate	Best	Least	Moderate	Moderate
Reduction in TMV	Least	Least	Least	Least	Least
Implementability	Best	Best	Moderate	Moderate	Moderate
Cost (in thousands)					
Capital costs	$0	$35	$1,365	$439	$947
Operating and maintenance costs	$0	$3,984	$0	$3,984	$3,984
Non-discounted costs	$0	$4,020	$1,365	$4,424	$4,932
Total present worth	$0	$866	$1,365	$1,270	$1,778
Analogous Site 216-A-34 Ditch		☑			
Threshold Criteria					
Overall protection	☐	☑	☑	☑	☑
Compliance with ARARs	☐	☑	☑	☑	☑
Balancing Criteria					
Long-term effectiveness	Least	Moderate	Best	Moderate	Moderate
Short-term effectiveness	Best	Best	Least	Moderate	Moderate
Reduction in TMV	Least	Least	Least	Least	Least
Implementability	Best	Moderate	Moderate	Moderate	Moderate
Cost (in thousands)					
Capital costs	$0	$35	$12,565	$1,015	$4,872
Operating and maintenance costs	$0	$3,996	$0	$5,657	$5,657
Non-discounted costs	$0	$4,031	$12,565	$6,671	$10,529
Total present worth	$0	$868	$12,565	$2,201	$6,058
Analogous Site 216-S-8 Trench		☑			
Threshold Criteria					
Overall protection	☐	☑[f]	☑	☑	☑
Compliance with ARARs	☐	☑[f]	☑	☑	☑

Table 8-3. Preferred Alternatives for the Representative Site 216-A-19 Trench and its Analogous Waste Sites[e] (costs in $1,000). (4 Pages)

Comparison of Alternatives - Representative Site 216-A-19 Trench and Associated Analogous Sites					
Criteria for Representative and Analogous Waste Sites	Alternatives				
	① No Action	② MESC, MNA, IC[a]	③ RTD[b]	④ Barriers	⑤ RTD/ Barrier[d]
Balancing Criteria					
Long-term effectiveness	Least	Least	Best	Moderate	Moderate
Short-term effectiveness	Best	Moderate	Least	Moderate	Moderate
Reduction in TMV	Least	Least	Least	Least	Least
Implementability	Best	Best	Moderate	Moderate	Moderate
Cost (in thousands)					
Capital costs	$0	$35	$8,431	$585	$4,580
Operating and maintenance costs	$0	$4,004	$0	$4,004	$4,004
Non-discounted costs	$0	$4,039	$8,431	$4,589	$8,584
Total present worth	$0	$870	$8,431	$1,419	$5,414
Analogous Site UPR-200-E-145			☑		
Threshold Criteria					
Overall protection	☐	☑	☑	☑	N/A
Compliance with ARARs	☐	☑	☑	☑	N/A
Balancing Criteria					
Long-term effectiveness	Least	Moderate	Best	Moderate	N/A
Short-term effectiveness	Best	Moderate	Least	Moderate	N/A
Reduction in TMV	Least	Least	Least	Least	N/A
Implementability	Best	Best	Moderate	Moderate	N/A
Cost (in thousands)					
Capital costs	$0	$35	$671	$464	N/A
Operating and maintenance costs	$0	$3,996	$0	$3,996	N/A
Non-discounted costs	$0	$4,031	$671	$4,460	N/A
Total present worth	$0	$868	$671	$1,297	N/A

[a]Maintain existing soil cover, monitored natural attenuation, and institutional controls.
[b]Removal, treatment, and disposal.
[c]Toxicity, mobility, or volume through treatment.
[d]Partial removal, treatment, and disposal with barrier.
[e]The choice of the preferred alternative is based on information at the writing of this feasibility study. The preferred alternative may be revised based on future characterization activities at the analogous sites.
[f]Most recent inventory estimate indicates minimal uranium and fission products (RPP-26744, *Hanford Soil Inventory*).

☑ = Indicates the preferred alternative (e).
☑ = Yes, meets threshold criterion.
☐ = No, does not meet threshold criterion.

ARAR = applicable or relevant and appropriate requirement.
IC = institutional controls.
MESC = maintain existing soil cover.
MNA = monitored natural attenuation.
N/A = not applicable.
RTD = removal, treatment, and disposal.
TMV = toxicity, mobility, or volume through treatment.

Table 8-4. Preferred Alternative for the Representative Site 216-A-36B Crib and its Analogous Waste Sites[e] (costs in $1,000). (2 Pages)

Comparison of Alternatives - Representative Site 216-A-36B Crib and Associated Analogous Sites					
Criteria for Representative and Analogous Waste Sites	Alternatives				
	① No Action	② MESC, MNA, IC[a]	③ RTD[b]	④ Barrier	⑤ RTD/ Barrier[d]
Representative Site 216-A-36B Crib[f]					☑
Threshold Criteria					
Overall protection	☐	☐	☑	☑	☑
Compliance with ARARs	☐	☐	☑	☑	☑
Balancing Criteria					
Long-term effectiveness	Least	Least	Best	Moderate	Best
Short-term effectiveness	Moderate	Moderate	Least	Moderate	Least
Reduction in TMV[c]	Least	Least	Least	Least	Least
Implementability	Best	Best	Moderate	Moderate	Least
Cost (in thousands)					
Capital costs	$0	$35	$100,070	$4,260	$16,957
Operating and maintenance costs	$0	$3,984	$0	$4,649	$4,649
Non-discounted costs	$0	$4,020	$100,070	$8,909	$21,607
Total present worth	$0	$866	$100,070	$5,232	$17,930
Analogous Site 216-A-36A Crib[g]					☑
Threshold Criteria					
Overall protection	☐	☐	☑	☑	☑
Compliance with ARARs	☐	☐	☑	☑	☑
Balancing Criteria					
Long-term effectiveness	Least	Least	Best	Moderate	Moderate
Short-term effectiveness	Moderate	Best	Least	Moderate	Least
Reduction in TMV[c]	Least	Least	Least	Least	Least
Implementability	Best	Best	Moderate	Moderate	Least
Cost (in thousands)					
Capital costs	$0	$35	$70,124	$3,391	$5,454
Operating and maintenance costs	$0	$3,984	$0	$3,984	$3,984
Non-discounted costs	$0	$4,020	$70,124	$7,376	$9,438
Total present worth	$0	$866	$70,124	$4,222	$6,285
Analogous Site UPR-200-E-39[h]			☑		
Threshold Criteria					
Overall protection	☐	☑	☑	☑	NA
Compliance with ARARs	☐	☑	☑	☑	NA
Balancing Criteria					
Long-term effectiveness	Least	Moderate	Best	Moderate	NA
Short-term effectiveness	Moderate	Best	Moderate	Moderate	NA
Reduction in TMV	Least	Least	Least	Least	NA
Implementability	Best	Best	Moderate	Moderate	NA

Table 8-4. Preferred Alternative for the Representative Site 216-A-36B Crib and its Analogous Waste Sites[e] (costs in $1,000). (2 Pages)

Comparison of Alternatives - Representative Site 216-A-36B Crib and Associated Analogous Sites					
Criteria for Representative and Analogous Waste Sites	Alternatives				
	① No Action	② MESC, MNA, IC[a]	③ RTD[b]	④ Barrier	⑤ RTD/ Barrier[d]
Cost (in thousands)					
Capital costs	$0	$35	$667	$677	N/A
Operating and maintenance costs	$0	$517	$0	$3,984	N/A
Non-discounted costs	$0	$552	$667	$4,661	N/A
Total present worth	$0	$421	$667	$1,508	N/A

[a]Maintain existing soil cover, monitored natural attenuation, and institutional controls.
[b]Removal, treatment, and disposal.
[c]Toxicity, mobility, or volume through treatment.
[d]Partial removal, treatment, and disposal with barrier.
[e]The choice of the preferred alternative is based on information at the writing of this feasibility study. The preferred alternative may be revised based on future characterization activities at the analogous sites.
[f]Without TRU waste removal and shipment to WIPP, Alternative 3 costs for 216-A-36B are as follows: capital cost is $94,186K, non-discounted cost is $94,186K, and present-worth cost is $87,383K.
[g]Without TRU waste removal and shipment to WIPP, Alternative 3 costs for 216-A-36A are as follows: capital cost is $65,711K, non-discounted cost is $65,711K, and present-worth cost is $61,876K.
[h]Alternative 2 costs are based on installation of a PUREX zone engineered barrier within 20 years. Without installation of the PUREX barrier, Alternative 2 costs for UPR-200-E-39 are as follows: capital cost is $35K, operating and maintenance costs are $3,984K, non-discounted cost is $4,020K, and present-worth cost is $866K.

☑ = Indicates the preferred alternative (f).
☑ = Yes, meets threshold criterion.
☐ = No, does not meet threshold criterion.

ARAR = applicable or relevant and appropriate requirement.
IC = institutional controls.
MESC = maintain existing soil cover.
MNA = monitored natural attenuation.
N/A = not applicable.
PUREX = Plutonium-Uranium Extraction (Plant).
RTD = removal, treatment, and disposal.
TMV = toxicity, mobility, or volume through treatment.
TRU = waste materials contaminated with more than 100 nCi/g of transuranic materials having half-lives longer than 20 years.
WIPP = Waste Isolation Pilot Plant.

Table 8-5. Preferred Alternative for the Waste Site 216-A-37-1 Crib[e] (costs in $1,000).

Comparison of Alternatives - Waste Site 216-A-37-1 Crib					
	Alternatives				
Criteria for Representative and Analogous Waste Sites	① No Action	② MESC, MNA, IC[a]	③ RTD[b]	④ Barrier	⑤ RTD/ Barrier[d]
Representative Site 216-A-37-1 Crib		☑			
Threshold Criteria					
Overall protection	☐	☑	☑	☑	☑
Compliance with ARARs	☐	☑	☑	☑	☑
Balancing Criteria					
Long-term effectiveness	Least	Moderate	Best	Moderate	Moderate
Short-term effectiveness	Best	Best	Least	Moderate	Least
Reduction in TMV[c]	Least	Least	Least	Least	Least
Implementability	Best	Best	Moderate	Moderate	Moderate
Cost (in thousands)					
Capital costs	$0	$35	$6,355	$1,029	$3,489
Operating and maintenance costs	$0	$3,984	$0	$5,551	$5,551
Non-discounted costs	$0	$4,020	$6,355	$6,580	$9,041
Total present worth	$0	$866	$6,355	$2,193	$4,654

[a]Maintain existing soil cover, monitored natural attenuation, and institutional controls.
[b]Removal, treatment, and disposal.
[c]Toxicity, mobility, or volume through treatment.
[d]Partial removal, treatment, and disposal with barrier.
[e]The choice of the preferred alternative is based on information at the writing of this feasibility study. The preferred alternative may be revised based on future characterization activities at the analogous sites.

☑ = Indicates the preferred alternative (e).
☑ = Yes, meets threshold criterion.
☐ = No, does not meet threshold criterion.

ARAR = applicable or relevant and appropriate requirement.
IC = institutional controls.
MESC = maintain existing soil cover.
MNA = monitored natural attenuation.
RTD = removal, treatment, and disposal.
TMV = toxicity, mobility, or volume through treatment.

Table 8-6. Preferred Alternative for the Representative Site 216-B-12 Crib and its Analogous Waste Sites[c] (costs in $1,000). (4 Pages)

Comparison of Alternatives - Representative Site 216-B-12 Crib and Associated Analogous Sites					
Criteria for Representative and Analogous Waste Sites	Alternatives				
	① No Action	② MESC, MNA, IC[a]	③ RTD[b]	④ Barrier	⑤ RTD/ Barrier[d]
Representative Site 216-B-12 Crib				☑	
Threshold Criteria					
Overall protection	☐	☐	☑	☑	☑
Compliance with ARARs	☐	☐	☑	☑	☑
Balancing Criteria					
Long-term effectiveness	Least	Least	Best	Moderate	Moderate
Short-term effectiveness	Moderate	Best	Least	Moderate	Moderate
Reduction in TMV[e]	Least	Least	Least	Least	Least
Implementability	Best	Best	Moderate	Moderate	Moderate
Cost (in thousands)					
Capital costs	$0	$35	$41,231	$637	$15,988
Operating and maintenance costs	$0	$3,995	$0	$3,995	$3,996
Non-discounted costs	$0	$4,030	$41,231	$4,632	$19,983
Total present worth	$0	$868	$41,231	$1,470	$16,821
Analogous Site 216-B-60 Crib		☑			
Threshold Criteria					
Overall protection	☐	☑[f]	☑	☑	☑
Compliance with ARARs	☐	☑[f]	☑	☑	☑
Balancing Criteria					
Long-term effectiveness	Least	Best	Best	Moderate	Moderate
Short-term effectiveness	Moderate	Best	Least	Moderate	Moderate
Reduction in TMV	Least	Least	Least	Least	Least
Implementability	Best	Best	Least	Least	Least
Cost (in thousands)					
Capital costs	$0	$35	$5,433	$464	$4,556
Operating and maintenance costs	$0	$3,995	$0	$3,995	$3,996
Non-discounted costs	$0	$4,030	$5,433	$4,459	$8,552
Total present worth	$0	$868	$5,433	$1,297	$5,389
Analogous Site 216-C-3 Crib			☑		
Threshold Criteria					
Overall protection	☐	☐	☑	☑	☑
Compliance with ARARs	☐	☐	☑	☑	☑
Balancing Criteria					
Long-term effectiveness	Least	Least	Best	Moderate	Moderate
Short-term effectiveness	Moderate	Best	Least	Moderate	Moderate
Reduction in TMV	Least	Least	Least	Least	Least
Implementability	Best	Best	Moderate	Moderate	Moderate

Table 8-6. Preferred Alternative for the Representative Site 216-B-12 Crib and its Analogous Waste Sites[e] (costs in $1,000). (4 Pages)

Comparison of Alternatives - Representative Site 216-B-12 Crib and Associated Analogous Sites					
	Alternatives				
Criteria for Representative and Analogous Waste Sites	① No Action	② MESC, MNA, IC[a]	③ RTD[b]	④ Barrier	⑤ RTD/ Barrier[d]
Cost (in thousands)					
Capital costs	$0	$35	$2,718	$474	$1,215
Operating and maintenance costs	$0	$4,042	$0	$4,042	$3,965
Non-discounted costs	$0	$4,078	$2,718	$4,516	$5,179
Total present worth	$0	$877	$2,718	$1,315	$2,043
Analogous Site 216-C-5 Crib			☑		
Threshold Criteria					
Overall protection	☐	☐	☑	☑	☑
Compliance with ARARs	☐	☐	☑	☑	☑
Balancing Criteria					
Long-term effectiveness	Least	Least	Best	Moderate	Moderate
Short-term effectiveness	Moderate	Best	Least	Moderate	Moderate
Reduction in TMV	Least	Least	Least	Least	Least
Implementability	Best	Best	Moderate	Moderate	Moderate
Cost (in thousands)					
Capital costs	$0	$35	$2,622	$447	$1,238
Operating and maintenance costs	$0	$4,042	$0	$4,042	$4,042
Non-discounted costs	$0	$4,078	$2,622	$4,490	$5,280
Total present worth	$0	$877	$2,622	$1,289	$2,079
Analogous Site 216-C-7 Crib			☑		
Threshold Criteria					
Overall protection	☐	☐	☑	☑	☑
Compliance with ARARs	☐	☐	☑	☑	☑
Balancing Criteria					
Long-term effectiveness	Least	Least	Best	Moderate	Moderate
Short-term effectiveness	Moderate	Best	Least	Moderate	Moderate
Reduction in TMV	Least	Least	Least	Least	Least
Implementability	Best	Best	Moderate	Moderate	Moderate
Cost (in thousands)					
Capital costs	$0	$35	$2,681	$462	$1,207
Operating and maintenance costs	$0	$4,042	$0	$4,042	$4,042
Non-discounted costs	$0	$4,078	$2,681	$4,504	$5,249
Total present worth	$0	$877	$2,681	$1,303	$2,048
Analogous Site 216-C-10 Crib			☑		
Threshold Criteria					
Overall protection	☐	☐	☑	☑	☑
Compliance with ARARs	☐	☐	☑	☑	☑

Table 8-6. Preferred Alternative for the Representative Site 216-B-12 Crib and its Analogous Waste Sites[c] (costs in $1,000). (4 Pages)

Comparison of Alternatives - Representative Site 216-B-12 Crib and Associated Analogous Sites					
	Alternatives				
Criteria for Representative and Analogous Waste Sites	① No Action	② MESC, MNA, IC[a]	③ RTD[b]	④ Barrier	⑤ RTD/ Barrier[d]
Balancing Criteria					
Long-term effectiveness	Least	Least	Best	Moderate	Moderate
Short-term effectiveness	Moderate	Best	Least	Moderate	Moderate
Reduction in TMV	Least	Least	Least	Least	Least
Implementability	Best	Best	Moderate	Moderate	Moderate
Cost (in thousands)					
Capital costs	$0	$35	$2,470	$451	$1,041
Operating and maintenance costs	$0	$4,042	$0	$4.042	$4,042
Non-discounted costs	$0	$4,078	$2,470	$4,493	$5,083
Total present worth	$0	$877	$2,470	$1,292	$1,882
Analogous Site 209-E-WS-3 Valve Pit and Hold-Up Tank			☑		
Threshold Criteria					
Overall protection	☐	☐	☑	N/A	N/A
Compliance with ARARs	☐	☐	☑	N/A	N/A
Balancing Criteria					
Long-term effectiveness	Least	Least	Best	Moderate	N/A
Short-term effectiveness	Moderate	Best	Least	Moderate	N/A
Reduction in TMV	Least	Least	Least	Least	N/A
Implementability	Best	Best	Moderate	Moderate	N/A
Cost (in thousands)					
Capital costs	$0	$35	$684	N/A	N/A
Operating and maintenance costs	$0	$4,042	$0	N/A	N/A
Non-discounted costs	$0	$4,078	$684	N/A	N/A
Total present worth	$0	$877	$684	N/A	N/A
Analogous Site 270-E-1 Neutralization Tank			☑		
Threshold Criteria					
Overall protection	☐	☐	☑	☑	N/A
Compliance with ARARs	☐	☐	☑	☑	N/A
Balancing Criteria					
Long-term effectiveness	Least	Least	Best	Moderate	N/A
Short-term effectiveness	Moderate	Best	Least	Moderate	N/A
Reduction in TMV	Least	Least	Least	Least	N/A
Implementability	Best	Best	Moderate	Moderate	N/A
Cost (in thousands)					
Capital costs	$0	$35	$824	$472	N/A
Operating and maintenance costs	$0	$3,995	$0	$3,994	N/A
Non-discounted costs	$0	$4,040	$824	$4,467	N/A
Total present worth	$0	$868	$824	$1,305	N/A

Table 8-6. Preferred Alternative for the Representative Site 216-B-12 Crib and its Analogous Waste Sites[e] (costs in $1,000). (4 Pages)

Comparison of Alternatives - Representative Site 216-B-12 Crib and Associated Analogous Sites					
Criteria for Representative and Analogous Waste Sites	Alternatives				
	① No Action	② MESC, MNA, IC[a]	③ RTD[b]	④ Barrier	⑤ RTD/ Barrier[d]
Analogous Site UPR-200-E-64		☑			
Threshold Criteria					
Overall protection	☐	☑	☑	☑	N/A
Compliance with ARARs	☐	☑	☑	☑	N/A
Balancing Criteria					
Long-term effectiveness	Least	Moderate	Best	Moderate	N/A
Short-term effectiveness	Moderate	Best	Least	Moderate	N/A
Reduction in TMV	Least	Least	Least	Least	N/A
Implementability	Best	Best	Moderate	Moderate	N/A
Cost (in thousands)					
Capital costs	$0	$35	$1,528	$972	N/A
Operating and maintenance costs	$0	$3,995	$0	$7,683	N/A
Non-discounted costs	$0	$4,030	$1,528	$8,655	N/A
Total present worth	$0	$868	$1,528	$2,590	N/A

[a]Maintain existing soil cover, monitored natural attenuation, and institutional controls.
[b]Removal, treatment, and disposal.
[c]Toxicity, mobility, or volume through treatment.
[d]Partial removal, treatment, and disposal with barrier.
[e]The choice of the preferred alternative is based on information at the writing of this feasibility study. The preferred alternative may be revised based on future characterization activities at the analogous sites.
[f]RPP-26744, *Hanford Soil Inventory*, predicts minimal contaminant inventory for this deep (~40 ft) waste site, which is beneath the Waste Encapsulation and Storage Facility (225-B Facility).

☑ = Indicates the preferred alternative (e).
☑ = Yes, meets threshold criterion.
☐ = No, does not meet threshold criterion.

ARAR = applicable or relevant and appropriate requirement.
IC = institutional controls.
MESC = maintain existing soil cover.
MNA = monitored natural attenuation.
N/A = not applicable.
RTD = removal, treatment, and disposal.
TMV = toxicity, mobility, or volume through treatment.

Table 8-7. Preferred Alternative for the Representative Site 216-S-7 Crib and its Analogous Waste Sites[c] (costs in $1,000). (3 Pages)

Comparison of Alternatives - Representative Site 216-S-7 Crib and Associated Analogous Sites					
Criteria for Representative and Analogous Waste Sites	Alternatives				
	① No Action	② MESC, MNA, IC[a]	③ RTD[b]	④ Barrier	⑤ RTD/ Barrier[d]
Representative Site 216-S-7 Crib					☑
Threshold Criteria					
Overall protection	☐	☐	☑	☑	☑
Compliance with ARARs	☐	☐	☑	☑	☑
Balancing Criteria					
Long-term effectiveness	Least	Least	Best	Moderate	Moderate
Short-term effectiveness	Moderate	Best	Least	Moderate	Moderate
Reduction in TMV[e]	Least	Least	Least	Least	Least
Implementability	Best	Best	Moderate	Moderate	Moderate
Cost (in thousands)					
Capital costs	$0	$35	$45,747	$567	$2,431
Operating and maintenance costs	$0	$4,004	$0	$4004	$4,042
Non-discounted costs	$0	$4,040	$45,747	$4,571	$6,473
Total present worth	$0	$870	$45,747	$1,402	$3,272
Analogous Site 216-S-1&2 Cribs and UPR-200-W-36				☑	
Threshold Criteria					
Overall protection	☐	☐	☑	☑	☑
Compliance with ARARs	☐	☐	☑	☑	☑
Balancing Criteria					
Long-term effectiveness	Least	Least	Best	Moderate	Moderate
Short-term effectiveness	Moderate	Best	Least	Moderate	Moderate
Reduction in TMV[e]	Least	Least	Least	Least	Least
Implementability	Best	Best	Moderate	Moderate	Moderate
Cost (in thousands)					
Capital costs	$0	$35	$46,708	$546	$2,680
Operating and maintenance costs	$0	$4,004	$0	$4,004	$4,042
Non-discounted costs	$0	$4,040	$46,708	$4,550	$6,722
Total present worth	$0	$870	$46,708	$1,380	$3,521
Analogous Site 216-S-4 French Drain			☑		
Threshold Criteria					
Overall protection	☐	☐	☑	☑	☑
Compliance with ARARs	☐	☐	☑	☑	☑
Balancing Criteria					
Long-term effectiveness	Least	Moderate	Best	Moderate	Moderate
Short-term effectiveness	Moderate	Best	Least	Moderate	Moderate
Reduction in TMV	Least	Least	Least	Least	Least
Implementability	Best	Best	Moderate	Moderate	Moderate

Table 8-7. Preferred Alternative for the Representative Site 216-S-7 Crib and its Analogous Waste Sites[e] (costs in $1,000). (3 Pages)

Comparison of Alternatives - Representative Site 216-S-7 Crib and Associated Analogous Sites					
	Alternatives				
Criteria for Representative and Analogous Waste Sites	① No Action	② MESC, MNA, IC[a]	③ RTD[b]	④ Barrier	⑤ RTD/ Barrier[d]
Cost (in thousands)					
Capital costs	$0	$35	$2,068	$433	$1,179
Operating and maintenance costs	$0	$4,042	$0	$4,042	$4,042
Non-discounted costs	$0	$4,078	$2,068	$4,475	$5,221
Total present worth	$0	$877	$2,068	$1,274	$2,020
Analogous Site 216-S-22 Crib			☑		
Threshold Criteria					
Overall protection	☐	☐	☑	☑	☑
Compliance with ARARs	☐	☐	☑	☑	☑
Balancing Criteria					
Long-term effectiveness	Least	Moderate	Best	Moderate	Moderate
Short-term effectiveness	Moderate	Best	Least	Moderate	Moderate
Reduction in TMV	Least	Least	Least	Least	Least
Implementability	Best	Best	Moderate	Moderate	Moderate
Cost (in thousands)					
Capital costs	$0	$35	$1,812	$504	$1,129
Operating and maintenance costs	$0	$4,004	$0	$4,004	$4,004
Non-discounted costs	$0	$4,040	$1,812	$4,508	$5,113
Total present worth	$0	$870	$1,812	$1,338	$1,964
Analogous Site 216-S-23 Crib		☑			
Threshold Criteria					
Overall protection	☐	☑	☑	☑	☑
Compliance with ARARs	☐	☑	☑	☑	☑
Balancing Criteria					
Long-term effectiveness	Least	Moderate	Best	Moderate	Moderate
Short-term effectiveness	Moderate	Best	Least	Moderate	Moderate
Reduction in TMV[c]	Least	Least	Least	Least	Least
Implementability	Best	Best	Moderate	Moderate	Moderate
Cost (in thousands)					
Capital costs	$0	$35	$5,564	$715	$3,377
Operating and maintenance costs	$0	$4,017	$0	$4,017	$4,004
Non-discounted costs	$0	$4,053	$5,564	$4,732	$7,381
Total present worth	$0	$872	$5,564	$1,552	$4,,212
Analogous Site 216-T-20 Trench			☑		
Threshold Criteria					
Overall protection	☐	☐	☑	☑	☑
Compliance with ARARs	☐	☐	☑	☑	☑

Table 8-7. Preferred Alternative for the Representative Site 216-S-7 Crib and its Analogous Waste Sites[e] (costs in $1,000). (3 Pages)

Comparison of Alternatives - Representative Site 216-S-7 Crib and Associated Analogous Sites					
Criteria for Representative and Analogous Waste Sites	Alternatives				
	① No Action	② MESC, MNA, IC[a]	③ RTD[b]	④ Barrier	⑤ RTD/ Barrier[d]
Balancing Criteria					
Long-term effectiveness	Least	Moderate	Best	Moderate	Moderate
Short-term effectiveness	Moderate	Best	Least	Moderate	Moderate
Reduction in TMV	Least	Least	Least	Least	Least
Implementability	Best	Best	Moderate	Moderate	Moderate
Cost (in thousands)					
Capital costs	$0	$35	$976	$439	$860
Operating and maintenance costs	$0	$3,993	$0	$3,993	$3,993
Non-discounted costs	$0	$4,029	$976	$4,432	$4,853
Total present worth	$0	$868	$976	$1,271	$1,693

[a]Maintain existing soil cover, monitored natural attenuation, and institutional controls.
[b]Removal, treatment, and disposal.
[c]Toxicity, mobility, or volume through treatment.
[d]Partial removal, treatment, and disposal with barrier.
[e]The choice of the preferred alternative is based on information at the writing of this feasibility study. The preferred alternative may be revised based on future characterization activities at the analogous sites.

☑ = Indicates the preferred alternative (e).
☑ = Yes, meets threshold criterion.
☐ = No, does not meet threshold criterion.

ARAR = applicable or relevant and appropriate requirement.
IC = institutional controls.
MESC = maintain existing soil cover.
MNA = monitored natural attenuation.
RTD = removal, treatment, and disposal.
TMV = toxicity, mobility, or volume through treatment.

Table 8-8. Sampling Before and After the Record of Decision.

Alternative	Confirmatory Sampling						Design Sampling[a]	Verification Sampling[b]			O&M[c]
	Confirm Appropriate Remedial Action	Nature of Contamination	Extent of Contamination	Groundwater Protection	Ecological Sampling	Observational Approach	Extent of Contamination	Verify No-Action Alternative	Ecological Sampling	Verify RAO Attainment	Monitor RAO Attainment
Alternative 1 – No Action								X	X	X	
Alternative 2 – Maintain Existing Soil Cover, Monitored Natural Attenuation, and Institutional Controls											
Representative Site			X		X				X	X	X
Analogous Site Equal to Representative Site			X							X	X
Analogous Site Less than Representative Site	X	X	X	If an issue at Rep Site						X	X
Analogous Site Greater than Representative Site	X	X	X	If an issue at Rep Site	X				X	X	X
Alternative 3 – Removal, Treatment, and Disposal											
Representative Site						X			X	X	
Analogous Site Equal to Representative Site						X				X	
Analogous Site Less than Representative Site	X					X				X	
Analogous Site Greater than Representative Site						X			X	X	
Alternative 4 – Engineered Surface Barrier											
Representative Site					X		X		X	X	X
Analogous Site Equal to Representative Site							X			X	X
Analogous Site Less than Representative Site	X						X			X	X
Analogous Site Greater than Representative Site					X		X		X	X	X
Alternative 5 – Partial Removal, Treatment, and Disposal with Engineered Barrier											
Representative Site						X	X		X	X	X
Analogous Site Equal to Representative Site						X	X			X	X
Analogous Site Less than Representative Site	X					X	X			X	X
Analogous Site Greater than Representative Site						X	X		X	X	X

[a]Confirmatory and design sampling can be conducted before or after the Record of Decision
[b]Verification sampling typically is conducted after the Record of Decision; however, as appropriate it may be conducted before the Record of Decision.
[c]O&M plan sampling will be accomplished after the Record of Decision.

O&M = operations and maintenance (plan).
RAO = remedial action objective.

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APPENDIX A

REMEDIAL INVESTIGATION FOR THE 216-S-7 CRIB

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CONTENTS

ATTACHMENTS

FIGURES

TABLES

TERMS

amsl	above mean sea level
ARAR	applicable or relevant and appropriate requirement
AUF	area-use factor
BAF	bioaccumulation factor
BCG	biota concentration guide
bgs	below ground surface
BV	background value
CERCLA	*Comprehensive Environmental Response, Compensation, and Liability Act of 1980*
CFR	*Code of Federal Regulation*
CLARC	cleanup levels and risk calculations (Ecology 94-145, *Cleanup Levels and Risk Calculations under the Model Toxics Control Act Cleanup Regulation; CLARC, Version 3.1*)
COC	contaminant of concern
COPC	contaminant of potential concern
COPEC	contaminant of potential ecological concern
CSM	conceptual site model
CZ	contaminated zone
DOE	U.S. Department of Energy
DQO	data quality objective
Ecology	Washington State Department of Ecology
Eco-SSL	ecological soil-screening level
ELCR	excess lifetime cancer risk
EPA	U.S. Environmental Protection Agency
EPC	exposure-point concentration
FOD	frequency of detection
FS	feasibility study
GWP	groundwater protection
H_{cc}	Henry's law constant
HEAST	Health Effects Assessment Summary Table
HHRA	human-health risk assessment
HI	hazard index
HQ	hazard quotient
HRLS	High-Rate Logging System
Implementation Plan	*200 Areas Remedial Investigation/Feasibility Study Implementation Plan – Environmental Restoration Program* (DOE/RL-98-28)
IRIS	*Integrated Risk Information System* database
K_d	distribution coefficient
K_{oc}	soil organic carbon-water partition coefficient
K_{plant}	plant uptake coefficient
LANL	Los Alamos National Laboratory
MCL	maximum contaminant level
MDL	minimum detection limit

NA	not available/not applicable
ND	nondetected, nondispersion
NLA	no laboratory analysis
OSWER	Office of Solid Waste and Emergency Response
OU	operable unit
PCB	polychlorinated biphenyl
PEF	particulate emission factor
PRG	preliminary remediation goal
QA	quality assurance
QC	quality control
RA	risk assessment
RAGS	risk assessment guidance for Superfund
RBC	risk-based concentration
RCRA	*Resource Conservation and Recovery Act of 1976*
REDOX	Reduction-Oxidation (Plant)
RESRAD	RESidual RADioactivity
RI	remedial investigation
RI/FS	remedial investigation/feasibility study
RME	"reasonable maximum" exposure
SAP	sampling and analysis plan
SGLS	Spectral Gamma-Ray Logging System
STOMP	subsurface transport over multiple phases
SVOA	semivolatile organic analysis
SVOC	semivolatile organic compound
SZ	saturated zone
TIC	tentatively identified compound
UCF	unit conversion factor
UCL	upper confidence limit
VF	volatilization factor
VOA	volatile organic analysis
VOC	volatile organic compound
WAC	*Washington Administrative Code*
WIDS	*Waste Information Data System* database
Work Plan	*Uranium-Rich/General Process Condensate and Process Waste Group Operable Units RI/FS Work Plan and RCRA TSD Unit Sampling Plan; Includes 200-PW-2 and 200-PW-4 Operable Units* (DOE/RL-2000-60)

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

APPENDIX A

REMEDIAL INVESTIGATION FOR THE 216-S-7 CRIB

A1.0 INTRODUCTION

The purpose of this remedial investigation (RI) Report is to evaluate the data generated during the RI and other characterization activities at the 216-S-7 Crib representative waste site, which is in the 200-PW-2 Process Waste Operable Unit (OU). Characterization activities for the 216-S-7 Crib were performed as part of supplemental activities for the remedial investigation of the 200-PW-2 and 200-PW-4 OU during the fall and winter of 2004. The activities included cable-tool drilling to facilitate the collection of soil samples for chemical, radiological, and physical properties analyses; stratigraphy definition; and determination of the nature and vertical extent of contamination at the 216-S-7 Crib.

These activities are summarized in D&D-25034, *200-PW-2 Operable Unit Borehole Summary Report for the 216-S-7 Crib*. Work activities were completed in accordance with WMP-21212, *Description of Work for Drilling a Characterization Borehole at the 216-S-7 Crib, CY 2004*.

A1.1 PURPOSE

This RI Report evaluates the data generated during the RI and other characterization activities to determine if sufficient data have been collected to support risk assessment (RA) and remedial decision making, to estimate risks at the 216-S-7 Crib based on the data collected during the RI and on existing data, to support the decision to proceed with a feasibility study (FS), and to determine those constituents and site-specific considerations that need to be addressed in the FS. This RI Report also provides data to support the evaluation of alternatives in the FS with regard to meeting potential applicable or relevant and appropriate requirements (ARAR), applying risk reduction, and identifying significant data gaps, if any. This RI Report includes an evaluation of the baseline risk using characterization data generated during the RI and significant data from other investigations. Risk is evaluated for nonradiological constituents using U.S. Environmental Protection Agency (EPA) RA guidance (see Section A4.3.1). Risk from radiological constituents is evaluated through the RESidual RADioactivity (RESRAD) computer dose model (ANL/EAD-4, *User's Manual for RESRAD, Version 6*).

A1.2 SUPPORTING DOCUMENTS AND REMEDIAL INVESTIGATION BASIS

Supporting documents that provided the basis for the RI Report are as follows:

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

- DOE/RL-98-28, *200 Areas Remedial Investigation/Feasibility Study Implementation Plan – Environmental Restoration Program* (Implementation Plan)
- DOE/RL-2000-60, *Uranium-Rich/General Process Condensate and Process Waste Group Operable Units RI/FS Work Plan and RCRA TSD Unit Sampling Plan; Includes 200-PW-2 and 200-PW-4 Operable Units* (Work Plan)
- DOE/RL-2004-25, *Remedial Investigation Report for the 200-PW-2 Uranium-Rich Process Waste Group and the 200-PW-4 General Process Condensate Group Operable Units*
- BHI-01411, *Remedial Investigation Data Quality Objectives Summary Report for the 200-PW-2 Uranium-Rich Process Water Group Operable Unit*
- CP-13935, *Waste Control Plan for the 200-PW-2 Operable Unit*
- CP-14682, *Data Quality Objectives Summary Report for the Designation of the 200-PW-2 and 200-PW-4 Investigation-Derived Wastes.*

A1.3 DATA EVALUATION METHODOLOGY

The data evaluation methodology used in this RI Report considers applicable regulatory requirements, data quality objective (DQO) processes (BHI-01411 and CP-14176, *Remedial Investigation Data Quality Objectives Summary Report for the 200-PW-4 Operable Unit*) conducted for the Work Plan (DOE/RL-2000-60, Rev. 1), land-use uncertainties, RA methodology, other OUs, and site-specific conditions. Additional details regarding data evaluation methodology for the entire 200-PW-2 OU are in DOE/RL-2004-25.

A1.3.1 Identification of Contaminants of Potential Concern

The entire data set initially was screened, and nondetected constituents were eliminated from further consideration. Because of the limited number of samples, 95 percent upper confidence limits (UCL) were not calculated; maximum concentrations for specific horizons were used for comparisons and evaluation. The data were compared to the 90th percentile of the background concentrations from DOE/RL-92-24, *Hanford Site Background: Part 1, Soil Background for Nonradioactive Analytes*; DOE/RL-96-12, *Hanford Site Background: Part 2, Soil Background for Radionuclides*; and Ecology 94-115, *Natural Background Soil Metals Concentrations in Washington State*. If the maximum detected value was less than the 90th percentile background value, the constituent was eliminated as a contaminant of concern (COC). If background data were not available for a constituent, the constituent was retained for further evaluation, as described in Sections A1.3.2 and A1.3.3.

A1.3.2 Human-Health Risk Evaluation

The risk evaluation for the 216-S-7 Crib is based on EPA RA guidance (see Section A4.3.1). Radiological constituents are addressed through a dose and risk evaluation. Human-health risks are evaluated for an industrial-exposure scenario using site-specific data and exposure assumptions obtained from state and Federal guidance documents. The land surrounding the 200 East and 200 West Areas was designated as industrial-exclusive in DOE/EIS-0222-F, *Final Hanford Comprehensive Land-Use Plan Environmental Impact Statement*. The 216-S-7 Crib, included in the 200-PW-2 OU, is located in this industrial-exclusive land-use area.

A1.3.3 Modeling Approach

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

Groundwater was evaluated for nonradiological constituents based on existing standards for protection of groundwater. The fate and transport evaluation included evaluating the frequency of detection, the location of the constituent within the soil column, the distribution coefficient (K_d), whether the constituent has already reached groundwater, and whether modeling would provide additional information beyond that already known. Additional information is provided in Chapters A4.0 and A5.0 of this RI Report.

A1.3.4 Ecological Risk Evaluation Methodology

DOE/RL-2001-54, *Central Plateau Ecological Evaluation*, has been prepared to support ecological evaluations under the remedial investigation/feasibility study (RI/FS) process for Central Plateau waste sites.

A1.4 WASTE SITE DESCRIPTION AND HISTORY

The 216-S-7 Crib is located in the 200 West Area, about 230 m (750 ft) northwest of the 202-S Canyon Building and 290 m (95 ft) east of the SX Tank Farm (Figure 2-11 in DOE/RL-2000-60, Rev. 1).

The waste site consists of two roofed wooden boxes, or cribs, each of which is 4.9 x 4.9 m (16 x 16 ft) square by 1.6 m (5.2 ft) tall. The wooden cribs are centered 15.2 m (50 ft) apart in an excavation with bottom dimensions of 15.2 x 30.4 m (50 x 100 ft). The cribs received liquid waste from the 202-S Reduction Oxidation (REDOX) Plant building through an 8.9 cm (3.5 in.) outside diameter, 304 L stainless steel pipeline buried approximately 4.6 m (15 ft) bgs. Within the waste site, the pipeline slopes at a 0.85 percent grade to maintain flow. The pipeline split at the center of the crib and fed the two boxes in parallel. Two risers extended from the roof of the cribs to above grade. Each riser was a Schedule 40, 10 cm (4 in.) diameter pipe. One riser was equipped with filters to ventilate the cribs, and the other probably was used to measure water levels in the cribs.

The excavation is 6.7 m (22 ft) deep. Surface elevation at the original ground surface is 205.5 m (674.2 ft) above mean sea level (amsl). The wood cribs rest on a 0.61 m (2 ft) thickness of 7.6+ cm (3+ in.) of washed gravel, which also filled the excavation around the cribs to a depth of at least 1.5 m (5 ft). This gravel is capped by a 10 cm (4 in.) thickness of 2 to 4 cm (0.75 to 1.5 in.) gravel which, in turn, is covered with a 5 cm (2 in.) thickness of 0.6 to 2 cm (0.25 to 0.75 in.) pea gravel. Covering this is a vapor barrier, composed of two layers of heavy Sisalkraft[1] construction paper. The paper extended over the entirety of the gravel bed and lapped 0.61 m (2 ft) up the side of the excavation. The 15 cm (6 in.) of finer gravels was carried over the tops of the cribs and required mounding of the coarser gravels around the sides of the cribs. The excavated soil probably was used as backfill over the gravel and Sisalkraft barrier. Surface dimensions of the excavation are 28.7 x 43.9 m (94 x 144 ft), based on a 45-degree slope into the excavation.

At least one 0.61 m (2 ft) thickness of clean soil was placed over the waste site in 1992. At least one, and possibly more, episodes of collapse at the wooden boxes are known and were stabilized with available fill. This may have raised the local stabilized soil thickness to greater than 0.61 m (2 ft). There are no indications of the Schedule 40 risers at ground level, and the *Waste Information Data System* (WIDS) report suggests that the above-ground risers were removed before August 1975.

The 216-S-7 Crib was constructed in 1955 to receive the waste treatment stream from the REDOX process and was active between January 1956 and July 1965. Before disposal at this crib began, the waste stream had been sent to the 216-S-1/216-S-2 Cribs.
The 216-S-1/216-S-2 Cribs were shut down when it was discovered that acidic wastes had corroded the monitoring well casing and penetrated to sediments near the groundwater.
A release of hexone-rich concentrator wastes to the 216-S-1/216-S-2 Cribs was documented as an unplanned release (UPR-200-W-36) in August 1955, and construction of the 216-S-7 Crib began shortly thereafter. After operations ceased in 1965, this waste stream was routed to the 216-S-9 Crib until January 1969 and then to the 216-S-23 Crib until July 1972.

The 216-S-7 Crib received 390,000,000 L (103,000,000 gal) of process wastes. The primary sources for the wastes were the D-1 and D-2 cell tanks in the 202-S REDOX Plant.
The discharged waste was acidic (as low as pH=2), at least at the start of 216-S-7 Crib operations. An estimated 3 percent by volume of the waste from this tank was settleable solids. Temperatures of the waste sent to the crib ranged up to 60°C (140°F).

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[1] Sisalkraft (paper) is a trademark of Fortifiber Corporation, Los Angeles, California.

The waste received by the crib was stored in the D-1 and D-2 tanks inside the 202-S REDOX Plant. The 202-S REDOX Plant was designed around a reduction-oxidation solvent-extraction separations process using methyl isobutyl ketone (hexone) to separate plutonium and uranium from decladded, dissolved fuel rod solutions. The process used a multicolumn solvent extraction system to (1) extract most of the uranium and plutonium from the fission products-rich dissolved fuel rod solution, (2) separate plutonium from uranium, and (3) refine resultant uranium and plutonium solutions in two- or three-step decontamination processes. Solvent (hexone) extraction, treatment, and recycling also was important to overall plant operations. The residual fuel rod solution was concentrated and sent to the S/SX Tank Farms for storage.

The D-2 tank discharged an estimated 63,200 L/day (16,700 gal) of waste from a series of concentrators and evaporators associated with each hexone-based solvent extraction decontamination column. These columns were first used to strip fission products from the dissolved fuel rods containing plutonium and uranium. This high-activity waste stream was sent to the tanks in the S Tank Farm after it had been treated in the D-12 waste concentrator. The D-12 vessel reduced and concentrated the liquid volume for disposal to the S Tank Farms; hexone and other volatiles were driven off in the heated vapor phase. This and other process condensate waste streams ultimately were sent to the D-5 condensate stripper, where the hexone was driven off for recovery and reuse. Residual liquid from this vessel was routed to the D-4 evaporator for concentration. The residual liquids from this step were sent to the D-2 holding tank and discharged to the crib in batches.

Cell drainage waste from the D-1 holding tank was collected from a variety of sources, cell floor drainage, and decontamination room drainage. The latter included caustics, acids solvents, grease, hexone, and miscellaneous materials from washing cask railcars.

The wastes discharged to the soil column at the 216-S-7 Crib included 2,560 kg of uranium, 440 g of plutonium, 703 Ci of Cs-137, and 1,390 Ci of Sr-90 (decayed through 1989). RHO-CD-673, *Handbook, 200 Areas Waste Sites*, Vol. 2, also indicated that the initial inventory included 25 Ci of Co-60 and 1,500 Ci of Ru-106. Chemical inventory data included 110,000 kg of nitrate, 40,000 kg of aluminum nitrate, 250,000 kg of nitric acid, and 7,000 kg of sodium.

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A2.0 INVESTIGATION APPROACH AND ACTIVITIES

This chapter summarizes the data collection activities performed during the 216-S-7 Crib RI. These activities are described in detail in CP-18666, *200-PW-2 and 200-PW-4 Operable Unit Borehole Summary Report*. The RI was conducted in accordance with the sampling and analysis plan (SAP) associated with the Work Plan (DOE/RL-2000-60, Rev. 1) for the 200-PW-2 and 200-PW-4 OU.

Data were collected to characterize the nature and vertical extent of chemical and radiological contamination and the physical conditions in the vadose zone underlying the historical boundaries of the 216-S-7 Crib in the 200-PW-2 OU. Borehole drilling and sampling, large-diameter push-hole (drive casing) installation, direct-push sampling, surface and borehole geophysical surveys, and sampling and analysis of soils were conducted during the field activities. All boreholes and test pits were completed, and all samples were collected and analyzed for COCs as identified in the DQO and SAP.

A2.1 216-S-7 CRIB REMEDIAL INVESTIGATION DRILLING

One borehole (Borehole C4557, Figure A2-1) was drilled and sampled during the 216-S-7 Crib RI. Cable-tool drilling with drive-barrel technology was used for Borehole C4557. No water was added during the drilling process. Multiple threaded carbon-steel temporary casings were installed to keep the borehole open and minimize the potential of downhole cross-contamination. Temporary casing strings of 30 and 22 cm (11.75 and 8.75-in.) outside diameters were employed. The borehole was drilled to a total depth of 69 m (226.5 ft) bgs.

A2.1.1 215-S-7 Crib Remedial Investigation Sampling and Analysis

Soil sample depths and volumes were collected in accordance with the sampling and analysis plan strategy in Appendix D of DOE/RL-2000-60, Rev. 1, and the analytical suites address the COCs specified therein. Table A2-1 provides Borehole C4557 soil sampling analytical data summary information.

Soil samples were selectively analyzed for ammonia, anions, hexavalent chromium, total cyanide, metals, nitrate/nitrite, oil and grease, pesticides and herbicides (for investigation-derived waste characterization of near-surface soils), pH, polychlorinated biphenyls(PCB), semivolatile organics, total petroleum hydrocarbons, radionuclides, volatile organics, moisture content, particle-size distribution, and bulk density.

A2.1.2 216-S-7 Crib Remedial Investigation Borehole Geophysical Logging

A Spectral Gamma-Ray Logging System (SGLS) was used to capture the downhole radiometric signature for Borehole C4557. As the SGLS became saturated, or reached the top end of the reliability curve, a High-Rate Logging System (HRLS) was employed to determine the total activity of the material present. The logging system provided a continuous radiometric signature of the soils, measured through a single thickness of casing, to total drilled depth. The complete geophysical report for Borehole C4557 is presented in Appendix C of D&D-25034.

A2.2 OTHER 216-S-7 CRIB ACTIVITIES

A2.2.1 Air Monitoring

Air monitoring during the RI field activities was conducted in accordance with CCN 087338, "Environmental Restoration Program ALARACT Demonstration for Drilling – Drilling Activities Outside the Tank Farms Fence Line on the Hanford Site") to verify that the breathing zone remained free of contamination and that the drill crew was wearing the proper protective equipment.

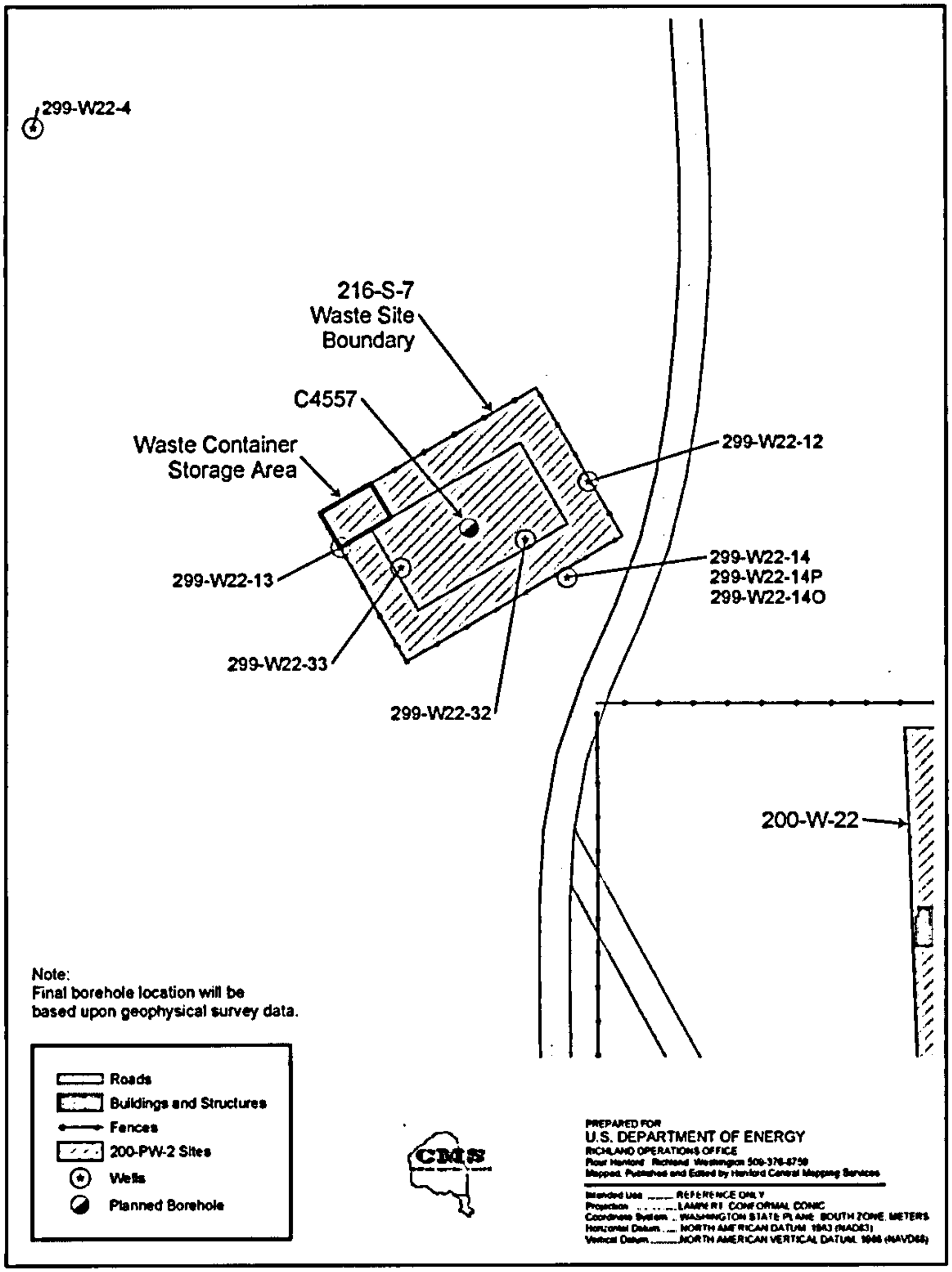
A2.2.2 Geodetic Survey

The borehole was surveyed in accordance with GRP-EE-01-1.6, *Environmental Information Systems -- Survey Requirements and Techniques*. Coordinates were recorded using NAVD88, *North American Vertical Datum of 1988* and the NAD83, *North American Datum of 1983*, for the Washington State Plane (South Zone) with the 1991 adjustment for horizontal coordinates. Survey data are presented in CP-18666.

A2.2.3 Quality Assurance Surveillance

A quality assurance (QA) surveillance was conducted on the borehole installed at the 216-S-7 Crib. The surveillance looked at placement of the borehole, materials and equipment used, driller qualification, hole decommissioning, borehole geophysical logging, and document and record generation. The surveillance of these activities was found to be satisfactory.

Figure A2-1. Borehole Location Map for the 216-S-7 Crib.



Projects\WIDS\040206_Crib216S7_HulstromMaps\040219_Crib216S7_ap_Rev1.mxd 2/20/04 dhl

Table A2-1. 200-PW-2 Operable Unit Borehole C4557 (216-S-7 Crib) Analytical Data Summary. (3 Pages)

HEIS Sample ID Number	Date Collected	Data Package Number	Depth Collected (ft bgs)	Depth Planned (ft bgs)	Labora-tory	Sample Data Received					Comments
						WSCF	Eberline	Lionville	Severn Trent	Shaw	
B1B568	10/29/2004	WSCF20042003	QC	QC	WSCF	12/06/2004	—	—	—	—	Equipment Blank
B1B569	10/29/2004	H2812	QC	QC	Eberline	—	01/31/2005	—	—	—	Equipment Blank
B1B570	12/15/2004	WSCF20042434	QC	QC	WSCF	01/18/2005	—	—	—	—	Trip Blank
B1B571	11/08/2004	H2833	0-3	0-3	Lionville	—	—	01/21/2005	—	—	
B1B572	11/11/2004	WSCF20042127	14.5-17	14.5-17	WSCF	12/16/2004	—	—	—	—	
B1B5D6	11/11/2004	H2840	14.5-17	14.5-17	Lionville	—	—	01/18/2005	—	—	
B1B5D6	11/11/2004	H2840-A	14.5-17	14.5-17	Eberline	—	02/04/2005	—	—	—	
B1B573	11/15/2004	WSCF20042230	24-26.5	24-26.5	WSCF	02/23/2005	—	—	—	—	
B1B573	11/15/2004	WO4382	24-26.5	24-26.5	Severn Trent	—	—	—	01/12/2005	—	
B1B5D7	11/15/2004	H2877-A	24-26.5	24-26.5	Lionville	—	—	01/21/2005	—	—	
B1B5D7	11/15/2004	H2877	24-26.5	24-26.5	Eberline	—	02/16/2005	—	—	—	
B1B574	11/16/2004	WSCF20042230	34-36.5	34-36.5	WSCF	02/23/2005	—	—	—	—	
B1B574	11/16/2004	WO4382	34-36.5	34-36.5	Severn Trent	—	—	—	01/12/2005	—	
B1B575	11/16/2004	WSCF20042230	34-36.5	34-36.5	WSCF	2/23/2005	—	—	—	—	Duplicate
B1B575	11/16/2004	WO4382	34-36.5	34-36.5	Severn Trent	—	—	—	01/12/2005	—	Duplicate
B1B5D8	11/16/2004	H2877	34-36.5	34-36.5	Eberline	—	02/16/2005	—	—	—	
B1B5D8	11/16/2004	H2877-A	34-36.5	34-36.5	Lionville	—	—	01/21/2005	—	—	
B1B5D9	11/16/2004	H2877	34-36.5	34-36.5	Eberline	—	02/16/2005	—	—	—	Duplicate
B1B5D9	11/16/2004	H2877-A	34-36.5	34-36.5	Lionville	—	—	01/21/2005	—	—	Duplicate
B1B576	11/17/2004	WSCF20042230	44-46.5	44-46.5	WSCF	02/23/2005	—	—	—	—	
B1B5F0	11/17/2004	H2860-B	44-46.5	44-46.5	Eberline	—	02/16/2005	—	—	—	
B1B5F0	11/17/2004	H2860	44-46.5	44-46.5	Lionville	—	—	02/09/2005	—	—	
B1B5F8	11/17/2004	H2860-B	44-46.5	44-46.5	Eberline	—	02/16/2005	—	—	—	Split

Table A2-1. 200-PW-2 Operable Unit Borehole C4557 (216-S-7 Crib) Analytical Data Summary. (3 Pages)

HEIS Sample ID Number	Date Collected	Data Package Number	Depth Collected (ft bgs)	Depth Planned (ft bgs)	Laboratory	Sample Data Received					Comments
						WSCF	Eberline	Lionville	Severn Trent	Shaw	
B1B5F8	11/17/2004	H2860	44-46.5	44-46.5	Lionville	---	---	02/09/2005	---	---	Split
B1BCF3	11/18/2004	WO4457	44-46.5	44-46.5	Severn Trent	---	---	---	01/27/2005	---	Split
B1B5F9	11/18/2004	WO4382	44-46.5	44-46.5	Severn Trent	---	---	---	01/12/2005	---	Split
B1B577	11/22/2004	WSCF20042230	54-56.5	54-56.5	WSCF	02/23/2005	---	---	---	---	
B1B5F1	11/22/2004	H2860-B	54-56.5	54-56.5	Eberline	---	02/16/2005	---	---	---	
B1B5F1	11/22/2004	H2860	54-56.5	54-56.5	Lionville	---	---	02/09/2005	---	---	
B1B5H0	11/22/2004	H2860-A	54-56.5	54-56.5	Shaw	---	---	---	---	01/21/2005	Physical Property
B1B578	11/24/2004	WSCF20042392	66-68.5	66-68.5	WSCF	01/18/2005	---	---	---	---	
B1B5F2	11/24/2004	H2925	66-68.5	66-68.5	Eberline	---	02/22/2005	---	---	---	
B1B5F2	11/24/2004	H2925-A	66-68.5	66-68.5	Lionville	---	---	02/02/2005	---	---	
B1B5H1	11/24/2004	H2908	66-68.5	66-68.5	Shaw	---	---	---	---	02/04/2005	Physical Property
B1B579	12/13/2004	WSCF20042392	126-128.5	126-128.5	WSCF	01/18/2005	---	---	---	---	
B1B5F3	12/13/2004	H2925	126-128.5	126-128.5	Eberline	---	02/22/2005	---	---	---	
B1B5F3	12/13/2004	H2925-A	126-128.5	126-128.5	Lionville	---	---	02/02/2005	---	---	
B1B580	12/15/2004	WSCF20042436	155-157.5	155-157.5	WSCF	1/21/2005	---	---	---	---	
B1B5F4	12/15/2004	H2915	155-157.5	155-157.5	Eberline	---	02/22/2005	---	---	---	
B1B5F4	12/15/2004	H2915-B	155-157.5	155-157.5	Lionville	---	---	02/02/2005	---	---	
B1B5H2	12/15/2004	H2915-A	155-157.5	155-157.5	Shaw	---	---	---	---	02/14/2005	Physical Property
B1B581	12/16/2004	WSCF20042466	180-182.5	180-182.5	WSCF	01/26/2005	---	---	---	---	
B1B5F5	12/16/2004	H2925	180-182.5	180-182.5	Eberline	---	02/23/2005	---	---	---	
B1B5F5	12/16/2004	H2955-A	180-182.5	180-182.5	Lionville	---	---	02/02/2005	---	---	
B1B582	12/22/2004	WSCF20042519	199-201.5	199-201.5	WSCF	01/27/2005	---	---	---	---	
B1B5F6	12/22/2004	H2936	199-201.5	199-201.5	Eberline	---	02/23/2005	---	---	---	

Table A2-1. 200-PW-2 Operable Unit Borehole C4557 (216-S-7 Crib) Analytical Data Summary. (3 Pages)

HEIS Sample ID Number	Date Collected	Data Package Number	Depth Collected (ft bgs)	Depth Planned (ft bgs)	Labora-tory	Sample Data Received					Comments
						WSCF	Eberline	Lionville	Severn Trent	Shaw	
B1B5F6	12/22/2004	H2936-B	199-201.5	199-201.5	Lionville	—	—	02/02/2005	—	—	
B1B5H3	12/22/2004	H2936-A	199-201.5	199-201.5	Shaw	—	—	—	—	02/14/2005	Physical Property
B1B583	12/29/2004	WSCF20042550	223-225.5	223-225.5	WSCF	01/27/2005	—	—	—	—	
B1B5F7	12/29/2004	H2936	223-225.5	223-225.5	Eberline	—	03/02/2005	—	—	—	
B1B5F7	12/29/2004	H2936-B	223-225.5	223-225.5	Lionville	—	—	02/02/2005	—	—	

Notes:
B1B575 is a duplicate sample of B1B574. B1B5D9 is a duplicate of B1B5D8.
B1B5F8, B1BCF3, and B1B5F9 are split lab samples tied to B1B5F0.
B1B568 and B1B569 are equipment blanks, while B1B570 is a trip blank.
B1B5H0, B1B5H1, B1B5H2, and B1B5H3 are physical property samples.
Data packages WSCF20042230, H2877 and H2877-A are being data validated.
Laboratories performing the analyses include: Eberline Services, Richmond, CA; Lionville Laboratory, Inc., Exton, PA; Severn Trent Laboratories, Inc., Earth City, MO; Shaw Group, Inc. – Geotechnical Laboratory, Oak Ridge, TN, and WSCF – Hanford Site, Richland, WA.
HEIS = Hanford Environmental Information System.
ID = identification.
WSCF = Waste Sampling and Characterization Facility.

A3.0 REMEDIAL INVESTIGATION RESULTS

This chapter describes the hydrogeologic framework in the 200-PW-2 OU and the nature and vertical extent of contamination at the 216-S-7 Crib representative waste site investigated during the RI. The information in this chapter is based on site-specific data (e.g., geologic logs, depth to water, soil chemistry) collected during the RI and on existing information contained in DOE/RL-98-28; DOE/RL-2000-60, Rev. 1; CP-18666; DOE/RL-95-13, *Limited Field Investigation for the 200-UP-2 Operable Unit*; and other 200 Areas reports.

A3.1 HYDROGEOLOGIC FRAMEWORK

This section summarizes the hydrogeologic framework in the 200-PW-2 OU and incorporates site-specific data obtained during the RI with historical data from the 200 Areas. Additional information on the hydrogeologic setting of the OU can be found in the Implementation Plan (DOE/RL-98-28), the Work Plan (DOE/RL-2000-60, Rev. 1), the 200-PW-2 and 200-PW-4 OUs RI Report (DOE/RL-2004-25), and other documents noted in the text.

A3.2 TOPOGRAPHY

The 200-PW-2 OU is located on the Central Plateau, which is a broad, relatively flat, prominent terrace (Cold Creek Bar) near the center of the Hanford Site (Figure A3-1).

A3.3 OPERABLE UNIT CONTAMINATION

This section describes and then summarizes the nature and extent of contamination at the 216-S-7 Crib (within the 200-PW-2 OU).

A3.3.1 Nature and Extent of Contamination in the 216-S-7 Crib Area

This section describes the nature and extent of contamination in the 216-S-7 Crib area. The 216-S-7 Crib is located in the 200 West Area, about 230 m (750 ft) northwest of the 202-S Canyon Building and 290 m (95 ft) east of the SX Tank Farm.

A3.3.1.1 Geophysical Logging Summary for the 216-S-7 Crib

This section describes the geophysical logging results made during drilling activities. The probe runs, data collection, and reduction were conducted by Stoller Geophysical Services, Grand Junction, Colorado[2].

[2] Stoller is a trademark of S. M. Stoller Corporation, Lafayette, Colorado.

An SGLS was used to capture the downhole radiometric signature for Borehole C4557. As the SGLS system became saturated, or reached the top end of the reliability curve, an HRLS was employed to determine the total activity of the material present.

In addition to Borehole C4557, existing boreholes in the vicinity of the waste site were SGLS logged before the drilling program was begun. These included Boreholes 299-W22-12, 299-W22-13, 299-W22-14, 299-W22-32, and 299-W22-33 (Figure A2-1).

The spectral gamma logs are a supplement to the analytical radionuclide data; they present a vertical distribution of radionuclides in the vadose zone beneath the waste site and aid in geological interpretation of subsurface stratigraphy. Laboratory analytical data are compared to SGLS/HRLS data in this section as appropriate to clarify results.

C4557: Cs-137 was detected by SGLS in this borehole between the ground surface and 39 m (128 ft). The maximum concentration was measured at approximately 2 million pCi/g at a depth of 7.6 m (25 ft). The highest concentration zone lies between 4.6 and 10.7 m (15 and 35 ft). Laboratory samples from Borehole C4557 indicate much lower peak Cs-137 concentrations of 20,000 pCi/g at 7.3 to 8.1 m (24 to 26.5 ft) bgs, which drop to ≤760 pCi/g at the 10.4 to 11.1 m (34 to 36.5 ft) level and (with one exception, a rise at 16.5 m [54 ft]) continue to drop markedly down the borehole. The Stoller log report for Borehole C4557 notes that because the inside of the casing was contaminated, the true Cs-137 concentration may be lower than reported by SGLS. The Cs-137 contamination at low concentrations observed by SGLS between 34.2 and 39.0 m (112 and 128 ft) may be the result of dragging down contamination from higher depth intervals (DOE-EM/GJ798-2005, *C4557 Log Data Report*).

299-W22-12 (A7837): The man-made radionuclides detected by SGLS in this borehole were Cs-137, Co-60, U-238, and Eu-154. Cesium-137 was detected between 7.6 and 19.5 m (25 and 64 ft) and at a few sporadic locations in the borehole near its minimum detection limit (MDL) of approximately 0.1 pCi/g. The maximum concentration was approximately 400 pCi/g at 11.9 m (39 ft). Co-60 was detected near its MDL of 0.05 pCi/g at depths of 11.9 to 13.4 m, 40.0 m, and 62.5 to 63.4 m (39 to 44 ft, 131 ft, and 205 to 208 ft). Eu-154 was detected near its MDL of 0.2 pCi/g at 9.8 and 12.8 m (32 and 42 ft). U-238 was detected near its MDL of 15 pCi/g at a depth of 15.9 m (52 ft) (DOE-EM/GJ668-2004, *299-W22-12 (A7837) Log Data Report*).

299-W22-13 (A7838): The man-made radionuclides detected by SGLS in this borehole were Cs-137, Co-60, and U-238. Cs-137 was detected between 6.1 and 25.0 m (20 and 82 ft) and at a few sporadic locations in the borehole near its MDL of approximately 0.2 pCi/g. The maximum concentration was measured at approximately 62 pCi/g at 11.3 m (37 ft). Co-60 was detected near its MDL of 0.05 pCi/g at depths of 12.8 to 13.4 m (42 to 44 ft). U-238 was detected at sporadic locations between 16.5 and 22.0 m (54 and 72 ft). The maximum concentration was 15 pCi/g at 20.1 m (66 ft) (DOE-EM/GJ667-2004, *299-W22-13 (A7838) Log Data Report*).

299-W22-14 (A7839): The man-made radionuclides detected by SGLS in this borehole were Cs-137, Co-60, and U-238. Cesium-137 was detected near the ground surface (0.9 to 1.2 m [3 to 4 ft]) at concentrations between 0.4 and 0.6 pCi/g. Cs-137 was detected in the interval between 7.6 and 18.3 m (25 and 60 ft) at concentrations ranging from the MDL (0.3 pCi/g) to 450 pCi/g. The maximum concentration of Cs-137 was measured at the 10.7-m (35-ft) log depth.

Cesium-137 was detected in the intervals from 21.4 to 25.6 m (70 to 84 ft) and 40.3 to 40.9 m (132 to 134 ft) at concentrations ranging from 0.3 to 0.7 pCi/g. In addition, Cs-137 was detected at 27.8 and 63.1 m (91 and 207 ft) at concentrations near the MDL.

Processed U-238 was detected at 14.0 and 14.3 m (46 and 47 ft) at concentrations of 24 and 31 pCi/g, respectively.

Cobalt-60 was detected at 14, 42.1, 64.1, 64.7, and 67.4 m (46, 138, 210, 212, and 221 ft) at concentrations near the MDL (0.1 pCi/g) (DOE-EM/GJ672-2004, *299-W22-14 (A7839) Log Data Report*).

299-W22-32 (A7851): The man-made radionuclides detected by SGLS in this borehole were Cs-137 and Co-60. Cesium-137 was detected throughout almost the entire length of the borehole. Concentrations ranged from the MDL (0.2 pCi/g) to 3,000,000 pCi/g. The maximum concentration of Cs-137 was measured at 8.5 m (28 ft). Cobalt-60 was detected at 42.1 m (138 ft) with a concentration of 0.2 pCi/g (DOE-EM/GJ638-2004, *299-W22-32 (A7851) Log Data Report*).

299-W22-33 (A7852): Cs-137 was the only man-made radionuclide detected by SGLS in this borehole. Cesium-137 was detected throughout almost the entire length of the borehole. Concentrations ranged from the MDL (0.2 pCi/g) to 300,000 pCi/g. The maximum concentration of Cs-137 was measured at 8.4 m (27.5 ft) (DOE-EM/GJ637-2004, *299-W22-33 (A7852) Log Data Report*).

Summary: Three boreholes, 299-W22-12, 299-W22-13, and 299-W22-14, are located immediately outside the crib boundary, to the west, south, and east. Borehole C4557 is located in the center of the crib. Boreholes 299-W22-32 and 299-W22-33 also are located within the boundaries of the 216-S-7 Crib. Borehole 299-W22-32 is east and slightly south of Borehole C4557, while Borehole 299-W22-33 is west and slightly south of Borehole C4557 (see Figure A2-1). Data from all six SGLS logs and the Borehole C4557 laboratory data clearly show a marked increase in Cs-137 at the crib bottom (about 7.6 m [25 ft]), followed by a marked decrease. Data from the boreholes within the crib boundaries (Boreholes C4557, 299-W22-32, and 299-W22-33) also show a second, lower Cs-137 concentration peak at about the 15.3 m (50 ft) level. The second peak is most marked in Boreholes 299-W22-32 and 299-W22-33. This level corresponds to a layer of silty sandy gravel in nearby Borehole C4557 (underbed of Hanford Unit 1).

A3.3.1.2 216-S-7 Crib Contamination – Laboratory Data

The waste site consists of two roofed wooden boxes, or cribs, that are buried in an excavation 6.7 m (22 ft) deep. The cribs received liquid waste from the 202-S REDOX Plant building.

Contamination was detected in the vadose zone beneath the 216-S-7 Crib in Borehole C4557 to a depth of 68.8 m (225.5 ft) bgs.

Maximum contaminant levels are shown in Attachment A (Table AA-1, Shallow Zone, and Table AA-2, Deep Zone) and are summarized here.

One radionuclide had a concentration greater than 1 pCi/g in shallow soils (<2.6 m [15 ft]):

- Tritium 184 pCi/g at 4.4-5.2 m (14.5-17 ft) bgs.

Maximum concentrations of radionuclides with concentrations greater than 1 pCi/g in deep soils were the following:

- Americium-241 1,900 pCi/g at 7.3 to 8.1 m (24 to 26.5 ft) bgs
- Cesium-137 20,000 pCi/g at 7.3 to 8.1 m (24 to 26.5 ft) bgs
- Neptunium-237 6.80 pCi/g at 7.3 to 8.1 m (24 to 26.5 ft) bgs
- Nickel-63 13.7 pCi/g at 7.3 to 8.1 m (24 to 26.5 ft) bgs
- Plutonium-238 190 pCi/g at 7.3 to 8.1 m (24 to 26.5 ft) bgs
- Plutonium 239/240 11,000 pCi/g at 7.3 to 8.1 m (24 to 26.5 ft) bgs
- Potassium-40 16.2 pCi/g at 13.4 to 14.2 m (44 to 46.5 ft) bgs
- Strontium-90 53,000 pCi/g at 7.3 to 8.1 m (24 to 26.5 ft) bgs
- Technetium-99 14.7 pCi/g at 7.3 to 8.1 m (24 to 26.5 ft) bgs
- Thorium-228 4.78 pCi/g at 7.3 to 8.1 m (24 to 26.5 ft) bgs
- Tritium 1,410 pCi/g at 47.3 to 48.0 m (155 to 157.5 ft) bgs
- Uranium 233/234 230 pCi/g at 7.3 to 8.1 m (24 to 26.5 ft) bgs
- Uranium-235 25.0 pCi/g at 7.3 to 8.1 m (24 to 26.5 ft) bgs
- Uranium-238 200 pCi/g at 7.3 to 8.1 m (24 to 26.5 ft) bgs.

Tables in Chapter A4.0 of this RI Report compare the nonradioactive COPCs against background and screening levels. For shallow soils, two nonradioactive contaminants were detected above background, mercury and silver; however, none exceeded a human-health screening level (based on *Washington Administrative Code* (WAC) 173-340-745, "Soil Cleanup Standards for Industrial Properties"). For shallow soils, one contaminant, hexavalent chromium, was detected and had no background and ecological screening level. In shallow soils, silver exceeded background and exceeded a terrestrial screening level for soil (WAC 173-340-900, "Tables," Table 749-3).

For deep soils, contaminants that were detected above background (or no background is available) and exceed a screening level (based on WAC 173-340-747(4), "Deriving Soil Concentrations for Ground Water Protection," "Fixed Parameter Three-Phase Partitioning Model"), or that were detected and have no available background and no risk-based concentration (RBC) are the following(maximum detected levels shown):

- Arsenic 7,090 µg/kg at 47.3 to 48.0 m (155 to 157.5 ft) bgs
- Nitrate 53,000 µg/kg at 38.4 to 39.2m (126 to 128.5 ft) bgs
- Nitrate/nitrite 45,000 µg/kg at 68 to 68.8m (223 to 225.5 ft) bgs
- Uranium 463,000µg/kg at 7.3 to 8.1 m (24 to 26.5 ft) bgs.

Residual concentrations of pesticides and herbicides used to kill vegetation on the crib surface were tested for at 0 to 0.9 m (0 to 3 ft) bgs; Delta-benzene hexachloride (Delta-1,2,3,4,5,6-hexachlorocyclohexane), 4,4'-DDE (Dichlorodiphenyldichloroethylene), 4-4'-DDT (Dichlorodiphenyltrichloroethane), Aldrin , Endosulfan II, and Endosulfan sulfate were detected at levels up to 1.4 µg/kg. This soil represents fill material.

A3.3.2 Summary for the 216-S-7 Crib

The 216-S-7 Crib received uranium-rich solutions from process condensates (vapors collected from thermally hot process steps, which were condensed and subsequently discharged to the ground), from the 202-S REDOX Plant and was active between January 1956 and July 1965. Some of the discharges to the 216-S-7 Crib are believed to be hexone-rich concentrator wastes. However, sampling and analysis of the 216-S-7 Crib indicate that few organics are present in the soil column. Uranium, plutonium, and fission products such as Cs-137 and Sr-90 are present in large quantities near the crib bed. Concentrations of radionuclides in the borehole at the 20.1 m (66 ft) level and below are ≤1.6 pCi/g with the exception of the highly mobile contaminants tritium and Tc-99. The distribution of radionuclides in the soil column at the 216-S-7 Crib is similar to the distribution in other 200-PW-2 and 200-PW-4 sites; concentrations are greatly elevated at the crib bottom and drop off markedly down the borehole, with the exception of the highly mobile contaminants.

A stratigraphy diagram for the 216-S-7 Crib is shown in Figure A3-2. Stratigraphy and data are shown in Figure A3-3. Vertical profile plots of contaminants are shown in Figure A3-4.

Figure A3-2. Stratigraphy of the 216-S-7 Crib.

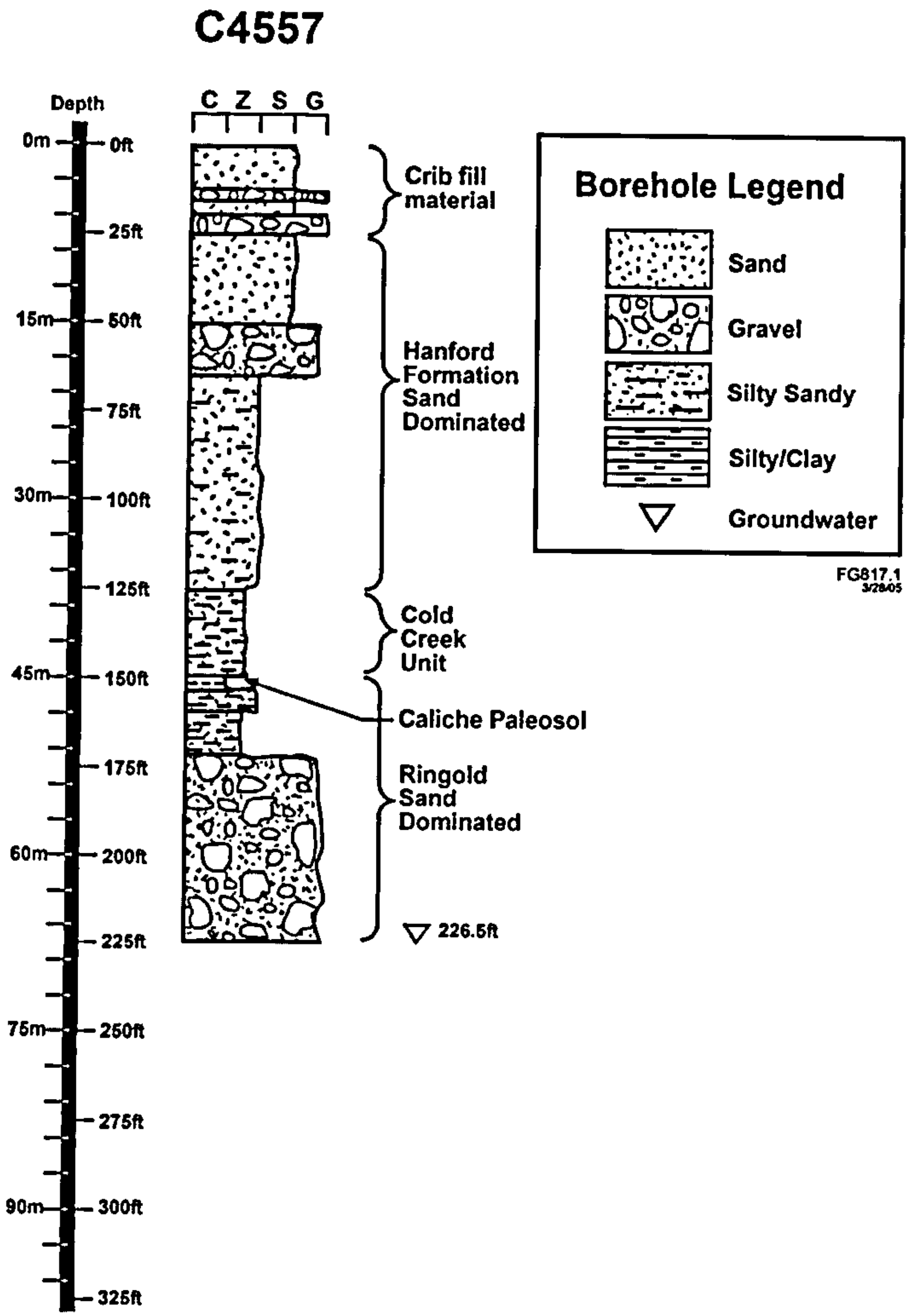
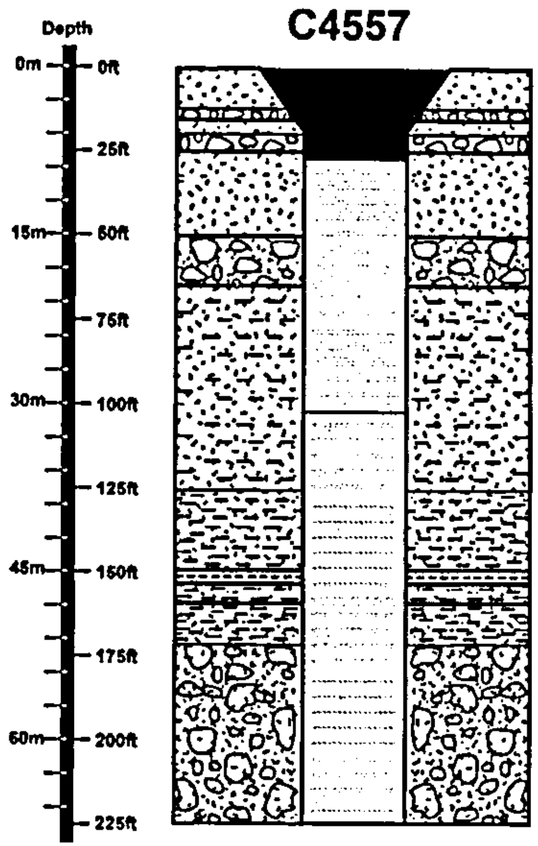


Figure A3-3. Stratigraphy Data for the 216-S-7 Crib (Borehole C4557).



Select Radionuclide and Non-Radionuclide Concentrations at the 216-S-7 Crib

Analyte	Unit	Depth		
		0 to 26.5 ft	>26.5 ft to 100 ft	>100 ft to 225.5 ft
Americium-241	pCi/g	ND-1,900	ND-0.53	0.022-0.054
Cesium-137	pCi/g	0.037 - 20,000	0.628 - 760	ND-0.513
Plutonium-239/240	pCi/g	ND-11,000	ND-26	All ND
Strontium-89/90	pCi/g	ND-53,000	ND-4,900	ND-0.5
Technetium-99	pCi/g	ND-14.7	4.03-14.6	ND-1.29
Thorium-232	pCi/g	0.656-0.772	0.488-0.775	0.447-0.813
Tritium	pCi/g	184-618	205-648	2.02-1,410
Total Uranium	ug/kg	ND-463,000	ND-32,800	ND-1,350
Uranium-233/234	pCi/g	0.16-230	0.016-7.8	0.098-0.33
Uranium-235	pCi/g	ND-25	ND-0.249	0.009-0.023
Uranium-238	pCi/g	0.17-200	0.008-12	0.068-0.35
Arsenic	ug/kg	ND-4,080	ND-4,310	ND-7,090
Hexavalent Chromium	ug/kg	ND-800	ND-295	ND-210

ND = non-detects, detection limits vary with the sample and are presented in the complete data tables in the appendix of this report.

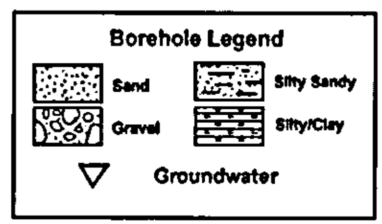


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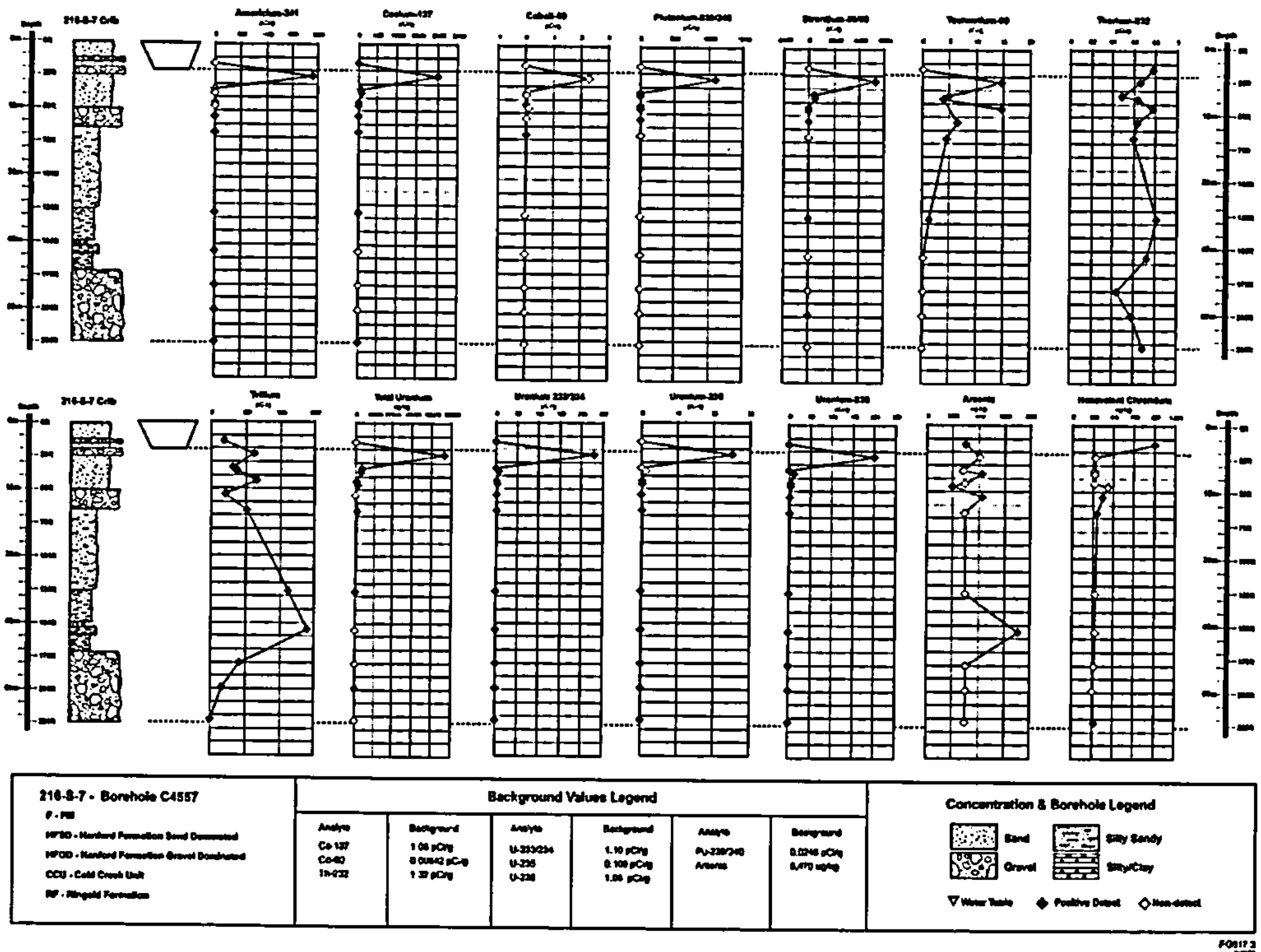
Figure A3-4. Profile Plots of Contaminants in the 216-S-7 Crib (Borehole C4557).



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A4.0 RISK ASSESSMENT

This chapter provides the results of the human-health baseline RA, which includes the human-health risk assessment (HHRA) for nonradionuclides and the RESRAD modeling for radionuclides (ANL/EAD-4). This evaluation consists of a discussion of the conceptual site model (CSM) (Section A4.2), HHRA for nonradionuclide contaminants (Section A4.3), and RESRAD modeling to assess the dose and risk from radionuclides (Section A4.4). The risk evaluation provides a characterization of site risks to determine if remedial actions are warranted and to support evaluation of remedial alternatives in the FS.

A4.1 INTRODUCTION

This chapter compares the ecological risk screening of contaminants in the 216-S-7 Crib against screening concentrations in WAC 173-340-900, Table 749-3, for nonradionuclides and calculated screening levels using DOE/EH-0676, *RESRAD-BIOTA: A Tool for Implementing a Graded Approach to Biota Dose Evaluation*, to implement DOE-STD-1153-2002, *A Graded Approach for Evaluating Radiation Doses to Aquatic and Terrestrial Biota*, for radionuclides (Section A4.5). DOE-STD-1153-2002 was prepared for the U.S. Department of Energy (DOE) by the Biota Dose Assessment Committee and presents a method for developing screening levels [biota concentration guide (BCG)] for radionuclides, as well as a methodology for conducting ecological RAs for radionuclides. DOE/RL-2001-54 contains additional details on DOE-STD-1153-2002.

Figure A4-1 shows the flow of analytical data for this 216-S-7 Crib RI Report, beginning with the reported laboratory data, through the selection of exposure-point concentrations (EPC), data screening, discussion of results (as addressed in Chapter A5.0), and the conclusions made in Chapter A6.0.

A4.2 CONCEPTUAL SITE MODEL

This CSM provides a current understanding of the sources of contamination, physical and ecological setting, and current and future land use and identifies potentially complete human and ecological exposure pathways for the 216-S-7 Crib. Information generated during the development of the RI/FS has been incorporated into this CSM to identify potential exposure scenarios.

A4.2.1 Physical Setting

The 216-S-7 Crib is in the 200-PW-2 OU on the Central Plateau in and near an industrial area. The areas proximal to the 216-S-7 Crib have been disturbed by operations for several decades. The surrounding habitats on the Central Plateau are described in Section A4.2.2. The Hanford Site climate is classified as mid-latitude semiarid or mid-latitude desert, depending on the climatological classification scheme. Most precipitation occurs during late autumn and winter with more than half of the annual amount occurring from November through February

(PNNL-6415, *Hanford Site National Environmental Policy Act (NEPA) Characterization*). Normal annual precipitation is 17.7 cm (6.98 in.). The prevailing wind direction is from the northwest, particularly in the winter and summer.

Wind speeds are lowest in the winter ([averaging 9.7 to 11.3 km/h (6 to 7 mi/h)) and highest in the summer (averaging 12.9 to 14.5 km/h (8 to-9 mi/h) with frequent gusts to 48.3 km/h (30 mi/h)). Summertime temperatures can exceed 37.8°°C (100°°F), and winter temperatures may drop below -17.8°°C (0°°F) (DOE/RL-2001-54).

The Central Plateau lies between the ridges of Gable Mountain and the lower altitude area of dunes. The 200 Areas lie on a prominent geologic flood bar, the Cold Creek bar. The Cold Creek Bar trends generally east-west with elevations between 197 and 225 m (647 and 740 ft) above mean sea level. The plateau drops off rather steeply to the north and northwest into a former flood channel with elevation changes of between 15 and 30 m (50 and 100 ft). The plateau decreases more gently in elevation to the south into the Cold Creek valley and to the east toward the Columbia River. Most of the 200 West Area and the southern half of the 200 East Area are situated on the Cold Creek Bar, while the northern half of the 200 East Area lies within the former flood channel. A secondary flood channel running south from the main channel bisects the 200 West Area. A generalized stratigraphic column and descriptions of the geologic strata are presented in Figure A3-2. Currently, much of the 200 Areas are covered with industrial facilities associated with current and past operations.

A4.2.2 Ecological Setting

The broad classification for the ecology of the Hanford Site area is shrub-steppe, although this broad classification can be refined into a number of separate types of communities found within the shrub-steppe classification. The 200 Areas representative waste sites consist mainly of highly disturbed areas with little vegetative cover because of past industrial and remedial activities. The sites have been stabilized with a substantial gravel cover, further impeding reestablishment of any of the surrounding habitats. In addition, some nearby areas, particularly near the 200 West Area sites, were burned in the 2000 range fire. However, these representative waste sites and their contamination can be accessed by species from the surrounding habitats; these species are considered to be the potential receptors for which this screening with generalized receptors was conducted. In the absence of future activities, any of the surrounding habitats potentially could occur on or near the representative waste sites. The surrounding plant communities and the available census data on plant, bird, and mammal species are described in depth in DOE/RL-2001-54 and only are summarized here. In general, aside from the highly disturbed areas, four plant communities occur in the vicinity of the 200 Areas: sagebrush-dominated communities, gray rabbitbrush-cheatgrass communities, bunchgrass communities, and cheatgrass-dominated communities. Characteristic vegetation and the percent cover of each plant species associated with each habitat type are described in detail in DOE/RL-2001-54.

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

Numerous species of birds and mammals occupy these habitats. Based on the results of bird point counts, the species of bird observed at the largest number of stations in the 200 East Area are the American robin (*Turdus migratus*), the European starling (*Sturnus vulgaris*), and the western meadowlark (*Sturnella neglecta*). The species of bird observed at the largest number of stations in the 200 West Area are the western meadowlark (*Sturnella neglecta*), the sage sparrow (*Amphispiza belli*), the lark sparrow (*Chondestes grammacus*), and the loggerhead shrike (*Lanius ludovicianus*). Mammal species in these habitats consist primarily of small rodents including the Great Basin pocket mouse (*Perognathus parvus*) and deer mice (*Peromyscus maniculatus*). Other small mammals such as the pocket gopher (*Thomomys talpoides*) potentially could occur in the less disturbed surrounding habitat. The surrounding habitats also are home to black-tailed jackrabbits (*Lepus californicus*), mountain cottontails (*Sylvilagus nutalli*), badgers (*Taxidiea taxus*), coyotes (*Canis latrans)*, mule deer (*Odocoileus hemionus*), and an occasional elk (*Cervus elaphus*) (DOE/RL-2001-54). This screening assessment uses soil-media concentrations based on species that are designed to be broad representatives of groups of mammals and birds that include the species occurring at the 200 Areas sites.

Three of the most common groups of insects found at the Hanford Site are darkling beetles, grasshoppers, and ants. Darkling beetles are a dominant part of the insect community in the 200 Areas, where they occur with very little seasonal restriction but exhibit dramatic changes in abundance from year to year (PNL-2253, *Ecology of the 200 Area Plateau Waste Management Environs: A Status Report*). Grasshoppers are herbivorous insects common to the Central Plateau. This screening assessment includes soil media concentrations based on soil invertebrate species that are designed to be broad representatives of insects and other soil invertebrates such as earthworms that include the invertebrate species occurring at the 200 Areas sites. The role of soil invertebrate species in transport of contaminants from the subsurface is discussed in Section A4.2.4.6.

A4.2.2.1 Sensitive Habitat

Sensitive habitats are those identified in DOE/RL-96-32, *Hanford Site Biological Resources Management Plan*, as rare or wetlands (riparian) habitat. The Federal and state governments protect wetlands. Rare habitats are those that have a low availability but are important for plant, fish, and wildlife species (DOE/RL-96-32). On the Central Plateau, the only identified rare habitat areas (rated as Level IV in DOE/RL-96-32) are located in proximity to the basalt ridges of Gable Butte and Gable Mountain. These basalt outcrops have limited availability, are associated with rare plant communities, and are easily disturbed. No waste sites are near these rare habitats.

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

Vernal pools, such as those on Gable Butte and Gable Mountain, are temporary and are considered seasonally flooded wetlands. Approximately 20 vernal pools were located on the eastern end of Umtanum Ridge, near the central part of Gable Butte, and on the eastern end of Gable Mountain. None of these pools are near waste sites in the Central Plateau (*Biodiversity Inventory and Analysis of the Hanford Site, Final Report 1994-1999* [TNC 1999]).

A4.2.2.2 Endangered, Threatened, and Sensitive Species

Two Federally protected species have been observed at the Hanford Site: the Aleutian Canada Goose (*Branta canadensis leucoparia*) and the bald eagle (Haliaeetus leucocephalus). Both depend on the river corridor and rarely are seen in the Central Plateau. As migratory birds, these species are protected under the *Migratory Bird Treaty Act* (1918).

No plants, invertebrates, amphibians, reptiles, or mammals on the Federal or State of Washington threatened and endangered species are known to inhabit the Central Plateau. Sensitive species include threatened and endangered species that are protected by Federal and state laws. Washington State defines sensitive species as "any wildlife species native to the State of Washington that is vulnerable or declining and is likely to become endangered or threatened throughout a significant portion of its range within the state without cooperative management or removal of threats" (WAC 232-12-297, "Endangered, Threatened, and Sensitive Wildlife Species Classification").

A4.2.2.3 Rare Plants

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

A4.2.2.4 Mammals of Concern

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

A4.2.2.5 New-to-Science Species

The Nature Conservancy conducted a biodiversity survey of plants, mammals, reptiles and amphibians, birds, and insects at the Hanford Site between 1994 and 1998 (TNC 1999). This survey found two species and one variety of plants and 41 species and two subspecies of insects that had not been known to science.

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

Service and the State of Washington have not yet determined the protective status of these new-to-science species (i.e., whether they are considered threatened or endangered). The habitat-based management plan at the Hanford Site will offer protection to most of these species. With the exception of some of the insects, none of these new-to-science species are expected to be located near the 216-S-7 Crib. Habitat protection will be key to preserving the insect diversity at the Hanford Site.

A4.2.3 Characterization of Land Use

As discussed in Section A1.3.2, the land-use boundary around the 200 East and 200 West Areas has been designated as industrial-exclusive in DOE/EIS-0222-F. Based on standards in specific sections of DOE/EIS-0222-F and the associated 64 FR 61615, "Record of Decision: Hanford Comprehensive Land-Use Plan Environmental Impact Statement (HCP EIS)," industrial-exclusive land use is defined as "preserving DOE control of the continuing remediation activities and use of the existing compatible infrastructure required to support activities such as dangerous waste, radioactive waste, and mixed waste treatment, storage, and disposal facilities" (DOE/EIS-0222-F). The 216-S-7 Crib is located within this industrial-exclusive land-use boundary.

A4.2.4 Conceptual Exposure Model for Human Health and the Environment

This section describes the potential exposure pathways from site contaminants, based on currently available site information. The conceptual exposure model is formulated according to EPA/540/G-89/004, *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA, Interim Final*, OSWER 9355.3-01. Guidance from the EPA and standards provided in specific sections of WAC 173-340, "Model Toxics Control Act -- Cleanup," were supplemented with the use of professional judgment and information on contaminant sources, release mechanisms, migration routes, potential exposure points, potential exposure routes, and potential receptor groups associated with the site.

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

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

In the absence of any one of these components, an exposure pathway is considered incomplete and, by definition, no risk or hazard exists. The conceptual exposure model for the waste sites is presented in Figure A4-2.

A4.2.4.1 Contaminant Sources

The 216-S-7 Crib received uranium-rich process condensate and/or process waste, primarily from waste streams generated at the REDOX Facility. Additional information is discussed in Section A1.4 of this RI Report.

A4.2.4.2 Release Mechanisms and Environmental Transport Media

The primary release and transport mechanisms for COPCs from the source, via environmental media, to potentially contaminated media are as follows:

- Surface and subsurface liquid discharge, followed by deposition on surface and subsurface soils
- Infiltration, percolation, and leaching contaminants from waste sites to subsurface soils and groundwater
- Generation of dust emanating from shallow-zone soil to ambient air from wind or during maintenance or construction activities at the release site
- Volatilization of chemicals emanating from shallow-zone soil to ambient air at the release site.

Additional information on environmental transport and release mechanisms may be found in WMP-20570, *Central Plateau Terrestrial Ecological Risk Assessment Data Quality Objectives Summary Report – Phase I*, Figure 2-1, "Conceptual Model of Contaminated Media and Biotic Exposure Pathways Associated with Hanford Facility Processes." To provide a comprehensive analysis of contaminant exposure, four primary impacted media were considered: air, groundwater, deep soil, and shallow soil.

Considering air, direct releases have occurred from facility operations. These airborne releases typically represented acute inhalation exposures. Airborne release also could represent longer-term exposure after contaminants are deposited on surface soil. Inhalation of surface air is not typically a risk driver in ecological assessments, but subsurface air may be an important exposure medium for solvents or other volatile organic compounds (VOC) emanating from the subsurface. For example, VOCs such as carbon tetrachloride can partition from the surface or subsurface matrix into water and gas phases and emanate into animal burrows (WMP-20570).

With regard to groundwater, terrestrial plants and animals are unlikely to be exposed to this contaminated medium over most of the Central Plateau, because the shallowest depth to groundwater is approximately 61 m (200 ft) bgs (PNNL-14187, *Hanford Site Groundwater Monitoring for Fiscal Year 2002*).

The above considerations suggest that the focus should be on contaminated soil pathways, which are addressed via the shallow and deep soil media in this chapter.

A4.2.4.3 Potentially Complete Human Exposure Pathways and Receptors

The most plausible exposure pathways considered for characterizing human-health risks were determined on the basis of the current understanding of land-use conditions at and near the site. The pathways are shown in Figure A4-2 and are described in the following sections.

The point of compliance for shallow-zone soils is defined as 0 to 4.6 m (0 to 15 ft) bgs. This soil depth is associated with potential exposure under unrestricted land use in WAC 173-340-740(6)(d), "Unrestricted Land Use Soil Cleanup Standards," "Point of Compliance," as follows:

> "For soil cleanup levels based on human exposure via direct contact or other exposure pathways where contact with the soil is required to complete the pathway, the point of compliance shall be established in the soils throughout the site from the ground surface to fifteen feet below the ground surface.
> This represents a reasonable estimate of the depth of soil that could be excavated and distributed at the soil surface as a result of site development activities."

The point of compliance to evaluate the protection of groundwater is defined as those samples collected throughout the soil profile.

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

A4.2.4.4 Industrial Land-Use Scenario

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

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

A4.2.4.5 Protection of Groundwater

Constituents were evaluated for protection of groundwater. Potential impacts to groundwater for nonradionuclides were screened by comparing the maximum detected soil concentration at any depth in the vadose zone to WAC 173-340-747, "Deriving Soil Concentrations for Ground Water

Protection," soil-screening values. The exposure parameters, chemical properties, and toxicity values used as the basis of these groundwater screening values are discussed in Section A4.3. Potential groundwater impacts of radionuclides were evaluated within the RESRAD modeling framework, as discussed in Section A5.2.2.

A4.2.4.6 Potentially Complete Ecological Exposure Pathways and Receptors

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

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

The major pathways of exposure expected at the waste sites in the 216-S-7 Crib are direct ingestion of contaminated soil and ingestion of food items that have taken up contaminants from soil. These pathways are the same pathways that were used to develop the screening levels for soil. Although some standing water potentially could remain after precipitation events, these sites contain no permanent bodies of water. Therefore, only pathways associated with exposure to contaminated soil are considered to be complete at this site. The Central Plateau terrestrial ecological DQO (WMP-20570) contains an ecological assessment and associated conceptual model that indicates water pathways and potential exposure of ecological receptors.

Species potentially present at the site include both surface-dwelling species and burrowing species such as harvester ants. Both plants and burrowing species may move contamination from the subsurface to the surface, potentially exposing other species to these contaminants.

The exposure pathways used to develop the screening levels consist of all complete exposure pathways except for inhalation and dermal exposure. Although these pathways contribute to the dose of contaminants of potential ecological concern (COPEC) received by animals, it is expected that the contribution from these pathways is relatively small and does not contribute significantly to receptor exposure as identified by the Office of Solid Waste and Emergency Response (OSWER) Directive 9285.7-55, *Guidance for Developing Ecological Soil Screening Levels* (EPA 2003a). Inhalation is viewed to be an insignificant pathway for contaminated soil in areas where plants cover the contaminated ground surface or where much of the contamination is buried. Dermal exposure to wildlife is mitigated by the fur or feathers that cover the bodies of most vertebrates. In addition, the incidental consumption of soil during grooming is assumed to be included in the direct soil-ingestion estimates. Dermal contact and inhalation and/or respiration pathways typically have not been assessed quantitatively in ecological RAs, based on guidance that suggests that the ingestion route is most important to terrestrial animals (EPA/540/R-97/006, *Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments (Interim Final)*). Therefore, the exposure pathways considered in the development of the screening values used for this site are likely to capture the primary exposures for wildlife receptors at this site.

The soil concentrations used to represent the EPCs for contaminants at this site are the maximum detected concentrations seen at any point within the top 4.6 m (15 ft) of the soil column below ground surface. This value was used as the exposure point concentration, because disturbance of the site through bioturbation or human activities potentially could bring these maximum concentrations of contaminants to the surface, where any terrestrial receptor could be exposed to them. Also, the screening levels are based on generalized receptor species, so excluding contaminants based on the burrowing depths of individual species is not appropriate at the level of a screening assessment. The 4.5 m (15-ft) depth provided in the Washington State department of Ecology (Ecology) guidance is deeper than the expected burrowing or rooting depth of species known to occur at the site (DOE/RL-2001-54) and should represent a protective section of the soil column for species expected to inhabit these sites both now and in the future.

A4.2.4.7 Computation of Exposure Point Concentrations

In the human and ecological RAs presented in this RI Report, EPCs are represented by the maximum detected concentration in the 0 to 4.6 m (0- to 15-ft) shallow-zone soil column. The COPC concentrations in deep-zone soils, which are used to evaluate potential impacts to groundwater, are defined as the maximum detected concentration in the 0 m-to-groundwater deep-zone soil column. The use of maximum detected concentrations results in a protective bias that potentially is much greater than that associated with the use of a UCL on an average concentration, which is the generally recommended approach for estimating an EPC (EPA 2002a, *Region 9 Preliminary Remediation Goals (PRG) 2002 Tables*). However, the relatively small number of sampling locations at the waste sites evaluated in this RI Report render the use of a maximum concentration appropriate because, in such cases, calculated UCL values may exceed the maximum detected concentration (EPA 2002a)

A4.3 HUMAN-HEALTH RISK ASSESSMENT FOR NONRADIOLOGICAL CONSTITUENTS

This section presents the HHRA for the 216-S-7 Crib site. This HHRA contains the following components:

- HHRA guidance documents. Lists the guidance documents used for the HHRA
- COPCs for human health. Identifies the constituents considered to be the most important to the evaluation of human-health risk
- Human exposure and toxicity assessment. Identifies the pathways by which potential human exposures could occur; describes how they are evaluated; and evaluates the magnitude, frequency, and duration of these exposures. Identifies the sources of toxicity values used

- RA results. Integrates information from the exposure and toxicity assessments to characterize the risks to human health from potential exposure to contaminants in environmental media
- Identification of major uncertainties and assumptions. Summarizes the basic assumptions used in the RA, as well as limitations of data and methodology.

A4.3.1 Human-Health Risk Evaluation Guidance Documents

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

- *Risk Assessment Guidance for Superfund (RAGS), Volume I -- Human Health Evaluation Manual, Part A (Interim Final),* (RAGS) OSWER 9285.7-01A (EPA/540/1-89/002)
- *Risk Assessment Guidance for Superfund, Volume 1, Human Health Evaluation Manual, Supplemental Guidance: Standard Default Exposure Factors, (Interim Final),* OSWER Directive 9285.6-03 (EPA 1991)
- *Exposure Factors Handbook* (EPA/600/P-95/002Fa)
- *Risk Assessment Guidance for Superfund, Volume I: Human Health Evaluation Manual, (Part E, Supplemental Guidance for Dermal Risk Assessment) Interim* (EPA/540/R-99/005)
- *Proposed Guidelines for Carcinogen Risk Assessment* (EPA/600/P-92/003C)
- *Supplemental Guidance to RAGS: Calculating the Concentration Term,* OSWER Directive 9285.7-081 (EPA 1992.

A4.3.2 Contaminants of Potential Concern for Human Health

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

A4.3.2.1 Criteria for Selection of Contaminants of Potential Concern for the Human-Health Risk Assessment

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

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

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

A4.3.2.2 Identification of Detected Contaminants

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

A4.3.2.2.1 Shallow Zone (Evaluation of Human-Health Risk Assessment)

The maximum and minimum results for all nonradiological contaminants in shallow-zone soil samples are presented in Attachment A. Only those analytes detected in at least one sample were carried forward to the next step in the risk-screening process. The maximum detected values were used because there is only one borehole and thus only one sample at each depth range; thus a statistical assessment could not be performed and the maximums were used. The maximum also was used where duplicate samples were collected at a particular depth.

A4.3.2.2.2 Deep Zone (Evaluation of Groundwater Protection)

The maximum and minimum results for all nonradiological contaminants in deep-zone soil samples are presented in Attachment A. Only those analytes detected in at least one sample were carried forward to the next step in the risk-screening process. As previously discussed, the maximum detected values were used.

A4.3.2.3 Essential Nutrients

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

A4.3.2.4 Background Screening

The next criterion for identifying a COPC is its presence at a concentration higher than naturally occurring levels. Site-wide soil background levels have been established for most metals and conventional chemistry (e.g., sulfate, nitrate) at the Hanford Site. The state-wide soil background level was used as the background level for cadmium. However, Site wide and state wide soil background levels are not available for antimony, boron, cyanide, hexavalent chromium, molybdenum, selenium, or thallium; if these metals were detected, they were carried forward into the RA. Because background criteria have not been developed for VOCs, PCBs, or semivolatile organic compounds (SVOC) in soils at the Hanford Site, any constituent detected in these fractions also was carried forward into the RA.

The maximum detected concentration of each metal detected in shallow- or deep-zone soil was compared to the 90th percentile background value. Summaries of metals and conventional parameters compared to background values are provided in Table A4-1 for shallow-zone soils and Table A4-2 for deep-zone soils. The results of the screening are summarized in Table A4-3 and are detailed in the following two paragraphs.

Using the screening criteria as applied to the shallow-soil results (Table A4-1), mercury and silver were carried through to the screening RA, because the maximum detected concentrations were greater than the 90^{th} percentile background values. Nitrate and nitrate/nitrite as nitrogen, and chromium (VI) were carried through to the RA screen, because no background values were available.

Metals present above background screening levels in deep-zone soils (Table A4-2) included arsenic, chromium (total), copper, mercury, nickel, and silver. The metals chromium (VI) and uranium have no background screening values and were carried through to the RA. Other inorganic compounds present above background screening levels in deep-zone soil were ammonia as nitrogen and nitrate as nitrogen. Sulfate was not carried through as a COPC, because it was below background. In addition, the inorganic analytes nitrate and nitrate/nitrite as nitrogen, and phosphate as PO_4, were carried through to the screening RA, because background values are not available.

A4.3.2.5 Availability of Toxicity Values

All of the available toxicity data for analytes detected are provided in Table A4-4. If a toxicity value was not available from a reliable source, the contaminant could not be included in the screening RA. The exclusion of constituents from this RA because of the lack of available toxicity data potentially could result in an underestimated risk at the site.

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

Toxicity values used to calculate the soil, air, and groundwater RBCs are presented in Table A4-4 and were obtained from the following sources:

- IRIS, a database prepared and maintained by the EPA and available through the National Center for Environmental Assessment. IRIS is an electronic database containing health risk and EPA regulatory information on specific chemicals (EPA 2003b)
- HEAST, provided by the EPA Office of Solid Waste and Emergency Response, is a compilation of toxicity values published in various health effects documents issued by EPA (EPA/540/R-97/036), since revised

- The EPA (2002a), *Region 9 Preliminary Remediation Goals (PRG) 2002 Tables* (October 2002)
- The EPA (2002b), *EPA Region 3 Risk-Based Concentration (RBC) Tables* (April 2002).

A4.3.2.6 Tentatively Identified Compounds

2-ethyl-1-hexanol was a tentatively identified compound (TIC) found in one sample at 4.4 to 5.2 m (14.5 to 17 ft) bgs at an estimated concentration of 40 µg/kg. By EPA's definition (SW-846, *Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, Third Edition; Final Update III-A*), a TIC is identified by a library search, and no calibration for that compound is performed. Concentrations are estimated based on the nearest internal standard. Thus, both the identification and quantification are tentative. When the TIC is not known to be part of the waste stream and is not identified in other samples within the borehole, the EPA RAGS allows one to consider it a false positive or remove it from risk evaluation. In addition, this compound is used in sizing of cotton. Frequently, cotton gloves are used by workers at the Hanford Site; this may be an artifact from sample handling or equipment handling (EPA/540/1-89/002 and Merck 1996, *The Merck Index: an Encyclopedia of Chemicals, Drugs, and Biologicals*). Ethyl acetate also is a TIC from one sample collected at 24 to 26.5 ft bgs, with an estimated concentration of 21 µg/kg. Based on similar logic previously presented, a one-time detection of this TIC in the borehole is not sufficient to consider it a positive response in the RA. In addition, the acetate compounds are well known to chromatograph poorly; thus, its identification is suspect.

Both 2-ethyl-1-hexanol and ethyl acetate were excluded from the screening RA.

A4.3.2.7 Computation of Exposure Point Concentrations

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

A4.3.2.7.1 Direct Soil Contact Exposure Point Concentrations

As a conservative estimate and as a result of the small number of samples collected, the maximum detected concentration was used for the EPC for shallow soils.

A4.3.2.7.2 Ambient-Air Exposure Point Concentrations

Air concentrations were estimated by modeling particulate or vapor emissions from soil. Air concentrations from vapor emissions were estimated using a volatilization factor (VF) for those constituents that are considered volatile. Volatile constituents considered for the inhalation pathway are operationally defined as those constituents with a Henry's Law constant greater than 10^{-5} atm-m^3/mole and a molecular weight of less than 200 g/M (EPA 2002a). Air concentrations from fugitive dust emissions were estimated using a particulate emission factor (PEF) for those constituents that are not volatile. Equation A4-1 was used to estimate air concentrations from volatile or particulate emissions and soil.

Equation A4-1: Calculated Air Concentration

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

where:

C_s = soil concentration (mg/kg)

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

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

The VFs for VOCs identified as a COPCs in shallow-zone soil were calculated using Equations A4-2 and A4-3. The PEF used to estimate fugitive dust emissions for nonvolatile compounds was obtained using Equation A4-4. Site specific assumptions used in these calculations are provided in Table A4-5.

Soil-To-Air Volatilization Factor (VF_S)

$$VF_s(m^3/kg) = (Q/C) \times \frac{(3.14 \times D_A \times T)^{1/2}}{(2 \times \rho_b \times D_A)} \times 10^4 (m^2/cm^2)$$

Equation A4-2: Derivation of the Volatilization Factor

$$D_A = \frac{[(\Theta_a^{10/3} D_i H' + \Theta_w^{10/3} D_w)/n^2]}{\rho_B K_d + \Theta_w + \Theta_a H'}$$

where:

Parameter	Definition (units)	Default
VF_s	volatilization factor (m^3/kg)	--
D_A	apparent diffusivity (cm^2/s)	--
Q/C	inverse of the mean conc. at the center of a 0.5-acre square source (g/m^2-s per kg/m^3)	Site specific
T	exposure interval (s)	9.5×10^8
ρ_b	dry soil bulk density (g/cm^3)	Site specific
θ_a	air-filled soil porosity (L_{air}/L_{soil})	Site specific or n-Θ_w
n	total soil porosity (L_{pore}/L_{soil})	Site specific 1 - (ρ_b/ρ_s)
Θ_w	water-filled soil porosity (L_{water}/L_{soil})	Site specific
ρ_s	soil particle density (g/cm^3)	Site specific
D_i	diffusivity in air (cm^2/s)	Chemical specific
H	Henry's Law constant (atm-m^3/mol)	Chemical specific
H'	dimensionless Henry's Law constant	Calculated from H by multiplying by 41 (EPA 1991)
D_w	diffusivity in water (cm^2/s)	Chemical specific
K_d	soil-water partition coefficient (cm^3/g) = $K_{oc}f_{oc}$	Chemical specific
K_{oc}	soil organic carbon-water partition coefficient (cm^3/g)	Chemical specific
f_{oc}	fraction organic carbon in soil (g/g)	Site specific

Soil Saturation Concentration (C_{sat})

Equation A4-3: Derivation of the Soil Saturation Limit

$$C_{sat} = \frac{S}{\rho_b}(K_d \rho_b + \Theta_w + H' \Theta_a)$$

where:

Parameter	Definition (units)	Default
C_{sat}	soil saturation concentration (mg/kg)	--
S	solubility in water (mg/L-water)	Chemical specific
ρ_b	dry soil bulk density (kg/L)	Site specific
n	total soil porosity (L_{pore}/L_{soil})	Site specific 1 - (ρ_b/ρ_s)
ρ_s	soil particle density (kg/L)	Site specific
K_d	soil-water partition coefficient (L/kg)	K_{oc} x f_{oc} (chemical specific)
K_{oc}	soil organic carbon/water partition coefficient (L/kg)	Chemical specific
f_{oc}	fraction organic carbon of soil (g/g)	Site specific
Θ_w	water-filled soil porosity (L_{water}/L_{soil})	Site specific
θ_a	air-filled soil porosity (L_{air}/L_{soil})	Site specific or n-Θ_w
H	Henry's Law constant (atm-m^3/mol)	Chemical specific
H'	dimensionless Henry's Law constant	H x 41, where 41 is a unit conversion factor

Soil-To-Air Particulate Emission Factor (PEF)

Equation A4-4: Derivation Of The Particulate Emission Factor

$$PEF(m^3/kg) = Q/C \times \frac{3600 s/h}{0.036 \times (1-V) \times (U_m/U_t)^3 \times F(x)}$$

where:

Parameter	Definition (units)	Default
PEF	Particulate emission factor (m^3/kg)	Site specific
Q/C	Inverse of the mean concentration at the center of a 0.5-acre-square source (g/m^2-s per kg/m^3)	73.44 (Salem, Oregon)
V	Fraction of vegetative cover (unitless)	Site specific or 0.5
U_m	Mean annual windspeed (m/s)	Site specific or 4.69
U_t	Equivalent threshold value of windspeed at 7 m (m/s)	Site specific or 11.32
F(x)	Function dependent on U_m/U_t derived using EPA/600/8-85/002, ***Rapid Assessment of Exposure to Particulate Emissions from Surface Contamination Sites*** (unitless)	Site specific or 0.194

Groundwater Exposure Point Concentrations

As a conservative estimate resulting from the small number of samples collected, the maximum detected concentration was used for the EPC for deep soils.

Summary of Contaminants of Potential Concern

Using the background screening results provided in Tables A4-1 and A4-2 and the toxicity data in Table A4-4, the direct-contact shallow-zone soil COPCs are provided in Table A4-6, the shallow-zone soil air COPCs in Table A4-7, and the deep-zone soil groundwater protection COPCs in Table A4-8.

A4.3.3 Human-Exposure Assessment

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

- Development of exposure assumptions for potentially complete exposure pathways
- Calculation of chemical intake for COPCs
- Source of toxicity values.

A4.3.3.1 Human-Exposure Assumptions

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

A4.3.3.2 Nonradiological Constituents

As discussed in the CSM, groundwater at the waste sites is not used for drinking water purposes. However, exposure assumptions are provided for the groundwater ingestion pathway as a means of evaluating the groundwater protection pathway. The exposure assumptions used to develop soil-screening RBCs for industrial direct soil contact, soil for the groundwater protection pathway, and soil for the ambient-air exposure pathway for nonradiological constituents are listed in Tables A4-9 and A4-10. The scenarios evaluated were selected based on the conceptual exposure model (Figure A4-1) and are consistent with the reasonably anticipated future land use.

A4.3.3.3 Industrial Land-Use Scenario

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

The models used to estimate risk and dose for nonradiological and radiological constituents are not directly comparable, primarily because the input factors differ for each model. The exposure assumptions under the industrial-exposure scenario for the nonradiological constituents are prescribed assumptions that cannot be modified. The model assumes that the industrial worker is at the site for 146 days per year over 20 years, resulting in a total of 2,920 days.

A4.3.3.4 Equations for Soil Risk-Based Concentrations

For the nonradiological constituents detected, soil RBCs were calculated using the methodology of WAC 173-340-745, used to develop the cleanup levels and calculations table in Ecology 94-145, *Cleanup Levels and Risk Calculations under the Model Toxics Control Act Cleanup Regulation; CLARC, Version 3.1* (CLARC). The following equations were used to calculate the soil RBCs under the industrial land-use exposure scenario for carcinogens and noncarcinogens.

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

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

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

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

A4.3.3.5 Equations for Ambient-Air Risk-Based Concentrations

Ambient-air RBCs were calculated for all COPCs. The following sections provide the equations used to calculate the ambient-air RBCs under the industrial land-use exposure scenario for carcinogens and noncarcinogens. The exposure assumptions used to calculate the RBCs for each exposure scenario are listed in Table A4-11.

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

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

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

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

A4.3.3.6 Equations for Groundwater Risk-Based Concentrations Used in Evaluating Protection of Groundwater

Groundwater RBCs are used to calculated soil concentrations protective of groundwater. For the constituents detected, groundwater RBCs were calculated according to the methodology provided from the CLARC Tables, Version 3.1 (Ecology 94-145). The following sections present the equations used to calculate the groundwater RBCs for carcinogens and noncarcinogens. The exposure assumptions used to calculate the RBCs are listed in Table A4-12.

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

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

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

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

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

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

where:

C_s = calculated soil concentration (mg/kg)

C_w = groundwater RBC (μg/L)

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

DF = dilution factor (20 unitless)

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

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

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

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

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

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

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

where:

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

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

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

The chemical-specific values used to calculate soil concentrations protective of groundwater are summarized in Table A4-13.

A4.3.4 Risk Assessment Results for Nonradiological Constituents

All nonradiological COPCs previously identified were compared to their respective RBCs for each of the three applicable exposure media.

All RBCs developed for this site were based on chronic or carcinogenic threats. The maximum soil concentration was compared with its respective RBC. For the purposes of this report, contaminant concentrations were compared to risk-based concentrations developed under *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA) guidance (EPA/540/R-92/003, *Risk Assessment Guidance for Superfund: Volume I -- Human Health Evaluation Manual (Part B. Development of Risk-Based Preliminary Remediation Goals), Interim*, Publication 9285.7-01B) using the excess lifetime cancer-risk range of 10^{-4} to 10^{-6} and using a hazard quotient of 1.0 and an industrial land-use scenario. Because the waste sites in these OUs are in the Core Zone, risk-based concentrations for shallow-zone soils used for screening correspond to a 10^{-5} risk level. Because groundwater protection RBCs are designed to protect potential future off-site users of groundwater, the screening calculations for the groundwater protection RBCs were determined using a target risk of 10^{-6}. This target risk is consistent with WAC 173-340.

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

Carcinogenic risk is expressed as a probability of developing cancer as a result of lifetime exposure. For a given chemical and exposure route, excess lifetime cancer risk (ELCR) can be back-calculated by dividing the concentration term by its cancer RBC, then multiplying by 10^{-5} (for industrial soil RBCs) to estimate chemical-specific risk. An ELCR that exceeds the target risk threshold of $1x10^{-5}$ indicates that, as a plausible upper bound, an individual has a 1-in-100,000 chance of developing cancer as a result of site-related exposure to a carcinogen during a 75-year lifetime under the specific exposure conditions at the site. The acceptable risk level for industrial land use is $1x10^{-5}$. Generally, the EPA considers action to be warranted at a site when cancer risks exceed $1x10^{-4}$, based on an RME scenario. Generally, action is not required for risks falling within or below $1x10^{-4}$ to $1x10^{-6}$. A hazard index greater than one indicates that some potential for adverse noncancer health effects is associated with exposure to the contaminants of concern (EPA 1991). Generally, action is not required for a hazard index of less than one.

A4.3.4.1 Comparison of Results to Risk-Based Concentrations

Direct Contact. Comparison of maximum shallow-zone soil concentrations is provided in Table A4-12. All of the selected COPCs were below their calculated screening levels.

Results of Comparison to Ambient-Air Risk-Based Concentrations. Table A4-13 provides the results of the comparison of maximum soil concentrations to ambient-air RBCs. No VOCs were detected in the shallow-zone soil at the 216-S-7 Crib and, therefore, the ambient-air screening is based solely on PEFs for nonvolatile compounds. All of the calculated maximum air concentrations were below their respective ambient-air RBCs.

Groundwater Protection. Comparisons of maximum detected deed-zone soil concentrations to their applicable soil RBCs protective of groundwater are provided in Table A4-14. Only nitrate as nitrogen, nitrate and nitrate/nitrite as nitrogen, arsenic, and uranium (total) concentrations exceeded their applicable RBCs. It should be noted that the maximum arsenic concentration was only slightly above the 90^{th} percentile background level and that the RBC was 200 times lower than the 90^{th} percentile background concentration.

A4.3.5 Uncertainty Analysis

Uncertainties associated with sampling and analysis include the inherent variability (standard error) in the analysis, representativeness of the samples, sampling errors, and heterogeneity of the sample matrix. While the QA/quality control (QC) program used in conducting the sampling and analysis serves to reduce errors, it cannot eliminate all errors associated with sampling and analysis.

A4.3.5.1 Uncertainty Associated with Exposure Assessment

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

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

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

A4.3.5.2 Uncertainty Associated with Toxicity Assessment

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

Exclusion of constituents without toxicity values from this RA potentially could underestimate risk at the site. Conversely, inclusion of metals with background values significantly greater than the RBC (e.g., arsenic) could results in overestimation of risk caused by site contaminants to which the public is routinely exposed because of background soil concentrations.

A4.3.5.3 Uncertainty Associated with Risk Characterization

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

A4.4 RESRAD MODELING

The RESRAD computer program, Version 6.21 (ANL 2002, *RESRAD for Windows*) was used to evaluate potential adverse health effects of residual radionuclides in the soil at the 216-S-7 Crib. The radiological COPCs identified in Section A4.4.1 were chosen based on detection status and comparison to background concentrations. The RESRAD input parameter values and the associated rationale and assumptions for the industrial scenario and groundwater protection modeling are discussed in Section A4.4.2. The results of RESRAD modeling of potential health effects and groundwater impacts associated with radionuclides in shallow- and deep-soil zones are described in Section A4.4.3. Both radiological dose and cancer risk are assessed as health-effects endpoints. An uncertainty analysis for the RESRAD modeling is provided in Section A4.4.4. The inputs and assumptions related to the intruder scenarios, and the results of these analyses, are provided in Section A4.4.5.

A4.4.1 Criteria for Selecting Radiological Contaminants of Potential Concern

Radionuclides identified in this section will be evaluated as COPCs in the RESRAD modeling. If potential exposure to radionuclide COPCs results in radiation dose or cancer risk exceeding target criteria, actions to improve the understanding of COPC distribution and/or migration in the environment or actions to mitigate potential exposures should be considered. The technical approach for identifying radionuclide COPCs is illustrated in Figure A4-2.

A4.4.1.1 Data Evaluation

All soil data collected under the Work Plan (DOE/RL-2000-60, Rev. 1) were considered in the radiological evaluation. Soil-sampling information, including collection dates, sample identification numbers, depths, and analytical laboratories, is summarized in Attachment B.

All radiological constituents detected in one or more samples were included in the radiological evaluation. Sample data with estimated concentrations ("B" or "J" qualification flags) were evaluated at the reported concentration in the radiological evaluation. Rejected ("R"-qualified) data were not used in the radiological evaluation. If duplicate sample results were available for a sample, the highest reported concentration was used.

The principal distinction for data used in the radiological evaluation was the sample depth. Analytical data from samples collected at depths of 4.6 m (15 ft) or less (shallow-zone soil) were evaluated for potentially unacceptable radiation dose and cancer risk to humans from exposure under an industrial land-use scenario. Analytical data from samples collected at all depths (deep-zone soil) were evaluated for potential groundwater impacts using the RESRAD vadose- and saturated-zone transport models.

Radionuclides detected in one or more samples at depths of 0 to 4.6 m (15 ft), and additional radionuclides detected only at depths below 4.6 m (15 ft), are listed in Table A4-15.

A4.4.1.2 Background Screening

Hanford Site 90th percentile background values were used to identify potentially waste site-related contaminants in the background screening. The background values were identified in Table 5-1 of DOE/RL-96-12.

Summary statistics are provided in Table 5-1 of DOE/RL-96-12 for several fallout radionuclides, including Co-60, Cs-137, Eu-154, Eu-155, Pu-238, Pu-239, and Sr-90. Background data for fallout radionuclides pertain only to undisturbed surface soil and even then are sufficient to calculate a 90th percentile value for only Cs-137, Sr-90, and Pu-239 (DOE/RL-96-12). Background comparisons will not be performed for fallout radionuclides, because the waste sites evaluated in this RI Report do not have undisturbed surface soils and because all site data have been collected from deep-zone soils that are associated with deposition of fallout radionuclides.

The background comparisons for radionuclides (other than fallout) are presented in Table A4-15. The use of shading indicates a concentration of a radionuclide that exceeds the background screening value. The background screening is conducted separately for shallow-zone [0 to 4.6 m (15 ft)] soils and deep-zone (0 m to groundwater) soils.

As shown in Figure A4-2, shallow-zone soil radionuclide concentrations are evaluated for health impacts related to surface exposure, whereas radionuclide concentrations from any depth may be evaluated for potential groundwater impacts. Constituents with a maximum detected concentration exceeding background in one or both soil strata (shaded cells) are identified as COPCs for the RESRAD modeling.

The following constituents are present at maximum concentrations greater than background, or do not have an applicable background value, and will be evaluated further for either surface exposure and/or potential groundwater impacts:

Am-241	Ni-63	Sr-90
Cs-137	Pu-238	H-3
Co-60	Pu-239/240	U-234
Eu-155	Tc-99	U-235
Np-237	Th-228	U-238

A4.4.2 RESRAD Assumptions and Input Parameters for the Industrial Scenario and Groundwater Protection Modeling

Waste site-specific or Hanford Site-specific data were used where available as input parameters for the RESRAD modeling. The types of parameters for which such data were used included vadose zone hydrogeologic characteristics, radionuclide K_d values, the dimensions of each site, and the depth of cover material over each site.

K_d values used preferentially in the RESRAD simulations were "conservative" values from Table E.15 of PNNL-11800, *Composite Analysis for Low-Level Waste Disposal in the 200 Area Plateau of the Hanford Site.* The 216-S-7 Crib was assigned Category "H" K_d values, corresponding to low-organic/low-salts/very-acidic releases. The category "H" K_d values pertain to a high-impact zone near the release point. However, because contaminant depth profiles at the 216-S-7 Crib indicate that liquid releases historically reached groundwater, the Category "H" K_d values were applied for modeling across the entire vadose zone.

An industrial-exposure scenario is used to evaluate potential surface exposure to radionuclides in soil. The exposure scenario pathway assumptions and generic RESRAD input parameter values are consistent with those employed in the 200-PW-2 and 200-PW-4 OU RI Report (DOE/RL-2004-25). The input parameter values also are largely in accord with those described in Appendices A and B of WDOH/320-015, *Hanford Guidance for Radiological Cleanup.* The specific parameter values and associated references for each RESRAD input parameter are provided in Table A4-16.

Maximum detected concentrations of radionuclides in the 0 to 4.6 m (15 ft) shallow-zone soil layer were evaluated for potential radiation dose and cancer risk in the industrial land-use scenario. The specific radionuclides and exposure concentrations used in RESRAD are those indicated in shading in the column labeled "Shallow-Zone Maximum Concentration" in Table A4-15. In the 200-PW-2 and 200-PW-4 OU RI Report (DOE/RL-2004-25), surface exposure to radionuclides generally was evaluated under two conditions. In the first condition, the site-specific cover depth was included in the RESRAD modeling. In the second condition, labeled the "no-cover" scenario, the maximum detected concentration was assumed to be uniformly present from 0 to 4.6 m (15 ft) bgs. An exception to this protocol was made for the 216-A-10 Crib, 216-A-36B Crib, and 216-B-12 Crib, because the cover thicknesses were so great (7.6 to 10.7 m [25 to 30 ft]) that removing the fill to create a "no-cover" scenario was judged to be implausible at these sites. This situation also is present at the 216-S-7 Crib, where the thickness of cover material is approximately 6.4 m (21 ft). However, as was the case with the 216-A-10 Crib and the 216-B-12 Crib (DOE/RL-2004-25), radionuclide COPCs were identified in samples of the cover material at the 216-S-7 Crib. Therefore, to ascertain whether unacceptable impacts may be associated with these COPCs, potential exposure to radionuclides in the existing cover was evaluated for the construction trench worker at the 216-S-7 Crib.

Maximum detected concentrations of radionuclides from 0 m to the top of the water table (deep-zone soil layer) were evaluated for potential groundwater impacts. The specific radionuclides and source-zone concentrations used in RESRAD for this evaluation are those indicated in shading in the column labeled "Deep-Zone Maximum Concentration" in Table A4-15. The actual vertical distribution of contamination indicated in the RI data was used to assign a protective estimate of the thickness of the contaminated zone for the groundwater-impact modeling. For tritium, a source thickness of 65 m (213 ft) was estimated. For all other radionuclides, a source thickness of 25 m (82 ft) was estimated.

A4.4.3 RESRAD Results for the Industrial Scenario and Groundwater Protection Modeling

Radionuclides with maximum detected concentrations exceeding background screening values, or for which background values were unavailable or not applicable, were evaluated for potential human-health effects and groundwater impacts using the RESRAD computer program, Version 6.21 (ANL 2002). The results of RESRAD modeling for surface exposure to contaminants in the shallow-zone soil layer and groundwater protection modeling for the deep-zone soil layer are discussed in this section.

RESRAD output was obtained at the following model years: 0, 1, 10, 30, 100, 150, 250, 500, and 1,000. The discussion of results reflects information obtained at these points in the modeling period of 0 to 1,000 years.

A4.4.3.1 RESRAD Results for the Industrial Scenario

The dose assessment and risk assessment results for the 216-S-7 Crib are shown in Tables A4-17 and A4-18, respectively. In addition to the radiation dose and cancer risk over time, the tables indicate the primary radionuclide and exposure pathway associated with dose and risk at each time. The percent contribution of individual radionuclides to dose and cancer risk is expressed in terms of the original radionuclides present at a site, rather than as the percent contribution across all parents and progeny present at some specific time. For example, dose and risk over time from some radionuclides may be associated with progeny as well as with the parent radionuclides themselves. If no single radionuclide contributes 40 percent or more to the total dose via the primary pathway, multiple radionuclides associated with the primary pathway are tabulated.

Health effects are modeled from the present day to 1,000 years in the future. Cancer risk estimates employ cancer risk morbidity slope factors from EPA/402/R-99/001, *Cancer Risk Coefficients for Environmental Exposure to Radionuclides*, Federal Guidance Report 13, provided in the RESRAD computer program, Version 6.21 (ANL 2002). The depth of cover over the contaminated zone at the 216-S-7 Crib is approximately 6.4 m (21 ft). Therefore, as described in Section A4.4.2, a no-cover evaluation was not conducted.

Radionuclide doses for each exposure pathway and radionuclide are summed to calculate the total dose to an individual. Radiation doses over the 1,000-year modeling period are below the 15 mrem/yr target dose limit. Cancer risks for each exposure pathway and radionuclide are summed to calculate the total cancer risk to an individual. Cancer risk estimates are evaluated relative to the target risk range of 10^{-6} to 10^{-4} described in 40 CFR Part 300, "National Oil and Hazardous Substances Pollution Contingency Plan." The time of maximum total dose and risk is at year 0. Figure A4-3 shows the summed dose and summed risk from all radionuclides for the industrial scenario at the 216-S-7 Crib.

A4.4.3.2 RESRAD Results for Groundwater Protection

The RESRAD model was run to 1,500 years to determine whether any radionuclides in deep-zone soil reached groundwater. Only tritium reached groundwater within this time period. Technetium-99 concentrations reached a peak of 2,000 pCi/L at year 1,240. Tritium concentrations reached a peak of 102,000 pCi/L at year 30. Although groundwater use is not anticipated under an industrial land-use scenario, dose and risk calculations for groundwater ingestion were performed to provide a context for evaluating the results of the groundwater impact modeling. A drinking water ingestion rate of 730 L/yr, corresponding to 2 L/day for 350 days/yr, was used for these calculations. A dose of 4.6 mrem/yr and a cancer risk of 1×10^{-4} for tritium were calculated at year 30. A dose of 2.1 mrem/yr and a cancer risk of 1×10^{-4} for Tc-99 were calculated at year 1,240. Radiation dose estimates were below 15 mrem/yr for both of these radionuclides.

Tritium breakthrough to groundwater occurred more quickly than breakthrough of Tc-99, because the tritium contamination extends to depths immediately above the water table, and because the K_d for Tc-99 is 0.1 while that of tritium is zero. The RESRAD model assumption of steady-state infiltration through the unsaturated zone resulted in immediate movement of tritium into groundwater near the beginning of the modeling period.

Groundwater modeling for tritium in the 216-S-7 Crib was performed separately from all other radionuclides, because the thickness of the contaminated zone is much greater for tritium than for the other radionuclides. Figure A4-4 presents the dose and risk for all radionuclides summed with Tc-99 contributing the entire dose and risk. The Tc-99 maximum reaches groundwater at year 1240. Figure A4-5 presents the dose and risk for tritium in groundwater at year 30.

A4.4.3.3 Summary of 216-S-7 Crib RESRAD Results

Industrial. Radiation dose for industrial land use was below the target criterion of 15 mrem/yr. Cancer risk was below the 10^{-6} to 10^{-4} risk range throughout the modeling period. Health impacts are associated primarily with Cs-137 via external irradiation throughout the modeling period.

Groundwater Protection. Tritium and Tc-99 were the only radionuclides to reach groundwater. Tc-99 was associated with a theoretical radiation dose of 2.1 mrem/yr and cancer risk of 1×10^{-4} via drinking water ingestion at year 1240. Tritium reached a maximum groundwater concentration at year 30. Tritium dose and cancer risk were estimated to be 4.6 mrem/yr and 1×10^{-4}, respectively.

A4.4.4 Uncertainty Analysis

The analysis of potential surface exposure and groundwater impacts using the RESRAD computer program, Version 6.21 (ANL 2002) contains protective biases meant to ensure that the results represent a reasonable worst case evaluation. Sources of uncertainty that are considered particularly significant are described in the following paragraphs. This uncertainty analysis will focus on identifying and qualifying these biases.

The RESRAD transport model protectively reflects one-dimensional flow in the vadose zone with no lateral dispersion. Conditions that facilitate migration of a particular radionuclide from soil to groundwater at a site include a low K_d value, high soil concentration, and short distance to groundwater. Among these variables, K_d values are likely to be particularly important. The sensitivity of the RESRAD vadose and groundwater transport model to K_d value in these model runs is evident in the groundwater protection modeling for the 216-S-7 Crib. Neptunium-237 and Sr-90, with K_d values of 3 and 10, respectively, did not reach groundwater even at 2,000 years. Even Tc-99, with a K_d value of 0.1, took over 1,000 years to reach groundwater through a vadose zone of approximately 44 m (144 ft). If the Tc-99 K_d is changed to zero, the breakthrough time to groundwater would be reduced by more than 50 percent. Because of the great sensitivity of K_d values in the RESRAD modeling, conservative estimates of K_d values were used in the groundwater protection screening. The selection of K_d values and the sources of the values is discussed in Chapter 5.0 of the 200-PW-2 and 200-PW-4 OU RI Report (DOE/RL-2004-25).

A major uncertainty associated with both the surface exposure and groundwater protection evaluations is the use of maximum detected constituent concentrations to represent a soil source term across an entire site. The use of maximum detected constituent concentrations almost certainly introduces a very conservative bias into the radionuclide dose and risk evaluations, although the magnitude of the bias cannot be well estimated with existing sample support.

The industrial-exposure scenario is based on reasonable worst case exposure conditions. Such input parameters as soil ingestion rate, exposure frequency, and exposure duration are biased toward the upper end of likely exposure values.

In addition to the protective bias related to specific parameter values, a question of theoretical versus actual land use arises when considering the RESRAD results. Presently, the primary receptors in the area of the waste sites in the 200-PW-2 and 200-PW-4 OUs are field personnel involved with sampling and monitoring. No chronic, daily exposure scenario is being realized at these sites at this time. Hence the industrial doses and risks are inherently theoretical. Because potential health impacts decrease over time (see Figure A4-3), the industrial scenario results also are biased from temporal discontinuity between the model time and a time when the exposure scenario might actually be realized.

Considerable uncertainty is associated with the radionuclide dose conversion factors and slope factors applied within RESRAD for these calculations. Most generally, these factors employ dose-response models that extrapolate from effects observed at relatively high radiation dose rates to the relatively low dose rates more common in environmental assessments. This type of dose-response model assumes that effects observed at high doses, such as cancer incidence, also may be observed at lower doses, albeit at correspondingly lower frequency. As dose rates decrease, it is possible, though uncertain, that the model fails and that at some dose rates little or no correlation exists between dose and response.

A4.5 ECOLOGICAL RISK SCREENING

Ecological screening of radionuclide and nonradionuclide chemicals at the 216-S-7 Crib was conducted according to Steps 1 and 2 of EPA/540/R-97/006. The ecological screening assessment compares concentrations of COPECs in site media to conservative ecotoxicity-based concentrations. Ecological screening at the 216-S-7 Crib was conducted in a manner consistent with the screening at other 200-PW-2 and 200-PW-4 OU sites. Soil-screening levels for nonradionuclide contaminants were obtained from WAC 173-340-900; Table 749-3, and the ecological soil-screening levels (Eco-SSL) developed by the EPA (EPA 2003a). Soil concentrations of radionuclides were compared to the dose-based soil-screening levels developed in the DOE BCGs for protection of terrestrial systems (DOE-STD-1153-2002). The basis of these screening levels and the assumptions incorporated into them are discussed in the 200-PW-2 and 200-PW-4 OU RI Report (DOE/RL-2004-25). The conceptual model, ecological setting, and ecological exposure pathways for the 216-S-7 Crib are identical to those developed for the other 200-PW-2 and 200-PW-4 OU areas, as presented in DOE/RL-2004-25.

All of these screening levels were developed based on mathematical models incorporating estimates of intake through food and soil ingestion pathways. These screening levels are based on modeled risk to generalized receptors representing plants, soil biota, mammals, and birds. The conservatively derived levels are expected to be protective of plant and animal species currently found at these sites, as well as those species that may be present at the sites in the future. The overall ecological screening approach for the 216-S-7 Crib is illustrated in Figure A4-6.

A4.5.1 Exposure Parameter Estimates

The DOE BCGs and the EPA Eco-SSLs were developed using the assumption that the receptor is exposed to the site 100 percent of the time. The WAC 173-340-900 wildlife screening values assume an area-use factor (AUF) of one for the mammalian herbivore receptor (a vole), but use an AUF of 0.52 for the avian predator (a robin) and an AUF of 0.50 for the mammalian predator (a shrew) to represent that these receptors may use areas outside of the site under consideration.

All screening levels considered in this analysis incorporate 100 percent bioavailability of chemicals and radionuclides in soil and food items. This assumption is conservative and appropriate in the absence of site-specific information regarding the actual bioavailability of these chemicals.

The exposure parameters used in developing the screening values are designed to provide an appropriate level of conservatism for a screening assessment. The equations for soil concentration include the estimated intake through the food chain and through direct ingestion of soil by the receptor. These food ingestion rates usually are based on empirically derived allometric equations originally developed by K. A. Nagy (Nagy 1987, "Field Metabolic Rate and Food Requirement Scaling in Mammals and Birds"); these allometric equations correlate food ingestion rate to body weight (EPA/600/R-93/187, *Wildlife Exposure Factors Handbook*). Body weights for receptor species used to develop screening levels are developed from EPA/600/R-93/187 or other literature values. Soil ingestion rates generally are estimated as a percentage of the total food intake (EPA/600/R-93/187).

Bioaccumulation factors are used to estimate the concentration of contaminants in food items consumed by the receptor species on which the screening levels are based.
The WAC 173-340-900 screening values use K_{plant} to represent the plant uptake coefficient and use bioaccumulation factor (BAF) to represent the earthworm BAF. Use of these factors accounts for the potential for some contaminants to concentrate in higher levels in food organisms, such as invertebrates and plants, than in the surrounding soil. These BAFs are conservative estimates of the reasonable maximum values and are based generally on the chemical properties of the contaminant, although empirical values sometimes are available.

To account for differences in accumulation and consumption, the screening levels calculated soil levels for species representing omnivores, carnivores, and herbivores. The lowest of these soil levels was selected as the screening value protective of wildlife.

A4.5.2 Ecological Toxicity of Possible Contaminants of Potential Ecological Concern

The exposure routes considered in developing the screening levels are direct ingestion of food and soil. The toxicity values used to develop the screening values therefore also are based on ingestion. The toxicity values for the WAC 173-340-7490, "Terrestrial Ecological Evaluation Procedures," screening values and the EPA Eco-SSLs correspond to doses that, based on the results of toxicity studies, are expected to be low enough to produce minimal or no adverse chronic or sublethal effects in the species being considered. The radionuclide screening levels are based on a total dose of 0.1 rad/day to the terrestrial wildlife species. This radiation dose was established as a predicted safe chronic exposure dose by the International Atomic Energy Agency (IAEA 332, *Effects of Ionizing Radiation on Plants and Animals at Levels Implied by Current Radiation Protection Standards*) and the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR, *Sources and Effects of Ionizing Radiation*). The screening levels for soil provided in the DOE BCGs include both the internal dose from ingesting radionuclides from food or soil and the external dose provided from surface exposure to soil.

The screening levels for radionuclides and nonradionuclides are based on estimates of effects to several categories of organisms. For both the WAC 173-340-900 screening values and the EPA Eco-SSLs, exposures were modeled based on plants, soil invertebrates, mammals, and birds. Other categories of receptors, such as reptiles, were not included because adequate toxicity information was not available to develop safe doses of chemicals or radiation for these categories of organisms. The screening levels for mammals and birds included animals modeled with different diets (herbivores and carnivores) but did not include receptors representing the higher level carnivores. Because the modeled herbivores and first-level carnivores are believed to have higher rates of exposure, the screening levels used should be protective of the higher level carnivores as well.

The DOE BCGs for terrestrial systems consider both terrestrial plants (1.0 rad/day dose) and terrestrial animals (0.1 rad/day dose) and are developed to be protective of populations of these plant and animal species. The concentration of each radionuclide was divided by its respective BCG to calculate the dose fraction for that radionuclide. If the concentration of any individual radionuclide generated a dose fraction greater than one, that radionuclide would be retained as a COPEC. Because the dose from different radionuclides is additive, the sum of all individual dose fractions also was calculated to assess the total dose from all radionuclides in comparison to the daily radiation dose limit. If the sum of fractions for a site is greater than one, all radionuclides at that site are retained as COPECs for further evaluation, and the relative contributions of each radionuclide to the sum of the dose fractions is considered.

A4.5.3 Screening-Level Risk Calculations

This section presents the results of the comparison of the maximum concentration detected in the upper 4.6 m (15 ft) of the soil column at each representative site with the applicable screening level.

For radionuclides, the results for both detected and nondetected compounds are included in these tables. Each radionuclide was screened against its individual dose guideline; therefore, no comparisons were made to gross alpha and beta measurements. Table A4-19 provides the screening results for radionuclides at the 216-S-7 Crib. Rows in the tables that are shaded designate COCs detected at a maximum concentration that exceeded their screening level or for which no screening level was available. Radionuclides and chemicals whose maximum detected concentration was less than their background concentration were not retained (and do not have shading). However, the dose fraction was calculated for any radionuclide for which a BCG was available, even if the radionuclide concentration was at or below the background concentration. The designation "NA" indicates that a value is not available or not applicable; "ND" designates a nondetected radionuclide. As shown in Table A4-19, only nine radionuclides were detected in 216-S-7 Crib soil. Eight of the nine (Cs-137, Ra-226, Ra-228, Th-228, Th-230, Th-232, U-233/234, U-238) were detected at concentrations less their respective background and BCG levels. Tritium, the remaining detected radionuclide, does not have an established background concentration, but the maximum detected concentration was three orders of magnitude below the BCG for tritium. The sum of dose fractions for all detected radionuclides was 0.0327, indicating there is no ecological risk from the cumulative dose of detected radionuclides. Thorium-228 and Thorium-230 were the only two detected radionuclides that could not be included in the sum of dose fractions, because no BCGs are available for these constituents.

Table A4-20 provides the screening results for nonradionuclide COPECs at the 216-S-7 Crib. Screening levels were obtained first from WAC 173-340-900, Table 749-3, for wildlife receptors. If this table contained no screening value for a wildlife receptor, a screening value for wildlife was obtained from EPA's Eco-SSLs for wildlife receptors (EPA 2003a). If no wildlife screening level was available from this source, a screening level from the lower of plant or soil biota screening levels from WAC 173-340-900, Table 749-3, was used. The table footnotes provide the source for each screening level. Silver is retained as a COC, because it exceeded both background levels and terrestrial wildlife screening values (HQ = 2.0). Hexavalent chromium, endosulfan II, and endosulfan sulfate were detected in soil and do not have available background levels. Hexavalent chromium does not have a soil-screening value; therefore, this constituent was retained as a COC. WAC 173-340-900, Table 749-3, did not contain screening values for endosulfan II and endosulfan sulfate; however, the Los Alamos National Laboratory (LANL) *EcoRisk Database Release 2.1* (LANL 2004) does provide screening values. When compared to the LANL values, the concentrations were almost 300 times below the screening value; thus, these were not retained as COCs. 2-Ethyl-1-hexanol was a TIC found in one sample at an estimated concentration of 40 µg/kg. By EPA SW-846 definition, a TIC is identified by a library search, and no calibration for that compound is performed. Concentrations are estimated based on the nearest internal standard. Thus, both the identification and quantification are tentative. When the TIC is not known to be part of the waste stream and is not identified in other samples within the borehole, the EPA RAGS allows one to consider it a false positive or to remove it from risk evaluation. In addition, the compound is used as sizing in cotton, and cotton gloves are used at the Hanford Site. Therefore, 2-ethyl-1 hexanol is not considered a COC at the 216-S-7 Crib and is not presented in Table A4-20.

A4.5.4 Uncertainty Assessment

One of the primary uncertainties associated with this ecological screening is that only a single sample was collected to represent the surface interval of soil at the 216-S-7 Crib. There is uncertainty associated with how well this sample represents the spatial area of the entire crib, as well as how well the interval analyzed represents average exposure across the top 4.6 m (15 ft) of soil. For pesticides and miscellaneous organic compounds, the 0 to 0.9 m (3 ft) bgs interval was used to represent the surface exposure interval for ecological receptors. However, for metals, SVOCs, VOCs, and radionuclides, the 0 to 0.9 m (3 ft) bgs interval was not analyzed. For these constituents, the uppermost interval analyzed was the 4.4 to 5.2 m (14.5 to 17 ft) bgs interval, and it is this interval that was used to represent the surface exposure for ecological receptors. This ecological screening assessment assumed that the available data adequately represent the exposure of ecological receptors to surface soils at the 216-S-7 Crib.

Only five chemicals, hexavalent chromium [(Cr (VI)], silver, endosulfan II, endosulfan sulfate, and nitrate/nitrite, were identified as COPCs at the 216-S-7 Crib. All but silver were identified as COCs, because no background or screening values were available from the WAC 173-340-900 screening levels or the EPA Eco-SSLs. The only available silver screening level was based on potential toxicity to plants – no wildlife screening values were available for silver. Toxicity information from scientific literature and other databases can be used to develop screening levels for the same receptor species modeled in the WAC 173-340-900 screening levels and the EPA Eco-SSLs. The *EcoRisk Database Release 2.1* compiled by LANL derived a soil-screening level of 350 µg/kg for endosulfan based on risk to shrews as a surrogate for all insectivorous mammals. This is nearly 300 times the concentration of endosulfan compounds observed at the 216-S-7 Crib, suggesting that it is unlikely that endosulfan poses risk to ecological receptors at this location. The LANL database derived a soil-screening level for Chromium (VI) of 0.2 mg/kg based on risk to soil-dwelling invertebrates. The observed surface soil concentration of Chromium (VI) at the 216-S-7 Crib was 0.8 mg/kg, suggesting that additional evaluation of Chromium (VI) at this location is warranted.

Concentrations of chloride, fluoride, and sulfate were measured in 216-S-7 Crib soils, but all concentrations were less than their respective background levels. These constituents, along with nitrate, nitrite, and fluoride, are not considered to be COCs in the ecological evaluation because of their general status as nutrients for plant species and their typically low toxicity.

A4.5.5 Ecological-Risk Screening Summary

The ecological screening assessment of the 216-S-7 Crib showed that radionuclides are not a concern at the site. Two inorganic chemicals [silver and Chromium (VI)] were identified as COCs. Silver exceeded background and ecological soil-screening values. No background or ecological screening values were available from WAC 173-340-900 or EPA (1993) for Chromium (VI). The two endosulfan compounds were significantly lower than soil-screening levels obtained from other sources (LANL 2004), suggesting that there is no potential risk from these chemicals at the 216-S-7 Crib. Chromium (VI) exceeded the available screening levels obtained from *EcoRisk Database Release 2.1* (LANL 2004). Because silver and Chromium (VI) exceeded ecological screening values, and silver also exceeded background concentrations, additional evaluation of these COCs at the 216-S-7 Crib are warranted.

Figure A4-1. Human Health Flowchart for Radionuclides.

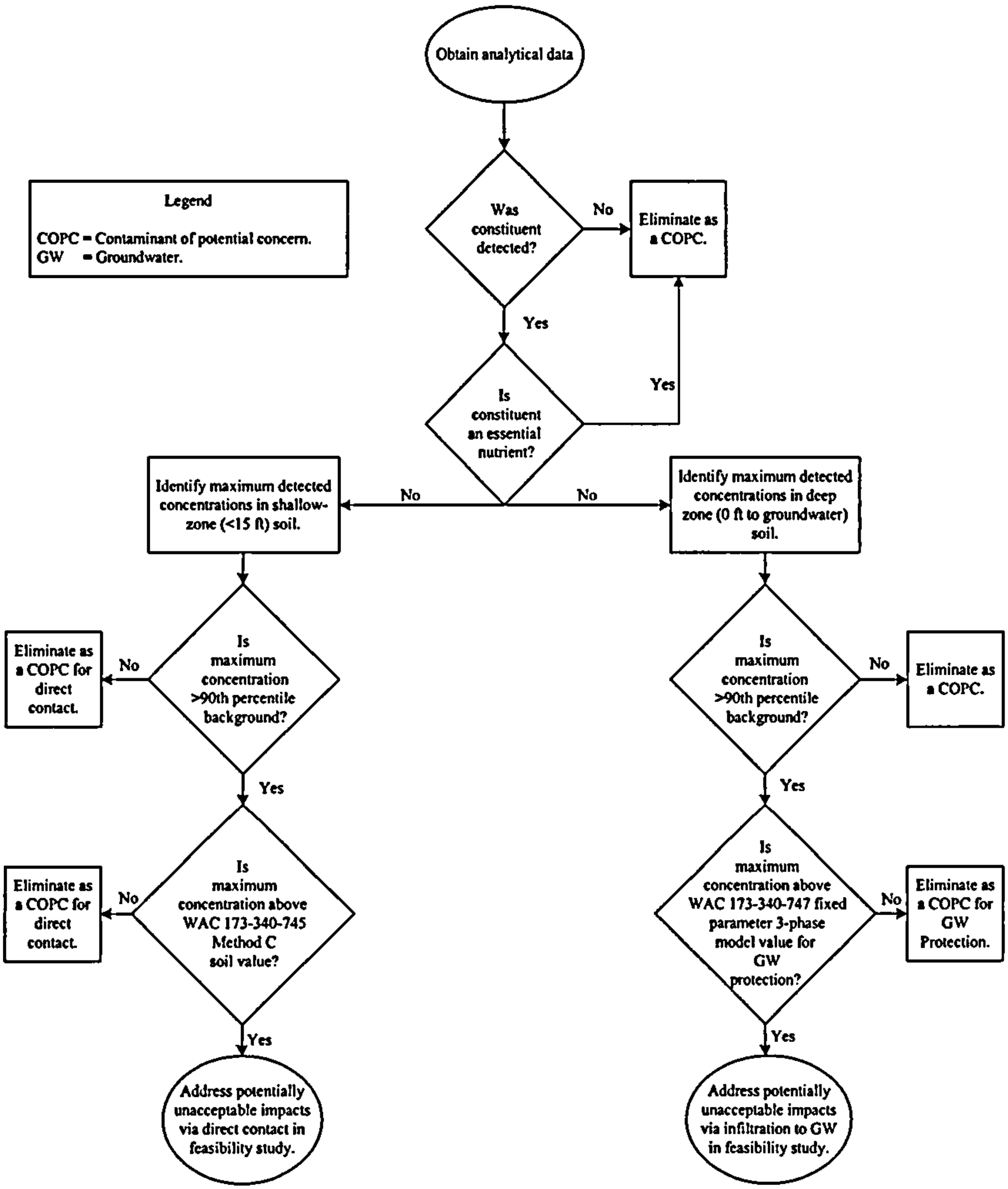


Figure A4-2. Conceptual Exposure Model.

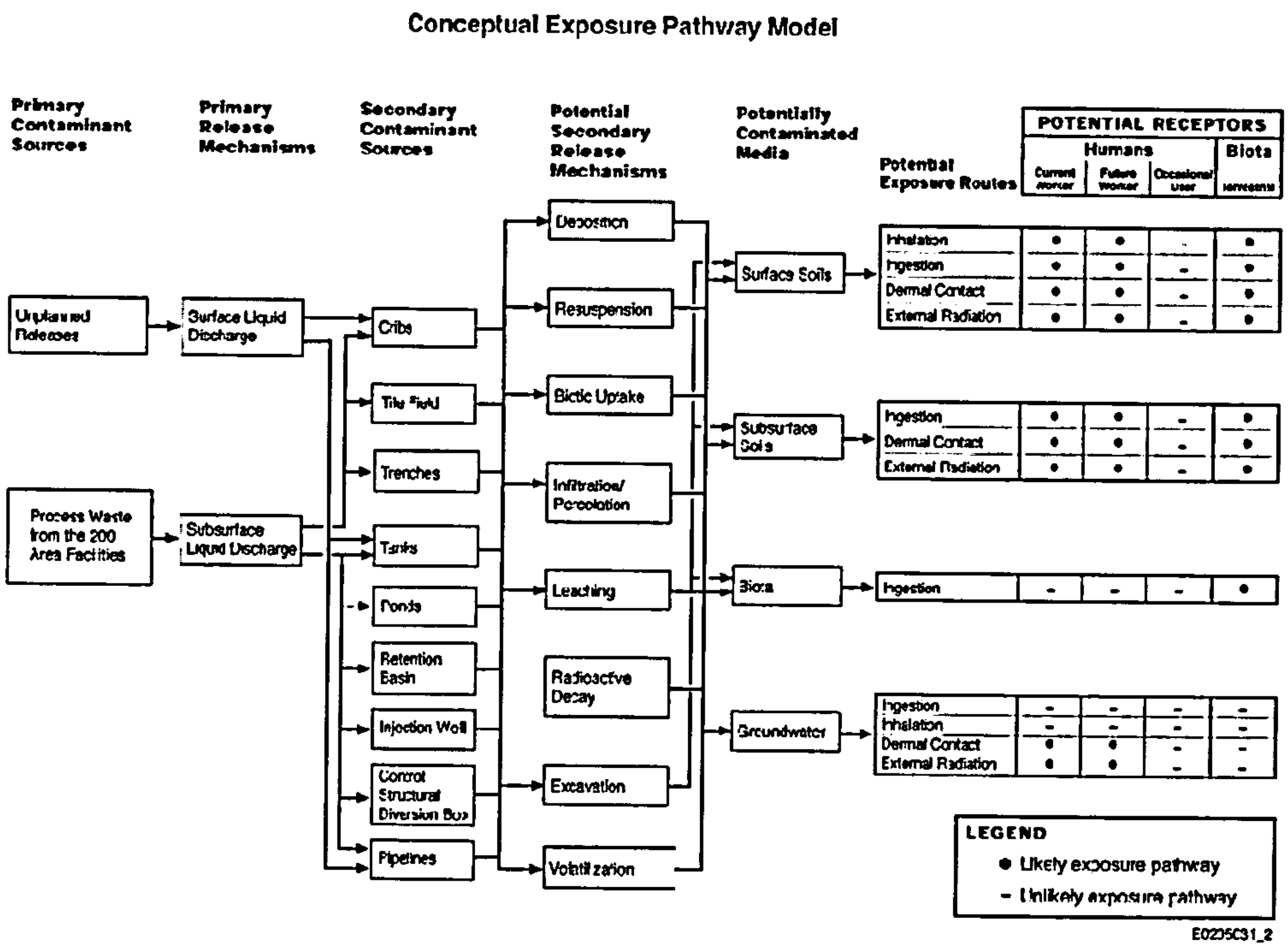
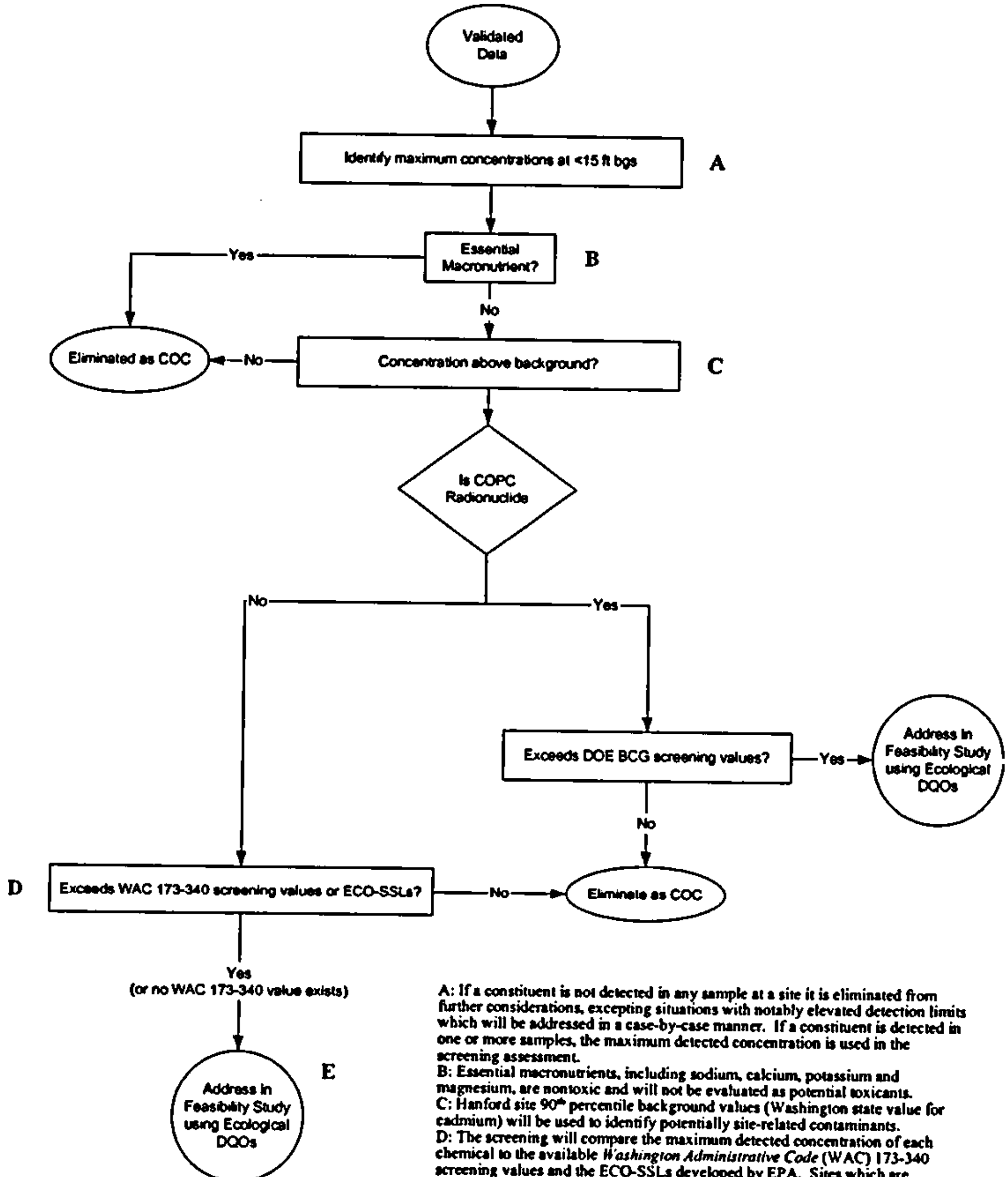


Figure A4-6. Ecological Risk Screening Approach.



A: If a constituent is not detected in any sample at a site it is eliminated from further considerations, excepting situations with notably elevated detection limits which will be addressed in a case-by-case manner. If a constituent is detected in one or more samples, the maximum detected concentration is used in the screening assessment.
B: Essential macronutrients, including sodium, calcium, potassium and magnesium, are nontoxic and will not be evaluated as potential toxicants.
C: Hanford site 90th percentile background values (Washington state value for cadmium) will be used to identify potentially site-related contaminants.
D: The screening will compare the maximum detected concentration of each chemical to the available *Washington Administrative Code* (WAC) 173-340 screening values and the ECO-SSLs developed by EPA. Sites which are evaluated based on human health industrial screening levels will be screened only against the WAC 173-340 screening value for wildlife in accordance with State of Washington guidance. Any chemicals for which no WAC 173-340 value or ECO-SSL screening levels exist will be carried through to the Feasibility Study.
E: Chemicals and radionuclides addressed in the Feasibility Study will be compared to screening levels developed for the site-specific suite of receptors developed under the site-wide ecological DQOs.

LEGEND:

BCG = Biota Concentration Guide
COC = Contaminant of Concern
DOE = Department of Energy
DQO = Data Quality Objectives
ECO-SSL = Ecological Soil Screening Level

Table A4-3. Summary of Screening Results
for the Human-Health Risk Assessment.

Constituent Name	Shallow Zone	Deep Zone
Ammonia as N		X
Chloride		
Nitrate and nitrate/nitrite as N	X	X
Nitrate as N		X
Phosphate as PO_4		X
Sulfate as SO_4		
Arsenic		X
Barium		
Beryllium		
Chromium (Total)		X
Copper		X
Hexavalent Chromium	X	X
Lead		
Mercury	X	X
Nickel		X
Silver	X	X
Uranium (total)		X

Table A4-4. Summary of Toxicity Values Used to Calculate Risk-Based Concentrations.

Chemical Name[a]	Oral Cancer Potency Factor (mg/kg-day)$^{-1}$	Source	Oral Reference Dose (mg/kg-day)	Source	Inhalation Cancer Potency Factor (mg/kg-day)$^{-1}$	Source	Inhalation Reference Dose (mg/kg-day)	Source
4,4'-DDE (Dichlorodiphenyldichloroethylene)	0.34	i	--	--	0.34	r	--	--
4-4'-DDT (Dichlorodiphenyltrichloroethane)	0.34	i	0.0005	i	0.3395	i	0.0005	r
Acetone	--	--	0.9	i	--	--	--	--
Aldrin	17	i	0.00003	i	17.15	i	0.00003	r
Arsenic	1.5	i	0.0003	i	15.05	i	15	c
Barium	--	--	0.07	i	--	--	0.0001	c
Bromomethane	--	--	0.0014	i	--	--	.0014286	i
Chromium (Total)	--	--	--	--	42	i	--	--
Copper	--	--	0.037142857	h	--	--	--	--
Diethylphthalate	--	--	0.8	i	--	--	0.8	r
Di-n-butylphthalate	--	--	0.1	i	--	--	0.1	r
Hexavalent Chromium	--	--	0.003	i	294	i	0.0000229	i
Mercury	--	--	0.0003	i	--	--	0.0000857	c
Methylene chloride	0.0075	i	0.06	i	0.001645	i	0.857142857	h
Nickel	--	--	0.02	i	--	--	--	--
Nitrate and nitrate/nitrite as N	--	--	0.1	i	--	--	--	--
Nitrate as N	--	--	1.6	i	--	--	--	--
Silver	--	--	0.005	i	--	--	--	--
Uranium (total)	--	--	0.003	i	--	--	--	--

a: Note that ammonia, Delta-benzene hexachloride, Endosulfan II, and Endosulfan sulfate have no toxicity values in the literature cited.
i: EPA, 2003, *Integrated Risk Information System*, a database available through the EPA National Center for Environmental Assessment. http://www.epa.gov/iris/.
r: Route extrapolation: a method that translates the oral toxicity factor into an inhalation toxicity factor.
h: EPA/540/R-97/036, *Health Effects Assessment Summary Tables, FY 1997 Update.*
c: Ecology 94-145, *Cleanup Levels and Risk Calculations under the Model Toxics Control Act Cleanup Regulation; CLARC, Version 3.1.*
-- = not applicable.

Table A4-5. Site-Specific Air Exposure-Point Concentration Calculation Input Parameters.

Parameter	Description	Value	Source
Q/C	Inverse of the mean concentration at the center of a 0.5-acre-square source (g/m^2-s per kg/m^3)	73.44	b
T	Exposure interval (s)	9.5 x 08	b
ρ_b	Dry soil bulk density (g/cm^3)	1.5	a
θ_a	Air filled soil porosity (L_{air}/L_{soil})	0.13	a
n	Total soil porosity (L_{pore}/L_{soil})	0.43	b
θ_w	Water-filled soil porosity (L_{water}/L_{soil})	0.3	a
ρ_s	Soil particle density (g/cm^3)	2.65	b
f_{oc}	Fraction organic carbon in soil (g/g)	0.001	a
V	Fraction of vegetative cover (unitless)	0.5	b
U_m	Mean annual windspeed (m/s)	4.69	b
U_t	Equivalent threshold value of windspeed at 7 m (m/s)	11.32	b
F(x)	Function dependent on U_m/U_t derived using EPA/600/8-85/002 (unitless)	0.194	b

a. WAC 173-340-750(4), "Cleanup Standards to Protect Air Quality," "Method C Air Cleanup Levels."
b. EPA/540/R-95/128, *Soil Screening Guidance: Technical Background Document.*
EPA/600/8-85/002, *Rapid Assessment of Exposure to Particulate Emissions from Surface Contamination Sites.*

Table A4-9. Summary of Exposure Assumptions for Industrial Soil and Ambient-Air Risk-Based Concentrations.

Parameter	Symbol	Units	Industrial Land Use [a, b]
Target risk	TR	unitless	1.0 E-05
Target hazard quotient	THQ	unitless	1
Oral reference dose	RfDo	mg/kg-day	chemical specific
Oral cancer potency factor	CPFo	kg-day/mg	chemical specific
Inhalation reference dose	CPFi	mg/kg-day	chemical specific
Inhalation cancer potency factor	RfDi	kg-day/mg	chemical specific
Unit conversion factor - soil	UCFs	mg/kg	1.0 E+06
Unit conversion factor - air	UCFa	µg/mg	1.0 E+03
Body weight –adult	BWa	kg	70
Carcinogenic averaging time	ATC	years	75
Noncarcinogenic averaging time	ATN	years	20
Exposure frequency	EF	unitless	0.4
Exposure duration	ED	years	20
Incidental soil ingestion rate	SIR	mg/day	50
Inhalation rate – carcinogens	INHc	m^3/day	20
Inhalation rate – noncarcinogens	INHnc	m^3/day	20
Gastrointestinal absorption factor	ABSgi	unitless	1
Inhalation absorption fraction	ABSinh	unitless	1

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

Table A4-10. Summary of Exposure Assumptions for Risk-Based Concentrations for Groundwater Protection.

Parameter	Symbol	Units	WAC 173-340-720 Method B Parameter*
Target risk	TR	unitless	1.0 E-06
Target hazard quotient	THQ	unitless	1
Oral reference dose	RfDo	mg/kg-day	chemical specific
Cancer potency factor	CPF	kg-day/mg	chemical specific
Unit conversion factor	UCF	µg/mg	1.000
Body weight – carcinogens	BW	kg	70
Body weight – noncarcinogens	BW	kg	16
Carcinogenic averaging time	ATC	years	75
Noncarcinogenic averaging time	ATN	years	6
Drinking water fraction	DWF	unitless	1
Exposure duration – carcinogens	ED	years	30
Exposure duration – noncarcinogens	ED	years	6
Drinking water ingestion rate – carcinogens	DWIR	L/day	2
Drinking water ingestion rate – noncarcinogens	DWIR	L/day	1
Inhalation correction factor - volatile compound	INH	unitless	2
Inhalation correction factor - nonvolatile compound	INH	unitless	1

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

Table A4-11. Summary of Chemical/Physical Parameters for Soil Risk-Based Concentrations Protective of Groundwater.

Chemical Name	Groundwater Risk-Based Concentration (µg/L)	Groundwater Risk-Based Concentration Basis	K_d (L/kg)	Source*	H_{cc} (dimensionless)	Source*	K_{oc}	Source
Acetone	7200	WAC 173-340-747(4)	5.75 E-04	1	0.00159	1	--	--
Aldrin	0.00515	WAC 173-340-747(4)	48.7	1	6.97 E-03	1	--	--
Arsenic	0.0583	WAC 173-340-747(4)	29	1	0	1	--	--
Barium	1,120	WAC 173-340-747(4)	41	1	--	--	--	--
Bromomethane	11.2	WAC 173-340-747(4)	0.009	1	0.256	1	--	--
Chromium, hexavalent	48	WAC 173-340-747(4)	19	1	--	--	--	--
Chromium, total	100	MCL	1,000	1	--	--	--	--
Copper	592	WAC 173-340-747(4)	22	1	--	--	--	--
DDE	0.257	WAC 173-340-747(4)	86.41	1	8.61 E-04	1	--	--
DDT	0.257	WAC 173-340-747(4)	677.91	1	3.32 E-04	1	--	--
Diethylphthalate	12,800	WAC 173-340-747(4)	0.082	1	1.85 E-05	1	--	--
Di-n-butylphthalate	1,600	WAC 173-340-747(4)	1.57	1	3.85 E-08	1	--	--
Mercury	2.0	MCL	52	1	0.47	1	--	--
Methylene chloride	5.0	MCL	0.010	1	0.0898	1	--	--
Nickel	100	MCL	65	1	0	1	--	--
Nitrate as nitrogen	10,000	MCL	0	2	0	2	--	--
Nitrate and nitrate/nitrite as nitrogen	1,000	MCL	0	2	0	2	--	--
Silver	80	WAC 173-340-747(4)	8.3	1	0	1	--	--
Uranium, total	30	MCL	2.0	3	0	1	--	--

WAC 173-340-747(4), "Deriving Soil Concentrations for Ground Water Protection," "Fixed Parameter Three-Phase Partitioning Model."

* 1. Ecology 94-145, *Cleanup Levels and Risk Calculations under the Model Toxics Control Act Cleanup Regulation; CLARC, Version 3.1.*
2. Conservative assumption.
3. DOE/RL-99-51, *Remedial Design Report and Remedial Action Work Plan for the 100-HR-3 Groundwater Operable Unit In Situ Redox Manipulation.*

-- = not applicable.
K_d = distribution coefficient.
MCL = maximum contaminant level.
H_{cc} = Henry's law constant.
K_{oc} = soil organic carbon-water partition coefficient.

Table A4-12. Comparison of Maximum Shallow Soil Concentrations from 216-S-7 Crib to Industrial Soil Risk-Based Concentrations.

Constituent Class	Constituent	Chemical Abstracts Service	Number of Samples	Number of Detects	Frequency of Detection	Maximum Detected Concentration (mg/kg)	90th Percentile Background Value (mg/kg)	Maximum Detected Greater Than Background Value?	WAC 173-340-745 Method C** Screening Value (mg/kg)	Does Maximum Concentration Exceed Screening Value?
CONV	Nitrate and nitrate/nitrite as N*	none	1	1	100%	6.0	No BV	--	3.5 E+05	No
METAL	Hexavalent chromium	18540-29-9	1	1	100%	0.8	No BV	--	1.05 E+04	No
METAL	Mercury	7487-94-7	1	1	100%	1.7	0.33	Yes	1.05 E+03	No
METAL	Silver	7440-22-4	1	1	100%	3.95	0.73	Yes	1.75 E+04	No
PEST	4,4'-DDE (Dichlorodiphenyldichloroethylene)	72-55-9	1	1	100%	1.4 E-03	No BV	--	3.86 E+02	No
PEST	4-4'-DDT (Dichlorodiphenyl-trichloroethane)	50-29-3	1	1	100%	4.2 E-04	No BV	--	3.86 E+02	No
PEST	Aldrin	309-00-2	1	1	100%	8.1 E-04	No BV	--	7.72 E+00	No
SVOA	Diethylphthalate	84-66-2	1	1	100%	6.6 E-01	No BV	--	2.80 E+06	No
SVOA	Di-n-butylphthalate	84-74-2	1	1	100%	7.9 E-01	No BV	--	3.50 E+05	No

* Risk-based concentration for nitrite was used for nitrate/nitrite.
** WAC 173-340-745(5), "Soil Cleanup Standards for Industrial Properties," "Method C Industrial Soil Cleanup Levels."
-- = not applicable.
BV = background value.
SVOA = semivolatile organic analysis.

Table A4-13. Comparison of Maximum Shallow Soil Concentrations from the 216-S-7 Crib to Industrial Ambient-Air Protection Risk-Based Concentrations.

Constituent Class	Constituent	Chemical Abstracts Service	Number of Samples	Number of Detects	FOD	Maximum Detected Concentration (µg/kg)	PEF (m^3/kg)	PEF or VF (m^3/kg)	1/PEF or 1/VF (kg/m^3)	Maximum Air Concentration (µg/m^3)	WAC 173-340-745 Method C Screening Level (µg/m^3)	Maximum Air Concentration Greater than RBC?
METAL	Barium	7440-39-3	1	1	100%	7.14 E+04	1.06 E+09	1.06 E+09	9.39 E-10	6.71 E-05	3.50 E-01	No
METAL	Chromium (Total)	7440-47-3	1	1	100%	1.20 E+04	1.06 E+09	1.06 E+09	9.39 E-10	1.13 E-05	3.13 E-03	No
METAL	Hexavalent chromium	18540-29-9	1	1	100%	8.00 E+02	1.06 E+09	1.06 E+09	9.39 E-10	7.51 E-07	4.46 E-04	No
PEST	Aldrin	309-00-2	1	1	100%	8.1 E-01	1.06 E+09	1.06 E+09	9.39 E-10	7.60 E-10	7.65 E-03	No
PEST	4,4'-DDE (Dichlorodiphenyldichloro-ethylene)	72-55-9	1	1	100%	1.40 E+00	1.06 E+09	1.06 E+09	9.39 E-10	1.32 E-09	3.86 E-01	No
PEST	4-4'-DDT (Dichlorodiphenyltrichloro-ethane)	50-29-3	1	1	100%	4.20 E-01	1.06 E+09	1.06 E+09	9.39 E-10	3.95 E-10	3.87 E-01	No
SVOA	Diethylphthalate	84-66-2	1	1	100%	6.60 E+02	1.06 E+09	1.06 E+09	9.39 E-10	6.20 E-07	2.80 E+03	No
SVOA	Di-n-butylphthalate	84-74-2	1	1	100%	7.90 E+02	1.06 E+09	1.06 E+09	9.39 E-10	7.42 E-07	3.50 E+02	No

WAC 173-340-745(5), "Method C, Model Toxics Control Act- Cleanup," "Soil Cleanup Standards for Industrial Properties," "Method C - Industrial Soil Cleanup Levels."
FOD = frequency of detection.
PEF = particulate emission factor.
RBC = risk-based concentration.
VF = volatilization factor.

Table A4-14. Comparison of Maximum Deep Soil Concentrations from the 216-S-7 Crib to Groundwater Protection Risk-Based Concentrations.

Constituent Class	Constituent	Chemical Abstracts Service	Number of Samples	Number of Detects	Frequency of Detection	Maximum Detected Concentration (mg/kg)	90th Percentile Background Value (mg/kg)	Maximum Detected Concentration Greater Than Background Value?	WAC 173-340-747 Screening Value (mg/kg)	Does Maximum Concentration Exceed Screening Value?
CONV	Nitrate as N	14797-55-8	13	13	100%	5.30 E+01	1.20 E+01	Yes	4.00 E+01	Yes
CONV	Nitrate and nitrate/nitrite as N	none	1	1	100%	4.5 E+01	--	No BV	4.0 E+00	Yes
METAL	Arsenic	7440-38-2	13	6	46%	7.09 E+00	6.47 E+00	Yes	3.40 E-02	Yes
METAL	Chromium (Total)	7440-47-3	13	10	77%	1.46 E+02	1.85 E+01	Yes	2.00 E+03	No
METAL	Copper	7440-50-8	13	13	100%	5.21 E+01	2.20 E+01	Yes	2.63 E+02	No
METAL	Hexavalent Chromium	18540-29-9	13	4	31%	8.00 E-01	--	No BV	1.84 E+01	No
METAL	Mercury	7487-94-7	13	2	15%	1.70 E+00	3.30 E-01	Yes	2.09 E+00	No
METAL	Nickel	7440-02-0	13	13	100%	8.24 E+01	1.91 E+01	Yes	1.30 E+02	No
METAL	Silver	7440-22-4	13	2	15%	3.95 E+00	7.30 E-01	Yes	1.36 E+01	No
METAL	Uranium (total)	7440-61-1	13	8	62%	4.63 E+02	--	No BV	1.32 E+00	Yes
PEST	4,4'-DDE (Dichlorodiphenyldichloroethylene)	72-55-9	1	1	100%	1.40 E-03	--	No BV	4.46 E-01	No
PEST	4-4'-DDT (Dichlorodiphenyltrichloroethane)	50-29-3	1	1	100%	4.20 E-04	--	No BV	3.49 E+00	No
PEST	Aldrin	309-00-2	1	1	100%	8.10 E-04	--	No BV	5.04 E-03	No
SVOA	Diethylphthalate	84-66-2	7	7	100%	6.60 E-01	--	No BV	7.22 E+01	No
SVOA	Di-n-butylphthalate	84-74-2	12	12	100%	1.10 E+00	--	No BV	5.65 E+01	No
VOA	Acetone	67-64-1	13	2	15%	1.60 E-02	--	No BV	2.89 E+01	No
VOA	Bromomethane	74-89-3	13	2	15%	1.10 E-03	--	No BV	5.18 E-03	No
VOA	Methylene chloride	75-09-2	13	4	31%	1.36 E-02	--	No BV	2.18 E-02	No

WAC 173-340-747, *Model Toxics Control Act- Cleanup*, "Deriving Soil Concentrations for Groundwater Protection."
BV = background value.

Table A4-16. RESidual RADioactivity Input Parameters – Industrial and Groundwater Protection Scenarios. (5 Pages)

Input Field Description	Parameter	Units	Industrial Scenario	Groundwater Protection	Rationale and Citation
Exposure pathways (active)	--	--	External gamma Inhalation Soil ingestion	Drinking water	Based on DOE/RL-2000-60, Rev. 1, and WDOH/320-015. For groundwater protection, drinking water pathway is activated to facilitate evaluation of potential groundwater impacts.
Soil concentrations	Soil concentration	pCi/g	nuclide-specific	nuclide-specific	See Table A4-15 for source term data.
	Distribution coefficients	cm^3/g	nuclide-specific	nuclide-specific	Distribution coefficients for groundwater protection screening were conservative Source Category H values from Table E.15 of PNNL-11800.
	Radiation dose limit	mrem/yr	15	15	This dose limit pertains to calculation of soil guidelines WDOH/320-015.
Contaminated zone (CZ)	Area of CZ	m^2	465	465	Site-specific dimensions from borehole report (D&D-25034).
	Thickness of CZ (Surface Exposure; No Cover)	m	6.4 (fill modeled as contaminated zone)	25 m (all radionuclides except tritium) 65 m (tritium)	Based on measured concentrations in RI data
	Length parallel to aquifer flow	m	30.5	30.5	Site-specific. For screening purposes, this value is the longest axis of the site and is conservative.
Cover and contaminated zone (CZ) hydrological data	Cover depth	m	0 (fill modeled as contaminated zone)	6.4 m	Based on measured thickness of fill in borehole logs.
	Cover material density	g/cm^3	NA	NA	
	Cover erosion rate	m/yr	NA	NA	
	Density of CZ	g/cm^3	2.0	2.0	Site-specific values based on RI results.
	CZ erosion rate	m/yr	0.001	0.001	RESRAD default.
	CZ total porosity	unitless	0.245	0.245	Assumed to be equal to mean effective porosity.

Table A4-16. RESidual RADioactivity Input Parameters – Industrial and Groundwater Protection Scenarios. (5 Pages)

Input Field Description	Parameter	Units	Industrial Scenario	Groundwater Protection	Rationale and Citation
Cover and contaminated zone (CZ) hydrological data (cont.)	CZ field capacity	unitless	0.11	0.11	Based on residual water content; consistent with RI moisture content data.
	CZ Hydraulic conductivity	m/yr	1892	1892	WHC-EP-0883, mean values for 200 Area soils.
	CZ "b" parameter	unitless	4.05	4.05	Derived from RESRAD Table E.2.
	Humidity in air	g/cm³	8	8	RESRAD default.
	Evapo-transpiration coefficient	unitless	0.91	0.91	WDOH/320-015.
	Wind speed	m/s	3.4	3.4	PNNL-13033.
	Precipitation	m/yr	0.16	0.16	Based on 16 cm (6.3-in.) average annual rainfall (DOE/RL-92-19).
	Irrigation	m/yr	0	0	
	Irrigation mode		-	-	
	Runoff coefficient	unitless	0.2	0.2	RESRAD default.
	Watershed area for nearby stream or pond	m^2	1.0 E+06	1.0 E+06	RESRAD default.
	Accuracy for water/soil computations	unitless	0.001	0.001	RESRAD default.
Saturated zone (SZ) hydrologic data	Density of SZ	g/cm³	2.1	2.1	Site-specific value based on RI results.
	SZ total porosity	unitless	0.21	0.21	Assumed equal to effective porosity.
	SZ effective porosity	unitless	0.21	0.21	WHC-EP-0883; assumed to be equal to mean effective porosity for 200 Areas soils.
	SZ field capacity	unitless	0.046	0.046	Based on residual water content.

Table A4-16. RESidual RADioactivity Input Parameters – Industrial and Groundwater Protection Scenarios. (5 Pages)

Input Field Description	Parameter	Units	Industrial Scenario	Groundwater Protection	Rationale and Citation
Saturated zone (SZ) hydrologic data (cont)	SZ hydraulic conductivity	m/yr	1577	1577	WHC-EP-0883; mean value for 200 Area soils, based on conductivity of last vadose stratum intersecting water table.
	SZ hydraulic gradient	unitless	0.0013	0.0013	PNNL-14187
	SZ "b" parameter	unitless	4.05	4.05	Derived from RESRAD Table E.2.
	Water table drop rate	m/yr	0.001	0.001	RESRAD default.
	Well pump intake depth below water table	m	4.6	4.6	Typical RCRA well screen length (DOE/RL-2002-42).
	Nondispersion or mass-balance transport model	--	ND	ND	Per RESRAD guidance, nondispersion (ND) model used to model potential GW impacts for sites >1000 m^2.
	Well pumping rate	m^3/yr	250	250	RESRAD default.
Uncontaminated unsaturated zone data	Number of unsaturated strata below CZ	--	5	2 1 (tritium)	Site-specific values based on RI results.
	Thickness of unsaturated strata	m	8.8, 4.6, 4.3, 28.3, 16.6	25.6, 16.6 4.2 m (tritium)	Site-specific values based on RI results.
	Soil Density	g/cm^3	2.0, 2.3, 2.0, 1.47, 2.1	1.47, 2.1	Site-specific values based on RI results.
	Total porosity	unitless	0.245, 0.13, 0.245, 0.445, 0.21	0.445, 0.21	See Cover and CZ inputs.
	Effective porosity	unitless	0.245, 0.13, 0.245, 0.445, 0.21	0.445, 0.21	See Cover and CZ inputs.
	Field capacity	unitless	0.11, 0.062, 0.11, 0.21, 0.046	0.21, 0.046	Based on residual water content: WHC-EP-0883, mean value for 200 Areas Soils.

Table A4-16. RESidual RADioactivity Input Parameters – Industrial and Groundwater Protection Scenarios. (5 Pages)

Input Field Description	Parameter	Units	Industrial Scenario	Groundwater Protection	Rationale and Citation
Uncontaminated unsaturated zone data (cont.)	Hydraulic conductivity	m/yr	1892, 4730, 1892, 315, 1577	315, 1577	See Cover and CZ inputs.
	Soil-specific "b" parameter	unitless	4.05, 4.05, 4.05, 4.38, 4.05	4.38, 4.05	Derived from RESRAD Table E.2.
Occupancy	Inhalation rate	m^3/yr	7,300	NA	WDOH/320-015
	Mass loading for inhalation	g/m^3	0.0001	0.0001	WDOH/320-015
	Exposure duration	yr	25	25	WDOH/320-015
	Indoor dust filtration factor	unitless	0.4	NA	RESRAD default.
	External gamma shielding factor	unitless	0.8	NA	WDOH/320-015.
	Indoor time fraction	unitless	0.137	NA	200 Areas industrial scenario; on site 2,000 h/yr; indoors 60% (DOE/RL-2002-42).
	Outdoor time fraction	unitless	0.091	NA	200 Areas industrial scenario; on site 2000 h/yr; outdoors 40% (DOE/RL-2002-42).
	Shape factor	unitless	Circular	NA	Shape factor area is used by RESRAD for area value in CZ field.
Ingestion pathway; dietary data	Soil ingestion rate	g/yr	36.5	NA	WDOH/320-015.
	Drinking water intake	L/yr	NA	730	WDOH/320-015. Only used to screen transport of contaminants of concern to groundwater.
	Drinking water contaminated fraction		1	1	RESRAD default; only used to screen transport of contaminants of concern to groundwater.
Ingestion pathway; nondietary data	Depth of soil mixing layer	m	0.15	0.15	RESRAD default.
	Drinking water fractional use		1	1	RESRAD default; only used to screen transport of contaminants of concern to groundwater.

Table A4-16. RESidual RADioactivity Input Parameters – Industrial and Groundwater Protection Scenarios. (5 Pages)

Input Field Description	Parameter	Units	Industrial Scenario	Groundwater Protection	Rationale and Citation
Storage times	Well water storage time	days	1	1	RESRAD default; only used to screen transport of contaminants of concern to groundwater.

D&D-25034, *200-PW-2 Operable Unit Borehole Summary Report for the 216-S-7 Crib.*
DOE/RL-92-19, *200 East Groundwater Aggregate Area Management Study.*
DOE/RL-2000-60, *Uranium Rich/General Process Condensate and Process Waste Group Operable Units RI/FS Work Plan and RCRA TSD Unit Sampling Plan; Includes 200-PW-2 and 200-PW-4 Operable Units.*
DOE/RL-2002-42, *Remedial Investigation Report for the 200-TW-1 and 200-TW-2 Operable Units (includes the 200-PW-5 Operable Unit).*
PNNL-11800, *Composite Analysis for Low-Level Waste Disposal in the 200 Area Plateau of the Hanford Site.*
PNNL-13033, *Recharge Data Package for the Immobilized Low-Activity Waste 2001 Performance Assessment.*
PNNL-14187, *Hanford Site Groundwater Monitoring for Fiscal Year 2002.*
WDOH/320-015, Hanford Guidance for Radiological Cleanup.
WHC-EP-0883, *Variability and Scaling of Hydraulic Properties for 200 Area Soils.*

CZ = contaminated zone.
NA = not applicable.
ND = nondispersion.
RCRA = *Resource Conservation and Recovery Act of 1976.*
RESRAD = RESidual RADioactivity (ANL/EAD-4, *User's Manual for RESRAD, Version 6).*
RI = remedial investigation.
SZ = saturated zone.

Table A4-17. Dose Assessment Results for the 216-S-7 Crib.

Scenario	Total Dose (mrem/yr)	Time (year)	Primary Radionuclide	Primary Pathway	Contribution, Primary Radiation Pathway
Industrial No Cover	0.024	0	Cesium-137	External	88%
	0.023	1	Cesium-137	External	90%
	0.017	10	Cesium-137	External	98%
	0.011	30	Cesium-137	External	100%
	0.0022	100	Cesium-137	External	100%
	6.8 E-04	150	Cesium-137	External	100%
	6.7 E-05	250	Cesium-137	External	100%
	2.1 E-07	500	Cesium-137	External	100%
	2.0 E-12	1,000	Cesium-137	External	100%

Table A4-18. Risk Assessment Results for the 216-S-7 Crib.

Scenario	Total Risk	Time (year)	Primary Radionuclide	Primary Pathway	Contribution, Primary Radiation Pathway
Industrial No Cover	5.0 E-07	0	Cesium-137 Tritium	External Inhalation	64% 36%
	4.0 E-07	1	Cesium-137 Tritium	External Inhalation	69% 31%
	3.0 E-07	10	Cesium-137	External	94%
	2.0 E-07	30	Cesium-137	External	100%
	3.0 E-08	100	Cesium-137	External	100%
	1.0 E-08	150	Cesium-137	External	100%
	1.0 E-09	250	Cesium-137	External	100%
	3.0 E-12	500	Cesium-137	External	100%
	3.0 E-17	1,000	Cesium-137	External	100%

Table A4-19. Ecological Screening Results for Radionuclides at the 216- S-7 Crib.

Radionuclides (pCi/g)	Exposure Point Concentration	90th Percentile Background Concentration	Exceeds Background?	DOE Biota Concentration Guideline (pCi/g)	Dose Fraction (EPC/BCG)	COC	Justification
Americium-241	ND	--	NA	3890	NA	No	Not detected
Carbon-14	ND	--	NA	--	NA	No	Not detected
Cesium-137	0.037	1.05	No	20.8	1.78E-03	No	Less than background and BCG
Cobalt-60	ND	0.0084	No	692	NA	No	Not detected
Europium-152	ND	--	NA	1520	NA	No	Not detected
Europium-154	ND	0.03344	No	1290	NA	No	Not detected
Europium-155	ND	0.0539	No	15800	NA	No	Not detected
Iodine-129	ND	--	NA	5670	NA	No	Not detected
Neptunium-237	ND	--	NA	--	NA	No	Not detected
Nickel-63	ND	--	NA	--	NA	No	Not detected
Plutonium-238	ND	.00378	No	--	NA	No	Not detected
Plutonium-239/240	ND	0.0248	No	6110	NA	No	Not detected
Radium-226	0.649	0.815	No	50.6	0.0128	No	Less than background and BCG
Radium-228	0.719	1.32	No	43.9	0.0164	No	Less than background and BCG
Technetium-99	ND	--	NA	4490	NA	No	Not detected
Thorium-230	0.527	1.10	No	--	NA	No	Less than background
Thorium-232	0.772	1.32	No	1510	5.12E-04	No	Less than background and BCG
Strontium 90	ND	0.178	No	22.5	NA	No	Not detected
Tritium	184	--	NA	174000	1.06E-03	No	Less than BCG
Uranium-233/234	0.16	1.10	No	5130	3.32E-05	No	Less than background and BCG
Uranium-235	ND	0.109	No	2770	NA	No	Not detected
Uranium-238	0.17	1.06	No	1580	1.08E-04	No	Less than background and BCG
Dose Fractions Sum						**HI for constituents with BCGs = 0.0327**	

-- = not applicable.
BCG = biota concentration guide.
COC = contaminant of concern.
DOE = U.S. Department of Energy.
EPC = exposure point concentration.
NA = not applicable.
ND = nondetect.

A5.0 VADOSE ZONE CONTAMINANT FATE AND TRANSPORT MODELING

Groundwater impacts were evaluated at the single representative waste site, the 216-S-7 Crib, in the 200-PW-2 OU. The evaluation was conducted to identify contaminants that pose a risk to groundwater at the representative waste sites, based on data collected during the RI. The results of the impact evaluations will support the evaluation of remedial alternatives and closure options that will be included in the group-specific FS.

A5.1 MODELING METHODOLOGY

Potential groundwater impact at the 216-S-7 Crib was evaluated using different methodologies for nonradioactive (Section A5.2.1) and radioactive (Section A5.2.2) constituents. Detailed process modeling of flow and transport using the STOMP code developed by the Pacific Northwest National Laboratory (PNNL-12030, *STOMP, Subsurface Transport Over Multiple Phases, Version 2.0, Theory Guide*) was not deemed necessary for this investigation. Modeling conducted previously at 200 Areas sites (DOE/RL-2002-42, *Remedial Investigation Report for the 200-TW-1 and 200-TW-2 Operable Units (includes the 200-PW-5 Operable Unit)*) for nonradioactive constituents consistently has indicated breakthrough to the water table for constituents with soil-water K_d of zero. The Pacific Northwest National Laboratory has documented that constituents with K_ds of 40 L/kg or greater are effectively immobile in the vadose zone and groundwater (PNNL-11800). For many of the constituents that exceeded groundwater thresholds in the screening phase, additional modeling would have served only to restate the finding that eventually the constituent will reach groundwater. These constituents will be considered further in the FS. For other constituents, the original concentrations were sufficiently small that, although they eventually may reach groundwater, the concentrations would be far below levels of concern and, therefore, no benefit would be derived from further modeling. The constituents anticipated to reach groundwater are discussed in Sections A4.3.4.1 and A4.4.3.

A5.1.1 Nonradioactive Constituents

For nonradioactive constituents, maximum constituent concentrations in the vadose zone were compared to soil-screening criteria calculated using the fixed-parameter three-phase partitioning model described in WAC 173-340-747. Use of this model for screening soil contamination for potential groundwater impacts is referenced under calculation of Method B and C soil cleanup levels in CLARC, Version 3.1 (Ecology 94-145) under WAC 173-340.

The fixed-parameter three-phase partitioning model used to calculate soil-screening values for groundwater protection is described by the following equation.

$$C_s = C_w (UCF) DF \left[K_d + \frac{(\theta_w + \theta_a H_{cc})}{\rho_b} \right]$$

where:

C_s = soil concentration (mg/kg)

C_w = groundwater cleanup level (μg/L)

UCF = unit conversion factor (1 mg/1000 μg)

DF = dilution factor (20)

K_d = distribution coefficient (L/kg)

θ_w = water-filled soil porosity (0.3)

θ_a = air-filled soil porosity (0.13)

H_{cc} = Henry's law constant

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

Chemical-specific K_ds and groundwater cleanup values used in the calculation of soil-screening criteria for groundwater impacts are provided in Table A4-11. Unless otherwise specified, the groundwater cleanup levels are from WAC 173-340-740, "Unrestricted Land Use Soil Cleanup Standards," and the K_d and H_{cc} values are default values from CLARC, Version 3.1 (Ecology 94-145).

The key variables in the fixed-parameter three-phase partitioning model, when applying this model to the 200 Areas sites in this report, are the dilution factor and the K_d values. Generic K_d values obtained in CLARC, Version 3.1 may not correspond to values estimated or measured in Hanford Site soils. The dilution factor in the fixed-parameter three-phase partitioning model is calculated as the sum of the volumetric infiltration and groundwater flow rates (m^3/yr) divided by the volumetric infiltration flow rate. The default value of 20 implies that groundwater flow volume beneath a site is about 20 times greater than the volume of vadose zone water infiltrating groundwater at the site. Considering aquifer flow rates and recharge rates for the 200 Areas, the RESRAD (ANL, 2002) default value of 20 is a minimum value for dilution for these sites.

The soil-screening criteria for groundwater impacts are provided in Chapter A4.0. The WAC 173-340-747 three-phase model and associated soil-screening criteria do not address transport through uncontaminated vadose zone soils below the area of contamination. Therefore, an additional screening evaluation for potential groundwater impacts was applied based on the Pacific Northwest National Laboratory report that indicated that a K_d value of 40 L/kg is a reasonable metric for considering transport from the vadose zone to groundwater. An analysis of K_d values and a table describing the physical and chemical parameters were used to develop the groundwater screening criteria given in Section A4.3.3 and Table A4-10. This screening supplements the comparison to the soil-screening criteria by identifying those constituents that are effectively immobile in the vadose zone and therefore highly unlikely to reach groundwater.

A5.1.2 Radioactive Constituents

For radioactive constituents, maximum constituent concentrations in the vadose zone were evaluated for potential groundwater impacts using the RESRAD computer model. RESRAD Version 6.21 (ANL 2002) was used for this evaluation. Implementation of the RESRAD model followed guidance described in ANL/EAD-4. Groundwater impacts were evaluated based on leaching of radionuclides from the contaminated zone, followed by infiltration through the vadose zone to groundwater, where exposure may occur via a well.

Leaching of radionuclides from the contaminated zone in RESRAD is described by a sorption-desorption model that incorporates such inputs as precipitation and irrigation rates, evapotranspiration rate, K_d values of the individual radionuclides, and physical characteristics of the contaminated zone such as area, thickness, soil density, and moisture content. Site- and/or 200 Areas-specific information generally was used to establish appropriate values for these inputs to the leaching model. The irrigation rate was set to zero in the RESRAD simulations.

RESRAD employs a one-dimensional simplification of infiltration through the vadose zone from the bottom of the contaminated zone to the water table. Site-specific data were used to characterize the vadose zone, under the model constraint of a maximum of five geologic strata. Parameters employed in the infiltration model include soil porosity and density, moisture content, field capacity, hydraulic conductivity, and thickness for each geologic stratum. The time at which a radionuclide reaches groundwater and the rate at which it enters groundwater are calculated in RESRAD as a function of these parameters.

RESRAD contains two models that are used to calculate the time at which groundwater radionuclide concentrations reach their maximum and the dilution factor between water infiltrating from the vadose zone and groundwater at a theoretical well. For sites of less than 1000 m^2, ANL/EAD-4 recommends using the RESRAD mass-balance model. In this model, all radionuclides released from the contaminated area are assumed to be withdrawn from the theoretical well, such as might be the case if the well were located in the middle of a small site. The mass balance model related to sites of less than 1000 m^2 was used for the 216-S-7 Crib.

Radionuclide concentrations at the theoretical groundwater well at the time of maximum concentrations were identified as the output of the RESRAD evaluation of groundwater impacts. Derivation of hydrogeological input parameter values for the RESRAD evaluation of groundwater impacts is discussed in Section A5.3. A complete tabulation of RESRAD input parameter values is provided in Table A4-16.

A5.2 SITE HYDROGEOLOGIC DATA FOR RESRAD MODELING

The RESRAD computer code requires information about the flow and transport characteristics of the vadose zone and saturated zone to estimate the movement of radionuclides from a contaminated zone through the soil to the groundwater. Requirements also include information about the site meteorology, surface water hydrology, and erosion, because these processes also may influence contaminant migration. Parameters related to flow will be discussed in Section A5.3.1, and those related to transport will be discussed in Section A5.3.2.

A5.2.1 RESRAD Flow Parameters

For the water pathway, RESRAD requires information for the cover and contaminated zone, the uncontaminated vadose zone, and the saturated zone. A number of inputs for the water pathway depend on the characteristics of the geologic material. To assign these properties appropriately, the hydrostratigraphy of the site needs to be approximated by layers in the RESRAD model. RESRAD allows a contaminated zone layer, up to five vadose zone layers, and a saturated zone layer to be parameterized. Previous analyses of the hydraulic properties of the 200 Areas soils (WHC-EP-0883, *Variability and Scaling of Hydraulic Properties for 200 Area Soils, Hanford Site*) grouped them into six categories, based on their hydraulic properties. These categories were used as the basis for identifying material layers for RESRAD from stratigraphic and lithologic descriptions from borehole logs at the 216-S-7 Crib. Hydrostratigraphic layer thicknesses and the associated hydraulic property category are shown in Table A4-16. This information was used to assign thicknesses and properties to the RESRAD model layers described in Table A5-1.

Values for the saturated hydraulic conductivity and field capacity were assigned to the cover, contaminated zone, uncontaminated vadose zone layers, and the saturated zone based on mean values from WHC-EP-0883 for the hydraulic property category associated with the given layer. Field capacity was approximated using the mean value of the residual water content for the category. The RESRAD "b" parameter for each layer was obtained from ANL/EAD-4, based on the dominant texture of the layer.

Parameters required for the saturated zone are the hydraulic gradient, water table drop rate, well pump intake depth, and the well pumping rate. Parameter values used for the well pumping rate and water table drop rate were RESRAD default values. The hydraulic gradient was obtained from PNNL-14187. The value used for the well pump intake depth was a typical well screen depth for the Hanford Site (DOE/RL-2002-42).

Additional meteorological parameters required are the evaporation coefficient, precipitation, wind speed, and humidity in air (for tritium only). The evaporation coefficient for the Hanford Site was obtained from WDOH/320-015. Mean annual precipitation for the Hanford Site was obtained from DOE/RL-92-19, *200 East Groundwater Aggregate Area Management Study Report*. Mean annual wind speed for the Hanford Site was obtained from 200 Areas data (PNNL-13033, *Recharge Data Package for the Immobilized Low-Activity Waste 2001 Performance Assessment*). Surface water parameters, humidity in air, the runoff coefficient, and the watershed area were set to the RESRAD default values.

A5.2.2 RESRAD Transport Parameters

Parameters required for modeling radionuclide transport include the area of the contaminated zone, the cover and contaminated zone thicknesses, estimates of the erosion rate for the cover and contaminated zones, and the length of the contaminated zone parallel to the aquifer flow. Values of the effective, total porosities and bulk densities of the geologic material composing the cover, contaminated zone, uncontaminated vadose zone, and the aquifer layers also are required. The K_d parameters that specify the concentration ratio of the adsorbed radionuclide to the radionuclide in solution also are required for each element modeled. Isotopes of an element are assumed to have the same K_d.

The area of the contaminated zone for the 216-S-7 Crib was obtained from the 200-PW-2 OU borehole report (D&D-25034). A contamination zone thickness of 6.4 m was used for the industrial scenario, corresponding to the actual depth of cover material in which radionuclides were detected. The thickness of the contaminated zone for the groundwater protection modeling was protectively defined based on the actual thickness of the vadose zone where radionuclide analytical results showed detected values. The length of the contaminated zone parallel to aquifer flow was protectively assumed to be equal to the longest axis of each site.

Values of effective porosity were obtained from measurements of mean porosity provided in the borehole report (D&D-25034). For RESRAD inputs, total and effective porosity were assumed to be equal. Soil bulk density was calculated from mean porosity data, assuming a particle density of 2.65 g/cm^3.

The K_ds for radionuclides and daughters for RESRAD models of the 200-PW-2 OU site was preferentially obtained from PNNL-11800, Appendix E. For the 200 Areas composite analysis, waste chemistry and background chemistry information were used to assign values of K_ds to elements. The waste sites evaluated in the 200-PW-2 and 200-PW-4 OU RI Report (DOE/RL-2004-25) mostly were characterized as "low-organic low-salts near neutral" releases in PNNL-11800, Table 4.4. These waste sites were assigned Source Category F K_d values in PNNL-11800. The 216-S-7 Crib, however, was reported in the Work Plan (DOE/RL-2000-60, Rev. 1) to have received very acidic process waste at approximately pH 2. In addition, borehole data for the 216-S-7 Crib indicates that liquid releases reached groundwater; the volume of discharged liquid (reported as 3.9 x 10^8 L in DOE/RL-2000-60, Rev. 1) supports this finding. Therefore, at the 216-S-7 Crib, Category "H" K_d values were applied for modeling across the entire vadose zone. The K_d values used for the RESRAD models were classified as "conservative" K_d values in PNNL-11800, Table E.15, and are listed in Table A5-2.

The values used for the erosion rate of both the cover and the contaminated zone were RESRAD default values. A complete tabulation of RESRAD input parameter values is provided in Chapter A4.0. RESRAD modeling and risk evaluation results are reported in Section A4.4. Conclusions from the modeling are summarized in Chapter A6.0.

A5.3 SUMMARY EVALUATION OF FATE AND TRANSPORT

This section provides the evaluation of the constituents that potentially exceed groundwater RBCs. This section also evaluates whether added modeling beyond that presented in Chapter A4.0 will provide information required to assess whether degradation of the groundwater has occurred. For example, if the constituent has already reached groundwater and already exceeds the RBC, then degradation has occurred and additional modeling will not alter that fact.

A5.3.1 Nonradioactive Constituents

Table A5-3 summarizes nonradioactive constituents exceeding RBCs for each site. The information includes the site, analyte, K_d, depth at which the maximum concentration occurs, maximum concentration, background, RBC, number of detects versus the number of samples collected, range of concentration of the nondetects, and range of concentration of the detects.

Some of the following discussion states that COPCs with high K_ds are not expected to travel farther down the vadose zone and reach groundwater. However, it also is noted that in some cases the COPC has already traveled to deeper soil levels than predicted, despite its high K_d. This is because of the large volumes of effluent that once were disposed to the 200-PW-2 OU waste sites. For example, an estimated 390 million liters (103 million gal) of process condensate were disposed to the 216-S-7 Crib, exceeding the approximate soil column pore volume (15,879 m^3) by a factor of greater than 24. The effluent, therefore, will have found a path through the soil column because of the volume of water and hydraulic head, and it will have deposited contaminants to the locations that the effluent water reached. When disposal to this site ceased, the chemical affinity to the soil became the controlling factor, not physical fluid flow pathways. In the absence of any more liquid to drive them down, associated COPCs with high K_ds (e.g., cobalt) would remain in place at the depth at which physical flow stopped movement. The weather conditions at the Hanford Site are dry (<25.4 cm or 10 in. of rain per year) and will not affect movement of COCs with high K_ds. Other contaminants with low K_ds (e.g., nitrate) will continue to migrate downward.

The following constituents exceed the groundwater RBCs in the 216-S-7 Crib.

- **Nitrate and nitrate/nitrite** exceeded the RBCs and are evaluated as one constituent. Concentrations increase from 4.4 to 7.3 m (14.5 to 24 ft) bgs and subsequently remain consistently high until 47.2 m (155 ft) bgs. The concentration for nitrate and nitrate/nitrite then decreases at 47.2 m (155 ft) bgs, with the exception that the nitrate/nitrite produces the highest number at groundwater. The K_d is zero, and previous modeling indicates that constituents with a K_d of zero always reach groundwater (DOE/RL 2002-42 and DOE/RL-2003-11, *Remedial Investigation for the 200-CW-5 U Pond/ Z Ditches Cooling Water Group, the 200-CW-2 S Pond and Ditches Cooling Water Group, the 200-CW-4 T Pond and Ditches Cooling Water Group, and the 200-CS-1 Steam Condensate Group Operable Units*). Added site-specific modeling would not be useful beyond confirming what has been observed from modeling at other sites.

- **Arsenic** was detected in 6 of 13 samples. Detections ranged from depths of 7.3 to 47.2 m (24 to 155 ft) bgs. The highest detect was at 47.2 m (155 ft) bgs, which is 21.3 m (70 ft) above groundwater. The K_d of arsenic is above that normally expected to reach groundwater. But the arsenic RBC is 200 times lower than the state-allowable background. Thus, concentrations in the soil column may be caused by the background.

- **Uranium** was detected in 8 of 13 samples. CLARC, Version 3.1 (Ecology 94-145) under WAC 173-340 uses a K_d of 2 L/kg, and 0.6 L/kg has been widely used at the Hanford Site in modeling performed using STOMP (DOE/RL-2002-42 and DOE/RL-2003-11). Either K_d results in uranium reaching groundwater. Modeling has shown that uranium reaches groundwater. No added modeling is required for this constituent.

A5.3.2 Radioactive Constituents

Table A5-4 summarizes the radioactive constituents predicted to break through to groundwater as shown by the RESRAD modeling reported in Chapter A4.0.

RESRAD modeling for the 216-S-7 Crib indicates that tritium and Tc-99 were the only radionuclides to reach groundwater. Tc-99 was associated with a theoretical radiation dose of 2.1 mrem/yr and a cancer risk of 1×10^{-4} via drinking water ingestion at year 1,240. Tritium reached a maximum groundwater concentration at year 30. Tritium dose and cancer risk were estimated to be 4.6 mrem/yr and 1×10^{-4}, respectively.

For all sites in the 200-PW-2 OU for which radionuclides are predicted to break through to groundwater, no extraordinary characterization data were found that warrant additional site-specific modeling. Tritium and Tc-99 are constituents known to be in the vadose zone at the Hanford Site. They have all been studied, monitored, and modeled extensively. No unusual concentrations, distributions, or geographic features have been found at the waste sites in this FS that require further modeling.

Table A5-1. Hydrostratigraphic Layer Thickness and Associated Hydraulic Property Category for the 216-S-7 Crib.

Layer Thickness (m)	Soil Category*
6.6	S
1.2	S
7.5	S
2.7	SSG
1.8	SSG
4.3	S
14.3	SS
7.9	SS
0.6	SS
0.8	SS
0.5	SS
4.3	SS
1.8	SG1
0.5	SG1
14.3	SG1

* Hydraulic property categories (WHC-EP-0883, *Variability and Scaling of Hydraulic Properties for 200 Area Soils*) are as follows.
S = sand.
SG1 = sandy gravel: gravel content < 60% by weight.
SS = sand mixed with finer fraction.
SSG = sand and gravel mixed with finer fraction.

Table A5-2. Distribution Coefficients for RESRAD Modeling for the 216-S-7 Crib.

Radionuclide	K_d[a] (L/kg)	Radionuclide	K_d[a] (L/kg)
Ac-227	25	Pu-238	20
Am-241	25	Pu-239/240	20
C-14	0.1	Ra-226	10
Co-60	1200	Ra-228	8
Cs-134	540	Sb-125[c]	45
Cs-137	10	Sr-90	10
H-3	0	Tc-99	0.1
Eu-154	100	Th-228	30
Eu-155	25	Th-229	30
I-129	0.1	Th-230	3
K-40[b]	5.5	Th-232	40
Nb-94	50	U-233	20
Ni-63	10	U-234	20
Np-237	3	U-235	20
Pa-231	3	U-236	0.6
Pb-210	25	U-238	20

[a] Values listed pertain to Source Category H in accordance with PNNL-11800, *Composite Analysis for Low-Level Waste Disposal in the 200 Area Plateau of the Hanford Site.*

[b] Source: BJC/OR-80, *Radiological Benchmarks for Screening Contaminants of Potential Concern for Effects on Aquatic Biota at Oak Ridge National Laboratory*, Oak Ridge, Tennessee.

[c] Source: EPA/530/D-98/001B, *Human Health Risk Assessment Protocol for Hazardous Waste Combustion Facilities*, Volume 2, Appendix A, *Chemical-Specific Data, Human Health Risk Assessment Protocol.*

RESRAD = RESidual RADioactivity

Table A5-3. Nonradioactive Constituents Evaluated for Additional Modeling for the 216-S-7 Crib.

Analyte	K_d[a] (L/kg)	Depth of Max (ft bgs)	Max Conc. (mg/kg)	Back-ground (mg/kg)	GW RBCs (mg/kg)	No. of Detections	No. of Samples	Range of Detection Limits (mg/kg)	Range of Detections (mg/kg)
Nitrate as N	0	155 - 157.5	53	12	40	13	13	NR	1.53 - 53
Nitrate and nitrite as N	0	223 - 225.5	45	No BV	4[b]	11	13	0.22 - NR	0.97 - 45
Arsenic	29	155 - 157.5	7.1	6.47	0.034	6	13	2.92 - 3.02	2.0 - 7.1
Total uranium	2.0 or 0.6[c]	24 - 26.5	463	No BV	1.32	8	13	0.95 - 1.0	1.2 - 463

[a] K_d source documentation is from CLARC, Version 3.1 (Ecology 94-145, *Cleanup Levels and Risk Calculations under the Model Toxics Control Act Cleanup Regulation; CLARC, Version 3.1*) under WAC 173-340, "Model Toxics Control Act -- Cleanup," used for screening.

[b] Use nitrite RBC.

[c] K_d of 2 L/kg is from CLARC, Version 3.1 (Ecology 94-145) under WAC 173-340, and 0.6 L/kg has been widely used at the Hanford Site in modeling performed using STOMP modeling (PNNL-12030, *STOMP, Subsurface Transport Over Multiple Phases, Version 2.0, Theory Guide*, (DOE/RL-2002-42, *Remedial Investigation Report for the 200-TW-1 and 200-TW-2 Operable Units (Includes the 200-PW-5 Operable Unit)*, and DOE/RL-2003-11, *Remedial Investigation for the 200-CW-5 U Pond/ Z Ditches Cooling Water Group, the 200-CW-2 S Pond and Ditches Cooling Water Group, the 200-CW-4 T Pond and Ditches Cooling Water Group, and the 200-CS-1 Steam Condensate Group Operable Units*). Using either K_d in modeling results in transport to groundwater.

BV = background value.
GW = groundwater.
K_d = distribution coefficient.
NR = no range applies when all results are detections, or the same detection limit applies for the entire data set.
RBC = risk-based concentration.

Table A5-4. Radioactive Constituents Evaluated for Additional Modeling for the 216-S-7 Crib.

Analyte	K_d (L/kg)	Depth of Max (ft bgs)	Max Conc. (pCi/g)	Notes[a]	No. of Detections	No. of Samples	Range of Detection Limits (pCi/g)	Range of Detections (pCi/g)
Tritium	0	155 - 157.5	463,000	4.6 mrem/yr at risk 1.0 E-04 at 30 yr.	12	12	NR	2.02 - 463,000
Tc-99	0	24 - 26.5	14.7	2.1 mrem/yr at risk 1.0 E-04 at 1,240 yr.	7	12	0.131 - 0.280	1.29 - 14.7

[a] Dose estimates based on 730 L/year ingestion of well water.

K_d = distribution coefficient.
NR = no range applies when all results are detections or a single detection applies.

A6.0 CONCLUSIONS AND PATH FORWARD

A6.1 REMEDIAL INVESTIGATION REPORT SUMMARY

The RI was conducted according to the Work Plan (DOE/RL-2000-60, Rev. 1). The data were evaluated against the DQOs identified in two DQO summary reports (BHI-01411 and CP-14176). Through a data quality assessment, the data were found to have met the DQOs established for this work. Contaminants were identified at the 216-S-7 representative waste site that may present a risk to human health and the environment. The data from this site were used to estimate the risk, determine the need to proceed with an FS, and determine those constituents and site-specific considerations that need to be addressed in the FS. This RI Report also provides data to support the evaluation of alternatives in the FS with regard to meeting potential ARARs and reducing risk.

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

A6.1.1 Characterization

Borehole drilling and sampling, SGLS and HRLS logging, direct-push sampling, and sampling and analysis of soils were used to characterize the 216-S-7 representative waste site. Data from this site were collected during characterization in fiscal year 2004.

Five existing boreholes were SGLS logged: wells 299-W22-12, 299-W22-13, 299-W22-14, 299-W22-32, and 299-W22-33. New Borehole C4557 was drilled, SGLS logged, and subsequently used to collect soil samples for laboratory chemical and physical property analysis.

A6.1.1.1 Contaminant Distribution Models and Exposure Models

The conceptual contaminant distribution models and the conceptual exposure model developed in the Work Plan (DOE/RL 2000-60, Rev. 1) were revised based on the data obtained during the RI and other data-collection activities. The contaminant distribution models are presented in Chapter A3.0, but generally can be described as follows.

- Contamination associated with less mobile COCs, such as cesium, neptunium, technetium, plutonium, and strontium, are detected in the highest concentrations near the bottom of waste sites.
- Contaminant concentrations generally decrease with depth below the waste site bottom, with the exception of the highly mobile constituents (e.g., tritium).
- Most of the contamination remains high in the vadose zone above the water table.

- Highly mobile COCs, such as technetium, have passed through the vadose zone and are detected sporadically across the vadose zone in low concentrations.

The exposure pathway model for the OU is presented in Chapter A4.0 and generally is summarized as follows.

- Potentially contaminated media are shallow-zone soils, deep-zone soils, biota, and groundwater.
- Potential receptors are mainly current and future workers (based on the current land-use assumptions) and terrestrial biota.
- Exposure pathways are ingestion, dermal contact, inhalation, and exposure to external radiation.

The contaminant distribution models in this RI Report generally have changed very little from the models in the Work Plan (DOE/RL-2000-60, Rev. 1) with respect to the distribution of contamination. However, the models were updated to better depict the nature and vertical extent of contamination relative to the physical setting. The revised models identify specific contaminants present, contaminant concentrations, and the vertical extent of contamination relative to the water table.

The conceptual model contains the following media types: surface soils or shallow-zone soils from 0 to 4.6 m (0 to 15 ft) bgs; subsurface soils or deep-zone soils from 0 m to groundwater; groundwater; and biota. Based on current land-use assumptions, potential receptors are current workers, future workers, and terrestrial biota.

A6.1.1.2 Contaminants of Concern and Site Risks

The COCs were identified by following a data evaluation process that is based on regulatory guidance and professional judgment. Nonradioactive constituents analyzed in the RI were screened based on detection (constituents with no detections were eliminated), comparison to background, and comparison to regulatory requirements. Estimates for cancer risk and HQ/hazard index also were generated. Radiological constituents were screened based on detection and background. Radiological dose and cancer risk to receptors were evaluated using RESRAD (ANL, 2002). The COCs, relative risks, and radiological dose rates for the 216-S-7 Crib representative waste site are summarized in Table A6-1. Table A6-1 identifies those COCs that, based on the results of the data evaluation, must be considered for remedial action in the FS. Table A6-2 identifies those COCs that were consistently identified in the 216-S-7 representative waste site of the 200-PW-2 OU and that are the most likely contaminants for future sampling efforts (i.e., confirmatory sampling, design sampling, verification sampling).

A6.1.2 Ecological Screening

Constituents in this report were compared to ecological soil-screening indicators in WAC-173-340-900, Table 749-3 (see Table A4-20 of this RI Report for chemical screening), and DOE-STD-1153-2002 (see Table A4-19 of this RI Report for radionuclide screening). The ecological COCs that will be carried forward to the FS for further ecological risk evaluation are identified in Table A6-2.

A6.1.3 Fate and Transport Modeling and Evaluation

The initial screening of the nonradioactive contaminants was performed by comparing the analysis results to the RBCs, based on WAC 173-340-720, "Ground Water Cleanup Standards." The COPCs were compared to background levels in Table A4-1 (for shallow-zone soils) and Table A4-2 (for deep soils). Organic COPCs were compared to human health RBCs in Table A4-6 (organic chemicals). Inorganic chemicals were screened in Table A4-6 (direct exposure) and Table A4-8 (protection of groundwater). For radionuclides, specific site contaminants were selected based on the results of transport screening analyses performed using RESRAD modeling (ANL, 2002) and regulatory considerations. Tables A4-17, A4-18, and Section A4.4.3.3 give RESRAD dose and risk assessment results for individual waste sites. A second evaluation was performed to assess whether additional modeling was required. This included evaluation of the partition coefficients, frequency of detection, location of any single detects in the soil column, and whether the constituent already has reached groundwater. The evaluation was qualitative and is provided in Section A5.4 of this RI Report. Based on this evaluation, sufficient data already existed to assess the fate and transport. A chart showing the flow of data through the screening and modeling processing is provided in Chapter A4.0, Figure A4-1.

The results of the fate and transport modeling and added evaluation indicate that most COCs are effectively attenuated in the vadose zone and do not pose a substantial threat to future groundwater quality during the 1,000-year simulation. Contaminants that affect groundwater in the future in significant concentrations are nitrate, nitrite, uranium, tritium, and Tc-99. Tritium is the only contaminant that is predicted to reach groundwater within the 1,000 years. Short-lived radionuclides, such as Cs-137 and Sr-90, were shown to decay long before reaching groundwater.

Table A6-1. Contaminants of Concern, Risk, and Dose Summary.

Site	Nonradiological			Radiological [a]						
	Total Excess Lifetime Cancer Risk from Shallow Nonradiological COCs	Nonradiological COCs Exceeding GWP Soil RBCs	Nonradiological COCs Exceeding Ecological Screening Levels (WAC 173-340-900, Table 749-3)	Total Maximum Excess Lifetime Cancer Risk from Radiological COCs	Total Maximum Dose Rate/Time	Primary Risk Contributor	Primary Dose Contributor	Total Excess Lifetime Cancer Risk, Drinking Water	Total Maximum Dose Rate for Groundwater at Years [b]	Radiological COCs Exceeding Ecological Screening Levels
216-S-7 Crib	<1.0 E-05	Arsenic Nitrate Nitrate/nitrite [c] Uranium (total)	Hexavalent chromium [d] Silver [d]	Cover scenario: not modeled[e]	Cover scenario: not modeled[e]	Cover scenario: not modeled[e]	Cover scenario: not modeled[e]	1.0 E-4	4.6 mrem/yr at 30 years for Tritium; 2.1 mrem/yr for Tc-99 [g].	none
				No-cover scenario[f]: 5.0 E-07	No-cover scenario[f]: 0.024 mrem/yr at 0 years for no-cover scenario [f].	No-cover scenario[f]: Cs-137	No-cover scenario[f]: Cs-137 Tritium			

[a] No cover = contaminated zone includes shallow soil (0 to 15 ft below ground surface).
[b] RESRAD Code (ANL 2002, *RESRAD for Windows*, Version 6.21) defines "cover" as any material above the source term. For groundwater, actual conditions/concentrations were used for the material above the source term.
[c] Nitrate/nitrite reported as "nitrate and nitrate/nitrite' were screened against risk-based concentration for nitrite.
[d] Metals without values provided in WAC 173-340-900, "Tables," Table 749-3.
[e] Modeling with clean cover in place (i.e., "clean cover" scenario as described in Section A4.4.2) was not performed, because existing cover is slightly contaminated.
[f] Contamination in the existing cover material is reported on this table under the "no-cover" (without clean cover) scenario, because the cover is contaminated. However, contamination in the cover did not exceed the industrial standard of greater than 15 mrem/yr dose or one in 10,000 cancer risk. Radionuclide was retained and carried to feasibility study for conservatism.
[g] Did not exceed industrial standard of greater than 4 mrem/yr dose; however, radionuclide was retained and carried to feasibility study for conservatism.
COC = contaminant of concern.
GWP = groundwater protection.
RBC = risk-based concentration.
WAC = Washington *Administrative Code*.

Table A6-2. Preliminary List of Contaminants for the Confirmatory Sampling Phase at the 200-PW-2 Operable Unit 216-S-7 Crib Representative Waste Site.

Radioactive Constituents
Cesium-137
Technetium-99
Tritium
Nonradioactive constituents with risk-based concentrations
Arsenic
Hexavalent chromium
Nitrate
Nitrate/nitrite *
Uranium (total)
Silver

* Nitrate/nitrite reported as "nitrate and nitrate/nitrite' was screened against risk-based concentration for nitrite.

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Table A-1. Data Summary Table -- Shallow Zone.

Constituent	Constituent Class	Units	Number of Samples	Number of Detects	Frequency of Detect	Minimum Nondetect	Maximum Nondetect	Minimum Result	Maximum Result (EPC)	Analytical Method, Minimum Nondetect or Result	Analytical Method, Maximum Nondetect or Result	Top 15 ft Max Conc (ft bgs)
216-S-7 Crib												
Americium-241	RAD	pCi/g	1	0	0%	0.004	0.004	--	--	Precipitation AEA	Precipitation AEA	--
Carbon-14	RAD	pCi/g	1	0	0%	0.391	0.391	--	--	Furnace/LSC	Furnace/LSC	--
Cesium-137	RAD	pCi/g	1	1	100%	--	--	0.037	0.037	GEA	GEA	14.5 - 17
Cobalt-60	RAD	pCi/g	1	0	0%	-0.003	-0.003	--	--	GEA	GEA	--
Europium-152	RAD	pCi/g	1	0	0%	-0.047	-0.047	--	--	GEA	GEA	--
Europium-154	RAD	pCi/g	1	0	0%	-0.041	-0.041	--	--	GEA	GEA	--
Europium-155	RAD	pCi/g	1	0	0%	0.056	0.056	--	--	GEA	GEA	--
Iodine-129	RAD	pCi/g	1	0	0%	-0.061	-0.061	--	--	LEPS	LEPS	--
Neptunium-237	RAD	pCi/g	1	0	0%	0.001	0.001	--	--	Precipitation AEA	Precipitation AEA	--
Nickel-63	RAD	pCi/g	1	0	0%	0.531	0.531	--	--	LSC	LSC	--
Plutonium-238	RAD	pCi/g	1	0	0%	0.021	0.021	--	--	Precipitation AEA	Precipitation AEA	--
Plutonium-239/240	RAD	pCi/g	1	0	0%	0.006	0.006	--	--	Precipitation AEA	Precipitation AEA	--
Radium-226	RAD	pCi/g	1	1	100%	--	--	0.649	0.649	GEA	GEA	14.5 - 17
Radium-228	RAD	pCi/g	1	1	100%	--	--	0.719	0.719	GEA	GEA	14.5 - 17
Strontium-89/90	RAD	pCi/g	1	0	0%	0.084	0.084	--	--	Separation GPC	Separation GPC	--
Technetium-99	RAD	pCi/g	1	0	0%	0.167	0.167	--	--	LSC	LSC	--
Thorium-228	RAD	pCi/g	1	1	100%	--	--	0.749	0.749	Electroplate AEA	Electroplate AEA	14.5 - 17
Thorium-230	RAD	pCi/g	1	1	100%	--	--	0.527	0.527	Electroplate AEA	Electroplate AEA	14.5 - 17
Thorium-232	RAD	pCi/g	1	1	100%	--	--	0.772	0.772	Electroplate AEA	Electroplate AEA	14.5 - 17
Tritium	RAD	pCi/g	1	1	100%	--	--	184	184	Furnace/LSC	Furnace/LSC	14.5 - 17
Uranium (total)	METAL	ug/kg	1	0	0%	993	993	--	--	ICP MS	ICP MS	--
Uranium-233/234	RAD	pCi/g	1	1	100%	--	--	0.160	0.160	Precipitation AEA	Precipitation AEA	14.5 - 17
Uranium-235	RAD	pCi/g	1	0	0%	0.016	0.016	--	--	Precipitation AEA	Precipitation AEA	--
Uranium-238	RAD	pCi/g	1	1	100%	--	--	0.170	0.170	Precipitation AEA	Precipitation AEA	14.5 - 17
Antimony	METAL	ug/kg	1	0	0%	4,960	4,960	--	--	ICP MS	ICP MS	--
Arsenic	METAL	ug/kg	1	0	0%	2,980	2,980	--	--	ICP MS	ICP MS	--
Barium	METAL	ug/kg	1	1	100%	--	--	71,400	71,400	ICP MS	ICP MS	14.5 - 17
Beryllium	METAL	ug/kg	1	0	0%	2,980	2,980	--	--	ICP MS	ICP MS	--
Cadmium	METAL	ug/kg	1	0	0%	993	993	--	--	ICP MS	ICP MS	--
Chromium (Total)	METAL	ug/kg	1	1	100%	--	--	12,000	12,000	ICP MS	ICP MS	14.5 - 17
Copper	METAL	ug/kg	1	1	100%	--	--	14,500	14,500	ICP MS	ICP MS	14.5 - 17
Hexavalent Chromium	METAL	ug/kg	1	1	100%	--	--	800	800	7196	7196	14.5 - 17
Lead	METAL	ug/kg	1	0	0%	11,900	11,900	--	--	ICP MS	ICP MS	--
Mercury	METAL	ug/kg	1	1	100%	--	--	1,700	1,700	ICP MS	ICP MS	14.5 - 17
Nickel	METAL	ug/kg	1	1	100%	--	--	10,400	10,400	ICP MS	ICP MS	14.5 - 17
Selenium	METAL	ug/kg	1	0	0%	2,980	2,980	--	--	ICP MS	ICP MS	--
Silver	METAL	ug/kg	1	1	100%	--	--	3,950	3,950	ICP MS	ICP MS	14.5 - 17
Ammonia as N	CONV	ug/kg	1	1	100%	--	--	1,190	1,190	300.7	300.7	14.5 - 17
Chloride	CONV	ug/kg	1	1	100%	--	--	4,270	4,270	300.0	300.0	14.5 - 17
Cyanide	CONV	ug/kg	1	0	0%	200	200	--	--	335.2	335.2	--
Fluoride	CONV	ug/kg	1	0	0%	1,150	1,150	--	--	300.0	300.0	--
Nitrate as N	CONV	ug/kg	1	1	100%	--	--	9,230	9,230	300.0	300.0	14.5 - 17
Nitrite as N	CONV	ug/kg	1	0	0%	950	950	--	--	300.0	300.0	--
Nitrate and nitrate/nitrite as N	CONV	ug/kg	1	1	100%	--	--	6,000	6,000	353.2	353.2	14.5 - 17
Phosphate as PO4	CONV	ug/kg	1	0	0%	8,280	8,280	--	--	300.0	300.0	--
Sulfate as SO4	CONV	ug/kg	1	1	100%	--	--	24,600	24,600	300.0	300.0	14.5 - 17
pH	CONV	pH	1	1	100%	--	--	8.24	8.24	150.1	150.1	14.5 - 17
Oil & grease	CONV	ug/kg	1	0	0%	704,000	704,000	--	--	413.1	413.1	--
2-(2,4,5-trichlorophenoxy)propionic acid	HERB	ug/kg	1	0	0%	18.0	18.0	--	--	8151	8151	--
2,4,5-trichlorophenoxyacetic acid	HERB	ug/kg	1	0	0%	18.0	18.0	--	--	8151	8151	--
2,4-dichlorophenoxyacetic acid	HERB	ug/kg	1	0	0%	35.0	35.0	--	--	8151	8151	--

Table A-1. Data Summary Table -- Shallow Zone.

Constituent	Constituent Class	Units	Number of Samples	Number of Detects	Frequency of Detect	Minimum Nondetect	Maximum Nondetect	Minimum Result	Maximum Result (EPC)	Analytical Method, Minimum Nondetect or Result	Analytical Method, Maximum Nondetect or Result	Top 15 ft Max Conc (ft bgs)
2-secButyl-4,6-dinitrophenol (Dinoseb)	HERB	ug/kg	1	0	0%	18.0	18.0	--	--	8151	8151	--
4-(2,4-Dichlorophenoxy)butanoic acid	HERB	ug/kg	1	0	0%	180	180	--	--	8151	8151	--
4,4'-DDD (Dichlorodiphenyldichloroethane)	PEST	ug/kg	1	0	0%	3.50	3.50	--	--	8081	8081	--
4,4'-DDE (Dichlorodiphenyldichloroethylene)	PEST	ug/kg	1	1	100%	--	--	1.40	1.40	8081	8081	0 - 3
4-4'-DDT (Dichlorodiphenyltrichloroethane)	PEST	ug/kg	1	1	100%	--	--	0.420	0.420	8081	8081	0 - 3
Aldrin	PEST	ug/kg	1	1	100%	--	--	0.810	0.810	8081	8081	0 - 3
Alpha-BHC	PEST	ug/kg	1	0	0%	1.80	1.80	--	--	8081	8081	--
alpha-Chlordane	PEST	ug/kg	1	0	0%	1.80	1.80	--	--	8081	8081	--
Beta-BHC (B-BHC)	PEST	ug/kg	1	0	0%	1.80	1.80	--	--	8081	8081	--
Dalapon	HERB	ug/kg	1	0	0%	180	180	--	--	8151	8151	--
Delta-BHC	PEST	ug/kg	1	1	100%	--	--	1.20	1.20	8081	8081	0 - 3
Dicamba	HERB	ug/kg	1	0	0%	70.0	70.0	--	--	8151	8151	--
Dichloroprop	HERB	ug/kg	1	0	0%	180	180	--	--	8151	8151	--
Dieldrin	PEST	ug/kg	1	0	0%	3.50	3.50	--	--	8081	8081	--
Endosulfan I	PEST	ug/kg	1	0	0%	1.80	1.80	--	--	8081	8081	--
Endosulfan II	PEST	ug/kg	1	1	100%	--	--	0.460	0.460	8081	8081	0 - 3
Endosulfan sulfate	PEST	ug/kg	1	1	100%	--	--	1.20	1.20	8081	8081	0 - 3
Endrin	PEST	ug/kg	1	0	0%	3.50	3.50	--	--	8081	8081	--
Endrin aldehyde	PEST	ug/kg	1	0	0%	3.50	3.50	--	--	8081	8081	--
Endrin ketone	PEST	ug/kg	1	0	0%	3.50	3.50	--	--	8081	8081	--
Gamma-BHC (Lindane)	PEST	ug/kg	1	0	0%	1.80	1.80	--	--	8081	8081	--
Gamma-Chlordane	PEST	ug/kg	1	0	0%	1.80	1.80	--	--	8081	8081	--
Heptachlor	PEST	ug/kg	1	0	0%	1.80	1.80	--	--	8081	8081	--
Heptachlor epoxide	PEST	ug/kg	1	0	0%	1.80	1.80	--	--	8081	8081	--
Methoxychlor	PEST	ug/kg	1	0	0%	18.0	18.0	--	--	8081	8081	--
Toxaphene	PEST	ug/kg	1	0	0%	180	180	--	--	8081	8081	--
1,1,1-Trichloroethane	VOA	ug/kg	1	0	0%	2.10	2.10	--	--	8260	8260	--
1,1,2,2-Tetrachloroethane	VOA	ug/kg	1	0	0%	2.10	2.10	--	--	8260	8260	--
1,1,2-Trichloroethane	VOA	ug/kg	1	0	0%	2.10	2.10	--	--	8260	8260	--
1,1-Dichloroethane	VOA	ug/kg	1	0	0%	2.10	2.10	--	--	8260	8260	--
1,1-Dichloroethene	VOA	ug/kg	1	0	0%	2.10	2.10	--	--	8260	8260	--
1,2-Dichloroethane	VOA	ug/kg	1	0	0%	2.10	2.10	--	--	8260	8260	--
1,2-Dichloroethene (Total)	VOA	ug/kg	1	0	0%	2.10	2.10	--	--	8260	8260	--
1,2-Dichloropropane	VOA	ug/kg	1	0	0%	2.10	2.10	--	--	8260	8260	--
2-Butanone	VOA	ug/kg	1	0	0%	2.10	2.10	--	--	8260	8260	--
2-Hexanone	VOA	ug/kg	1	0	0%	2.10	2.10	--	--	8260	8260	--
4-Methyl-2-Pentanone	VOA	ug/kg	1	0	0%	2.10	2.10	--	--	8260	8260	--
Acetone	VOA	ug/kg	1	0	0%	2.10	2.10	--	--	8260	8260	--
Benzene	VOA	ug/kg	1	0	0%	2.10	2.10	--	--	8260	8260	--
Bromodichloromethane	VOA	ug/kg	1	0	0%	2.10	2.10	--	--	8260	8260	--
Bromoform	VOA	ug/kg	1	0	0%	2.10	2.10	--	--	8260	8260	--
Bromomethane	VOA	ug/kg	1	0	0%	2.10	2.10	--	--	8260	8260	--
Carbon disulfide	VOA	ug/kg	1	0	0%	2.10	2.10	--	--	8260	8260	--
Carbon tetrachloride	VOA	ug/kg	1	0	0%	2.10	2.10	--	--	8260	8260	--
Chlorobenzene	VOA	ug/kg	1	0	0%	2.10	2.10	--	--	8260	8260	--
Chloroethane	VOA	ug/kg	1	0	0%	2.10	2.10	--	--	8260	8260	--
Chloroform	VOA	ug/kg	1	0	0%	2.10	2.10	--	--	8260	8260	--
Chloromethane	VOA	ug/kg	1	0	0%	2.10	2.10	--	--	8260	8260	--
cis-1,3-Dichloropropene	VOA	ug/kg	1	0	0%	2.10	2.10	--	--	8260	8260	--
Dibromochloromethane	VOA	ug/kg	1	0	0%	2.10	2.10	--	--	8260	8260	--
Ethylbenzene	VOA	ug/kg	1	0	0%	2.10	2.10	--	--	8260	8260	--
Methylene chloride	VOA	ug/kg	1	0	0%	2.10	2.10	--	--	8260	8260	--

Table A-1. Data Summary Table -- Shallow Zone.

Constituent	Constituent Class	Units	Number of Samples	Number of Detects	Frequency of Detect	Minimum Nondetect	Maximum Nondetect	Minimum Result	Maximum Result (EPC)	Analytical Method, Minimum Nondetect or Result	Analytical Method, Maximum Nondetect or Result	Top 15 ft Max Conc (ft bgs)
Styrene	VOA	ug/kg	1	0	0%	2.10	2.10	--	--	8260	8260	--
Tetrachloroethene	VOA	ug/kg	1	0	0%	2.10	2.10	--	--	8260	8260	--
Toluene	VOA	ug/kg	1	0	0%	2.10	2.10	--	--	8260	8260	--
trans-1,3-Dichloropropene	VOA	ug/kg	1	0	0%	2.10	2.10	--	--	8260	8260	--
Trichloroethene	VOA	ug/kg	1	0	0%	2.10	2.10	--	--	8260	8260	--
Vinyl chloride	VOA	ug/kg	1	0	0%	2.10	2.10	--	--	8260	8260	--
Xylenes (total)	VOA	ug/kg	1	0	0%	2.10	2.10	--	--	8260	8260	--
1,2,4-Trichlorobenzene	SVOA	ug/kg	1	0	0%	310	310	--	--	8270	8270	--
1,4-Dichlorobenzene	SVOA	ug/kg	1	0	0%	330	330	--	--	8270	8270	--
2,4-Dinitrotoluene	SVOA	ug/kg	1	0	0%	70.0	70.0	--	--	8270	8270	--
2-Chlorophenol	SVOA	ug/kg	1	0	0%	150	150	--	--	8270	8270	--
2-Ethyl-1-hexanol	SVOA	ug/kg	2	2	100%	--	--	40.0	1,900	8260	8270	14.5 - 17
4-Chloro-3-methylphenol	SVOA	ug/kg	1	0	0%	70.0	70.0	--	--	8270	8270	--
4-Nitrophenol	SVOA	ug/kg	1	0	0%	680	680	--	--	8270	8270	--
Acenaphthene	SVOA	ug/kg	1	0	0%	70.0	70.0	--	--	8270	8270	--
Diethylphthalate	SVOA	ug/kg	1	1	100%	--	--	660	660	8270	8270	14.5 - 17
Di-n-butylphthalate	SVOA	ug/kg	1	1	100%	--	--	790	790	8270	8270	14.5 - 17
N-Nitrosodi-n-dipropylamine	SVOA	ug/kg	1	0	0%	70.0	70.0	--	--	8270	8270	--
Pentachlorophenol	SVOA	ug/kg	1	0	0%	320	320	--	--	8270	8270	--
Phenol	SVOA	ug/kg	1	0	0%	110	110	--	--	8270	8270	--
Pyrene	SVOA	ug/kg	1	0	0%	70.0	70.0	--	--	8270	8270	--
Tributyl phosphate	SVOA	ug/kg	1	0	0%	70.0	70.0	--	--	8270	8270	--
TPH -diesel range	TPH	ug/kg	1	0	0%	3,900	3,900	--	--	WTPH	WTPH	--
TPH -kerosene range	TPH	ug/kg	1	0	0%	3,900	3,900	--	--	WTPH	WTPH	--
TPH -gasoline range	TPH	ug/kg	1	0	0%	250	250	--	--	WTPH	WTPH	--

DEFINITIONS:	
150.1	150.1 Method for pH
300.0	300.0 Ion Chromatography Method for Anions
300.7	300.7 Ion Chromatography Method for Anions
335.2	335.2 Method for Cyanide
353.2	353.2 Method for Nitrogen in Nitrate and Nitrite
413.1	413.1 Gravimetric Method for Oil and Grease
7196	7196 Method for Hexavalent Chromium
8081	8081 Gas Chromatography Method for Pesticides
8151	8151 Gas Chromatography Method for Herbicides
8260	8260 Gas Chromatography/Mass Spectrometry Method for Volatile Organic Analysis
8270	8270 Gas Chromatography/Mass Spectrometry Method for Semi-Volatile Organic Analysis
9010	9010 Method for Cyanide
BHC	1,2,3,4,5,6-hexachlorocyclohexane
Electroplate AEA	Electroplate with Alpha Energy Analysis
ft bgs	feet below ground surface
Furnace/LSC	Furnace with Liquid Scintillation Counting
GEA	Gamma Energy Analysis
ICP	Inductively Coupled Plasma
ICP MS	Inductively Coupled Plasma Mass Spectrometry
LEPS	Low-Energy Photon Spectroscopy
LSC	Liquid Scintillation Counting
Precip AEA	Precipitation with Alpha Energy Analysis
Separation GPC	Separation Gas Proportional Counting
TPH	Total Petroleum Hydrocarbons
WTPH	Washington State Method to Determine Total Petroleum Hydrocarbons by Gas Chromatography

Table A-2. Data Summary Table -- Deep Zone.

Constituent	Constituent Class	Units	Number of Samples	Number of Detects	Frequency of Detect	Minimum Nondetect	Maximum Nondetect	Minimum Result	Maximum Result (EPC)	Analytical Method, Minimum Nondetect or Result	Analytical Method, Maximum Nondetect or Result	Overall Maximum Depth (ft bgs)
216-S-7 Crib												
Americium-241	RAD	pCi/g	13	9	69%	0.004	6.10	0.022	1,900	Precipitation AEA	Precipitation AEA	24 - 26.5
Antimony-125	RAD	pCi/g	2	0	0%	-14.2	0.027	--	--	GEA	GEA	--
Carbon-14	RAD	pCi/g	12	0	0%	-2.28	2.32	--	--	Furnace/LSC	Furnace/LSC	--
Cesium-134	RAD	pCi/g	2	0	0%	0.040	0.265	--	--	GEA	GEA	--
Cesium-137	RAD	pCi/g	13	10	77%	0.001	0.009	0.012	20,000	GEA	GEA	24 - 26.5
Cobalt-60	RAD	pCi/g	13	2	15%	-0.006	2.30	0.015	0.022	GEA	GEA	44 - 46.5
Europium-152	RAD	pCi/g	13	0	0%	-12.3	0.260	--	--	GEA	GEA	--
Europium-154	RAD	pCi/g	13	0	0%	-0.050	13.9	--	--	GEA	GEA	--
Europium-155	RAD	pCi/g	13	1	8%	-6.63	0.220	0.063	0.063	GEA	GEA	66 - 68.5
Iodine-129	RAD	pCi/g	12	0	0%	-0.982	0.378	--	--	LEPS	LEPS	--
Neptunium-237*	RAD	pCi/g	11	1	9%	-2.80	1.10	6.80	6.80	Precipitation AEA	Precipitation AEA	24 - 26.5
Nickel-63	RAD	pCi/g	12	1	8%	-1.78	0.553	13.7	13.7	LSC	LSC	24 - 26.5
Plutonium-238	RAD	pCi/g	13	1	8%	-0.026	4.70	190	190	Precipitation AEA	Precipitation AEA	24 - 26.5
Plutonium-239/240	RAD	pCi/g	13	6	46%	0.002	0.018	0.039	11,000	Precipitation AEA	Precipitation AEA	24 - 26.5
Potassium-40	RAD	pCi/g	1	1	100%	--	--	16.2	16.2	GEA	GEA	44 - 46.5
Radium-226	RAD	pCi/g	13	10	77%	-8.22	0.892	0.271	0.649	GEA	GEA	14.5 - 17
Radium-228	RAD	pCi/g	13	11	85%	0.479	2.70	0.431	0.846	GEA	GEA	34 - 36.5, 44 - 46.5
Strontium-89/90	RAD	pCi/g	13	8	62%	-0.400	0.084	0.310	53,000	Separation GPC	Separation GPC	24 - 26.5
Technetium-99	RAD	pCi/g	12	7	58%	0.131	0.280	1.29	14.7	LSC	LSC	24 - 26.5
Thorium-228	RAD	pCi/g	12	12	100%	--	--	0.485	4.78	Electroplate AEA	Electroplate AEA	24 - 26.5
Thorium-230	RAD	pCi/g	12	12	100%	--	--	0.350	0.844	Electroplate AEA	Electroplate AEA	155 - 157.5
Thorium-232	RAD	pCi/g	12	12	100%	--	--	0.447	0.846	Electroplate AEA	GEA	126 - 128.5
Tin-126	RAD	pCi/g	2	0	0%	-1.11	0.216	--	--	GEA	GEA	--
Tritium	RAD	pCi/g	12	12	100%	--	--	2.02	1,410	906.0	906.0	155 - 157.5
Uranium (total)	METAL	ug/kg	13	8	62%	945	1,010	1,180	463,000	ICP MS	ICP MS	24 - 26.5
Uranium-233/234	RAD	pCi/g	13	13	100%	--	--	0.016	230	Precipitation AEA	Precipitation AEA	24 - 26.5
Uranium-235	RAD	pCi/g	13	10	77%	0.001	1.10	0.009	25.0	Precipitation AEA	Precipitation AEA	24 - 26.5
Uranium-238	RAD	pCi/g	13	13	100%	--	--	0.008	200	Precipitation AEA	Precipitation AEA	24 - 26.5
Antimony	METAL	ug/kg	13	0	0%	278	5,030	--	--	ICP	ICP MS	--
Arsenic	METAL	ug/kg	13	6	46%	2,920	3,020	2,000	7,090	ICP	ICP MS	155 - 157.5
Barium	METAL	ug/kg	13	13	100%	--	--	42,100	127,000	ICP MS	ICP MS	24 - 26.5
Beryllium	METAL	ug/kg	13	1	8%	2,570	3,020	31.0	31.0	ICP	ICP	44 - 46.5
Bismuth	METAL	ug/kg	1	0	0%	1,920	1,920	--	--	ICP	ICP	--
Boron	METAL	ug/kg	1	0	0%	2,270	2,270	--	--	ICP	ICP	--
Cadmium	METAL	ug/kg	13	0	0%	30.0	1,010	--	--	ICP	ICP MS	--
Chromium (Total)	METAL	ug/kg	13	10	77%	2,840	2,960	4,210	146,000	ICP MS	ICP MS	199 - 201.5
Copper	METAL	ug/kg	13	13	100%	--	--	7,890	52,100	ICP MS	ICP MS	223 - 225.5
Hexavalent Chromium	METAL	ug/kg	13	4	31%	200	350	210	800	7196	7196	14.5 - 17
Lead	METAL	ug/kg	13	1	8%	10,300	12,100	3,800	3,800	ICP	ICP	44 - 46.5
Mercury	METAL	ug/kg	13	2	15%	16	1,010	990	1,700	ICP MS	ICP MS	14.5 - 17
Nickel	METAL	ug/kg	13	13	100%	--	--	5,390	82,400	ICP MS	ICP MS	199 - 201.5
Selenium	METAL	ug/kg	13	0	0%	367	3,020	--	--	ICP	ICP MS	--
Silver	METAL	ug/kg	13	2	15%	99.0	2,010	2,850	3,950	ICP MS	ICP MS	14.5 - 17
Ammonia as N	CONV	ug/kg	13	11	85%	201	11,200	387	14,600	300.7	300.7	24 - 26.5
Chloride	CONV	ug/kg	13	9	69%	2,600	10,200	2,610	16,700	300.0	300.0	44 - 46.5
Cyanide	CONV	ug/kg	13	0	0%	200	520	--	--	335.2	9010	--
Fluoride	CONV	ug/kg	13	0	0%	1,080	4,510	--	--	300.0	300.0	--
Nitrate as N	CONV	ug/kg	13	13	100%	--	--	1,510	53,000	300.0	300.0	126 - 128.5
Nitrite as N	CONV	ug/kg	13	0	0%	329	3,720	--	--	300.0	300.0	--
Nitrate and nitrate/nitrite as N	CONV	ug/kg	13	11	85%	220	220	970	45,000	353.2	353.2	223 - 225.5

Table A-2. Data Summary Table -- Deep Zone.

Constituent	Constituent Class	Units	Number of Samples	Number of Detects	Frequency of Detect	Minimum Nondetect	Maximum Nondetect	Minimum Result	Maximum Result (EPC)	Analytical Method, Minimum Nondetect or Result	Analytical Method, Maximum Nondetect or Result	Overall Maximum Depth (ft bgs)
Phosphate as PO4	CONV	ug/kg	13	1	8%	8,130	32,500	2,110	2,110	300.0	300.0	44 - 46.5
Sulfate as SO4	CONV	ug/kg	13	11	85%	19,500	19,600	12,400	41,600	300.0	300.0	44 - 46.5
pH	CONV	pH	13	13	100%	--	--	8.21	10.20	150.1	150.1	54 - 56.5
Oil & grease	CONV	ug/kg	6	3	50%	697,000	736,000	751,000	3,330,000	413.1	413.1	54 - 56.5
2-(2,4,5-trichlorophenoxy)propionic acid	HERB	ug/kg	1	0	0%	18.0	18.0	--	--	8151	8151	--
2,4,5-trichlorophenoxyacetic acid	HERB	ug/kg	1	0	0%	18.0	18.0	--	--	8151	8151	--
2,4-dichlorophenoxyacetic acid	HERB	ug/kg	1	0	0%	35.0	35.0	--	--	8151	8151	--
2-secButyl-4,6-dinitrophenol (Dinoseb)	HERB	ug/kg	1	0	0%	18.0	18.0	--	--	8151	8151	--
4-(2,4-Dichlorophenoxy)butanoic acid	HERB	ug/kg	1	0	0%	180	180	--	--	8151	8151	--
4,4'-DDD (Dichlorodiphenyldichloroethane)	PEST	ug/kg	1	0	0%	3.50	3.50	--	--	8081	8081	--
4,4'-DDE (Dichlorodiphenyldichloroethylene)	PEST	ug/kg	1	1	100%	--	--	1.40	1.40	8081	8081	0 - 3
4-4'-DDT (Dichlorodiphenyltrichloroethane)	PEST	ug/kg	1	1	100%	--	--	0.420	0.420	8081	8081	0 - 3
Aldrin	PEST	ug/kg	1	1	100%	--	--	0.810	0.810	8081	8081	0 - 3
Alpha-BHC	PEST	ug/kg	1	0	0%	1.80	1.80	--	--	8081	8081	--
alpha-Chlordane	PEST	ug/kg	1	0	0%	1.80	1.80	--	--	8081	8081	--
Beta-BHC (B-BHC)	PEST	ug/kg	1	0	0%	1.80	1.80	--	--	8081	8081	--
Dalapon	HERB	ug/kg	1	0	0%	180	180	--	--	8151	8151	--
Delta-BHC	PEST	ug/kg	1	1	100%	--	--	1.20	1.20	8081	8081	0 - 3
Dicamba	HERB	ug/kg	1	0	0%	70.0	70.0	--	--	8151	8151	--
Dichloroprop	HERB	ug/kg	1	0	0%	180	180	--	--	8151	8151	--
Dieldrin	PEST	ug/kg	1	0	0%	3.50	3.50	--	--	8081	8081	--
Endosulfan I	PEST	ug/kg	1	0	0%	1.80	1.80	--	--	8081	8081	--
Endosulfan II	PEST	ug/kg	1	1	100%	--	--	0.460	0.460	8081	8081	0 - 3
Endosulfan sulfate	PEST	ug/kg	1	1	100%	--	--	1.20	1.20	8081	8081	0 - 3
Endrin	PEST	ug/kg	1	0	0%	3.50	3.50	--	--	8081	8081	--
Endrin aldehyde	PEST	ug/kg	1	0	0%	3.50	3.50	--	--	8081	8081	--
Endrin ketone	PEST	ug/kg	1	0	0%	3.50	3.50	--	--	8081	8081	--
Gamma-BHC (Lindane)	PEST	ug/kg	1	0	0%	1.80	1.80	--	--	8081	8081	--
Gamma-Chlordane	PEST	ug/kg	1	0	0%	1.80	1.80	--	--	8081	8081	--
Heptachlor	PEST	ug/kg	1	0	0%	1.80	1.80	--	--	8081	8081	--
Heptachlor epoxide	PEST	ug/kg	1	0	0%	1.80	1.80	--	--	8081	8081	--
Methoxychlor	PEST	ug/kg	1	0	0%	18.0	18.0	--	--	8081	8081	--
Toxaphene	PEST	ug/kg	1	0	0%	180	180	--	--	8081	8081	--
1,1,1-Trichloroethane	VOA	ug/kg	13	0	0%	0.110	6.00	--	--	8260	8260	--
1,1,2,2-Tetrachloroethane	VOA	ug/kg	13	0	0%	0.750	6.00	--	--	8260	8260	--
1,1,2-Trichloroethane	VOA	ug/kg	13	0	0%	0.790	6.00	--	--	8260	8260	--
1,1-Dichloroethane	VOA	ug/kg	13	0	0%	0.210	6.00	--	--	8260	8260	--
1,1-Dichloroethene	VOA	ug/kg	13	0	0%	0.690	6.00	--	--	8260	8260	--
1,2-Dichlorobenzene	VOA	ug/kg	3	0	0%	0.890	1.00	--	--	8260	8260	--
1,2-Dichloroethane	VOA	ug/kg	13	0	0%	0.140	6.00	--	--	8260	8260	--
1,2-Dichloroethene (Total)	VOA	ug/kg	13	0	0%	0.620	6.00	--	--	8260	8260	--
1,2-Dichloropropane	VOA	ug/kg	13	0	0%	0.100	6.00	--	--	8260	8260	--
1,3-Dichlorobenzene	VOA	ug/kg	3	0	0%	0.530	0.600	--	--	8260	8260	--
1,4-Dichlorobenzene	VOA	ug/kg	3	0	0%	0.400	0.450	--	--	8260	8260	--
1-Butanol	VOA	ug/kg	3	0	0%	34.0	38.0	--	--	8260	8260	--
2-Butanone	VOA	ug/kg	13	0	0%	1.10	11.0	--	--	8260	8260	--
2-Hexanone	VOA	ug/kg	13	0	0%	1.30	11.0	--	--	8260	8260	--
4-Methyl-2-Pentanone	VOA	ug/kg	13	0	0%	0.920	11.0	--	--	8260	8260	--
Acetone	VOA	ug/kg	13	2	15%	1.30	11.0	8.90	16.0	8260	8260	199 - 201.5
Benzene	VOA	ug/kg	13	0	0%	0.110	6.00	--	--	8260	8260	--
Bromodichloromethane	VOA	ug/kg	13	0	0%	0.071	6.00	--	--	8260	8260	--
Bromoform	VOA	ug/kg	13	0	0%	0.630	6.00	--	--	8260	8260	--

Table A-2. Data Summary Table -- Deep Zone.

Constituent	Constituent Class	Units	Number of Samples	Number of Detects	Frequency of Detect	Minimum Nondetect	Maximum Nondetect	Minimum Result	Maximum Result (EPC)	Analytical Method, Minimum Nondetect or Result	Analytical Method, Maximum Nondetect or Result	Overall Maximum Depth (ft bgs)
Bromomethane	VOA	ug/kg	13	2	15%	0.920	11.0	0.930	1.10	8260	8260	24 26.5
Carbon disulfide	VOA	ug/kg	13	0	0%	0.280	6.00	--	--	8260	8260	--
Carbon tetrachloride	VOA	ug/kg	13	0	0%	0.140	6.00	--	--	8260	8260	--
Chlorobenzene	VOA	ug/kg	13	0	0%	0.120	6.00	--	--	8260	8260	--
Chloroethane	VOA	ug/kg	13	0	0%	0.570	11.0	--	--	8260	8260	--
Chloroform	VOA	ug/kg	13	0	0%	0.120	6.00	--	--	8260	8260	--
Chloromethane	VOA	ug/kg	13	0	0%	0.230	11.0	--	--	8260	8260	--
cis-1,3-Dichloropropene	VOA	ug/kg	13	0	0%	0.150	6.00	--	--	8260	8260	--
Dibromochloromethane	VOA	ug/kg	13	0	0%	0.600	6.00	--	--	8260	8260	--
Ethylbenzene	VOA	ug/kg	13	0	0%	0.390	6.00	--	--	8260	8260	--
Methylene chloride	VOA	ug/kg	13	4	31%	2.00	2.20	2.80	13.6	8260	8260	44 - 46.5
n-Butylbenzene	VOA	ug/kg	3	0	0%	0.770	0.870	--	--	8260	8260	--
Styrene	VOA	ug/kg	13	0	0%	0.200	6.00	--	--	8260	8260	--
Tetrachloroethene	VOA	ug/kg	13	0	0%	0.200	6.00	--	--	8260	8260	--
Toluene	VOA	ug/kg	13	0	0%	0.600	12.0	--	--	8260	8260	--
trans-1,3-Dichloropropene	VOA	ug/kg	13	0	0%	0.540	6.00	--	--	8260	8260	--
Trichloroethene	VOA	ug/kg	13	0	0%	0.061	6.00	--	--	8260	8260	--
Vinyl chloride	VOA	ug/kg	13	0	0%	0.650	11.0	--	--	8260	8260	--
Xylenes (total)	VOA	ug/kg	13	0	0%	0.840	6.00	--	--	8260	8260	--
1,2,4-Trichlorobenzene	SVOA	ug/kg	12	0	0%	230	330	--	--	8270	8270	--
1,2-Dichlorobenzene	SVOA	ug/kg	1	0	0%	380	380	--	--	8270	8270	--
1,3-Dichlorobenzene	SVOA	ug/kg	1	0	0%	340	340	--	--	8270	8270	--
1,4-Dichlorobenzene	SVOA	ug/kg	12	0	0%	250	350	--	--	8270	8270	--
2,4,5-Trichlorophenol	SVOA	ug/kg	1	0	0%	78.0	78.0	--	--	8270	8270	--
2,4,6-Trichlorophenol	SVOA	ug/kg	1	0	0%	71.0	71.0	--	--	8270	8270	--
2,4-Dichlorophenol	SVOA	ug/kg	1	0	0%	85.0	85.0	--	--	8270	8270	--
2,4-Dimethylphenol	SVOA	ug/kg	1	0	0%	71.0	71.0	--	--	8270	8270	--
2,4-Dinitrophenol	SVOA	ug/kg	1	0	0%	710	710	--	--	8270	8270	--
2,4-Dinitrotoluene	SVOA	ug/kg	12	0	0%	53.0	74.0	--	--	8270	8270	--
2,6-Dinitrotoluene	SVOA	ug/kg	1	0	0%	71.0	71.0	--	--	8270	8270	--
2-Chloronapthalene	SVOA	ug/kg	1	0	0%	71.0	71.0	--	--	8270	8270	--
2-Chlorophenol	SVOA	ug/kg	12	0	0%	120	160	--	--	8270	8270	--
2-Ethyl-1-hexanol	SVOA	ug/kg	2	2	100%	--	--	40.0	1,900	8260	8270	14.5 - 17
2-Methylnapthalene	SVOA	ug/kg	1	0	0%	190	190	--	--	8270	8270	--
2-Methylphenol (cresol, o-)	SVOA	ug/kg	1	0	0%	71.0	71.0	--	--	8270	8270	--
2-Nitroaniline	SVOA	ug/kg	1	0	0%	71.0	71.0	--	--	8270	8270	--
2-Nitrophenol	SVOA	ug/kg	1	0	0%	180	180	--	--	8270	8270	--
3,3'-Dichlorobenzidine	SVOA	ug/kg	1	0	0%	85.0	85.0	--	--	8270	8270	--
3+4 Methylphenol (cresol m+p)	SVOA	ug/kg	1	0	0%	120	120	--	--	8270	8270	--
3-Nitroaniline	SVOA	ug/kg	1	0	0%	71.0	71.0	--	--	8270	8270	--
4,6-Dinitro-2-methylphenol	SVOA	ug/kg	1	0	0%	710	710	--	--	8270	8270	--
4-Bromophenylphenylether	SVOA	ug/kg	1	0	0%	71.0	71.0	--	--	8270	8270	--
4-Chloro-3-methylphenol	SVOA	ug/kg	12	0	0%	53.0	74.0	--	--	8270	8270	--
4-Chloroaniline	SVOA	ug/kg	1	0	0%	99.0	99.0	--	--	8270	8270	--
4-Chlorophenylphenyl ether	SVOA	ug/kg	1	0	0%	71.0	71.0	--	--	8270	8270	--
4-Nitroaniline	SVOA	ug/kg	1	0	0%	260	260	--	--	8270	8270	--
4-Nitrophenol	SVOA	ug/kg	12	0	0%	510	720	--	--	8270	8270	--
Acenaphthene	SVOA	ug/kg	12	0	0%	53.0	74.0	--	--	8270	8270	--
Acenaphthylene	SVOA	ug/kg	1	0	0%	85.0	85.0	--	--	8270	8270	--
Anthracene	SVOA	ug/kg	1	0	0%	71.0	71.0	--	--	8270	8270	--
Benzo(a)anthracene	SVOA	ug/kg	1	0	0%	71.0	71.0	--	--	8270	8270	--
Benzo(a)pyrene	SVOA	ug/kg	1	0	0%	71.0	71.0	--	--	8270	8270	--

Table A-2. Data Summary Table – Deep Zone.

Constituent	Constituent Class	Units	Number of Samples	Number of Detects	Frequency of Detect	Minimum Nondetect	Maximum Nondetect	Minimum Result	Maximum Result (EPC)	Analytical Method, Minimum Nondetect or Result	Analytical Method, Maximum Nondetect or Result	Overall Maximum Depth (ft bgs)
Benzo(b)fluoranthene	SVOA	ug/kg	1	0	0%	71.0	71.0	--	--	8270	8270	--
Benzo(ghi)perylene	SVOA	ug/kg	1	0	0%	71.0	71.0	--	--	8270	8270	--
Benzo(k)fluoranthene	SVOA	ug/kg	1	0	0%	71.0	71.0	--	--	8270	8270	--
Benzyl alcohol	SVOA	ug/kg	1	0	0%	78.0	78.0	--	--	8270	8270	--
Bis(2-chloro-1-methylethyl)ether	SVOA	ug/kg	1	0	0%	270	270	--	--	8270	8270	--
Bis(2-Chloroethoxy)methane	SVOA	ug/kg	1	0	0%	120	120	--	--	8270	8270	--
Bis(2-chloroethyl) ether	SVOA	ug/kg	1	0	0%	260	260	--	--	8270	8270	--
Bis(2-ethylhexyl)phthalate	SVOA	ug/kg	1	0	0%	590	590	--	--	8270	8270	--
Butylbenzylphthalate	SVOA	ug/kg	1	0	0%	71.0	71.0	--	--	8270	8270	--
Carbazole	SVOA	ug/kg	1	0	0%	85.0	85.0	--	--	8270	8270	--
Chrysene	SVOA	ug/kg	1	0	0%	71.0	71.0	--	--	8270	8270	--
Dibenz[a,h]anthracene	SVOA	ug/kg	1	0	0%	71.0	71.0	--	--	8270	8270	--
Dibenzofuran	SVOA	ug/kg	1	0	0%	71.0	71.0	--	--	8270	8270	--
Diethylphthalate	SVOA	ug/kg	7	7	100%	--	--	200	660	8270	8270	14.5 - 17
Dimethylphthalate	SVOA	ug/kg	1	0	0%	71.0	71.0	--	--	8270	8270	--
Di-n-butylphthalate	SVOA	ug/kg	12	12	100%	--	--	140	1,100	8270	8270	34 - 36.5
Di-n-octylphthalate	SVOA	ug/kg	1	0	0%	71.0	71.0	--	--	8270	8270	--
Fluoranthene	SVOA	ug/kg	1	0	0%	71.0	71.0	--	--	8270	8270	--
Fluorene	SVOA	ug/kg	1	0	0%	71.0	71.0	--	--	8270	8270	--
Hexachlorobenzene	SVOA	ug/kg	1	0	0%	71.0	71.0	--	--	8270	8270	--
Hexachlorobutadiene	SVOA	ug/kg	1	0	0%	390	390	--	--	8270	8270	--
Hexachlorocyclopentadiene	SVOA	ug/kg	1	0	0%	330	330	--	--	8270	8270	--
Hexachloroethane	SVOA	ug/kg	1	0	0%	490	490	--	--	8270	8270	--
Ideno(1,2,3-cd)pyrene	SVOA	ug/kg	1	0	0%	71.0	71.0	--	--	8270	8270	--
Isophorone	SVOA	ug/kg	1	0	0%	71.0	71.0	--	--	8270	8270	--
N-Nitrosodi-n-dipropylamine	SVOA	ug/kg	12	0	0%	53.0	74.0	--	--	8270	8270	--
N-Nitrosodiphenylamine	SVOA	ug/kg	1	0	0%	71.0	71.0	--	--	8270	8270	--
Naphthalene	SVOA	ug/kg	1	0	0%	300	300	--	--	8270	8270	--
Nitrobenzene	SVOA	ug/kg	1	0	0%	280	280	--	--	8270	8270	--
Pentachlorophenol	SVOA	ug/kg	12	0	0%	240	330	--	--	8270	8270	--
Phenanthrene	SVOA	ug/kg	1	0	0%	71.0	71.0	--	--	8270	8270	--
Phenol	SVOA	ug/kg	12	0	0%	79.0	110	--	--	8270	8270	--
Pyrene	SVOA	ug/kg	12	0	0%	53.0	74.0	--	--	8270	8270	--
Tributyl phosphate	SVOA	ug/kg	12	0	0%	53.0	74.0	--	--	8270	8270	--
TPH -diesel range	TPH	ug/kg	13	0	0%	12.9	5,600	--	--	WTPH	WTPH	--
TPH -kerosene range	TPH	ug/kg	13	0	0%	12.9	5,600	--	--	WTPH	WTPH	--
TPH -gasoline range	TPH	ug/kg	12	0	0%	20.0	250	--	--	WTPH	WTPH	--

*Two Neptunium-237 results were rejected by the data validator and have not been included in the total.

DEFINITIONS:	
150.1	150.1 Method for pH
300.0	300.0 Ion Chromatography Method for Anions
300.7	300.7 Ion Chromatography Method for Anions
335.2	335.2 Method for Cyanide
353.2	353.2 Method for Nitrogen in Nitrate and Nitrite
413.1	413.1 Gravimetric Method for Oil and Grease
906.0	906.0 Liquid Scintillation Method for Tritium
7196	7196 Method for Hexavalent Chromium
8081	8081 Gas Chromatography Method for Pesticides
8151	8151 Gas Chromatography Method for Herbicides
8260	8260 Gas Chromatography/Mass Spectrometry Method for Volatile Organic Analysis

Table A-2. Data Summary Table – Deep Zone.

Constituent	Constituent Class	Units	Number of Samples	Number of Detects	Frequency of Detect	Minimum Nondetect	Maximum Nondetect	Minimum Result	Maximum Result (EPC)	Analytical Method, Minimum Nondetect or Result	Analytical Method, Maximum Nondetect or Result	Overall Maximum Depth (ft bgs)
8270	8270 Gas Chromatography/Mass Spectrometry Method for Semi-Volatile Organic Analysis											
9010	9010 Method for Cyanide											
BHC	1,2,3,4,5,6-hexachlorocyclohexane											
Electroplate AEA	Electroplate with Alpha Energy Analysis											
ft bgs	feet below ground surface											
Furnace/LSC	Furnace with Liquid Scintillation Counting											
GEA	Gamma Energy Analysis											
ICP	Inductively Coupled Plasma											
ICP MS	Inductively Coupled Plasma Mass Spectrometry											
LEPS	Low-Energy Photon Spectroscopy											
LSC	Liquid Scintillation Counting											
Precip AEA	Precipitation with Alpha Energy Analysis											
Separation GPC	Separation Gas Proportional Counting											
TPH	Total Petroleum Hydrocarbons											
WTPH	Washington State Method to Determine Total Petroleum Hydrocarbons by Gas Chromatography											

Table B-1. Volatile Organic Analysis Results for 216-S-7 Crib (C4557) Samples.

Depth (ft bgs)	Sample Number	Units	1,1,1-Trichloro-ethane 8260		1,1,2,2-Tetrachloro-ethane 8260		1,1,2-Trichloro-ethane 8260		1,1-Dichloro-ethane 8260		1,1-Dichloro-ethene 8260		1,2-Dichloro-benzene 8260		1,2-Dichloro-ethane 8260		1,2-Dichloro-ethene(Total) 8260		1,2-Dichloro-propane 8260	
			Conc'n	Q	Conc'n	Q	Conc'n	Q	Conc'n	Q	Conc'n	Q	Conc'n	Q	Conc'n	Q	Conc'n	Q	Conc'n	Q
0-3	B1B571	ug/kg																		
14.5-17	B1B572	ug/kg	2.1	U	2.1	U	2.1	U	2.1	U	2.1	U			2.1	U	2.1	U	2.1	U
14.5-17	B1B5D6	ug/kg																		
24-26.5	B1B573	ug/kg	0.13	U	0.85	U	0.89	U	0.24	U	0.79	U	1	U	0.16	U	0.71	U	0.12	U
24-26.5	B1B5D7	ug/kg																		
34-36.5	B1B574	ug/kg	0.11	U	0.75	U	0.79	U	0.21	U	0.69	U	0.89	U	0.14	U	0.62	U	0.1	U
34-36.5 (dup)	B1B575	ug/kg	0.11	U	0.76	U	0.8	U	0.22	U	0.71	U	0.9	U	0.15	U	0.63	U	0.1	U
34-36.5	B1B5D8	ug/kg																		
34-36.5 (dup)	B1B5D9	ug/kg																		
44-46.5	B1B576	ug/kg	2.2	U	2.2	U	2.2	U	2.2	U	2.2	U			2.2	U	2.2	U	2.2	U
44-46.5	B1B5F0	ug/kg																		
44-46.5 (split)	B1B5F8	ug/kg	6	U	6	U	6	U	6	U	6	U			6	U	6	U	6	U
44-46.5 (split)	B1BCF3	ug/kg																		
44-46.5 (split)	B1B5F9	ug/kg																		
54-56.5	B1B577	ug/kg	2.1	U	2.1	U	2.1	U	2.1	U	2.1	U			2.1	U	2.1	U	2.1	U
54-56.5	B1B5F1	ug/kg																		
66-68.5	B1B578	ug/kg	2.1	U	2.1	U	2.1	U	2.1	U	2.1	U			2.1	U	2.1	U	2.1	U
66-68.5	B1B5F2	ug/kg																		
126-128.5	B1B579	ug/kg	2.2	U	2.2	U	2.2	U	2.2	U	2.2	U			2.2	U	2.2	U	2.2	U
126-128.5	B1B5F3	ug/kg																		
155-157.5	B1B580	ug/kg	2.2	U	2.2	U	2.2	U	2.2	U	2.2	U			2.2	U	2.2	U	2.2	U
155-157.5	B1B5F4	ug/kg																		
180-182.5	B1B581	ug/kg	2.1	U	2.1	U	2.1	U	2.1	U	2.1	U			2.1	U	2.1	U	2.1	U
180-182.5	B1B5F5	ug/kg																		
199-201.5	B1B582	ug/kg	2	U	2	U	2	U	2	U	2	U			2	U	2	U	2	U
199-201.5	B1B5F6	ug/kg																		
223-225.5	B1B583	ug/kg	2.1	U	2.1	U	2.1	U	2.1	U	2.1	U			2.1	U	2.1	U	2.1	U
223-225.5	B1B5F7	ug/kg																		
Rinsate	B1B568	ug/L	1	U	1	U	1	U	1	U	1	U			1	U	1	U	1	U
Rinsate	B1B569	ug/L																		
Trip Blank	B1B570	ug/L	1	U	1	U	1	U	1	U	1	U			1	U	1	U	1	U
Target Quantitation Limit		ug/kg																		

Table B-1. Volatile Organic Analysis Results for 216-S-7 Crib (C4557) Samples.

Depth (ft bgs)	Sample Number	Units	1,3-Dichloro-benzene 8260		1,4-Dichloro-benzene 8260		1,4-Dioxane 8260		1-Butanol 8260		2-Butanone 8260		2-Ethyl-1-hexanol 8260		2-Hexanone 8260		2-Pentanone 8260		4-Methyl-2-Pentanone 8260	
			Conc'n	Q	Conc'n	Q	Conc'n	Q	Conc'n	Q	Conc'n	Q	Conc'n	Q	Conc'n	Q	Conc'n	Q	Conc'n	Q
0-3	B1B571	ug/kg																		
14.5-17	B1B572	ug/kg									2.1	U	40	J, M	2.1	U			2.1	U
14.5-17	B1B5D6	ug/kg																		
24-26.5	B1B573	ug/kg	0.6	U	0.45	U			38	U	1.3	U			1.5	U			1	U
24-26.5	B1B5D7	ug/kg																		
34-36.5	B1B574	ug/kg	0.53	U	0.4	U			34	U	1.1	U			1.3	U			0.92	U
34-36.5 (dup)	B1B575	ug/kg	0.54	U	0.41	U			34	U	1.2	U			1.3	U			0.94	U
34-36.5	B1B5D8	ug/kg																		
34-36.5 (dup)	B1B5D9	ug/kg																		
44-46.5	B1B576	ug/kg									2.2	U			2.2	U			2.2	U
44-46.5	B1B5F0	ug/kg																		
44-46.5 (split)	B1B5F8	ug/kg									11	U			11	U			11	U
44-46.5 (split)	B1BCF3	ug/kg																		
44-46.5 (split)	B1B5F9	ug/kg																		
54-56.5	B1B577	ug/kg									2.1	U			2.1	U			2.1	U
54-56.5	B1B5F1	ug/kg																		
66-68.5	B1B578	ug/kg									2.1	U			2.1	U			2.1	U
66-68.5	B1B5F2	ug/kg																		
126-128.5	B1B579	ug/kg									2.2	U			2.2	U			2.2	U
126-128.5	B1B5F3	ug/kg																		
155-157.5	B1B580	ug/kg									2.2	U			2.2	U			2.2	U
155-157.5	B1B5F4	ug/kg																		
180-182.5	B1B581	ug/kg									2.1	U			2.1	U			2.1	U
180-182.5	B1B5F5	ug/kg																		
199-201.5	B1B582	ug/kg									2	U			2	U			2	U
199-201.5	B1B5F6	ug/kg																		
223-225.5	B1B583	ug/kg									2.1	U			2.1	U			2.1	U
223-225.5	B1B5F7	ug/kg																		
Rinsate	B1B568	ug/L							20	U	1	U			1	U	1	U	1	U
Rinsate	B1B569	ug/L																		
Trip Blank	B1B570	ug/L					5.9	J	20	U	1	U			1	U	1	U	1	U
Target Quantitation Limit		ug/kg																	10	

Table B-1. Volatile Organic Analysis Results for 216-S-7 Crib (C4557) Samples.

Depth (ft bgs)	Sample Number	Units	Acetone 8260		Benzene 8260		Bromodichloro-methane 8260		Bromoform 8260		Bromomethane 8260		Carbon disulfide 8260		Carbon tetrachloride 8260		Chloro-benzene 8260	
			Conc'n	Q	Conc'n	Q	Conc'n	Q	Conc'n	Q	Conc'n	Q	Conc'n	Q	Conc'n	Q	Conc'n	Q
0-3	B1B571	ug/kg																
14.5-17	B1B572	ug/kg	2.1	U	2.1	U	2.1	U	2.1	U	2.1	U	2.1	U	2.1	U	2.1	U
14.5-17	B1B5D6	ug/kg																
24-26.5	B1B573	ug/kg	1.5	U	0.13	U	0.081	U	0.72	U	1.1	J	0.31	U	0.16	U	0.14	U
24-26.5	B1B5D7	ug/kg																
34-36.5	B1B574	ug/kg	1.3	U	0.11	U	0.071	U	0.63	U	0.93	J	0.28	U	0.14	U	0.12	U
34-36.5 (dup)	B1B575	ug/kg	1.4	U	0.11	U	0.073	U	0.64	U	0.92	U	0.28	U	0.15	U	0.12	U
34-36.5	B1B5D8	ug/kg																
34-36.5 (dup)	B1B5D9	ug/kg																
44-46.5	B1B576	ug/kg	2.2	U	2.2	U	2.2	U	2.2	U	2.2	U	2.2	U	2.2	U	2.2	U
44-46.5	B1B5F0	ug/kg																
44-46.5 (split)	B1B5F8	ug/kg	11	U	6	U	6	U	6	U	11	U	6	U	6	U	6	U
44-46.5 (split)	B1BCF3	ug/kg																
44-46.5 (split)	B1B5F9	ug/kg																
54-56.5	B1B577	ug/kg	2.1	U	2.1	U	2.1	U	2.1	U	2.1	U	2.1	U	2.1	U	2.1	U
54-56.5	B1B5F1	ug/kg																
66-68.5	B1B578	ug/kg	2.1	U	2.1	U	2.1	U	2.1	U	2.1	U	2.1	U	2.1	U	2.1	U
66-68.5	B1B5F2	ug/kg																
126-128.5	B1B579	ug/kg	2.2	U	2.2	U	2.2	U	2.2	U	2.2	U	2.2	U	2.2	U	2.2	U
126-128.5	B1B5F3	ug/kg																
155-157.5	B1B580	ug/kg	2.2	U	2.2	U	2.2	U	2.2	U	2.2	U	2.2	U	2.2	U	2.2	U
155-157.5	B1B5F4	ug/kg																
180-182.5	B1B581	ug/kg	2.1	U	2.1	U	2.1	U	2.1	U	2.1	U	2.1	U	2.1	U	2.1	U
180-182.5	B1B5F5	ug/kg																
199-201.5	B1B582	ug/kg	16		2	U	2	U	2	U	2	U	2	U	2	U	2	U
199-201.5	B1B5F6	ug/kg																
223-225.5	B1B583	ug/kg	8.9	J	2.1	U	2.1	U	2.1	U	2.1	U	2.1	U	2.1	U	2.1	U
223-225.5	B1B5F7	ug/kg																
Rinsate	B1B568	ug/L	1	U	1	U	1	U	1	U	1	U	1	U	1	U	1	U
Rinsate	B1B569	ug/L																
Trip Blank	B1B570	ug/L	1	U	1	U	1	U	1	U	1	U	1	U	1	U	1	U
Target Quantitation Limit		ug/kg																

Table B-1. Volatile Organic Analysis Results for 216-S-7 Crib (C4557) Samples.

Depth (ft bgs)	Sample Number	Units	Chloro-ethane 8260		Chloroform 8260		Chloro-methane 8260		cis-1,3-Dichloro-propene 8260		Dibromochloro-methane 8260		Ethyl acetate 8260			Ethylbenzene 8260		Methylene chloride 8260	
			Conc'n	Q	Conc'n	Q	Conc'n	Q	Conc'n	Q	Conc'n	Q	Conc'n	Q	Val Qual	Conc'n	Q	Conc'n	Q
0-3	B1B571	ug/kg																	
14.5-17	B1B572	ug/kg	2.1	U	2.1	U	2.1	U	2.1	U	2.1	U				2.1	U	2.1	U
14.5-17	B1B5D6	ug/kg																	
24-26.5	B1B573	ug/kg	0.65	U	0.14	U	0.27	U	0.17	U	0.68	U	21		M	0.44	U	4.4	JB
24-26.5	B1B5D7	ug/kg																	
34-36.5	B1B574	ug/kg	0.57	U	0.12	U	0.23	U	0.15	U	0.6	U				0.39	U	2.8	JB
34-36.5 (dup)	B1B575	ug/kg	0.58	U	0.12	U	0.24	U	0.16	U	0.61	U				0.39	U	3	J
34-36.5	B1B5D8	ug/kg																	
34-36.5 (dup)	B1B5D9	ug/kg																	
44-46.5	B1B576	ug/kg	2.2	U	2.2	U	2.2	U	2.2	U	2.2	U				2.2	U	2.2	U
44-46.5	B1B5F0	ug/kg																	
44-46.5 (split)	B1B5F8	ug/kg	11	U	6	U	11	U	6	U	6	U				6	U	13.625	B
44-46.5 (split)	B1BCF3	ug/kg																	
44-46.5 (split)	B1B5F9	ug/kg																	
54-56.5	B1B577	ug/kg	2.1	U	2.1	U	2.1	U	2.1	U	2.1	U				2.1	U	2.1	U
54-56.5	B1B5F1	ug/kg																	
66-68.5	B1B578	ug/kg	2.1	U	2.1	U	2.1	U	2.1	U	2.1	U				2.1	U	2.1	U
66-68.5	B1B5F2	ug/kg																	
126-128.5	B1B579	ug/kg	2.2	U	2.2	U	2.2	U	2.2	U	2.2	U				2.2	U	2.2	U
126-128.5	B1B5F3	ug/kg																	
155-157.5	B1B580	ug/kg	2.2	U	2.2	U	2.2	U	2.2	U	2.2	U				2.2	U	2.2	U
155-157.5	B1B5F4	ug/kg																	
180-182.5	B1B581	ug/kg	2.1	U	2.1	U	2.1	U	2.1	U	2.1	U				2.1	U	2.1	U
180-182.5	B1B5F5	ug/kg																	
199-201.5	B1B582	ug/kg	2	U	2	U	2	U	2	U	2	U				2	U	2	U
199-201.5	B1B5F6	ug/kg																	
223-225.5	B1B583	ug/kg	2.1	U	2.1	U	2.1	U	2.1	U	2.1	U				2.1	U	2.1	U
223-225.5	B1B5F7	ug/kg																	
Rinsate	B1B568	ug/L	1	U	1	U	1	U	1	U	1	U				1	U	1	U
Rinsate	B1B569	ug/L																	
Trip Blank	B1B570	ug/L	1	U	1	U	1	U	1	U	1	U				1	U	1	U
Target Quantitation Limit		ug/kg																	

Table B-1. Volatile Organic Analysis Results for 216-S-7 Crib (C4557) Samples.

Depth (ft bgs)	Sample Number	Units	n-Butyl-benzene 8260		Styrene 8260		Tetrachloro-ethene 8260		Toluene 8260			trans-1,3-Dichloro-propene 8260		Trichloro-ethene 8260		Trimethyl-silanol 8260			Vinyl chloride 8260	
			Conc'n	Q	Conc'n	Q	Conc'n	Q	Conc'n	Q	Val Qual	Conc'n	Q	Conc'n	Q	Conc'n	Q	Val Qual	Conc'n	Q
0-3	B1B571	ug/kg																		
14.5-17	B1B572	ug/kg			2.1	U	2.1	U	2.1	U		2.1	U	2.1	U				2.1	U
14.5-17	B1B5D6	ug/kg																		
24-26.5	B1B573	ug/kg	0.87	U	0.23	U	0.23	U	0.68	U		0.61	U	0.07	U	5.9		M, R	0.74	U
24-26.5	B1B5D7	ug/kg																		
34-36.5	B1B574	ug/kg	0.77	U	0.2	U	0.2	U	0.6	U		0.54	U	0.061	U				0.65	U
34-36.5 (dup)	B1B575	ug/kg	0.78	U	0.21	U	0.21	U	0.61	U		0.55	U	0.062	U				0.66	U
34-36.5	B1B5D8	ug/kg																		
34-36.5 (dup)	B1B5D9	ug/kg																		
44-46.5	B1B576	ug/kg			2.2	U	2.2	U	12	B	U	2.2	U	2.2	U				2.2	U
44-46.5	B1B5F0	ug/kg																		
44-46.5 (split)	B1B5F8	ug/kg			6	U	6	U	6	U		6	U	6	U				11	U
44-46.5 (split)	B1BCF3	ug/kg																		
44-46.5 (split)	B1B5F9	ug/kg																		
54-56.5	B1B577	ug/kg			2.1	U	2.1	U	8.4	BJ	U	2.1	U	2.1	U				2.1	U
54-56.5	B1B5F1	ug/kg																		
66-68.5	B1B578	ug/kg			2.1	U	2.1	U	2.1	U		2.1	U	2.1	U				2.1	U
66-68.5	B1B5F2	ug/kg																		
126-128.5	B1B579	ug/kg			2.2	U	2.2	U	2.2	U		2.2	U	2.2	U				2.2	U
126-128.5	B1B5F3	ug/kg																		
155-157.5	B1B580	ug/kg			2.2	U	2.2	U	2.2	U		2.2	U	2.2	U				2.2	U
155-157.5	B1B5F4	ug/kg																		
180-182.5	B1B581	ug/kg			2.1	U	2.1	U	2.1	U		2.1	U	2.1	U				2.1	U
180-182.5	B1B5F5	ug/kg																		
199-201.5	B1B582	ug/kg			2	U	2	U	2	U		2	U	2	U				2	U
199-201.5	B1B5F6	ug/kg																		
223-225.5	B1B583	ug/kg			2.1	U	2.1	U	2.1	U		2.1	U	2.1	U				2.1	U
223-225.5	B1B5F7	ug/kg																		
Rinsate	B1B568	ug/L	1	U	1	U	1	U	1	U		1	U	1	U				1	U
Rinsate	B1B569	ug/L																		
Trip Blank	B1B570	ug/L	1	U	1	U	1	U	1	U		1	U	1	U				1	U
Target Quantitation Limit		ug/kg																		

Table B-1. Volatile Organic Analysis Results for 216-S-7 Crib (C4557) Samples.

Depth (ft bgs)	Sample Number	Units	Xylenes (total) 8260	
			Conc'n	Q
0-3	B1B571	ug/kg		
14.5-17	B1B572	ug/kg	2.1	U
14.5-17	B1B5D6	ug/kg		
24-26.5	B1B573	ug/kg	0.95	U
24-26.5	B1B5D7	ug/kg		
34-36.5	B1B574	ug/kg	0.84	U
34-36.5 (dup)	B1B575	ug/kg	0.85	U
34-36.5	B1B5D8	ug/kg		
34-36.5 (dup)	B1B5D9	ug/kg		
44-46.5	B1B576	ug/kg	2.2	U
44-46.5	B1B5F0	ug/kg		
44-46.5 (split)	B1B5F8	ug/kg	6	U
44-46.5 (split)	B1BCF3	ug/kg		
44-46.5 (split)	B1B5F9	ug/kg		
54-56.5	B1B577	ug/kg	2.1	U
54-56.5	B1B5F1	ug/kg		
66-68.5	B1B578	ug/kg	2.1	U
66-68.5	B1B5F2	ug/kg		
126-128.5	B1B579	ug/kg	2.2	U
126-128.5	B1B5F3	ug/kg		
155-157.5	B1B580	ug/kg	2.2	U
155-157.5	B1B5F4	ug/kg		
180-182.5	B1B581	ug/kg	2.1	U
180-182.5	B1B5F5	ug/kg		
199-201.5	B1B582	ug/kg	2	U
199-201.5	B1B5F6	ug/kg		
223-225.5	B1B583	ug/kg	2.1	U
223-225.5	B1B5F7	ug/kg		
Rinsate	B1B568	ug/L	1	U
Rinsate	B1B569	ug/L		
Trip Blank	B1B570	ug/L	1	U
Target Quantitation Limit		ug/kg		

B = Analyte found in associated method blank
Conc'n = Concentration
ft bgs = Feet below ground surface
J = Estimated
JB = Estimated; analyte found in associated method blank
M = This is a tentatively identified compound; it is a product of gas chromatograph column bleed and an artifact.
Q = Laboratory qualifier
R = Result is rejected for decision-making
U = Undetected
Val Qual = Validation qualifier

Table B-2. Semivolatile Organic Analysis Results for 216-S-7 Crib (C4557) Samples.

Depth (ft bgs)	Sample Number	Units	1,2,4-Trichloro-benzene 8270		1,2-Dichloro-benzene 8270		1,3-Dichloro-benzene 8270		1,4-Dichloro-benzene 8270		2,4,5-Trichloro-phenol 8270		2,4,6-Trichloro-phenol 8270		2,4-Dichloro-phenol 8270		2,4-Dimethyl-phenol 8270	
			Conc'n	Q	Conc'n	Q	Conc'n	Q	Conc'n	Q	Conc'n	Q	Conc'n	Q	Conc'n	Q	Conc'n	Q
0-3	B1B571	ug/kg																
14.5-17	B1B572	ug/kg	310	U					330	U								
14.5-17	B1B5D6	ug/kg																
24-26.5	B1B573	ug/kg	310	U	380	U	340	U	330	U	78	U	71	U	85	U	71	U
24-26.5	B1B5D7	ug/kg																
34-36.5	B1B574	ug/kg	300	U					320	U								
34-36.5 (dup)	B1B575	ug/kg	300	U					320	U								
34-36.5	B1B5D8	ug/kg																
34-36.5 (dup)	B1B5D9	ug/kg																
44-46.5	B1B576	ug/kg	240	U					260	U								
44-46.5	B1B5F0	ug/kg																
44-46.5 (split)	B1B5F8	ug/kg																
44-46.5 (split)	B1BCF3	ug/kg																
44-46.5 (split)	B1B5F9	ug/kg																
54-56.5	B1B577	ug/kg	230	U					250	U								
54-56.5	B1B5F1	ug/kg																
66-68.5	B1B578	ug/kg	310	U					340	U								
66-68.5	B1B5F2	ug/kg																
126-128.5	B1B579	ug/kg	320	U					340	U								
126-128.5	B1B5F3	ug/kg																
155-157.5	B1B580	ug/kg	330	U					350	U								
155-157.5	B1B5F4	ug/kg																
180-182.5	B1B581	ug/kg	300	U					320	U								
180-182.5	B1B5F5	ug/kg																
199-201.5	B1B582	ug/kg	300	U					320	U								
199-201.5	B1B5F6	ug/kg																
223-225.5	B1B583	ug/kg	300	U					320	U								
223-225.5	B1B5F7	ug/kg																
Rinsate	B1B568	ug/L	2.9	U	4.1	U	5	U	4.9	U	1.8	U	2.3	U	1.4	U	4.2	U
Rinsate	B1B569	ug/L																
Trip Blank	B1B570	ug/L																
Target Quantitation Limit		ug/kg																

Table B-2. Semivolatile Organic Analysis Results for 216-S-7 Crib (C4557) Samples.

Depth (ft bgs)	Sample Number	Units	2,4-Dinitro-phenol 8270		2,4-Dinitro-toluene 8270		2,6-Dinitro-toluene 8270		2-Butoxy-ethanol 8270		2-Chloronaph-thalene 8270		2-Chloro-phenol 8270		2-Ethyl-1-hexanol 8270		2-Methyl-naphthalene 8270	
			Conc'n	Q	Conc'n	Q	Conc'n	Q	Conc'n	Q	Conc'n	Q	Conc'n	Q	Conc'n	Q	Conc'n	Q
0-3	B1B571	ug/kg																
14.5-17	B1B572	ug/kg			70	U							150	U	1900	J		
14.5-17	B1B5D6	ug/kg																
24-26.5	B1B573	ug/kg	710	U	71	U	71	U			71	U	160	U			190	U
24-26.5	B1B5D7	ug/kg																
34-36.5	B1B574	ug/kg			69	U							150	U				
34-36.5 (dup)	B1B575	ug/kg			68	U							150	U				
34-36.5	B1B5D8	ug/kg																
34-36.5 (dup)	B1B5D9	ug/kg																
44-46.5	B1B576	ug/kg			56	U							120	U				
44-46.5	B1B5F0	ug/kg																
44-46.5 (split)	B1B5F8	ug/kg																
44-46.5 (split)	B1BCF3	ug/kg																
44-46.5 (split)	B1B5F9	ug/kg																
54-56.5	B1B577	ug/kg			53	U							120	U				
54-56.5	B1B5F1	ug/kg																
66-68.5	B1B578	ug/kg			71	U							160	U				
66-68.5	B1B5F2	ug/kg																
126-128.5	B1B579	ug/kg			73	U							160	U				
126-128.5	B1B5F3	ug/kg																
155-157.5	B1B580	ug/kg			74	U							160	U				
155-157.5	B1B5F4	ug/kg																
180-182.5	B1B581	ug/kg			69	U							150	U				
180-182.5	B1B5F5	ug/kg																
199-201.5	B1B582	ug/kg			68	U							150	U				
199-201.5	B1B5F6	ug/kg																
223-225.5	B1B583	ug/kg			68	U							150	U				
223-225.5	B1B5F7	ug/kg																
Rinsate	B1B568	ug/L	3.2	U	1.7	U	2.1	U	3	U	2.2	U	1.7	U			1.8	U
Rinsate	B1B569	ug/L																
Trip Blank	B1B570	ug/L																
Target Quantitation Limit		ug/kg																

Table B-2. Semivolatile Organic Analysis Results for 216-S-7 Crib (C4557) Samples.

Depth (ft bgs)	Sample Number	Units	2-Methylphenol (cresol, o-)		2-Nitroaniline		2-Nitrophenol		3,3'-Dichloro-benzidine		3+4 Methylphenol (cresol, m+p)		3-Nitroaniline		4,6-Dinitro-2-methylphenol		4-Bromophenyl-phenyl ether	
			8270		8270		8270		8270		8270		8270		8270		8270	
			Conc'n	Q	Conc'n	Q	Conc'n	Q	Conc'n	Q	Conc'n	Q	Conc'n	Q	Conc'n	Q	Conc'n	Q
0-3	B1B571	ug/kg																
14.5-17	B1B572	ug/kg																
14.5-17	B1B5D6	ug/kg																
24-26.5	B1B573	ug/kg	71	U	71	U	180	U	85	U	120	U	71	U	710	U	71	U
24-26.5	B1B5D7	ug/kg																
34-36.5	B1B574	ug/kg																
34-36.5 (dup)	B1B575	ug/kg																
34-36.5	B1B5D8	ug/kg																
34-36.5 (dup)	B1B5D9	ug/kg																
44-46.5	B1B576	ug/kg																
44-46.5	B1B5F0	ug/kg																
44-46.5 (split)	B1B5F8	ug/kg																
44-46.5 (split)	B1BCF3	ug/kg																
44-46.5 (split)	B1B5F9	ug/kg																
54-56.5	B1B577	ug/kg																
54-56.5	B1B5F1	ug/kg																
66-68.5	B1B578	ug/kg																
66-68.5	B1B5F2	ug/kg																
126-128.5	B1B579	ug/kg																
126-128.5	B1B5F3	ug/kg																
155-157.5	B1B580	ug/kg																
155-157.5	B1B5F4	ug/kg																
180-182.5	B1B581	ug/kg																
180-182.5	B1B5F5	ug/kg																
199-201.5	B1B582	ug/kg																
199-201.5	B1B5F6	ug/kg																
223-225.5	B1B583	ug/kg																
223-225.5	B1B5F7	ug/kg																
Rinsate	B1B568	ug/L	2.2	U	2	U	1.9	U	4	U	3.1	U	4.4	U	1.7	U	1.8	U
Rinsate	B1B569	ug/L																
Trip Blank	B1B570	ug/L																
Target Quantitation Limit		ug/kg																

Table B-2. Semivolatile Organic Analysis Results for 216-S-7 Crib (C4557) Samples.

Depth (ft bgs)	Sample Number	Units	4-Chloro-3-methylphenol		4-Chloroaniline		4-Chlorophenyl-phenyl ether		4-Nitroaniline		4-Nitrophenol		Acenaphthene		Acenaph-thylene		Anthracene	
			8270		8270		8270		8270		8270		8270		8270		8270	
			Conc'n	Q	Conc'n	Q	Conc'n	Q	Conc'n	Q	Conc'n	Q	Conc'n	Q	Conc'n	Q	Conc'n	Q
0-3	B1B571	ug/kg																
14.5-17	B1B572	ug/kg	70	U							680	U	70	U				
14.5-17	B1B5D6	ug/kg																
24-26.5	B1B573	ug/kg	71	U	99	U	71	U	260	U	690	U	71	U	85	U	71	U
24-26.5	B1B5D7	ug/kg																
34-36.5	B1B574	ug/kg	69	U							670	U	69	U				
34-36.5 (dup)	B1B575	ug/kg	68	U							660	U	68	U				
34-36.5	B1B5D8	ug/kg																
34-36.5 (dup)	B1B5D9	ug/kg																
44-46.5	B1B576	ug/kg	56	U							540	U	56	U				
44-46.5	B1B5F0	ug/kg																
44-46.5 (split)	B1B5F8	ug/kg																
44-46.5 (split)	B1BCF3	ug/kg																
44-46.5 (split)	B1B5F9	ug/kg																
54-56.5	B1B577	ug/kg	53	U							510	U	53	U				
54-56.5	B1B5F1	ug/kg																
66-68.5	B1B578	ug/kg	71	U							690	U	71	U				
66-68.5	B1B5F2	ug/kg																
126-128.5	B1B579	ug/kg	73	U							700	U	73	U				
126-128.5	B1B5F3	ug/kg																
155-157.5	B1B580	ug/kg	74	U							720	U	74	U				
155-157.5	B1B5F4	ug/kg																
180-182.5	B1B581	ug/kg	69	U							670	U	69	U				
180-182.5	B1B5F5	ug/kg																
199-201.5	B1B582	ug/kg	68	U							660	U	68	U				
199-201.5	B1B5F6	ug/kg																
223-225.5	B1B583	ug/kg	68	U							660	U	68	U				
223-225.5	B1B5F7	ug/kg																
Rinsate	B1B568	ug/L	1.3	U	7	U	2.1	U	2.8	U	1.4	U	2.3	U	2.2	U	1.9	U
Rinsate	B1B569	ug/L																
Trip Blank	B1B570	ug/L																
Target Quantitation Limit		ug/kg																

Table B-2. Semivolatile Organic Analysis Results for 216-S-7 Crib (C4557) Samples.

Depth (ft bgs)	Sample Number	Units	Benzo(a)-anthracene 8270		Benzo(a)-pyrene 8270		Benzo(b)-fluoranthene 8270		Benzo(ghi)-perylene 8270		Benzo(k)-fluoranthene 8270		Benzyl alcohol 8270		Bis(2-chloro-1-methylethyl)ether 8270		Bis(2-Chloroethoxy)-methane 8270	
			Conc'n	Q	Conc'n	Q	Conc'n	Q	Conc'n	Q	Conc'n	Q	Conc'n	Q	Conc'n	Q	Conc'n	Q
0-3	B1B571	ug/kg																
14.5-17	B1B572	ug/kg																
14.5-17	B1B5D6	ug/kg																
24-26.5	B1B573	ug/kg	71	U	71	U	71	U	71	U	71	U	78	U	270	U	120	U
24-26.5	B1B5D7	ug/kg																
34-36.5	B1B574	ug/kg																
34-36.5 (dup)	B1B575	ug/kg																
34-36.5	B1B5D8	ug/kg																
34-36.5 (dup)	B1B5D9	ug/kg																
44-46.5	B1B576	ug/kg																
44-46.5	B1B5F0	ug/kg																
44-46.5 (split)	B1B5F8	ug/kg																
44-46.5 (split)	B1BCF3	ug/kg																
44-46.5 (split)	B1B5F9	ug/kg																
54-56.5	B1B577	ug/kg																
54-56.5	B1B5F1	ug/kg																
66-68.5	B1B578	ug/kg																
66-68.5	B1B5F2	ug/kg																
126-128.5	B1B579	ug/kg																
126-128.5	B1B5F3	ug/kg																
155-157.5	B1B580	ug/kg																
155-157.5	B1B5F4	ug/kg																
180-182.5	B1B581	ug/kg																
180-182.5	B1B5F5	ug/kg																
199-201.5	B1B582	ug/kg																
199-201.5	B1B5F6	ug/kg																
223-225.5	B1B583	ug/kg																
223-225.5	B1B5F7	ug/kg																
Rinsate	B1B568	ug/L	2	U	2	U	1.7	U	2.4	U	2.7	U	1.7	U	2	U	1.9	U
Rinsate	B1B569	ug/L																
Trip Blank	B1B570	ug/L																
Target Quantitation Limit		ug/kg																

Table B-2. Semivolatile Organic Analysis Results for 216-S-7 Crib (C4557) Samples.

Depth (ft bgs)	Sample Number	Units	Bis(2-chloroethyl) ether		Bis(2-ethylhexyl) phthalate		Butylbenzyl-phthalate		Carbazole		Chrysene		Dibenz[a,h]-anthracene		Dibenzofuran		Diethyl-phthalate	
			8270		8270		8270		8270		8270		8270		8270		8270	
			Conc'n	Q	Conc'n	Q	Conc'n	Q	Conc'n	Q	Conc'n	Q	Conc'n	Q	Conc'n	Q	Conc'n	Q
0-3	B1B571	ug/kg																
14.5-17	B1B572	ug/kg															660	
14.5-17	B1B5D6	ug/kg																
24-26.5	B1B573	ug/kg	260	U	590	U	71	U	85	U	71	U	71	U	71	U	200	J
24-26.5	B1B5D7	ug/kg																
34-36.5	B1B574	ug/kg															340	
34-36.5 (dup)	B1B575	ug/kg															440	
34-36.5	B1B5D8	ug/kg																
34-36.5 (dup)	B1B5D9	ug/kg																
44-46.5	B1B576	ug/kg															200	
44-46.5	B1B5F0	ug/kg																
44-46.5 (split)	B1B5F8	ug/kg																
44-46.5 (split)	B1BCF3	ug/kg																
44-46.5 (split)	B1B5F9	ug/kg																
54-56.5	B1B577	ug/kg																
54-56.5	B1B5F1	ug/kg																
66-68.5	B1B578	ug/kg																
66-68.5	B1B5F2	ug/kg																
126-128.5	B1B579	ug/kg																
126-128.5	B1B5F3	ug/kg																
155-157.5	B1B580	ug/kg																
155-157.5	B1B5F4	ug/kg																
180-182.5	B1B581	ug/kg																
180-182.5	B1B5F5	ug/kg																
199-201.5	B1B582	ug/kg															460	
199-201.5	B1B5F6	ug/kg																
223-225.5	B1B583	ug/kg															300	B
223-225.5	B1B5F7	ug/kg																
Rinsate	B1B568	ug/L	3.3	U	2.5	U	1.9	U	1.4	U	2.2	U	2.5	U	1.8	U	6.1	U
Rinsate	B1B569	ug/L																
Trip Blank	B1B570	ug/L																
Target Quantitation Limit		ug/kg																

Table B-2. Semivolatile Organic Analysis Results for 216-S-7 Crib (C4557) Samples.

Depth (ft bgs)	Sample Number	Units	Dimethyl phthalate		Di-n-butyl-phthalate		Di-n-octyl-phthalate		Fluoranthene		Fluorene		Hexachloro-benzene		Hexachloro-butadiene		Hexachlorocyclo-pentadiene	
			8270		8270		8270		8270		8270		8270		8270		8270	
			Conc'n	Q	Conc'n	Q	Conc'n	Q	Conc'n	Q	Conc'n	Q	Conc'n	Q	Conc'n	Q	Conc'n	Q
0-3	B1B571	ug/kg																
14.5-17	B1B572	ug/kg			790													
14.5-17	B1B5D6	ug/kg																
24-26.5	B1B573	ug/kg	71	U	590	J	71	U	71	U	71	U	71	U	390	U	330	U
24-26.5	B1B5D7	ug/kg																
34-36.5	B1B574	ug/kg			310													
34-36.5 (dup)	B1B575	ug/kg			1100													
34-36.5	B1B5D8	ug/kg																
34-36.5 (dup)	B1B5D9	ug/kg																
44-46.5	B1B576	ug/kg			370													
44-46.5	B1B5F0	ug/kg																
44-46.5 (split)	B1B5F8	ug/kg																
44-46.5 (split)	B1BCF3	ug/kg																
44-46.5 (split)	B1B5F9	ug/kg																
54-56.5	B1B577	ug/kg			320													
54-56.5	B1B5F1	ug/kg																
66-68.5	B1B578	ug/kg			240													
66-68.5	B1B5F2	ug/kg																
126-128.5	B1B579	ug/kg			180													
126-128.5	B1B5F3	ug/kg																
155-157.5	B1B580	ug/kg			420													
155-157.5	B1B5F4	ug/kg																
180-182.5	B1B581	ug/kg			900													
180-182.5	B1B5F5	ug/kg																
199-201.5	B1B582	ug/kg			220													
199-201.5	B1B5F6	ug/kg																
223-225.5	B1B583	ug/kg			140													
223-225.5	B1B5F7	ug/kg																
Rinsate	B1B568	ug/L	2	U	5	J	2.4	U	2	U	1.9	U	2	U	3.5	U	7.6	U
Rinsate	B1B569	ug/L																
Trip Blank	B1B570	ug/L																
Target Quantitation Limit		ug/kg																

Table B-2. Semivolatile Organic Analysis Results for 216-S-7 Crib (C4557) Samples.

Depth (ft bgs)	Sample Number	Units	Hexachloro-ethane 8270		Indeno(1,2,3-cd)-pyrene 8270		Isophorone 8270		Naphthalene 8270		Nitrobenzene 8270		N-Nitrosodi-n-dipropylamine 8270		N-Nitrosodi-phenylamine 8270		Pentachloro-phenol 8270	
			Conc'n	Q	Conc'n	Q	Conc'n	Q	Conc'n	Q	Conc'n	Q	Conc'n	Q	Conc'n	Q	Conc'n	Q
0-3	B1B571	ug/kg																
14.5-17	B1B572	ug/kg											70	U			320	U
14.5-17	B1B5D6	ug/kg																
24-26.5	B1B573	ug/kg	490	U	71	U	71	U	300	U	280	U	71	U	71	U	320	U
24-26.5	B1B5D7	ug/kg																
34-36.5	B1B574	ug/kg											69	U			310	U
34-36.5 (dup)	B1B575	ug/kg											68	U			310	U
34-36.5	B1B5D8	ug/kg																
34-36.5 (dup)	B1B5D9	ug/kg																
44-46.5	B1B576	ug/kg											56	U			250	U
44-46.5	B1B5F0	ug/kg																
44-46.5 (split)	B1B5F8	ug/kg																
44-46.5 (split)	B1BCF3	ug/kg																
44-46.5 (split)	B1B5F9	ug/kg																
54-56.5	B1B577	ug/kg											53	U			240	U
54-56.5	B1B5F1	ug/kg																
66-68.5	B1B578	ug/kg											71	U			320	U
66-68.5	B1B5F2	ug/kg																
126-128.5	B1B579	ug/kg											73	U			330	U
126-128.5	B1B5F3	ug/kg																
155-157.5	B1B580	ug/kg											74	U			330	U
155-157.5	B1B5F4	ug/kg																
180-182.5	B1B581	ug/kg											69	U			310	U
180-182.5	B1B5F5	ug/kg																
199-201.5	B1B582	ug/kg											68	U			310	U
199-201.5	B1B5F6	ug/kg																
223-225.5	B1B583	ug/kg											68	U			310	U
223-225.5	B1B5F7	ug/kg																
Rinsate	B1B568	ug/L	5.3	U	2.5	U	1.8	U	2.3	U	1.9	U	1.7	U	2.2	U	1.7	U
Rinsate	B1B569	ug/L																
Trip Blank	B1B570	ug/L																
Target Quantitation Limit		ug/kg																

Table B-2. Semivolatile Organic Analysis Results for 216-S-7 Crib (C4557) Samples.

Depth (ft bgs)	Sample Number	Units	Phenanthrene		Phenol		Pyrene		Tributyl phosphate	
			8270		8270		8270		8270	
			Conc'n	Q	Conc'n	Q	Conc'n	Q	Conc'n	Q
0-3	B1B571	ug/kg								
14.5-17	B1B572	ug/kg			110	U	70	U	70	U
14.5-17	B1B5D6	ug/kg								
24-26.5	B1B573	ug/kg	71	U	110	U	71	U	71	U
24-26.5	B1B5D7	ug/kg								
34-36.5	B1B574	ug/kg			100	U	69	U	69	U
34-36.5 (dup)	B1B575	ug/kg			100	U	68	U	68	U
34-36.5	B1B5D8	ug/kg								
34-36.5 (dup)	B1B5D9	ug/kg								
44-46.5	B1B576	ug/kg			84	U	56	U	56	U
44-46.5	B1B5F0	ug/kg								
44-46.5 (split)	B1B5F8	ug/kg								
44-46.5 (split)	B1BCF3	ug/kg								
44-46.5 (split)	B1B5F9	ug/kg								
54-56.5	B1B577	ug/kg			79	U	53	U	53	U
54-56.5	B1B5F1	ug/kg								
66-68.5	B1B578	ug/kg			110	U	71	U	71	U
66-68.5	B1B5F2	ug/kg								
126-128.5	B1B579	ug/kg			110	U	73	U	73	U
126-128.5	B1B5F3	ug/kg								
155-157.5	B1B580	ug/kg			110	U	74	U	74	U
155-157.5	B1B5F4	ug/kg								
180-182.5	B1B581	ug/kg			100	U	69	U	69	U
180-182.5	B1B5F5	ug/kg								
199-201.5	B1B582	ug/kg			100	U	68	U	68	U
199-201.5	B1B5F6	ug/kg								
223-225.5	B1B583	ug/kg			100	U	68	U	68	U
223-225.5	B1B5F7	ug/kg								
Rinsate	B1B568	ug/L	2.1	U	1.7	U	2	U	2.4	U
Rinsate	B1B569	ug/L								
Trip Blank	B1B570	ug/L								
Target Quantitation Limit		ug/kg							3300	

B = Analyte found in associated method blank
Conc'n = Concentratin
ft bgs = Feet below ground surface
J = Estimated
Q = Laboratory qualifier
U = Undetected

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Table B-3. Miscellaneous Organic Analysis Results for 216-S-7 Crib (C4557) Samples.

Depth (ft bgs)	Sample Number	Units	2-(2,4,5-Trichlorophenoxy)-propionic acid		2,4,5-Trichlorophenoxy-acetic acid		2,4-Dichlorophenoxy-acetic acid		2-secButyl-4,6-dinitrophenol (Dinoseb)		4-(2,4-Dichlorophenoxy)-butanoic acid		4,4'-DDD (Dichlorodiphenyl-dichloroethane)	
			8151		8151		8151		8151		8151		8081	
			Conc'n	Q	Conc'n	Q	Conc'n	Q	Conc'n	Q	Conc'n	Q	Conc'n	Q
0-3	B1B571	ug/kg	18	U	18	U	35	U	18	U	180	U	3.5	U
14.5-17	B1B572	ug/kg												
14.5-17	B1B5D6	ug/kg												
24-26.5	B1B573	ug/kg												
24-26.5	B1B5D7	ug/kg												
34-36.5	B1B574	ug/kg												
34-36.5 (dup)	B1B575	ug/kg												
34-36.5	B1B5D8	ug/kg												
34-36.5 (dup)	B1B5D9	ug/kg												
44-46.5	B1B576	ug/kg												
44-46.5	B1B5F0	ug/kg												
44-46.5 (split)	B1B5F8	ug/kg												
44-46.5 (split)	B1BCF3	ug/kg												
44-46.5 (split)	B1B5F9	ug/kg												
54-56.5	B1B577	ug/kg												
54-56.5	B1B5F1	ug/kg												
66-68.5	B1B578	ug/kg												
66-68.5	B1B5F2	ug/kg												
126-128.5	B1B579	ug/kg												
126-128.5	B1B5F3	ug/kg												
155-157.5	B1B580	ug/kg												
155-157.5	B1B5F4	ug/kg												
180-182.5	B1B581	ug/kg												
180-182.5	B1B5F5	ug/kg												
199-201.5	B1B582	ug/kg												
199-201.5	B1B5F6	ug/kg												
223-225.5	B1B583	ug/kg												
223-225.5	B1B5F7	ug/kg												
Rinsate	B1B568	ug/L												
Rinsate	B1B569	ug/L												
Trip Blank	B1B570	ug/L												
Target Quantitation Limit		ug/kg												

Table B-3. Miscellaneous Organic Analysis Results for 216-S-7 Crib (C4557) Samples.

Depth (ft bgs)	Sample Number	Units	4,4'-DDE (Dichlorodiphenyl-dichloroethylene)		4,4'-DDT (Dichlorodiphenyl-trichloroethane)		Aldrin		Alpha-BHC		alpha-Chlordane		beta-1,2,3,4,5,6-Hexachloro-cyclohexane (beta-BHC)	
			8081		8081		8081		8081		8081		8081	
			Conc'n	Q	Conc'n	Q	Conc'n	Q	Conc'n	Q	Conc'n	Q	Conc'n	Q
0-3	B1B571	ug/kg	1.4	J	0.42	J	0.81	J	1.8	U	1.8	U	1.8	U
14.5-17	B1B572	ug/kg												
14.5-17	B1B5D6	ug/kg												
24-26.5	B1B573	ug/kg												
24-26.5	B1B5D7	ug/kg												
34-36.5	B1B574	ug/kg												
34-36.5 (dup)	B1B575	ug/kg												
34-36.5	B1B5D8	ug/kg												
34-36.5 (dup)	B1B5D9	ug/kg												
44-46.5	B1B576	ug/kg												
44-46.5	B1B5F0	ug/kg												
44-46.5 (split)	B1B5F8	ug/kg												
44-46.5 (split)	B1BCF3	ug/kg												
44-46.5 (split)	B1B5F9	ug/kg												
54-56.5	B1B577	ug/kg												
54-56.5	B1B5F1	ug/kg												
66-68.5	B1B578	ug/kg												
66-68.5	B1B5F2	ug/kg												
126-128.5	B1B579	ug/kg												
126-128.5	B1B5F3	ug/kg												
155-157.5	B1B580	ug/kg												
155-157.5	B1B5F4	ug/kg												
180-182.5	B1B581	ug/kg												
180-182.5	B1B5F5	ug/kg												
199-201.5	B1B582	ug/kg												
199-201.5	B1B5F6	ug/kg												
223-225.5	B1B583	ug/kg												
223-225.5	B1B5F7	ug/kg												
Rinsate	B1B568	ug/L												
Rinsate	B1B569	ug/L												
Trip Blank	B1B570	ug/L												
Target Quantitation Limit		ug/kg												

Table B-3. Miscellaneous Organic Analysis Results for 216-S-7 Crib (C4557) Samples.

Depth (ft bgs)	Sample Number	Units	Dalapon 8151		Delta-BHC 8081		Dicamba 8151		Dichloroprop 8151		Dieldrin 8081		Endosulfan I 8081		Endosulfan II 8081	
			Conc'n	Q	Conc'n	Q	Conc'n	Q	Conc'n	Q	Conc'n	Q	Conc'n	Q	Conc'n	Q
0-3	B1B571	ug/kg	180	U	1.2	J	70	U	180	U	3.5	U	1.8	U	0.46	J
14.5-17	B1B572	ug/kg														
14.5-17	B1B5D6	ug/kg														
24-26.5	B1B573	ug/kg														
24-26.5	B1B5D7	ug/kg														
34-36.5	B1B574	ug/kg														
34-36.5 (dup)	B1B575	ug/kg														
34-36.5	B1B5D8	ug/kg														
34-36.5 (dup)	B1B5D9	ug/kg														
44-46.5	B1B576	ug/kg														
44-46.5	B1B5F0	ug/kg														
44-46.5 (split)	B1B5F8	ug/kg														
44-46.5 (split)	B1BCF3	ug/kg														
44-46.5 (split)	B1B5F9	ug/kg														
54-56.5	B1B577	ug/kg														
54-56.5	B1B5F1	ug/kg														
66-68.5	B1B578	ug/kg														
66-68.5	B1B5F2	ug/kg														
126-128.5	B1B579	ug/kg														
126-128.5	B1B5F3	ug/kg														
155-157.5	B1B580	ug/kg														
155-157.5	B1B5F4	ug/kg														
180-182.5	B1B581	ug/kg														
180-182.5	B1B5F5	ug/kg														
199-201.5	B1B582	ug/kg														
199-201.5	B1B5F6	ug/kg														
223-225.5	B1B583	ug/kg														
223-225.5	B1B5F7	ug/kg														
Rinsate	B1B568	ug/L														
Rinsate	B1B569	ug/L														
Trip Blank	B1B570	ug/L														
Target Quantitation Limit		ug/kg														

Table B-3. Miscellaneous Organic Analysis Results for 216-S-7 Crib (C4557) Samples.

Depth (ft bgs)	Sample Number	Units	Endosulfan sulfate		Endrin		Endrin aldehyde		Endrin ketone		Gamma-BHC (Lindane)		gamma-Chlordane		Heptachlor	
			8081		8081		8081		8081		8081		8081		8081	
			Conc'n	Q	Conc'n	Q	Conc'n	Q	Conc'n	Q	Conc'n	Q	Conc'n	Q	Conc'n	Q
0-3	B1B571	ug/kg	1.2	J	3.5	U	3.5	U	3.5	U	1.8	U	1.8	U	1.8	U
14.5-17	B1B572	ug/kg														
14.5-17	B1B5D6	ug/kg														
24-26.5	B1B573	ug/kg														
24-26.5	B1B5D7	ug/kg														
34-36.5	B1B574	ug/kg														
34-36.5 (dup)	B1B575	ug/kg														
34-36.5	B1B5D8	ug/kg														
34-36.5 (dup)	B1B5D9	ug/kg														
44-46.5	B1B576	ug/kg														
44-46.5	B1B5F0	ug/kg														
44-46.5 (split)	B1B5F8	ug/kg														
44-46.5 (split)	B1BCF3	ug/kg														
44-46.5 (split)	B1B5F9	ug/kg														
54-56.5	B1B577	ug/kg														
54-56.5	B1B5F1	ug/kg														
66-68.5	B1B578	ug/kg														
66-68.5	B1B5F2	ug/kg														
126-128.5	B1B579	ug/kg														
126-128.5	B1B5F3	ug/kg														
155-157.5	B1B580	ug/kg														
155-157.5	B1B5F4	ug/kg														
180-182.5	B1B581	ug/kg														
180-182.5	B1B5F5	ug/kg														
199-201.5	B1B582	ug/kg														
199-201.5	B1B5F6	ug/kg														
223-225.5	B1B583	ug/kg														
223-225.5	B1B5F7	ug/kg														
Rinsate	B1B568	ug/L														
Rinsate	B1B569	ug/L														
Trip Blank	B1B570	ug/L														
Target Quantitation Limit		ug/kg														

Table B-3. Miscellaneous Organic Analysis Results for 216-S-7 Crib (C4557) Samples.

Depth (ft bgs)	Sample Number	Units	Heptachlor epoxide 8081		Methoxychlor 8081		Oil and grease 413.1			Total petroleum hydrocarbons - diesel range WTPH		Total petroleum hydrocarbons - gasoline range WTPH	
			Conc'n	Q	Conc'n	Q	Conc'n	Q	Val Qual	Conc'n	Q	Conc'n	Q
0-3	B1B571	ug/kg	1.8	U	18	U							
14.5-17	B1B572	ug/kg								3900	U	250	U
14.5-17	B1B5D6	ug/kg					704000	U					
24-26.5	B1B573	ug/kg								3800	U	20	U
24-26.5	B1B5D7	ug/kg					736000	U	J				
34-36.5	B1B574	ug/kg								3800	U	20	U
34-36.5 (dup)	B1B575	ug/kg								4000	U	20	U
34-36.5	B1B5D8	ug/kg					697000	U	J				
34-36.5 (dup)	B1B5D9	ug/kg					751000		J				
44-46.5	B1B576	ug/kg								5600	U	250	U
44-46.5	B1B5F0	ug/kg					1240000						
44-46.5 (split)	B1B5F8	ug/kg								12.9	U		
44-46.5 (split)	B1BCF3	ug/kg											
44-46.5 (split)	B1B5F9	ug/kg											
54-56.5	B1B577	ug/kg								5300	U	250	U
54-56.5	B1B5F1	ug/kg					3330000						
66-68.5	B1B578	ug/kg								4000	U	250	U
66-68.5	B1B5F2	ug/kg											
126-128.5	B1B579	ug/kg								4100	U	250	U
126-128.5	B1B5F3	ug/kg											
155-157.5	B1B580	ug/kg								4200	U	250	U
155-157.5	B1B5F4	ug/kg											
180-182.5	B1B581	ug/kg								3900	U	250	U
180-182.5	B1B5F5	ug/kg											
199-201.5	B1B582	ug/kg								3800	U	250	U
199-201.5	B1B5F6	ug/kg											
223-225.5	B1B583	ug/kg								3900	U	250	U
223-225.5	B1B5F7	ug/kg											
Rinsate	B1B568	ug/L								72	U	50	U
Rinsate	B1B569	ug/L											
Trip Blank	B1B570	ug/L											
Target Quantitation Limit		ug/kg											

Table B-3. Miscellaneous Organic Analysis Results for 216-S-7 Crib (C4557) Samples.

Depth (ft bgs)	Sample Number	Units	Total petroleum hydrocarbons - kerosene range WTPH Conc'n	WTPH Q	Toxaphene 8081 Conc'n	8081 Q
0-3	B1B571	ug/kg			180	U
14.5-17	B1B572	ug/kg	3900	U		
14.5-17	B1B5D6	ug/kg				
24-26.5	B1B573	ug/kg	3800	U		
24-26.5	B1B5D7	ug/kg				
34-36.5	B1B574	ug/kg	3800	U		
34-36.5 (dup)	B1B575	ug/kg	4000	U		
34-36.5	B1B5D8	ug/kg				
34-36.5 (dup)	B1B5D9	ug/kg				
44-46.5	B1B576	ug/kg	5600	U		
44-46.5	B1B5F0	ug/kg				
44-46.5 (split)	B1B5F8	ug/kg	12.9	U		
44-46.5 (split)	B1BCF3	ug/kg				
44-46.5 (split)	B1B5F9	ug/kg				
54-56.5	B1B577	ug/kg	5300	U		
54-56.5	B1B5F1	ug/kg				
66-68.5	B1B578	ug/kg	4000	U		
66-68.5	B1B5F2	ug/kg				
126-128.5	B1B579	ug/kg	4100	U		
126-128.5	B1B5F3	ug/kg				
155-157.5	B1B580	ug/kg	4200	U		
155-157.5	B1B5F4	ug/kg				
180-182.5	B1B581	ug/kg	3900	U		
180-182.5	B1B5F5	ug/kg				
199-201.5	B1B582	ug/kg	3800	U		
199-201.5	B1B5F6	ug/kg				
223-225.5	B1B583	ug/kg	3900	U		
223-225.5	B1B5F7	ug/kg				
Rinsate	B1B568	ug/L	72	U		
Rinsate	B1B569	ug/L				
Trip Blank	B1B570	ug/L				
Target Quantitation Limit		ug/kg	5000			

Conc'n = Concentration
ft bgs = Feet below ground surface
J = Estimated
Q = Laboratory qualifier
U = Undetected
Val Qual = Validation qualifier
WTPH = Total petroleum hydrocarbons, Washington State method

Table B-4. Metal Analysis Results for 216-S-7 Crib (C4557) Samples.

Depth (ft bgs)	Sample Number	Units	Antimony				Arsenic				Barium				Beryllium				Bismuth	
			ICP MS		ICP		ICP MS		ICP		ICP MS		ICP		ICP MS		ICP		ICP	
			Conc'n	Q	Conc'n	Q	Conc'n	Q	Conc'n	Q	Conc'n	Q	Conc'n	Q	Conc'n	Q	Conc'n	Q	Conc'n	Q
0-3	B1B571	ug/kg																		
14.5-17	B1B572	ug/kg	4960	U			2980	U			71400				2980	U				
14.5-17	B1B5D6	ug/kg																		
24-26.5	B1B573	ug/kg	4710	U			4080				127000				2830	U			1920	U
24-26.5	B1B5D7	ug/kg																		
34-36.5	B1B574	ug/kg	4280	U			2820				83800				2570	U				
34-36.5 (dup)	B1B575	ug/kg	4460	U			4310				81100				2670	U				
34-36.5	B1B5D8	ug/kg																		
34-36.5 (dup)	B1B5D9	ug/kg																		
44-46.5	B1B576	ug/kg	4860	U			2920	U			48700				2920	U				
44-46.5	B1B5F0	ug/kg																		
44-46.5 (split)	B1B5F8	ug/kg			278	U			2000				53800				31			
44-46.5 (split)	B1BCF3	ug/kg																		
44-46.5 (split)	B1B5F9	ug/kg																		
54-56.5	B1B577	ug/kg	4880	U			4290				74800				2930	U				
54-56.5	B1B5F1	ug/kg																		
66-68.5	B1B578	ug/kg	4900	U			2940	U			51900				2940	U				
66-68.5	B1B5F2	ug/kg																		
126-128.5	B1B579	ug/kg	4930	U			2960	U			91100				2960	U				
126-128.5	B1B5F3	ug/kg																		
155-157.5	B1B580	ug/kg	4720	U			7090				82800				2840	U				
155-157.5	B1B5F4	ug/kg																		
180-182.5	B1B581	ug/kg	5030	U			3020	U			42100				3020	U				
180-182.5	B1B5F5	ug/kg																		
199-201.5	B1B582	ug/kg	5010	U			3010	U			72700				3010	U				
199-201.5	B1B5F6	ug/kg																		
223-225.5	B1B583	ug/kg	5000	U			3000	U			81200				3000	U				
223-225.5	B1B5F7	ug/kg																		
Rinsate	B1B568	ug/L	1.1	U			0.4	U			3.5	U			0.1	U			22	U
Rinsate	B1B569	ug/L																		
Trip Blank	B1B570	ug/L																		
Target Quantitation Limit		ug/kg	6000				10000				20000				500					

Table B-4. Metal Analysis Results for 216-S-7 Crib (C4557) Samples.

Depth (ft bgs)	Sample Number	Units	Boron		Cadmium				Chromium				Copper				Lead			
			ICP		ICP MS		ICP		ICP MS		ICP		ICP MS		ICP		ICP MS		ICP	
			Conc'n	Q	Conc'n	Q	Conc'n	Q	Conc'n	Q	Conc'n	Q	Conc'n	Q	Conc'n	Q	Conc'n	Q	Conc'n	Q
0-3	B1B571	ug/kg																		
14.5-17	B1B572	ug/kg			993	U			12000				14500				11900	U		
14.5-17	B1B5D6	ug/kg																		
24-26.5	B1B573	ug/kg	2270	U	942	U			11600				15000				11300	U		
24-26.5	B1B5D7	ug/kg																		
34-36.5	B1B574	ug/kg			857	U			11600				9510				10300	U		
34-36.5 (dup)	B1B575	ug/kg			891	U			4210				9200				10700	U		
34-36.5	B1B5D8	ug/kg																		
34-36.5 (dup)	B1B5D9	ug/kg																		
44-46.5	B1B576	ug/kg			972	U			8850				7890				11700	U		
44-46.5	B1B5F0	ug/kg																		
44-46.5 (split)	B1B5F8	ug/kg					30	U			11000				10900				3800	
44-46.5 (split)	B1BCF3	ug/kg																		
44-46.5 (split)	B1B5F9	ug/kg																		
54-56.5	B1B577	ug/kg			976	U			24700				13200				11700	U		
54-56.5	B1B5F1	ug/kg																		
66-68.5	B1B578	ug/kg			979	U			2940	U			11500				11700	U		
66-68.5	B1B5F2	ug/kg																		
126-128.5	B1B579	ug/kg			986	U			2960	U			11800				11800	U		
126-128.5	B1B5F3	ug/kg																		
155-157.5	B1B580	ug/kg			945	U			2840	U			16400				11300	U		
155-157.5	B1B5F4	ug/kg																		
180-182.5	B1B581	ug/kg			1010	U			7380				20600				12100	U		
180-182.5	B1B5F5	ug/kg																		
199-201.5	B1B582	ug/kg			1000	U			146000				25500				12000	U		
199-201.5	B1B5F6	ug/kg																		
223-225.5	B1B583	ug/kg			1000	U			44900				52100				12000	U		
223-225.5	B1B5F7	ug/kg																		
Rinsate	B1B568	ug/L	26	U					3.3	U							0.2	U		
Rinsate	B1B569	ug/L																		
Trip Blank	B1B570	ug/L																		
Target Quantitation Limit		ug/kg			500				1000				2500				10000			

Table B-4. Metal Analysis Results for 216-S-7 Crib (C4557) Samples.

Depth (ft bgs)	Sample Number	Units	Mercury				Nickel				Selenium				Silver			
			ICP MS		CVAA		ICP MS		ICP		ICP MS		ICP		ICP MS		ICP	
			Conc'n	Q	Conc'n	Q	Conc'n	Q	Conc'n	Q	Conc'n	Q	Conc'n	Q	Conc'n	Q	Conc'n	Q
0-3	B1B571	ug/kg																
14.5-17	B1B572	ug/kg	1700				10400				2980	U			3950			
14.5-17	B1B5D6	ug/kg																
24-26.5	B1B573	ug/kg	942	U			7780				2830	U			1880	U		
24-26.5	B1B5D7	ug/kg																
34-36.5	B1B574	ug/kg	857	U			7250				2570	U			1710	U		
34-36.5 (dup)	B1B575	ug/kg	891	U			5390				2670	U			1780	U		
34-36.5	B1B5D8	ug/kg																
34-36.5 (dup)	B1B5D9	ug/kg																
44-46.5	B1B576	ug/kg	972	U			7830				2920	U			1940	U		
44-46.5	B1B5F0	ug/kg																
44-46.5 (split)	B1B5F8	ug/kg			16	U			7300				367	U			99	U
44-46.5 (split)	B1BCF3	ug/kg																
44-46.5 (split)	B1B5F9	ug/kg																
54-56.5	B1B577	ug/kg	976	U			18400				2930	U			1950	U		
54-56.5	B1B5F1	ug/kg																
66-68.5	B1B578	ug/kg	990	E			9430				2940	U			1960	U		
66-68.5	B1B5F2	ug/kg																
126-128.5	B1B579	ug/kg	986	U			16100				2960	U			1970	U		
126-128.5	B1B5F3	ug/kg																
155-157.5	B1B580	ug/kg	945	U			12500				2840	U			1890	U		
155-157.5	B1B5F4	ug/kg																
180-182.5	B1B581	ug/kg	1010	U			8650				3020	U			2010	U		
180-182.5	B1B5F5	ug/kg																
199-201.5	B1B582	ug/kg	1000	U			82400				3010	U			2850			
199-201.5	B1B5F6	ug/kg																
223-225.5	B1B583	ug/kg	1000	U			25100				3000	U			2000	U		
223-225.5	B1B5F7	ug/kg																
Rinsate	B1B568	ug/L	0.314				0.32	C							0.1	U		
Rinsate	B1B569	ug/L																
Trip Blank	B1B570	ug/L																
Target Quantitation Limit		ug/kg	200				4000				10000				2000			

Table B-4. Metal Analysis Results for 216-S-7 Crib (C4557) Samples.

Depth (ft bgs)	Sample Number	Units	Uranium				
			KPA			ICP MS	
			Conc'n	Q	MDA	Conc'n	Q
0-3	B1B571	ug/kg					
14.5-17	B1B572	ug/kg				993	U
14.5-17	B1B5D6	ug/kg					
24-26.5	B1B573	ug/kg				463000	
24-26.5	B1B5D7	ug/kg					
34-36.5	B1B574	ug/kg				32800	
34-36.5 (dup)	B1B575	ug/kg				26800	
34-36.5	B1B5D8	ug/kg					
34-36.5 (dup)	B1B5D9	ug/kg					
44-46.5	B1B576	ug/kg				3560	
44-46.5	B1B5F0	ug/kg					
44-46.5 (split)	B1B5F8	ug/kg	11300		98		
44-46.5 (split)	B1BCF3	ug/kg					
44-46.5 (split)	B1B5F9	ug/kg					
54-56.5	B1B577	ug/kg				976	U
54-56.5	B1B5F1	ug/kg					
66-68.5	B1B578	ug/kg				6800	
66-68.5	B1B5F2	ug/kg					
126-128.5	B1B579	ug/kg				1180	
126-128.5	B1B5F3	ug/kg					
155-157.5	B1B580	ug/kg				945	U
155-157.5	B1B5F4	ug/kg					
180-182.5	B1B581	ug/kg				1010	U
180-182.5	B1B5F5	ug/kg					
199-201.5	B1B582	ug/kg				1350	
199-201.5	B1B5F6	ug/kg					
223-225.5	B1B583	ug/kg				1000	U
223-225.5	B1B5F7	ug/kg					
Rinsate	B1B568	ug/L				0.1	U
Rinsate	B1B569	ug/L					
Trip Blank	B1B570	ug/L					
Target Quantitation Limit		ug/kg	1000				

C = Analyte was detected in blank; sample result is ≤ 5 times blank
Conc'n = Concentration
CVAA = Cold vapor atomic absorption
E = Estimated due to interference
ft bgs = Feet below ground surface
ICP = Inductively coupled plasma emission spectrometry
ICP MS = Inductively coupled plasma mass spectrometry
KPA = Kinetic phosphorimetric analysis
Q = Laboratory qualifier
U = Undetected

Table B-5. General Inorganic Analysis Results for 216-S-7 Crib (C4557) Samples.

Depth (ft bgs)	Sample Number	Units	Ammonia as N				Chloride		Cyanide					Fluoride		Hexavalent Chromium		
			350.3		300.7		300.0		335.2		9010			300.0		7196		
			Conc'n	Q	Conc'n	Q	Conc'n	Q	Conc'n	Q	Conc'n	Q	Val Qual	Conc'n	Q	Conc'n	Q	Val Qual
0-3	B1B571	ug/kg																
14.5-17	B1B572	ug/kg			1190	B	4270	B	200	U				1150	U			
14.5-17	B1B5D6	ug/kg														800		
24-26.5	B1B573	ug/kg			14600		12400	B	200	U			J	4320	U			
24-26.5	B1B5D7	ug/kg														220	U	J
34-36.5	B1B574	ug/kg			6670	B	10200	U	200	U			J	4510	U			
34-36.5 (dup)	B1B575	ug/kg			4200	B	10100	U	200	U			J	4480	U			
34-36.5	B1B5D8	ug/kg														210	U	J
34-36.5 (dup)	B1B5D9	ug/kg														210	U	J
44-46.5	B1B576	ug/kg			1110	B	3910	B	200	U				1130	U			
44-46.5	B1B5F0	ug/kg														214	U	
44-46.5 (split)	B1B5F8	ug/kg	11200	U			16700				520	U		1080	U			
44-46.5 (split)	B1BCF3	ug/kg														350	U	
44-46.5 (split)	B1B5F9	ug/kg																
54-56.5	B1B577	ug/kg			1460	B	3920	B	200	U				1130	U			
54-56.5	B1B5F1	ug/kg														295		
66-68.5	B1B578	ug/kg			390	B	3880	B	200	U				1150	U			
66-68.5	B1B5F2	ug/kg														240		
126-128.5	B1B579	ug/kg			1350		2600	U	200	U				1150	U			
126-128.5	B1B5F3	ug/kg														220	U	
155-157.5	B1B580	ug/kg			6260		2600	U	200	U				1150	U			
155-157.5	B1B5F4	ug/kg														220	U	
180-182.5	B1B581	ug/kg			201	U	2610	B	200	U				1150	U			
180-182.5	B1B5F5	ug/kg														210	U	
199-201.5	B1B582	ug/kg			387	B	4430	B	200	U				1150	U			
199-201.5	B1B5F6	ug/kg														200	U	
223-225.5	B1B583	ug/kg			528	B	8090		200	U				1150	U			
223-225.5	B1B5F7	ug/kg														210		
Rinsate	B1B568	ug/L			3.00	B	34.0	U	4.00	U				18.0	U	3.00	U	
Rinsate	B1B569	ug/L																
Trip Blank	B1B570	ug/L																
Target Quantitation Limit		ug/kg	500				2000		500					5000		500		

Table B-5. General Inorganic Analysis Results for 216-S-7 Crib (C4557) Samples.

Depth (ft bgs)	Sample Number	Units	Nitrate as N		Nitrite as N		Nitrogen in Nitrite and Nitrate					pH					Phosphate as PO_4		Sulfate as SO_4	
			300.0		300.0		353.1		353.2			150.1			9045		300.0		300.0	
			Conc'n	Q	Conc'n	Q	Conc'n	Q	Conc'n	Q	Val Qual	Conc'n	Q	Val Qual	Conc'n	Q	Conc'n	Q	Conc'n	Q
0-3	B1B571	ug/kg																		
14.5-17	B1B572	ug/kg	9230		950	U						8.24					8280	U	24600	
14.5-17	B1B5D6	ug/kg							6000											
24-26.5	B1B573	ug/kg	34500		3570	U						9.88		J			31300	U	22500	B
24-26.5	B1B5D7	ug/kg							32400	D	J									
34-36.5	B1B574	ug/kg	20700	B	3720	U						10		J			32500	U	19600	U
34-36.5 (dup)	B1B575	ug/kg	16200	B	3700	U						9.89		J			32200	U	19500	U
34-36.5	B1B5D8	ug/kg							14300	D	J									
34-36.5 (dup)	B1B5D9	ug/kg							14000	D	J									
44-46.5	B1B576	ug/kg	28400		931	U						9.79		J			8130	U	27900	B
44-46.5	B1B5F0	ug/kg							36000											
44-46.5 (split)	B1B5F8	ug/kg	35000		329	U									9.73		2110		41600	
44-46.5 (split)	B1BCF3	ug/kg																		
44-46.5 (split)	B1B5F9	ug/kg					33000													
54-56.5	B1B577	ug/kg	8660		931	U						10.2		J			8130	U	21500	B
54-56.5	B1B5F1	ug/kg							11900											
66-68.5	B1B578	ug/kg	46500		950	U						9.81					8280	U	29800	B
66-68.5	B1B5F2	ug/kg							39800	D										
126-128.5	B1B579	ug/kg	53000		950	U						9.6					8280	U	26400	B
126-128.5	B1B5F3	ug/kg							220	U										
155-157.5	B1B580	ug/kg	1670	B	950	U						9.59					8280	U	12400	B
155-157.5	B1B5F4	ug/kg							220	U										
180-182.5	B1B581	ug/kg	2910	B	950	U						8.21					8280	U	21700	B
180-182.5	B1B5F5	ug/kg							970											
199-201.5	B1B582	ug/kg	1760	B	950	U						8.99					8280	U	18500	B
199-201.5	B1B5F6	ug/kg							3200											
223-225.5	B1B583	ug/kg	1510	B	950	U						8.61					8280	U	13200	B
223-225.5	B1B5F7	ug/kg							45000	D										
Rinsate	B1B568	ug/L	22.0	U	6.00	U											239	U	150	U
Rinsate	B1B569	ug/L																		
Trip Blank	B1B570	ug/L																		
Target Quantitation Limit		ug/kg	2500		2500												5000		5000	

B = Inorganic analyte concentration is between the instrument reporting limit and the laboratory reporting limit.
Conc'n = Concentration
D = Sample reanalyzed at higher dilution factor
ft bgs = Feet below ground surface
J = Estimated
Q = Laboratory qualifier
U = Undetected
Val Qual = Validation qualifier

Table B-6. Radionuclide Analysis Results for 216-S-7 Crib (C4557) Samples.

Depth (ft bgs)	Sample Number	Units	Americium-241												Antimony-125			Carbon-14					
			Electroplate AEA			Precipitation AEA				GEA			GEA			ChemOx/LSC			Furnace/LSC		
			Conc'n	Q	MDA	Conc'n	Q	Val Qual	MDA	Conc'n	Q	MDA	Conc'n	Q	MDA	Conc'n	Q	MDA	Conc'n	Q	MDA
0-3	B1B571	pCi/g																			
14.5-17	B1B572	pCi/g				0.004	U		0.063												
14.5-17	B1B5D6	pCi/g																			
24-26.5	B1B573	pCi/g				1900		J	11										0.391	U	5.6
24-26.5	B1B5D7	pCi/g											-14.2	U	36						
34-36.5	B1B574	pCi/g				6.1	U	J	6.5										2.16	U	3.3
34-36.5 (dup)	B1B575	pCi/g				3.1	U	J	7.4												
34-36.5	B1B5D8	pCi/g																			
34-36.5 (dup)	B1B5D9	pCi/g																	2.15	U	3.3
44-46.5	B1B576	pCi/g				0.032		J	0.019										2.29	U	2.9
44-46.5	B1B5F0	pCi/g																			
44-46.5 (split)	B1B5F8	pCi/g	0.027	U	0.043						U	0.25							-0.222	U	2.8
44-46.5 (split)	B1BCF3	pCi/g																			
44-46.5 (split)	B1B5F9	pCi/g																			
54-56.5	B1B577	pCi/g				0.53			0.013												
54-56.5	B1B5F1	pCi/g																			
66-68.5	B1B578	pCi/g				0.023			0.004										1.02	U	3
66-68.5	B1B5F2	pCi/g																			
126-128.5	B1B579	pCi/g				0.036			0.021										-2.28	U	3.3
126-128.5	B1B5F3	pCi/g											0.027	U	0.034						
155-157.5	B1B580	pCi/g				0.033			0.014										1.16	U	3.2
155-157.5	B1B5F4	pCi/g																			
180-182.5	B1B581	pCi/g				0.022			0.013										2.32	U	3.1
180-182.5	B1B5F5	pCi/g																			
199-201.5	B1B582	pCi/g				0.048			0.015										0.867	U	2.9
199-201.5	B1B5F6	pCi/g																			
223-225.5	B1B583	pCi/g				0.054			0.021										-1.09	U	3
223-225.5	B1B5F7	pCi/g																			
Rinsate	B1B568	pCi/L				0.095	U		0.14										0.274	U	3.1
Rinsate	B1B569	pCi/L																			
Trip Blank	B1B570	pCi/L														-10.1	U	37			
Target Quantitation Limit		pCi/g	1													50					

Table B-6. Radionuclide Analysis Results for 216-S-7 Crib (C4557) Samples.

Depth (ft bgs)	Sample Number	Units	Cesium-134			Cesium-137			Cobalt-60			Europium-152			Europium-154			Europium-155		
			GEA			GEA			GEA			GEA			GEA			GEA		
			Conc'n	Q	MDA	Conc'n	Q	MDA	Conc'n	Q	MDA	Conc'n	Q	MDA	Conc'n	Q	MDA	Conc'n	Q	MDA
0-3	B1B571	pCi/g																		
14.5-17	B1B572	pCi/g				0.037		0.023	-0.003	U	0.02	-0.047	U	0.056	-0.041	U	0.06	0.056	U	0.066
14.5-17	B1B5D6	pCi/g																		
24-26.5	B1B573	pCi/g	0.265	U	9.6	20000		13	2.3	U	3.4	-12.3	U	31	13.9	U	14	-6.63	U	26
24-26.5	B1B5D7	pCi/g																		
34-36.5	B1B574	pCi/g				501		0.56	0.06	U	0.12	-0.153	U	2.3	0.005	U	0.33	-0.376	U	3.6
34-36.5 (dup)	B1B575	pCi/g				760		0.63	0.025	U	0.11	-1.09	U	2.4	0.226	U	0.45	0.133	U	3.4
34-36.5	B1B5D8	pCi/g																		
34-36.5 (dup)	B1B5D9	pCi/g																		
44-46.5	B1B576	pCi/g				2.41		0.019	0.022		0.021	-0.028	U	0.062	-0.05	U	0.061	0.009	U	0.081
44-46.5	B1B5F0	pCi/g																		
44-46.5 (split)	B1B5F8	pCi/g				2.96		0.12		U	0.11		U	0.26		U	0.3		U	0.22
44-46.5 (split)	B1BCF3	pCi/g																		
44-46.5 (split)	B1B5F9	pCi/g																		
54-56.5	B1B577	pCi/g				30.9		0.055	0.013	U	0.024	-0.175	U	0.26	-0.001	U	0.079	-0.188	U	0.33
54-56.5	B1B5F1	pCi/g																		
66-68.5	B1B578	pCi/g				0.628		0.014	0.015		0.013	-0.007	U	0.036	-0.038	U	0.042	0.063		0.05
66-68.5	B1B5F2	pCi/g																		
126-128.5	B1B579	pCi/g	0.04	U	0.04	0.513		0.012	0.004	U	0.012	0.012	U	0.035	-0.008	U	0.035	0.043	U	0.048
126-128.5	B1B5F3	pCi/g																		
155-157.5	B1B580	pCi/g				0.008	U	0.012	0.006	U	0.012	-0.005	U	0.035	-0.022	U	0.036	0.002	U	0.05
155-157.5	B1B5F4	pCi/g																		
180-182.5	B1B581	pCi/g				0.001	U	0.011	0.003	U	0.011	-0.017	U	0.027	0.006	U	0.037	0.039	U	0.039
180-182.5	B1B5F5	pCi/g																		
199-201.5	B1B582	pCi/g				0	U	0.009	-0.006	U	0.008	-0.011	U	0.028	-0.012	U	0.027	-0.037	U	0.048
199-201.5	B1B5F6	pCi/g																		
223-225.5	B1B583	pCi/g				0.012		0.009	-0.001	U	0.008	-0.022	U	0.025	-0.01	U	0.027	0.027	U	0.038
223-225.5	B1B5F7	pCi/g																		
Rinsate	B1B568	pCi/L	-0.61	U	7.2	-0.517	U	7.2	4.59	U	7.6	0.46	U	21	-3.26	U	20	-3.54	U	22
Rinsate	B1B569	pCi/L																		
Trip Blank	B1B570	pCi/L																		
Target Quantitation Limit		pCi/g					0.1			0.05			0.1			0.1			0.1	

Table B-6. Radionuclide Analysis Results for 216-S-7 Crib (C4557) Samples.

Depth (ft bgs)	Sample Number	Units	Iodine-129			Neptunium-237							Nickel-63			Plutonium-238						
			LEPS			Precipitation/AEA				Electroplate/AEA			LSC			Precipitation/AEA				Electroplate/AEA		
			Conc'n	Q	MDA	Conc'n	Q	Val Qual	MDA	Conc'n	Q	MDA	Conc'n	Q	MDA	Conc'n	Q	Val Qual	MDA	Conc'n	Q	MDA
0-3	B1B571	pCi/g																				
14.5-17	B1B572	pCi/g				0.001	U		0.008							0.021	U		0.049			
14.5-17	B1B5D6	pCi/g	-0.061	U	1.7								0.531	U	3.2							
24-26.5	B1B573	pCi/g				6.8	X	J	3.3							190		J	13			
24-26.5	B1B5D7	pCi/g	0.04	U	1.5								13.7		3.5							
34-36.5	B1B574	pCi/g				1.1	U	J	4.1							4.7	U	J	5.6			
34-36.5 (dup)	B1B575	pCi/g				-2.8	U	J	7.9							1.4	U	J	12			
34-36.5	B1B5D8	pCi/g	-0.982	U	4.6								-0.504	U	3.3							
34-36.5 (dup)	B1B5D9	pCi/g	-0.445	U	1.4								-0.157	U	3.4							
44-46.5	B1B576	pCi/g				-0.002	U	R	0.01							0.022	U	J	0.055			
44-46.5	B1B5F0	pCi/g	0.164	U	1.4								-0.57	U	3.5							
44-46.5 (split)	B1B5F8	pCi/g								0.011	U	0.63								-0.004	U	0.029
44-46.5 (split)	B1BCF3	pCi/g																				
44-46.5 (split)	B1B5F9	pCi/g																				
54-56.5	B1B577	pCi/g				-0.003	U	R	0.009							0.048	U	J	0.052			
54-56.5	B1B5F1	pCi/g	0.085	U	1								-0.828	U	3.4							
66-68.5	B1B578	pCi/g				-0.002	U		0.011							-0.026	U		0.07			
66-68.5	B1B5F2	pCi/g	0.159	U	2.8								-0.081	U	3.4							
126-128.5	B1B579	pCi/g				0.001	U		0.009							-0.024	U		0.057			
126-128.5	B1B5F3	pCi/g	0.284	U	1.6								-0.201	U	3.4							
155-157.5	B1B580	pCi/g				0.001	U		0.003							0.002	U		0.044			
155-157.5	B1B5F4	pCi/g	0.378	U	1.3								0.553	U	3.6							
180-182.5	B1B581	pCi/g				-0.002	U		0.011							-0.002	U		0.034			
180-182.5	B1B5F5	pCi/g	0.257	U	1.3								-1.72	U	3.3							
199-201.5	B1B582	pCi/g				-0.003	U		0.011							-0.006	U		0.028			
199-201.5	B1B5F6	pCi/g	0.118	U	1.6								-1.22	U	3.3							
223-225.5	B1B583	pCi/g				0.003	U		0.009							0.01	U		0.037			
223-225.5	B1B5F7	pCi/g	0.06	U	0.97								-1.78	U	3.5							
Rinsate	B1B568	pCi/L														0.027	U		0.13			
Rinsate	B1B569	pCi/L	-1.57	U	4.4								-2.02	U	2.8							
Trip Blank	B1B570	pCi/L																				
Target Quantitation Limit		pCi/g	2			1							30			1						

Table B-6. Radionuclide Analysis Results for 216-S-7 Crib (C4557) Samples.

Depth (ft bgs)	Sample Number	Units	Plutonium-239/240 Precipitation/AEA Conc'n	Q	Val Qual	MDA	Plutonium-239/240 Electroplate/AEA Conc'n	Q	MDA	Potassium-40 GEA Conc'n	Q	MDA	Radium-226 GEA Conc'n	Q	Val Qual	MDA	Radium-228 GEA Conc'n	Q	MDA	Strontium-89/90 Separation GPC Conc'n	Q	Val Qual	MDA
0-3	B1B571	pCi/g																					
14.5-17	B1B572	pCi/g	0.006	U		0.025																	
14.5-17	B1B5D6	pCi/g											0.649			0.036	0.719		0.068	0.084	U		0.2
24-26.5	B1B573	pCi/g	11000		J	3.4																	
24-26.5	B1B5D7	pCi/g											-8.22	U		18	2.7	U	24	53000		J	130
34-36.5	B1B574	pCi/g	26		J	4																	
34-36.5 (dup)	B1B575	pCi/g	13		J	4.4							0.892	U		1.1	0.479	U	0.51	4100		J	140
34-36.5	B1B5D8	pCi/g											0.36	U		1.2	0.846		0.68	4900		J	150
34-36.5 (dup)	B1B5D9	pCi/g																					
44-46.5	B1B576	pCi/g	0.039			0.022																	
44-46.5	B1B5F0	pCi/g											0.468		J	0.039	0.573		0.061	1.1		J	0.2
44-46.5 (split)	B1B5F8	pCi/g																					
44-46.5 (split)	B1BCF3	pCi/g					0.041		0.036	16.2		1.1	0.583			0.19	0.846		0.39	1.26			0.21
44-46.5 (split)	B1B5F9	pCi/g																					
54-56.5	B1B577	pCi/g	3			0.005																	
54-56.5	B1B5F1	pCi/g											0.394		J	0.13	0.535		0.091	12		J	0.2
66-68.5	B1B578	pCi/g	0.002	U		0.021																	
66-68.5	B1B5F2	pCi/g											0.54			0.024	0.723		0.04	-0.12	U		0.2
126-128.5	B1B579	pCi/g	0.018	U		0.018																	
126-128.5	B1B5F3	pCi/g											0.627			0.02	0.828		0.035	0.5			0.2
155-157.5	B1B580	pCi/g	0.014	U		0.018																	
155-157.5	B1B5F4	pCi/g											0.539			0.024	0.627		0.04	-0.25	U		0.2
180-182.5	B1B581	pCi/g	0.005	U		0.016																	
180-182.5	B1B5F5	pCi/g											0.271			0.019	0.438		0.036	0.021	U		0.2
199-201.5	B1B582	pCi/g	0.008	U		0.014																	
199-201.5	B1B5F6	pCi/g											0.324			0.018	0.458		0.029	0.31			0.25
223-225.5	B1B583	pCi/g	0.002	U		0.013																	
223-225.5	B1B5F7	pCi/g											0.328			0.016	0.431		0.027	-0.4	U		0.2
Rinsate	B1B568	pCi/L	0.059			0.015																	
Rinsate	B1B569	pCi/L											0.019	U		0.037	0.11	U	2.8				
Trip Blank	B1B570	pCi/L																					
Target Quantitation Limit		pCi/g	1										0.1				0.2			1			

Table B-6. Radionuclide Analysis Results for 216-S-7 Crib (C4557) Samples.

Depth (ft bgs)	Sample Number	Units	Technetium-99 LSC				Thorium-228 GEA			Thorium-228 Electroplate AEA				Thorium-230 Electroplate AEA			Thorium-232 GEA			Thorium-232 Electroplate AEA			
			Conc'n	Q	Val Qual	MDA	Conc'n	Q	MDA	Conc'n	Q	Val Qual	MDA	Conc'n	Q	MDA	Conc'n	Q	MDA	Conc'n	Q	Val Qual	MDA
0-3	B1B571	pCi/g																					
14.5-17	B1B572	pCi/g																					
14.5-17	B1B5D6	pCi/g	0.167	U		0.61				0.749			0.066	0.527		0.22				0.772			0.074
24-26.5	B1B573	pCi/g																					
24-26.5	B1B5D7	pCi/g	14.7		J	0.45				4.78		J	0.5	0.779		0.21				0.656		J	0.062
34-36.5	B1B574	pCi/g																					
34-36.5 (dup)	B1B575	pCi/g																					
34-36.5	B1B5D8	pCi/g	4.98			0.55				3.67		J	0.51	0.522		0.21				0.488		J	0.051
34-36.5 (dup)	B1B5D9	pCi/g	4.03			0.56				3.97		J	0.4	0.498		0.21				0.63		J	0.051
44-46.5	B1B576	pCi/g																					
44-46.5	B1B5F0	pCi/g	14.6			0.55				0.811			0.054	0.486		0.23				0.775			0.067
44-46.5 (split)	B1B5F8	pCi/g					0.896		0.1								0.846		0.39				
44-46.5 (split)	B1BCF3	pCi/g																					
44-46.5 (split)	B1B5F9	pCi/g																					
54-56.5	B1B577	pCi/g																					
54-56.5	B1B5F1	pCi/g	6.54			0.53				0.528			0.17	0.35		0.23				0.63			0.13
66-68.5	B1B578	pCi/g																					
66-68.5	B1B5F2	pCi/g	4.6			0.46				0.699			0.077	0.662		0.22				0.592			0.067
126-128.5	B1B579	pCi/g																					
126-128.5	B1B5F3	pCi/g	1.29			0.38				0.683			0.097	0.688		0.21				0.813			0.075
155-157.5	B1B580	pCi/g																					
155-157.5	B1B5F4	pCi/g	0.28	U		0.54				0.706			0.071	0.844		0.21				0.722			0.088
180-182.5	B1B581	pCi/g																					
180-182.5	B1B5F5	pCi/g	0.262	U		0.54				0.533			0.095	0.397		0.19				0.447			0.054
199-201.5	B1B582	pCi/g																					
199-201.5	B1B5F6	pCi/g	0.131	U		0.72				0.721			0.37	0.384		0.37				0.576			0.37
223-225.5	B1B583	pCi/g																					
223-225.5	B1B5F7	pCi/g	0.142	U		0.55				0.485			0.31	0.363		0.31				0.686			0.31
Rinsate	B1B568	pCi/L																					
Rinsate	B1B569	pCi/L								-0.008	U		0.031	-0.003	U	0.1				-0.003	U		0.034
Trip Blank	B1B570	pCi/L																					
Target Quantitation Limit		pCi/g	15																	1			

Table B-6. Radionuclide Analysis Results for 216-S-7 Crib (C4557) Samples.

Depth (ft bgs)	Sample Number	Units	Tin-126 GEA			Tritium 906.0			Tritium Furnace/LSC			Tritium Distillation/LSC			Uranium (a) KPA			Uranium (a) ICP MS	
			Conc'n	Q	MDA	Conc'n	Q	MDA	Conc'n	Q	MDA	Conc'n	Q	MDA	Conc'n	Q	MDA	Conc'n	Q
0-3	B1B571	pCi/g																	
14.5-17	B1B572	pCi/g																993	U
14.5-17	B1B5D6	pCi/g							184		6.1								
24-26.5	B1B573	pCi/g	-1.11	U	16													463000	
24-26.5	B1B5D7	pCi/g				618		4.4											
34-36.5	B1B574	pCi/g																32800	
34-36.5 (dup)	B1B575	pCi/g																26800	
34-36.5	B1B5D8	pCi/g				312		2.2											
34-36.5 (dup)	B1B5D9	pCi/g				374		2.5											
44-46.5	B1B576	pCi/g																3560	
44-46.5	B1B5F0	pCi/g				648		3.5											
44-46.5 (split)	B1B5F8	pCi/g													11300		98		
44-46.5 (split)	B1BCF3	pCi/g																	
44-46.5 (split)	B1B5F9	pCi/g																	
54-56.5	B1B577	pCi/g																976	U
54-56.5	B1B5F1	pCi/g				205		1.7											
66-68.5	B1B578	pCi/g																6800	
66-68.5	B1B5F2	pCi/g				508		2.2											
126-128.5	B1B579	pCi/g	0.216	U	0.22													1180	
126-128.5	B1B5F3	pCi/g				1120		3.5											
155-157.5	B1B580	pCi/g																945	U
155-157.5	B1B5F4	pCi/g				1410		4											
180-182.5	B1B581	pCi/g																1010	U
180-182.5	B1B5F5	pCi/g				420		2											
199-201.5	B1B582	pCi/g																1350	
199-201.5	B1B5F6	pCi/g				158		1.1											
223-225.5	B1B583	pCi/g																1000	U
223-225.5	B1B5F7	pCi/g				2.02		0.36											
Rinsate	B1B568	pCi/L	2.65	U	14							-22	U	200				0.1	U
Rinsate	B1B569	pCi/L																	
Trip Blank	B1B570	pCi/L																	
Target Quantitation Limit		pCi/g				400									1000				

Table B-6. Radionuclide Analysis Results for 216-S-7 Crib (C4557) Samples.

Depth (ft bgs)	Sample Number	Units	Uranium-233/234							Uranium-235									
			Precipitation/AEA				Electroplate AEA			GEA			Precipitation AEA				Electroplate AEA		
			Conc'n	Q	Val Qual	MDA	Conc'n	Q	MDA	Conc'n	Q	MDA	Conc'n	Q	Val Qual	MDA	Conc'n	Q	MDA
0-3	B1B571	pCi/g																	
14.5-17	B1B572	pCi/g	0.16			0.006							0.016	U		0.016			
14.5-17	B1B5D6	pCi/g																	
24-26.5	B1B573	pCi/g	230		J	5							25		J	5.5			
24-26.5	B1B5D7	pCi/g																	
34-36.5	B1B574	pCi/g	0.016		J	0.004							0.001	U	J	0.005			
34-36.5 (dup)	B1B575	pCi/g	7.8		J	3.6							1.1	U	J	3.9			
34-36.5	B1B5D8	pCi/g																	
34-36.5 (dup)	B1B5D9	pCi/g																	
44-46.5	B1B576	pCi/g	2.6		J	0.014							0.16		J	0.006			
44-46.5	B1B5F0	pCi/g																	
44-46.5 (split)	B1B5F8	pCi/g					3.71		0.18		U	0.66					0.249		0.21
44-46.5 (split)	B1BCF3	pCi/g																	
44-46.5 (split)	B1B5F9	pCi/g																	
54-56.5	B1B577	pCi/g	1.4		J	0.005							0.11		J	0.005			
54-56.5	B1B5F1	pCi/g																	
66-68.5	B1B578	pCi/g	1.6			0.021							0.12			0.014			
66-68.5	B1B5F2	pCi/g																	
126-128.5	B1B579	pCi/g	0.33			0.005							0.023			0.006			
126-128.5	B1B5F3	pCi/g																	
155-157.5	B1B580	pCi/g	0.23			0.005							0.019			0.006			
155-157.5	B1B5F4	pCi/g																	
180-182.5	B1B581	pCi/g	0.098			0.005							0.019			0.005			
180-182.5	B1B5F5	pCi/g																	
199-201.5	B1B582	pCi/g	0.12			0.015							0.009			0.006			
199-201.5	B1B5F6	pCi/g																	
223-225.5	B1B583	pCi/g	0.12			0.005							0.012			0.005			
223-225.5	B1B5F7	pCi/g																	
Rinsate	B1B568	pCi/L	0.028			0.013							0.005	U		0.038			
Rinsate	B1B569	pCi/L																	
Trip Blank	B1B570	pCi/L																	
Target Quantitation Limit		pCi/g	1							1									

Table B-6. Radionuclide Analysis Results for 216-S-7 Crib (C4557) Samples.

Depth (ft bgs)	Sample Number	Units	Uranium-238 GEA Conc'n	GEA Q	GEA MDA	Precipitation AEA Conc'n	Precipitation AEA Q	Precipitation AEA MDA	Electroplate AEA Conc'n	Electroplate AEA Q	Electroplate AEA MDA
0-3	B1B571	pCi/g									
14.5-17	B1B572	pCi/g				0.17		0.022			
14.5-17	B1B5D6	pCi/g									
24-26.5	B1B573	pCi/g				200		1.5			
24-26.5	B1B5D7	pCi/g									
34-36.5	B1B574	pCi/g				0.008		0.001			
34-36.5 (dup)	B1B575	pCi/g				12		1.3			
34-36.5	B1B5D8	pCi/g									
34-36.5 (dup)	B1B5D9	pCi/g									
44-46.5	B1B576	pCi/g				2.9		0.005			
44-46.5	B1B5F0	pCi/g									
44-46.5 (split)	B1B5F8	pCi/g		U	11				3.96		0.18
44-46.5 (split)	B1BCF3	pCi/g									
44-46.5 (split)	B1B5F9	pCi/g									
54-56.5	B1B577	pCi/g				1.4		0.013			
54-56.5	B1B5F1	pCi/g									
66-68.5	B1B578	pCi/g				1.6		0.005			
66-68.5	B1B5F2	pCi/g									
126-128.5	B1B579	pCi/g				0.35		0.005			
126-128.5	B1B5F3	pCi/g									
155-157.5	B1B580	pCi/g				0.23		0.005			
155-157.5	B1B5F4	pCi/g									
180-182.5	B1B581	pCi/g				0.14		0.005			
180-182.5	B1B5F5	pCi/g									
199-201.5	B1B582	pCi/g				0.068		0.006			
199-201.5	B1B5F6	pCi/g									
223-225.5	B1B583	pCi/g				0.14		0.005			
223-225.5	B1B5F7	pCi/g									
Rinsate	B1B568	pCi/L				0.019		0.013			
Rinsate	B1B569	pCi/L									
Trip Blank	B1B570	pCi/L									
Target Quantitation Limit		pCi/g				1					

a. Total uranium results are reported in ug/kg for soil samples and ug/L for rinsate.

AEA = Alpha energy analysis
ChemOx = Chemical oxidation
Conc'n = Concentration
ft bgs = Feet below ground surface
GEA = Gamma energy analysis
GPC = Gas proportional counting
J = Estimated
ICP MS = Inductively couple plasma mass spectrometry
KPA = Kinetic phosphorimetric analysis
LEPS = Low energy photon spectrometry
LSC = Liquid scintillation counting
MDA = Minimum detectable activity
Q = Laboratory qualifier
R = Result is rejected for decision-making
U = Undetected
Val Qual = Validation qualifier
X = Required manual data entry

APPENDIX B

WASTE SITE PHOTOGRAPHS

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FIGURES

APPENDIX B

WASTE SITE PHOTOGRAPHS

This appendix provides a photographic summary of the waste sites addressed in this feasibility study. This appendix is organized by representative and analogous site groupings. Where appropriate, photographs are included that show waste sites that are in proximity to each other.

Figure B-6. 216-A-28 Waste Site.

To be provided

Figure B-25. 216-A-5 and 200-E-58 (Adjacent Underground Tank) Waste Sites.

To be provided

APPENDIX C

POTENTIAL APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

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CONTENTS

TABLES

TERMS

ARAR	applicable or relevant and appropriate requirement
CERCLA	*Comprehensive Environmental Response, Compensation, and Liability Act of 1980*
CFR	*Code of Federal Regulations*
DOE	U.S. Department of Energy
EPA	U.S. Environmental Protection Agency
ERDF	Environmental Restoration Disposal Facility
MCL	maximum contaminant level
OU	operable unit
PCB	polychlorinated biphenyl
RCRA	*Resource Conservation and Recovery Act of 1976*
TBC	to be considered
TSCA	*Toxic Substances Control Act of 1976*
TSD	treatment, storage, and disposal (unit)
WAC	*Washington Administrative Code*

APPENDIX C

POTENTIAL APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

C1.0 IDENTIFICATION OF POTENTIAL APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS FOR THE 200-PW-2 AND 200-PW-4 OPERABLE UNITS

This appendix identifies and evaluates potential applicable or relevant and appropriate requirements (ARAR) for waste site remediation in the 200-PW-2 and 200-PW-4 Operable Units (OU). The potential ARARs identified in this appendix have been used to form the basis for the levels to which contaminants must be remediated to protect human health and the environment. The *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA) provides for the identification of to-be-considered (TBC) nonpromulgated advisories, criteria, guidance, or proposed standards that may be consulted to interpret remediation goals when ARARs do not exist or are insufficient. Independent of the TBC and ARARs identification process at the Hanford Site, the requirements of U.S. Department of Energy (DOE) directives must be met.

Because the waste sites in the 200-PW-2 and 200-PW-4 OUs will be remediated under a CERCLA decision document, remedial and corrective actions at the sites will be required to meet ARARs. This appendix identifies and evaluates potential ARARs for these sites. Final ARARs for remediation will be established in the record of decision. In many cases, the ARARs form the basis for the preliminary remediation goals to which contaminants must be remediated to protect human health and the environment. In other cases, the ARARs define or restrict how specific remedial measures can be implemented.

The ARARs identification process is based on CERCLA guidance (EPA/540/G-89/006, *CERCLA Compliance with Other Laws Manual: Interim Final*, and EPA/540/G-89/004, *Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA, Interim Final*, OSWER 9355.3-01). Section 121 of CERCLA as amended, requires, in part, that any applicable or relevant and appropriate standard, requirement, criterion, or limitation promulgated under any Federal environmental law, or any more stringent state requirement promulgated pursuant to a state environmental statute, be met (or a waiver justified) for any hazardous substance, pollutant, or contaminant that will remain on site after completion of remedial action.

An "applicable" requirement is a requirement that a private party would have to comply with by law if the same action were being undertaken apart from CERCLA authority. All jurisdictional prerequisites of the requirement must be met for the requirement to be applicable.

"Relevant and appropriate" requirements means those cleanup standards that address problems or situations sufficiently similar to those encountered at the CERCLA site that their use is well suited to the particular site (40 CFR 300.5, "National Oil and Hazardous Substances Pollution Contingency Plan," "Definitions"). An ARAR may not meet one or more jurisdictional prerequisites for applicability but still may make sense at the site, given the circumstances of the site and the release. In evaluating the relevance and appropriateness of a requirement, the eight comparison factors in 40 CFR 300.400(g)(2), "Identification of Applicable or Relevant and Appropriate Requirements," are considered:

(i) The purpose of the requirement and the purpose of the CERCLA action

(ii) The medium regulated or affected by the requirement and the medium contaminated or affected at the CERCLA site

(iii) The substances regulated by the requirement and the substances found at the CERCLA site

(iv) The actions or activities regulated by the requirement and the remedial action contemplated at the CERCLA site

(v) Any variances, waivers, or exemptions of the requirement and their availability for the circumstances at the CERCLA site

(vi) The type of place regulated and the type of place affected by the release or CERCLA action

(vii) The type and size of structure or facility regulated and the type and size of structure or facility affected by the release or contemplated by the CERCLA action

(viii) Any consideration of use or potential use of affected resources in the requirement and the use or potential use of the affected resource at the CERCLA site.

In addition, potential ARARs were evaluated to determine if they fall into one of three categories: chemical-specific, location-specific, or action-specific. These categories are defined as follows.

- Chemical-specific requirements are usually health- or risk-based numerical values or methodologies that, when applied to site-specific conditions, result in the establishment of public- and worker-safety levels and site-cleanup levels.
- Location-specific requirements are restrictions placed on the concentration of dangerous substances or the conduct of activities solely because they occur in special geographic areas.
- Action-specific requirements are usually technology- or activity-based requirements or limitations triggered by the remedial actions performed at the site.

In summary, a requirement is applicable if the specific terms or jurisdictional prerequisites of the law or regulations directly address the circumstances at a site. If not applicable, a requirement may nevertheless be relevant and appropriate if (1) circumstances at the site are, based on best professional judgment, sufficiently similar to the problems or situations regulated by the requirement and (2) the requirement's use is well suited to the site. Only the substantive requirements (e.g., use of control/containment equipment, compliance with numerical standards) associated with ARARs apply to CERCLA on-site activities. ARARs associated with administrative requirements, such as permitting, are not applicable to CERCLA on-site activities (CERCLA, Section 121[e][1]). In general, this CERCLA permitting exemption will be extended to all remedial and corrective action activities conducted at the 200-PW-2 and 200-PW-4 OUs, with the exception of the *Resource Conservation and Recovery Act of 1976* (RCRA) treatment, storage, and/or disposal units, which will be incorporated into WA7890008967, *Hanford Facility Resource Conservation and Recovery Act Permit, Dangerous Waste Portion, Revision 8, for the Treatment, Storage, and Disposal of Dangerous Waste.*

TBC information is nonpromulgated advisories or guidance issued by Federal or state governments that is not legally binding and does not have the status of potential ARARs. In some circumstances, TBCs will be considered along with ARARs in determining the remedial action necessary for protection of human health and the environment. The TBCs complement the ARARs in determining protectiveness at a site or implementation of certain actions. For example, because soil cleanup standards do not exist for all contaminants, health advisories, which would be TBCs, may be helpful in defining appropriate remedial action goals.

C1.1 WAIVERS FROM APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

The U.S. Environmental Protection Agency (EPA) may waive ARARs and select a remedial action that does not attain the same level of site cleanup as that identified by the ARARs. Section 121 of the *Superfund Amendments and Reauthorization Act of 1986* identifies six circumstances in which the EPA may waive ARARs for on-site remedial actions. The six circumstances are as follows:

- The remedial action selected is only a part of a total remedial action (such as an interim action), and the final remedy will attain the ARAR upon its completion
- Compliance with the ARAR will result in a greater risk to human health and the environment than alternative options
- Compliance with the ARAR is technically impracticable from an engineering perspective
- An alternative remedial action will attain an equivalent standard of performance through the use of another method or approach
- The ARAR is a state requirement that the state has not consistently applied (or demonstrated the intent to apply consistently) in similar circumstances
- In the case of Section 104 (Superfund-financed remedial actions), compliance with the ARAR will not provide a balance between protecting human health and the environment and the availability of Superfund money for response at other facilities.

No waivers are being requested for the 200-PW-2 and 200-PW-4 OUs.

C1.2 POTENTIAL APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS APPLICABLE TO REMEDIAL ACTIONS FOR WASTE SITES IN THE 200-PW-2 AND 200-PW-4 OPERABLE UNITS

Potential Federal and state ARARs are presented in Tables C-1 and C-2, respectively. The chemical-specific ARARs likely to be most relevant to remediation of the 200-PW-2 and 200-PW-4 OUs are elements of the Washington State regulations that implement WAC 173-340, "Model Toxics Control Act -- Cleanup," specifically associated with developing risk-based concentrations for cleanup (WAC 173-340-745, "Soil Cleanup Standards for Industrial Properties"). The requirements of WAC 173-340-745 help establish soil cleanup standards for nonradioactive contaminants at waste sites. The state air emission standards are likely to be important in identifying air emission limits and control requirements for any remedial actions that produce air emissions. RCRA land-disposal restrictions will be important standards during the management of wastes generated during remedial actions.

No location-specific ARARs have been identified for the waste sites considered in this feasibility study.

Action-specific ARARs that could be pertinent to remediation are state solid and dangerous waste regulations (for management of characterization and remediation of wastes and performance standards for waste left in place) and *Atomic Energy Act of 1954* regulations (for performance standards for radioactive waste sites). For radionuclides, the ARAR is a TBC, DOE O 435.1, *Radioactive Waste Management.*

Regarding waste management activities during remediation, a variety of waste streams may be generated under the proposed remedial-action alternatives. It is anticipated that most of the waste will be designated as low-level waste. However, quantities of dangerous or mixed waste, polychlorinated biphenyl (PCB)-contaminated waste, and asbestos and asbestos-containing material also could be generated. The great majority of the waste will be in a solid form.

The identification, storage, treatment, and disposal of hazardous waste and the hazardous component of mixed waste generated during the remedial action would be subject to the substantive provisions of RCRA. In the State of Washington, RCRA is implemented through WAC 173-303, "Dangerous Waste Regulations," which is an EPA-authorized State RCRA program. The substantive portions of the dangerous-waste standards for generation and storage would apply to the management of any dangerous or mixed waste generated during this remedial action. Treatment standards for dangerous or mixed waste that is subject to RCRA land-disposal restrictions are specified in WAC 173-303-140, "Land Disposal Restrictions," which incorporates 40 CFR 268, "Land Disposal Restrictions," by reference.

The *Toxic Substances Control Act of 1976* (TSCA) and regulations at 40 CFR 761, "Polychlorinated Biphenyls (PCBs) Manufacturing, Processing, Distribution in Commerce, and Use Prohibitions," govern the management and disposal of PCB wastes. The TSCA regulations contain specific provisions for PCB waste, including PCB waste that contains a radioactive component. PCBs also are considered underlying hazardous constituents under RCRA and thus could be subject to WAC 173-303 and 40 CFR 268 requirements for wastes that also designate as hazardous or mixed wastes.

Removal and disposal of asbestos and asbestos-containing material are regulated under the *Clean Air Act of 1990*, and 40 CFR 61, Subpart M, "National Emission Standards for Asbestos." These regulations provide for special precautions to prevent environmental releases or exposure to personnel of airborne emissions of asbestos fibers during remedial actions. Packaging requirements are identified in 40 CFR 61.52, "Emission Standard." Asbestos and asbestos-containing material would be removed, packaged as appropriate, and disposed of in the Environmental Restoration Disposal Facility (ERDF).

Waste designated as low-level waste that meets ERDF acceptance criteria is assumed to be disposed of at ERDF, which is engineered to meet appropriate performance standards of 10 CFR 61, "Licensing Requirements for Land Disposal of Radioactive Waste." In addition, waste designated as dangerous or mixed waste would be treated as appropriate to meet land-disposal restrictions and ERDF acceptance criteria, and would be disposed of at ERDF. ERDF is engineered to meet minimum technical requirements for landfills under WAC 173-303-665, "Landfills." Applicable packaging and pre-transportation requirements for dangerous or mixed waste generated at the 200-PW-2 and 200-PW-4 OUs would be identified and implemented before any waste was moved. Alternate disposal locations may be considered when the remedial action occurs, if a suitable and cost-effective location is identified. Any potential alternate disposal location will be evaluated for appropriate performance standards to ensure that it is adequately protective of human health and the environment.

Waste designated as PCB remediation waste likely would be disposed of at ERDF, depending on whether it is low-level waste and meets the waste acceptance criteria. PCB waste that does not meet ERDF waste acceptance criteria would be retained at a PCB storage area that meets the requirements for TSCA storage and would be transported for future treatment and disposal at an appropriate disposal facility.

CERCLA Section 104(d)(4) states that where two or more noncontiguous facilities are reasonably related on the basis of geography, or on the basis of the threat or potential threat to the public health or welfare or the environment, the facilities can be treated as one for purposes of CERCLA response actions. Consistent with this, the 200-PW-2 and 200-PW-4 OUs and ERDF would be considered to be onsite for purposes of Section 104 of CERCLA, and waste may be transferred between the facilities without requiring a permit.

All alternative actions will be performed in compliance with the waste management ARARs. Waste streams will be evaluated, designated, and managed in compliance with the ARAR requirements. Before disposal, waste will be managed in a protective manner to prevent releases to the environment or unnecessary exposure to personnel.

The proposed remedial-action alternatives have the potential to generate airborne emissions of both radioactive and criteria/toxic pollutants.

The RCW 70.94, "Washington Clean Air Act," requires regulation of radioactive air pollutants. The state implementing regulation WAC 173-480, "Ambient Air Quality Standards and Emission Limits for Radionuclides," sets standards that are as stringent or more so than the

Federal standards under the Federal *Clean Air Act of 1990*, and under the Federal implementing regulation, 40 CFR 61, Subpart H, "National Emission Standards for Emissions of Radionuclides Other than Radon from Department of Energy Facilities." The state standards protect the public by establishing exposure standards applicable to even the maximally exposed public individual, be that individual real or hypothetical. To that end, the standards address any member of the public, at the point of maximum annual air concentration in an unrestricted area where any member of the public may be. Radionuclide airborne emissions from the facility are not to exceed amounts that would cause an exposure to any said member of the public of greater than 10 mrem/yr effective dose equivalent. The state implementing regulation WAC 246-247, "Radiation Protection – Air Emissions," which adopts the WAC 173-480 standards, and requires verification of compliance with the 10 mrem/yr standard, would be applicable to the remedial action.

The WAC 246-247 further addresses emission sources emitting radioactive airborne emissions by requiring monitoring of such sources. Such monitoring requires physical measurement of the effluent or ambient air. The substantive provisions of WAC 246-247 that require monitoring of radioactive airborne emissions would be applicable to the remedial action.

The above state implementing regulations further address control of radioactive airborne emissions where economically and technologically feasible (WAC 246-247-040(3) and -040(4), "Radiation Protection - Air Emissions," "General Standards," and associated definitions). To address the substantive aspect of these requirements, best or reasonably achieved control technology will be addressed by ensuring that applicable emission control technologies (those successfully operated in similar applications) will be used when economically and technologically feasible (i.e., based on cost/benefit). If it is determined that there are substantive aspects of the requirement for control of radioactive airborne emissions, then controls will be administered as appropriate using reasonable and effective methods.

The Federal implementing regulations also contain requirements for managing asbestos material associated with demolition and waste disposal (40 CFR 61, Subpart M).

C2.0 REFERENCES

10 CFR 61, "Licensing Requirements for Land Disposal of Radioactive Waste," Title 10, *Code of Federal Regulations*, Part 61, as amended.

40 CFR 61, "National Emission Standards for Hazardous Air Pollutants," Title 40, *Code of Federal Regulations*, Part 61, as amended.

- 40 CFR 61, Subpart H, "National Emission Standards for Emissions of Radionuclides Other than Radon from Department of Energy Facilities."
- 40 CFR 61, Subpart M, "National Emission Standards for Asbestos."
- 40 CFR 61.52, "Emission Standard."
- 40 CFR 61.140, "Applicability."
- 40 CFR 61.145, "Standard for Demolition and Renovation."

- 40 CFR 61.150, "Standard for Waste Disposal for Manufacturing, Fabricating, Demolition, Renovation, and Spraying Operations."

40 CFR 141, "National Primary Drinking Water Regulations," Title 40, *Code of Federal Regulations*, Part 141, as amended.

- 40 CFR 141.61, "Maximum Contaminant Levels for Organic Constituents."
- 40 CFR 141.62, "Maximum Contaminant Levels for Inorganic Constituents."
- 40 CFR 141.66, "Maximum Contaminant Levels for Radionuclides."

40 CFR 268, "Land Disposal Restrictions," Title 40, *Code of Federal Regulations*, Part 268, as amended.

40 CFR 300.5, "National Oil and Hazardous Substances Pollution Contingency Plan," "Definitions," Title 40, *Code of Federal Regulations*, Part 300.5, as amended.

40 CFR 300.400, "National Oil and Hazardous Substances Pollution Contingency Plan," "General," Title 40, *Code of Federal Regulations*, Part 300.400, as amended.

- 40 CFR 300.400(g), ""Identification of Applicable or Relevant and Appropriate Requirements."

40 CFR 761, "Polychlorinated Biphenyls (PCBs) Manufacturing, Processing, Distribution in Commerce, and Use Prohibitions," Title 40, *Code of Federal Regulations*, Part 761, as amended.

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- 40 CFR 761.50(c), "Applicability," "Storage for Disposal."

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- 173-160-171, "What are the Requirements for the Location of the Well Site and Access to the Well?"
- 173-160-181, "What are the Requirements for Preserving the Natural Barriers to Ground Water Movement Between Aquifers?"
- 173-160-191, "What are the Design and Construction Requirements for Completing Wells?"
- 173-160-201, "What are the Casing and Liner Requirements?"
- 173-160-221, "What are the Standards for Sealing Materials?"
- 173-160-231, "What are the Standards for Surface Seals?"
- 173-160-241, "What are the Requirements for Formation Sealing?"
- 173-160-271, "What are the Special Sealing Standards for Driven Wells, Jetted Wells, and Dewatering Wells?"
- 173-160-281, "What are the Construction Standards for Artificial Gravel-Packed Wells?"
- 173-160-291, "What are the Standards for the Upper Terminal of Water Wells?"
- 173-160-301, "What are the Requirements for Temporary Capping?"
- 173-160-311, "What are the Well Tagging Requirements?"
- 173-160-321, "How do I Test a Well?"
- 173-160-331, "How do I Make Sure My Equipment and the Water Well are Free of Contaminants?"
- 173-160-341, "How do I Ensure the Quality of Drilling Water?"
- 173-160-351, "What are the Standards for Pump Installation?"
- 173-160-371, "What are the Standards for Chemical Conditioning?"

- 173-160-381, "What are the Standards for Decommissioning a Well?"
- 173-160-400, "What are the Minimum Standards for Resource Protection Wells and Geotechnical Soil Borings?"
- 173-160-420, "What are the General Construction Requirements for Resource Protection Wells?"
- 173-160-430, "What are the Minimum Casing Standards?"
- 173-160-440, "What are the Equipment Cleaning Standards?"
- 173-160-450, "What are the Well Sealing Requirements?"
- 173-160-460, "What is the Decommissioning Process for Resource Protection Wells?"

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- 173-303-016, "Identifying Solid Waste."
- 173-303-017, "Recycling processes involving solid waste."
- 173-303-040, "Definitions."
- 173-303-050, "Department of Ecology Cleanup Authority."
- 173-303-070(3), "Designation of Dangerous Waste," "Designation Procedures."
- 173-303-071, "Excluded Categories of Waste."
- 173-303-073, "Conditional Exclusion of Special Wastes."
- 173-303-077, "Requirements for Universal Waste."
- 173-303-120, "Recycled, Reclaimed, and Recovered Wastes."
- 173-303-140, "Land Disposal Restrictions."
- 173-303-140(4), "Land Disposal Restrictions," "Land Disposal Restrictions and Prohibitions."
- 173-303-170, "Requirements for Generators of Dangerous Waste."
- 173-303-200, "Accumulating Dangerous Waste On-Site."
- 173-303-573, "Standards for Universal Waste Management."
- 173-303-610, "Closure and Post-Closure."
- 173-303-630, "Use and Management of Containers."
- 173-303-640, "Tank Systems."
- 173-303-650, "Surface Impoundments."
- 173-303-665, "Landfills."
- 173-303-960, "Special Powers and Authorities of the Department."

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- 173-304-200(2), "On-Site Containerized Storage, Collection and Transportation Standards for Solid Waste," "On-Site Storage Standards."

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- 173-340-745, "Soil Cleanup Standards for Industrial Properties."

- 173-340-745(5)(b), "Soil Cleanup Standards for Industrial Properties," "Method C Industrial Soil Cleanup Levels," "Standard Method C Industrial Soil Cleanup Levels."

WAC 173-350, "Solid Waste Handling Standards," *Washington Administrative Code*, as amended, Washington State Department of Ecology, Olympia, Washington.

- 173-350-300, "On-Site Storage, Collection, and Transportation Standards."

WAC 173-400, "General Regulations for Air Pollution Sources," *Washington Administrative Code*, as amended, Washington State Department of Ecology, Olympia, Washington.

- 173-400-040, "General Standards for Maximum Emissions."
- 173-400-113, "Requirements for New Sources in Attainable or Unclassifiable Areas."

WAC 173-460, "Controls for New Sources of Toxic Air Pollutants," *Washington Administrative Code*, as amended, Washington State Department of Ecology, Olympia, Washington.

- 173-460-030, "Requirements, Applicability and Exemptions."
- 173-460-060, "Control Technology Requirements."
- 173-460-070, "Ambient Impact Requirement."

WAC 173-480, "Ambient Air Quality Standards and Emission Limits for Radionuclides," *Washington Administrative Code*, as amended, Washington State Department of Ecology, Olympia, Washington.

- 173-480-050, "Standards."
- 173-480-070, "Emission Monitoring and Compliance Procedures."

WAC 246-247, "Department of Health," "Radiation Protection - Air Emissions," *Washington Administrative Code*, as amended, Washington State Department of Health, Olympia, Washington.

- 246-247-040, "General Standards."
- 246-247-075, "Monitoring, Testing, and Quality Assurance."

Table C-1. Identification of Potential Federal Applicable or Relevant and Appropriate Requirements and to be Considered for the Remedial Action Sites. (3 Pages)

ARAR Citation	ARAR or TBC	Requirement	Rationale for Use
"National Primary Drinking Water Regulations," 40 CFR 141			
"Maximum Contaminant Levels for Organic Contaminants," 40 CFR 141.61	ARAR	Establishes maximum contaminant levels (MCL) that are drinking water criteria designed to protect human health from the potential adverse effects of organic contaminants in drinking water.	The groundwater in the 200-PW-2 and 200-PW-4 OUs is not currently used for drinking water. However, Central Plateau groundwater may be considered a potential drinking water source and, because the groundwater discharges to the Columbia River (which is used for drinking water), the substantive requirements in 40 CFR 141.61 for organic constituents are relevant and appropriate.

Table C-1. Identification of Potential Federal Applicable or Relevant and Appropriate Requirements and to be Considered for the Remedial Action Sites. (3 Pages)

ARAR Citation	ARAR or TBC	Requirement	Rationale for Use
"Maximum Contaminant Levels for Inorganic Contaminants," 40 CFR 141.62	ARAR	Establishes MCLs that are drinking water criteria designed to protect human health from the potential adverse effects of inorganic contaminants in drinking water.	The groundwater in the 200-PW-2 and 200-PW-4 OUs is not currently used for drinking water. However, Central Plateau groundwater may be considered a potential drinking water source and, because the groundwater discharges to the Columbia River (which is used for drinking water), the substantive requirements in 40 CFR 141.62 for inorganic constituents are relevant and appropriate.
"Maximum Contaminant Levels for Radionuclides," 40 CFR 141.66	ARAR	Establishes MCLs that are drinking water criteria designed to protect human health from the potential adverse effects of radionuclides in drinking water.	The groundwater in the 200-PW-2 and 200-PW-4 OUs is not currently used for drinking water. However, Central Plateau groundwater may be considered a potential drinking water source and because the groundwater discharges to the Columbia River (which is used for drinking water), the substantive requirements in 40 CFR 141.66 for radionuclides are relevant and appropriate.
"Polychlorinated Biphenyls (PCBs) Manufacturing, Processing, Distribution in Commerce, and Use Prohibitions," 40 CFR 761			
"Applicability," Specific Subsections: 40 CFR 761.50(b)(1) 40 CFR 761.50(b)(2) 40 CFR 761.50(b)(3) 40 CFR 761.50(b)(4) 40 CFR 761.50(b)(7) 40 CFR 761.50(c)	ARAR	These regulations establish standards for the storage and disposal of PCB wastes.	The substantive requirements of these regulations are applicable or relevant and appropriate to the storage and disposal of PCB liquids, items, remediation waste, and bulk product waste at ≥ 50 p/m. The specific subsections identified from 40 CFR 761.50(b) reference the specific sections for the management of PCB waste type. The disposal requirements for radioactive PCB waste are addressed in 40 CFR 761.50(b)(7).
Archeological and Historic Preservation Act, 16 USC 469aa-mm	ARAR	Requires that remedial actions at 200-CS-1 OU waste sites do not cause the loss of any archaeological or historic data. This act mandates preservation of the data and does not require protection of the actual waste site or facility.	Archeological and historic sites have been identified within the 200 Areas; therefore, the substantive requirements of this act are applicable to actions that might disturb these sites.
National Historic Preservation Act of 1966, 16 USC 470, Section 106	ARAR	Requires federal agencies to consider the impacts of their undertaking on cultural properties through identification, evaluation and mitigation processes, and consultation with interested parties.	Cultural and historic sites have been identified within the 200 Areas, and therefore the substantive requirements of this act are applicable to actions that might disturb these types of sites.
Native American Graves Protection and Repatriation Act, 25 USC 3001, et seq.	ARAR	Establishes federal agency responsibility for discovery of human remains, associated and unassociated funerary objects, sacred objects and items of cultural patrimony.	Substantive requirements of this act are applicable if remains and sacred objects are found during remediation and will require Native American Tribal consultation in the event of discovery.
Endangered Species Act of 1973, 16 USC 1531 et seq., subsection 16 USC 1536(c)	ARAR	Prohibits actions by federal agencies that are likely to jeopardize the continued existence of listed species or result in the destruction or adverse modification or critical habitat. If remediation is within	Substantive requirements of this act are applicable if threatened or endangered species are identified in areas where remedial actions will occur.

Table C-1. Identification of Potential Federal Applicable or Relevant and Appropriate Requirements and to be Considered for the Remedial Action Sites. (3 Pages)

ARAR Citation	ARAR or TBC	Requirement	Rationale for Use
		critical habitat or buffer zones surrounding threatened or endangered species, mitigation measures must be taken to protect the resource.	
"National Emission Standard for Asbestos," 40 CFR 61 Subpart M; "Applicability," 40 CFR 61.140			
"Standard for Demolition and Renovation," 40 CFR 61.145	ARAR	Specifies that facilities are to be inspected for the presence of asbestos before demolition. The standard defines regulated asbestos-containing materials and establishes removal requirements based on quantity present and handling requirements. These requirements also specify handling and disposal requirements for regulated sources that have the potential to emit asbestos. Specifically, no visible emissions are allowed during handling, packaging, and transport of asbestos-containing materials.	Although asbestos-containing materials are not anticipated, substantive requirements of this standard are applicable, should this remedial action include abatement of asbestos and asbestos-containing materials on pipelines or buried asbestos. As a result, there is a potential to emit asbestos to unrestricted areas, and the requirements for the removal, handling, and packaging of asbestos apply.
"Standard for Waste Disposal for Manufacturing, Fabricating, Demolition, Renovation, and Spraying Operations," 40 CFR 61.150	ARAR	Identifies the requirements for the removal and disposal of asbestos from demolition and renovation activities.	Although asbestos-containing materials are not anticipated, the substantive requirements of this standard are applicable, should asbestos-containing material be located during remedial action activities of associated pipelines and buried asbestos.
Atomic Energy Act of 1954, as amended, 42 USC 2011, et seq.			
DOE M 435.1-1 Specific subsections: Chapter IV, paragraph (P)(1) through (3)	TBC	Establishes performance objectives and performance assessment criteria for low-level waste disposal facilities	The specified paragraphs provide criteria consistent with DOE expectations for protection of the public and the environment
Regulations pursuant to the *Resource Conservation and Recovery Act of 1976* and implemented through WAC 173-303, "Dangerous Waste Regulations" (see Table C-2).			

ARAR = applicable or relevant and appropriate requirement.
CFR = *Code of Federal Regulations.*
DOE = U.S. Department of Energy.
EPA = U.S. Environmental Protection Agency.
MCL = maximum contaminant level.
PCB = polychlorinated biphenyl.
TBC = to-be-considered.
WAC = *Washington Administrative Code.*

Table C-2. Identification of Potential State Applicable and Relevant or Appropriate Requirements and To Be Considered for the Remedial Action Sites. (6 Pages)

ARAR Citation	ARAR or TBC	Requirement	Rationale for Use
"Dangerous Waste Regulations," WAC 173-303			
"Identifying Solid Waste," WAC 173-303-016	ARAR	Identifies those materials that are and are not solid wastes.	Substantive requirements of these regulations are applicable, because these define how to determine which materials are subject to the designation regulations. Specifically, materials that are generated for removal from the CERCLA site during the remedial action would be subject to the procedures for identification of solid waste to ensure proper management.
"Recycling Processes Involving Solid Waste," WAC 173-303-017	ARAR	Identifies materials that are and are not solid wastes when recycled.	Substantive requirements of these regulations are applicable, because these define how to determine which materials are subject to the designation regulations. Specifically, materials that are generated for removal from the CERCLA site during the remedial action would be subject to the procedures for identification of solid waste to ensure proper management.
"Designation of Dangerous Waste," WAC 173-303-070(3)	ARAR	Establishes the method for determining whether a solid waste is, or is not, a dangerous waste or an extremely hazardous waste.	Substantive requirements of these regulations are applicable to materials encountered during the remedial action. Specifically, solid waste that is generated for removal from the CERCLA site during this remedial action would be subject to the dangerous waste designation procedures to ensure proper management.
"Excluded Categories of Waste," WAC 173-303-071	ARAR	Describes those categories of wastes that are excluded from the requirements of WAC 173-303 (excluding WAC 173-303-050).	The conditions of this requirement are applicable to remedial actions in the 200-PW-2 and 200-PW-4 OUs, should wastes identified in WAC 173-303-071 be encountered.
"Conditional Exclusion of Special Wastes," WAC 173-303-073	ARAR	Establishes the conditional exclusion and the management requirements of special wastes, as defined in WAC 173-303-040.	Substantive requirements of these regulations are applicable to materials encountered during the remedial action. Specifically, the substantive standards for management of special waste are applicable to the interim management of certain waste that will be generated during the remedial action.
"Requirements for Universal Waste," WAC 173-303-077	ARAR	Identifies those wastes exempted from regulation under WAC 173-303-140 and WAC 173-303-170 through 173-303-9907 (excluding WAC 173-303-960). These wastes are subject to regulation under WAC 173-303-573.	Substantive requirements of these regulations are applicable to materials encountered during the remedial action. Specifically, the substantive standards for management of universal waste are applicable to the interim management of certain waste that will be generated during the remedial action.

Table C-2. Identification of Potential State Applicable and Relevant or Appropriate Requirements and To Be Considered for the Remedial Action Sites. (6 Pages)

ARAR Citation	ARAR or TBC	Requirement	Rationale for Use
"Recycled, Reclaimed, and Recovered Wastes," WAC 173-303-120 Specific Subsections: WAC 173-303-120(3) WAC 173-303-120(5)	ARAR	These regulations define the requirements for recycling materials that are solid and dangerous waste. Specifically, WAC 173-303-120(3) provides for the management of certain recyclable materials, including spent refrigerants, antifreeze, and lead-acid batteries. WAC 173-303-120(5) provides for the recycling of used oil.	Substantive requirements of these regulations are applicable to certain materials that might be encountered during the remedial action. Recyclable materials that are exempt from regulation as dangerous waste and that are not otherwise subject to CERCLA as hazardous substances can be recycled and/or conditionally excluded from certain dangerous waste requirements.
"Land Disposal Restrictions," WAC 173-303-140(4)	ARAR	This regulation establishes state standards for land disposal of dangerous waste and incorporates, by reference, Federal land-disposal restrictions of 40 CFR 268 that are applicable to solid waste that is designated as dangerous or mixed waste in accordance with WAC 173-303-070(3).	The substantive requirements of this regulation are applicable to materials encountered during the remedial action. Specifically, dangerous/mixed waste that is generated and removed from the CERCLA site during the remedial action for off-site (as defined by CERCLA) land disposal would be subject to the identification of applicable land-disposal restrictions at the point of generation of the waste. The actual off-site treatment of such waste would not be ARAR to this remedial action, but instead would be subject to all applicable laws and regulations.
"Requirements for Generators of Dangerous Waste," WAC 173-303-170	ARAR	Establishes the requirements for dangerous waste generators.	Substantive requirements of these regulations are applicable to materials encountered during the remedial action. Specifically, the substantive standards for management of dangerous/mixed waste are applicable to the interim management of certain waste that will be generated during the remedial action. For purposes of this remedial action, WAC 173-303-170(3) includes the substantive provisions of WAC 173-303-200 by reference. WAC 173-303-200 further includes certain substantive standards from WAC 173-303-630 and -640 by reference.
"Closure and Post-closure," WAC 173-303-610	ARAR	This regulation establishes the closure performance standards applicable to all Hanford Site TSD units.	These requirements are applicable to the closure of RCRA TSD unit OUs: 216-A-36B Crib, 216-A-37-1 Crib, and 207-A South Retention Basin.
"Surface Impoundments," WAC 173-303-650	ARAR	Specifies closure and postclosure requirements for surface impoundments.	This regulation is applicable to the 207-A South Retention Basin TSD unit, because this unit is permitted as a "Surface Impoundment" and is subject to the requirements identified in WAC 173-303-665.
"Landfills," WAC 173-303-665	ARAR	Specifies closure and postclosure requirements for landfills.	This regulation is applicable to the 216-A-10, 216-A-36B, and 216-A-37-1 Cribs and 207-A South Retention Basin TSD units, because these units are permitted as a "landfill" and are subject to the requirements identified in WAC 173-303-665.

Table C-2. Identification of Potential State Applicable and Relevant or Appropriate Requirements and To Be Considered for the Remedial Action Sites. (6 Pages)

ARAR Citation	ARAR or TBC	Requirement	Rationale for Use
"Model Toxics Control Act -- Cleanup," WAC 173-340			
"Soil Cleanup Standards for Industrial Properties," WAC 173-340-745(5)(b)	ARAR	Identifies the methods used to identify risk-based concentrations and their use in the selection of a cleanup action. Cleanup and remediation levels are based on protection of human health and the environment, the location of the site, and other regulations that apply to the site. The standard specifies cleanup goals that implement the strictest Federal or state cleanup criteria.	The State-established risk-based concentrations for soils and protection of groundwater are relevant and appropriate to the 200-PW-2 and 200-PW-4 OUs waste-site remedial actions, because no Federal standard exists.
"Minimum Functional Standards for Solid Waste Handling," WAC 173-304			
"On-Site Containerized Storage, Collection and Transportation Standards for Solid Waste," WAC 173-304-200(2)	ARAR	Establishes the requirements for the on-site storage of solid wastes that are not radioactive or dangerous wastes.	Substantive requirements of these regulations are applicable to materials encountered during the remedial action. Specifically, nondangerous, nonradioactive solid wastes (i.e., hazardous substances that are only regulated as solid waste) that will be containerized for removal from the CERCLA site would be managed on site according to the substantive requirements of this standard.
"Solid Waste Handling Standards," WAC 173-350			
"On-Site Storage, Collection and Transportation Standards," WAC 173-350-300	ARAR	Establishes the requirements for the temporary storage of solid waste in a container on site and the collecting and transporting of the solid waste.	The substantive requirements of this newly promulgated rule are relevant and appropriate to the on-site collection and temporary storage of solid wastes at the 200-PW-2 and 200-PW-4 OUs remediation waste sites. Compliance with this regulation is being implemented in phases for existing facilities.
"Minimum Standards for Construction and Maintenance of Wells," WAC 173-160			
WAC 173-160-161	ARAR	Identifies well planning and construction requirements.	The substantive requirements of this regulation are applicable to actions that include construction of wells used for groundwater extraction, monitoring, or injection of treated groundwater or wastes. The requirements of WAC 173-160-161 through 173-160-381 (excluding 173-160-211, 173-160-251, 173-160-261, 173-160-361), 173-160-400, 173-160-420, 173-303-430, 173-160-440, 173-160-450, and 173-160-460 are applicable to groundwater well construction, monitoring, or injection of treated groundwater or wastes in the 200-PW-2 and 200-PW-4 OUs.
WAC 173-160-171	ARAR	Identifies the requirements for locating a well.	
WAC 173-160-181	ARAR	Identifies the requirements for preserving natural barriers to groundwater movement between aquifers.	
WAC 173-160-191	ARAR	Identifies the design and construction requirements for completing wells.	
WAC 173-160-201	ARAR	Identifies the casing and liner requirements for water supply wells.	
WAC 173-160-221	ARAR	Identifies the requirements for sealing materials.	
WAC 173-160-231	ARAR	Identifies the requirements for surface seals on water wells.	

Table C-2. Identification of Potential State Applicable and Relevant or Appropriate Requirements and To Be Considered for the Remedial Action Sites. (6 Pages)

ARAR Citation	ARAR or TBC	Requirement	Rationale for Use
WAC 173-160-241	ARAR	Identifies the requirements for formation sealing.	
WAC 173-160-271	ARAR	Identifies the special sealing standards for driven wells, jetted wells, and dewatering wells.	
WAC 173-160-281	ARAR	Identifies the construction standards for artificial gravel-packed wells.	
WAC 173-160-291	ARAR	Identifies the standards for the upper terminal of water wells.	
WAC 173-160-301	ARAR	Identifies the requirements for the temporary surface barrier.	
WAC 173-160-311	ARAR	Identifies the requirements for well tagging.	
WAC 173-160-321	ARAR	Identifies the standards for testing a well.	
WAC 173-160-331	ARAR	Identifies the method for keeping equipment and the water well free of contaminants.	
WAC 173-160-341	ARAR	Identifies the method for ensuring the quality of the well water.	
WAC 173-160-351	ARAR	Identifies the standards for the installation of a pump.	
WAC 173-160-371	ARAR	Identifies the standard for chemical conditioning.	
WAC 173-160-381	ARAR	Identifies the standard for decommissioning a well.	
WAC 173-160-400	ARAR	Identifies the minimum standards for resource protection wells and geotechnical soil borings.	
WAC 173-160-420	ARAR	Identifies the general construction requirements for resource protection wells.	
WAC 173-160-430	ARAR	Identifies the minimum casing standards.	
WAC 173-160-440	ARAR	Identifies the equipment cleaning standards.	
WAC 173-160-450	ARAR	Identifies the well sealing requirements.	
WAC 173-160-460	ARAR	Identifies the decommissioning process for resource protection wells.	

Table C-2. Identification of Potential State Applicable and Relevant or Appropriate Requirements and To Be Considered for the Remedial Action Sites. (6 Pages)

ARAR Citation	ARAR or TBC	Requirement	Rationale for Use
"General Regulations for Air Pollution Sources," WAC 173-400			
"General Standards for Maximum Emissions," WAC 173-400-040 WAC 173-400-113	ARAR	Methods of control shall be employed to minimize the release of air contaminants associated with fugitive emissions resulting from materials handling, construction, demolition, or other operations. Emissions are to be minimized through application of best available control technology.	Substantive requirements of these standards are relevant and appropriate to this remedial action, because there may be visible, particulate, fugitive, and hazardous air emissions and odors resulting from decontamination, demolition, and excavation activities. As a result, standards established for the control and prevention of air pollution are relevant and appropriate.
"Controls for New Sources of Toxic Air Pollutants," WAC 173-460			
"Control Technology Requirements," WAC 173-460-030 WAC 173-460-060	ARAR	Requires that new sources of air emissions provide the emission estimates identified in this regulation.	Substantive requirements of these standards are applicable to this remedial action, because there is the potential for toxic air pollutants to become airborne as a result of decontamination, demolition, and excavation activities. As a result, standards established for the control of toxic air contaminants are relevant and appropriate.
"Ambient Impact Requirement," WAC 173-460-070	ARAR	Requires that when applying for a notice of construction, the owner/operator of a new toxic air pollutant source that is likely to increase toxic air pollutant emissions shall demonstrate that emissions from the source are sufficiently low to protect human health and safety from potential carcinogenic and/or other toxic effects.	The substantive requirements of this standard are applicable to remedial actions in the 200-PW-2 and 200-PW-4 OUs, should the remedial action result in the treatment of the soil or debris that contains contaminants of concern identified in the regulation as a toxic air pollutant.
"Ambient Air Quality Standards and Emission Limits for Radionuclides," WAC 173-480			
"Standards," WAC 173-480-050	ARAR	Whenever another Federal or state regulation or limitation in effect controls the emission of radionuclides to the ambient air, the more stringent control of emissions shall govern.	The substantive requirements of this standard are applicable in that the more stringent aspect of Federal or state emission limitation is specified as governing.
"Compliance," WAC 173-480-070(2)	ARAR	Requires that radionuclide emissions compliance shall be determined by calculating the dose to members of the public at the point of maximum annual air concentration in an unrestricted area where any member of the public may be.	The substantive requirements of this standard are applicable to remedial actions involving disturbance or ventilation of radioactively contaminated areas or structures, because airborne radionuclides may be emitted to unrestricted areas where any member of the public may be.

Table C-2. Identification of Potential State Applicable and Relevant or Appropriate Requirements and To Be Considered for the Remedial Action Sites. (6 Pages)

ARAR Citation	ARAR or TBC	Requirement	Rationale for Use
"Radiation Protection – Air Emissions," WAC 246-247			
"General Standards," WAC 246-247-040(1)	ARAR	Requires that emissions of radionuclides to the ambient air from DOE facilities shall not exceed amounts that would cause any member of the public to receive in any year an effective dose equivalent of 10 mrem/yr.	Substantive requirements of this standard are applicable, because this remedial action may include activates such as decontamination and stabilization of contaminated structures, treatment of sludge, and operation of exhausters and vacuums, each of which may provide airborne emissions of radioactive particulates to unrestricted areas. As a result, requirements limiting emissions apply. This is a risk-based standard for the purposes of protecting human health and the environment.
"Monitoring, Testing, and Quality Assurance," WAC 246-247-075(1)	ARAR	Specifies that radionuclide emission measurements shall be made at all release points that have the potential to discharge radionuclides to the air in quantities that cause an effective dose equivalent in excess of 1% of the standard. The regulation also requires that all radionuclides be measured that could contribute greater than 10% of the potential dose equivalent for a release point.	Substantive requirements of this standard are applicable, because major point source emissions of radionuclides to the ambient air may result from activities performed during the remedial action, such as decontamination and stabilization of contaminated structures, treatment of sludge, and operation of exhauster and vacuums. This standard exists to ensure compliance with emission standards.
"General Standards," WAC 246-247-040 "BARCT," WAC 246-247-040(3) "ALARACT," WAC 246-247-040(4)	ARAR	Emissions shall be controlled on an ALARA basis, at a minimum, to ensure that emission standards are not exceeded.	Substantive requirements of this standard are applicable, because fugitive, diffuse, and point-source emissions of radionuclides to the ambient air may result from activities performed during the remedial action, such as open-air demolition of contaminated structures, excavation of contaminated soils, and operation of exhauster and vacuums. This standard exists to ensure enhanced compliance with emission standards.
"Monitoring, Testing, and Quality Assurance," WAC 246-247-075(1), (2) WAC 246-247-075(8)	ARAR	Establishes the monitoring, testing, and quality assurance requirements for radioactive air emissions. Facility (site) emissions resulting from non-point and fugitive sources of airborne radioactive material shall be measured. Measurement techniques may include ambient air measurements, or in-line radiation detector or withdrawal of representative samples from the effluent stream, as determined by the lead agency.	Substantive requirements of this standard are applicable, because fugitive and non-point source emissions of radionuclides to the ambient air may result from activities performed during the remedial action, such as open-air demolition of contaminated structures and excavation of contaminated soils. This standard exists to ensure compliance with emission standards.

ALARA = as low as reasonably achievable.
ARAR = applicable or relevant and appropriate requirement.
CERCLA = *Comprehensive Environmental Response, Compensation, and Liability Act of 1980.*
CFR = *Code of Federal Regulations.*
OU = operable unit.
RCRA = *Resource Conservation and Recovery Act of 1976.*
TBC = to be considered.
TSD = treatment, storage, and disposal.
WAC = *Washington Administrative Code.*

APPENDIX D

TABLES FOR THE BASELINE HUMAN-HEALTH RISK ASSESSMENT, SCREENING-LEVEL ECOLOGICAL RISK ASSESSMENT, AND GROUNDWATER PROTECTION RISK ASSESSMENT

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CONTENTS

TABLES

ATTACHMENTS

TERMS

BCG	biota concentration guide
BHC	benzene hexachloride
COC	contaminant of concern
COEC	contaminant of ecological concern
CONV	conventional parameter
COPC	contaminant of potential concern
CZ	contaminated zone
DDE	dichlorodiphenyldichloroethylene
DDT	dichlorodiphenyltrichloroethane
Eco	ecological
EPC	exposure-point concentration
FOD	frequency of detection
GW	groundwater (protection)
GWP	groundwater protection
IND	industrial direct exposure
LANL	Los Alamos National Laboratory
MB	mass balance
NA	not applicable, not available
ND	nondispersion, not detected
PEF	particulate emissions factor
Pest/PCB	pesticide/polychlorinated biphenyl
RBC	risk-based concentration
RCRA	*Resource Conservation and Recovery Act of 1976*
RESRAD	RESidual RADioactivity (dose model) (ANL 2002, *RESRAD for Windows*, Version 6.21)
RI	remedial investigation
SVOC	semivolatile organic compound
SZ	saturated zone
TPH	total petroleum hydrocarbon
VF	volatilization factor
VOC	volatile organic compound
WAC	*Washington Administrative Code*