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Rev. 6, Draft A Redline 1

Remedial Design Report/ Remedial Action Work Plan for the 100 Area

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Remedial Design Report/ Remedial Action Work Plan for the 100 Area

July 2008

United States Department of Energy

P.O. Box 550, Richland, Washington 99352

For External Review

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ACRONYMS AND ABBREVIATIONS

AMP	air monitoring plan
AOC	area of contamination
ARAR	applicable or relevant and appropriate requirements
AWQC	Ambient Water Quality Criteria
BMP	best management practice
CERCLA	*Comprehensive Environmental Response, Compensation, and Liability Act of 1980*
CFR	*Code of Federal Regulations*
COC	contaminant of concern
CTF	container transfer facility
CWFM	conceptual waste form model
DAF	dilution attenuation factor
DCG	derived concentration guide
DOE	U.S. Department of Energy
DOT	U.S. Department of Transportation
Ecology	Washington State Department of Ecology
EPA	U.S. Environmental Protection Agency
ERC	Environmental Restoration Contractor
ERDF	Environmental Restoration Disposal Facility
ESD	explanation of significant difference
ETF	Effluent Treatment Facility
IDW	investigation-derived waste
IRIS	Integrated Risk Information System
LDR	land disposal restriction
MCL	maximum contaminant level
MCLG	maximum contamination level goal
MTCA	*Model Toxics Control Act*
NCP	National Oil and Hazardous Substances Contingency Plan
NESHAP	National Emissions Standards for Hazardous Air Pollutants
NPL	National Priorities List
NRC	U.S. Nuclear Regulatory Commission
OU	operable unit
RAG	remedial action goal
RAO	remedial action objective
RCRA	*Resource Conservation and Recovery Act of 1976*
RDL	required detection limit
RDR/RAWP	remedial design report/remedial action work plan
RESRAD	RESidual RADioactivity (dose model)
RFP	request for proposal
RL	DOE, Richland Operations Office
ROD	record of decision
RTD	remove, treat, and dispose
S&H	safety and health
SAP	sampling and analysis plan
SDWA	*Safe Drinking Water Act*
SNF	spent nuclear fuel
TBC	to be considered

Acronyms and Abbreviations

TCLP	toxicity characteristic leaching procedure
Tri-Party Agreement	*Hanford Federal Facility Agreement and Consent Order*
UCL	upper confidence limit
UMM	Unit Manager's Meeting
WAC	*Washington Administrative Code*
WBS	work breakdown structure
WCH	Washington Closure Hanford, LLC
WIDS	Waste Information Data System

100 Area Burial Grounds ROD: *Record of Decision for the 100-BC-1, 100-BC-2, 100-DR-1, 100-DR-2, 100-FR-2, 100-HR-2, and 100-KR-2 Operable Units* (EPA 2000b)

100 Area Burial Grounds SAP: *100 Area Burial Grounds Remedial Action Sampling and Analysis Plan* (DOE-RL 2001a)

100 Area SAP: *100 Area Remedial Action Sampling and Analysis Plan* (DOE-RL 2008)

Interim Action ROD: *Interim Action Record of Decision for the 100-BC-1, 100-DR-1, and 100-HR-1 Operable Units* (EPA 1995)

Remaining Sites ESD: *Explanation of Significant Difference for the 100 Area Remaining Sites ROD* (EPA 2000a)

Remaining Sites ESD: *Explanation of Significant Differences for the 100 Area Remaining Sites Interim Remedial Action ROD* (EPA 2004)

Remaining Sites ROD: *Interim Action Record of Decision for the 100-BC-1, 100-BC-2, 100-DR-1, 100-DR-2, 100-FR-1, 100-FR-2, 100-HR-1, 100-HR-2, 100-KR-1, 100-KR-2, 100-IU-2, 100-IU-6, and 200-CW-3 Operable Units* (EPA 1999)

ERDF ROD Amendment: *Amended Record of Decision, Decision Summary and Responsiveness Summary for the Environmental Restoration Disposal Facility, Hanford Site – 200 Area, Benton County, Washington* (EPA 2002)

ROD Amendment: *Amendment to the Interim Action Record of Decision for the 100-BC-1, 100-DR-1, and 100-HR-1 Operable Units* (EPA 1997a)

1.0 INTRODUCTION

The Hanford Site is a 1,450-km^2 (560-mi^2) federal facility located along the Columbia River in southeastern Washington State. From 1943 until 1990, the primary mission of the Hanford Site was to produce nuclear materials for the nation's defense mission. In July 1989, the Hanford Site was listed on the National Priorities List (NPL) under the *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA), as amended by the *Superfund Amendments and Reauthorization Act of 1986*. The Hanford Site was divided up and listed as four NPL sites: the 100 Area, the 200 Area, the 300 Area, and the 1100 Area. The 100 Area is the subject of this document.

The 100 Area, which encompasses approximately 68 km^2 (26 mi^2) bordering the southern shore of the Columbia River, is the site of six reactor areas that contained a total of nine reactors (i.e., the 100-B/C, 100-D/DR, 100-F, 100-H, 100-KE/KW, and 100-N Reactor). Each of these reactor areas has several operable units (OUs). The OUs are currently in various stages of the CERCLA process. This revision of the document addresses the remedial designs and remedial actions for waste sites in the Environmental Restoration Contract and River Corridor Closure Contract scope for the 100-B/C, 100-D, 100-H, 100-F, and 100-K Areas, and the 100-IU-2 and 100-IU-6 OUs. It is expected that this document will form the basis for remedial actions at contaminated sites across the 100 Area.

1.1 PURPOSE AND OBJECTIVES

The primary purpose of this remedial design report/remedial action work plan (RDR/RAWP) is to describe the design and the implementation of the remedial action processes required by the following:

- *Interim Action Record of Decision for the 100-BC-1, 100-DR-1, and 100-HR-1 Operable Units, Hanford Site, Benton County, Washington* (hereinafter referred to as the Interim Action Record of Decision [ROD]) (EPA 1995)

- *Amendment to the Interim Action Record of Decision for the 100-BC-1, 100-DR-1, and 100-HR-1 Operable Units* (hereinafter referred to as the ROD Amendment) (EPA 1997a)

- *Interim Action Record of Decision for the 100-BC-1, 100-BC-2, 100-DR-1, 100-DR-2, 100-FR-1, 100-FR-2, 100-HR-1, 100-HR-2, 100-KR-1, 100-KR-2, 100-IU-2, 100-IU-6, and 200-CW-3 Operable Units, Hanford Site, Benton County, Washington* (hereinafter referred to as the Remaining Sites ROD) (EPA 1999)

- *Record of Decision for the 100-BC-1, 100-BC-2, 100-DR-1, 100-DR-2, 100-FR-2, 100-HR-2, and 100-KR-2 Operable Units, Hanford Site (100 Area Burial Grounds), Benton County, Washington* (hereinafter referred to as the 100 Area Burial Grounds ROD) (EPA 2000b).

1.2 SCOPE

The *Hanford Federal Facility Agreement and Consent Order* (Tri-Party Agreement) (Ecology et al. 1998) specifically lists the RDR and the RAWP as two separate documents. However, this document streamlines the requirements; the RDR and RAWP are combined to cover both the remedial designs and remedial actions. This document pertains to all of the waste sites included in the Interim Action ROD, the ROD Amendment, the Remaining Sites ROD, and the 100 Area Burial Grounds ROD (as described in Section 1.3), and provides a basis that could be followed, with minimal additions, by future 100 Area source OU RODs.

1.3 INTERIM ACTION ROD, ROD AMENDMENT, REMAINING SITES ROD, AND 100 AREA BURIAL GROUNDS ROD

The Interim Action ROD and the ROD Amendment define the remedial actions for selected radioactive liquid effluent waste disposal sites located in the 100 Area (EPA 1995, 1997a). The Remaining Sites ROD defines the remedial actions for selected remaining sites (EPA 1999). The 100 Area Burial Grounds ROD defines the remedial actions for burial ground sites located in the 100 Area (EPA 2000b). It is expected that remedial action will also address sites adjacent to and within the area affected by remediation of the waste sites listed in the Interim Action ROD, the ROD Amendment, the Remaining Sites ROD, and the 100 Area Burial Grounds ROD. These additional sites will be identified during detailed design and remediation activities for each group of sites. (Detailed design includes estimating the dimensions of the excavated waste sites and identifying potential overlap of excavated areas with other waste sites.) Before any of these additional sites are remediated, the U.S. Department of Energy (DOE), Richland Operations Office (RL) will obtain concurrence from the appropriate regulatory agencies. Appendix A lists all the waste sites identified in the RODs and provides information for each waste site.

1.3.1 Interim Action ROD and ROD Amendment Waste Sites in the 100-D Area

Three OUs are associated with the 100-D/DR Area at the Hanford Site. 100-DR-1 and 100-DR-2 are source OUs. The third OU, 100-HR-3, is the groundwater OU for the 100-D/DR and 100-H Areas. The 100-D/DR Area contains two reactors: the D Reactor within the 100-DR-1 OU and the DR Reactor within the 100-DR-2 OU. The D Reactor operated from 1944 to 1967, and the DR Reactor operated from 1950 to 1964. The 100-D Area includes former radioactive liquid waste disposal sites and buried debris resulting from demolition of some reactor support facilities. Interim remedial actions for the 100-D Area focused on the waste sites shown in Figure 1-1. Most of these sites have been remediated (Appendix A).

1.3.2 Interim Action ROD and ROD Amendment Waste Sites in the 100-B/C Area

Three OUs are associated with the 100-B/C Area at the Hanford Site. 100-BC-1 and 100-BC-2 are source OUs. The third OU, 100-BC-5, is the groundwater OU for the 100-B/C Area. The 100-B/C Area contains two reactors: the B Reactor within the 100-BC-1 OU and the C Reactor within the 100-BC-2 OU. The B Reactor operated from 1944 to 1968, and the C Reactor operated from 1952 to 1969. In general, the area contains waste units associated with the

original plant facilities constructed to support B and C Reactor operations, as well as the cooling water retention basin systems for both B and C Reactors. Interim remedial actions for the 100-B/C Area focused on the waste sites shown in Figure 1-2 that have all been remediated (Appendix A).

1.3.3 Interim Action ROD and ROD Amendment Waste Sites in the 100-H Area

Three OUs are associated with the 100-H Area at the Hanford Site. The 100-HR-1 and 100-HR-2 are source OUs. The third OU, 100-HR-3, is the groundwater OU for the 100-H Area. The 100-H Area contains one reactor that operated from 1949 to 1965. In general, the area contains waste units associated with the original plant facilities constructed to support H Reactor operation. Interim remedial actions for the 100-H Area focused on the waste sites shown in Figure 1-3, of which all have been remediated (Appendix A).

1.3.4 Interim Action ROD and ROD Amendment Waste Sites in the 100-F Area

Three OUs are associated with the 100-F Area at the Hanford Site. 100-FR-1 and 100-FR-2 are source OUs. The third OU, 100-FR-3, is the groundwater OU for the 100-F Area. The 100-F Area contains one reactor that operated from 1945 to 1965. In general, the area contains waste units associated with the original plant facilities constructed to support F Reactor operation. Interim remedial actions for the 100-F Area focused on the waste sites shown in Figure 1-4 that have all been remediated (Appendix A).

1.3.5 Interim Action ROD and ROD Amendment Waste Sites in the 100-K Area

Three OUs are associated with the 100-K Area at the Hanford Site. 100-KR-1 and 100-KR-2 are source OUs. The third OU, 100-KR-4, is the groundwater OU for the 100-K Area. The 100-K Area contains two reactors, 105-KE that operated from 1955 to 1971 and 105-KW that operated from 1955 to 1970. In general, the area contains waste units associated with the original plant facilities constructed to support K Reactor operation. Interim remedial actions for the 100-K Area focused on the waste sites shown in Figure 1-5, of which five have been completely or partially remediated (Appendix A).

1.3.6 Remaining Sites ROD

The Remaining Sites ROD (EPA 1999) contains provisions for removal, treatment, and disposal of miscellaneous sites not covered under prior RODs. Waste sites 600-23 and JA Jones No. 1 were added to the Remaining Sites ROD (as part of the 100-IU-6 OU) by an explanation of significant difference (ESD) (EPA 2000a) issued in June 2000. Another 28 waste sites were added to the Remaining Sites ROD by an ESD issued in March 2004 (EPA 2004). These sites are shown in Figures 1-6 through 1-11. An upcoming ESD is expected to add additional waste sites for confirmatory sampling and/or remove, treat, and dispose (RTD) to the Remaining Sites ROD and, potentially, address other administrative cleanup issues. **These sites and any others from future applicable ESDs are considered to be included in this document without it requiring additional revisions.**

The Remaining Sites ROD also contains provisions for confirmatory sampling at sites identified as candidates for no action. This designation is based on an evaluation of the sites that determined that there is a high level of confidence that these sites comply with remedial action objectives (RAOs) (DOE-RL 1998). Furthermore, the Remaining Sites ROD provides the guidelines by which newly discovered sites may be designated for RTD or categorized as candidates for no action.

1.3.7 100 Area Burial Grounds ROD

The 100 Area Burial Grounds ROD (EPA 2000b) presents the selected interim remedial actions for burial grounds in the 100 Area. Figures 1-12 through 1-16 show the 100 Area burial grounds.

Figure 1-1. 100-D Area Radioactive Liquid Effluent Waste Sites.

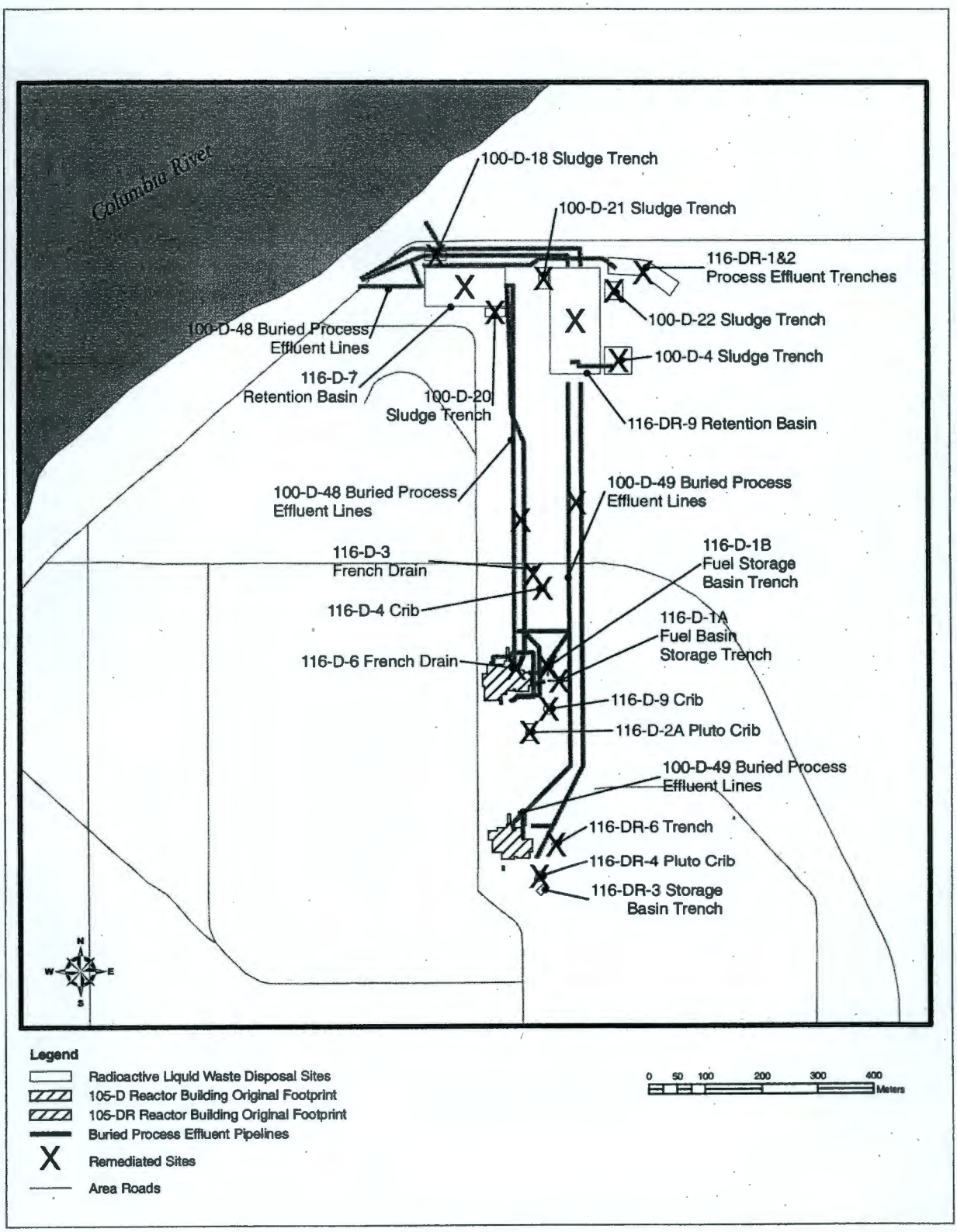


Figure 1-2. 100-B/C Area Radioactive Liquid Effluent Waste Sites.

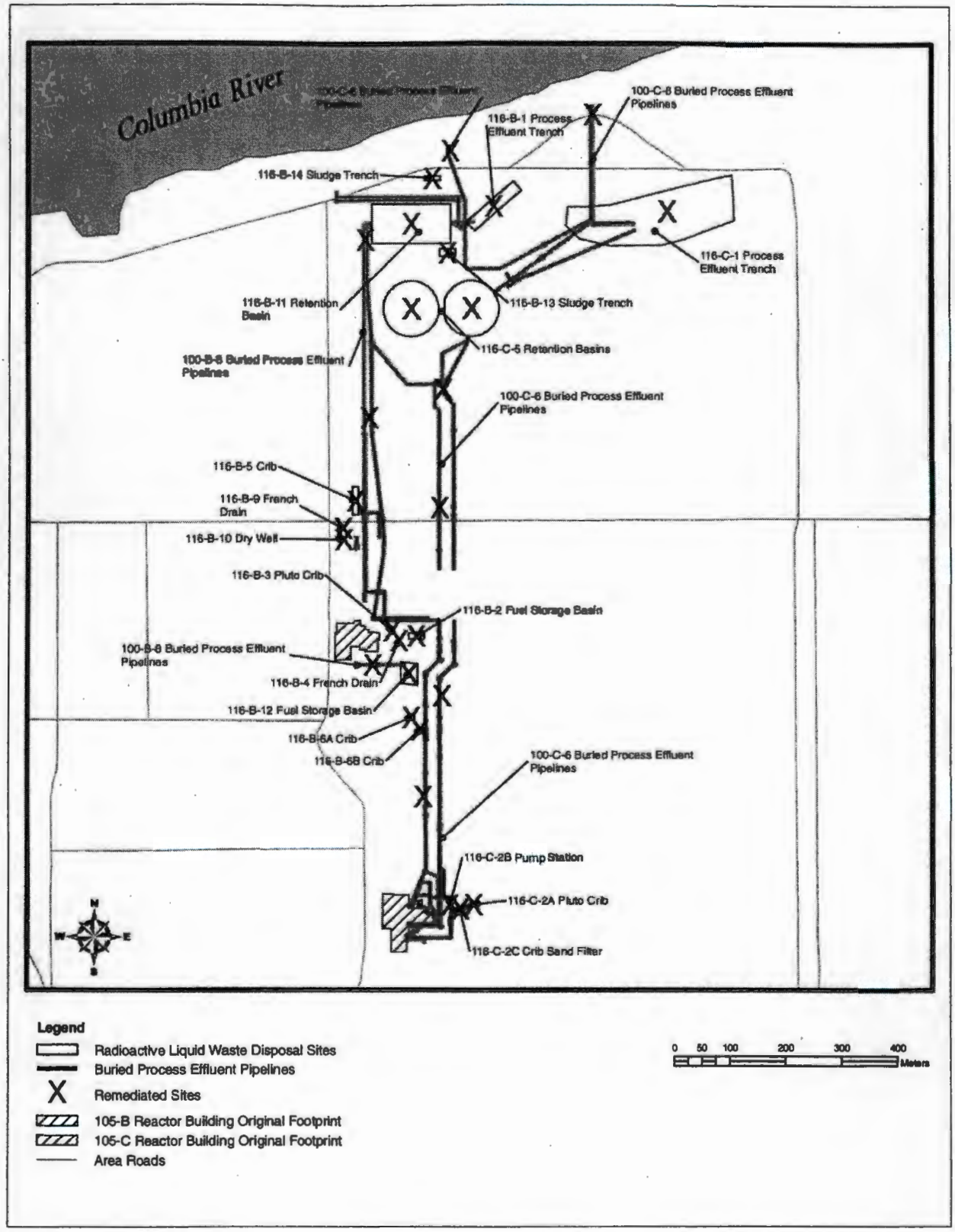


Figure 1-3. 100-H Area Radioactive Liquid Effluent Waste Sites.

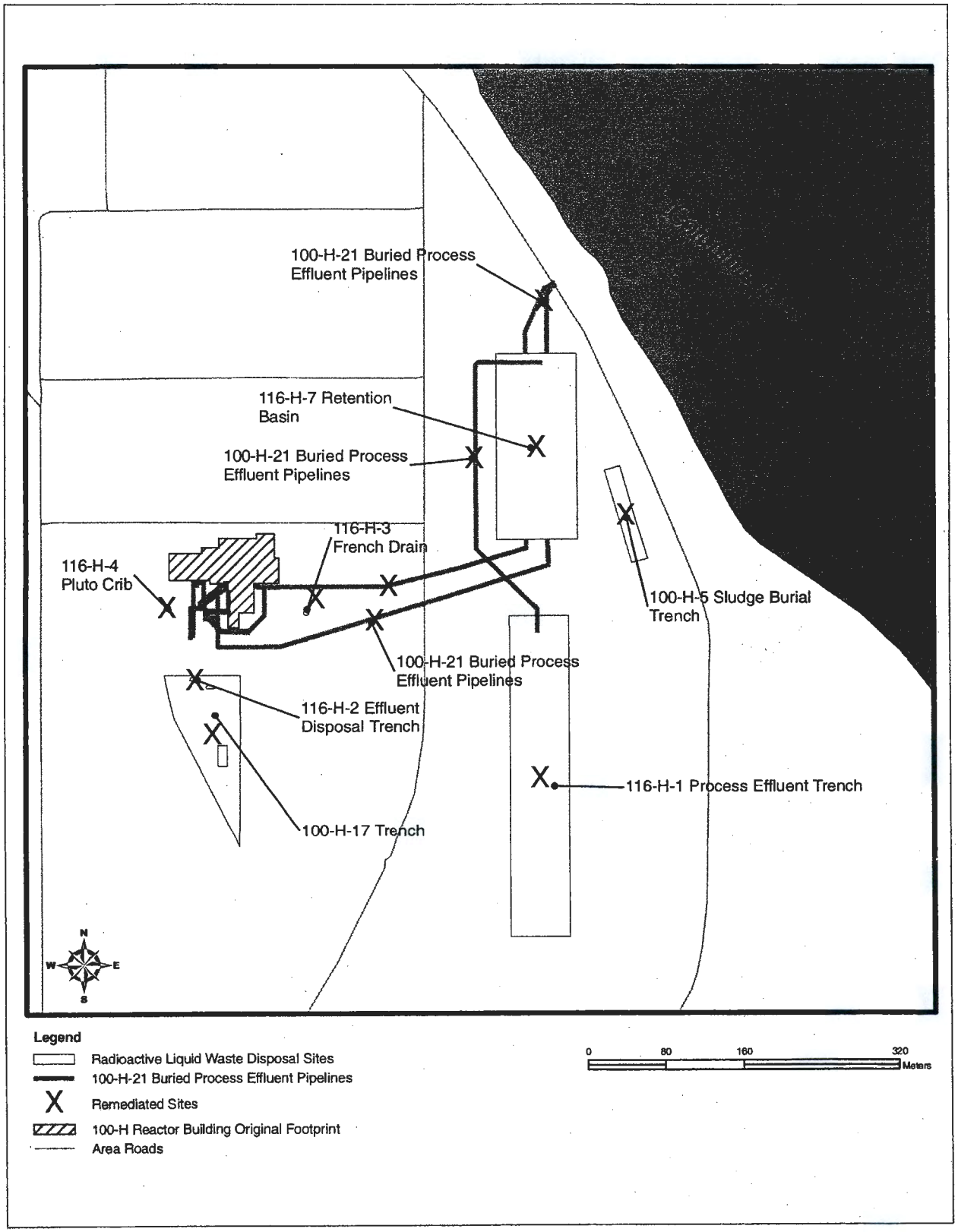


Figure 1-4. 100-F Area Radioactive Liquid Effluent Waste Sites.

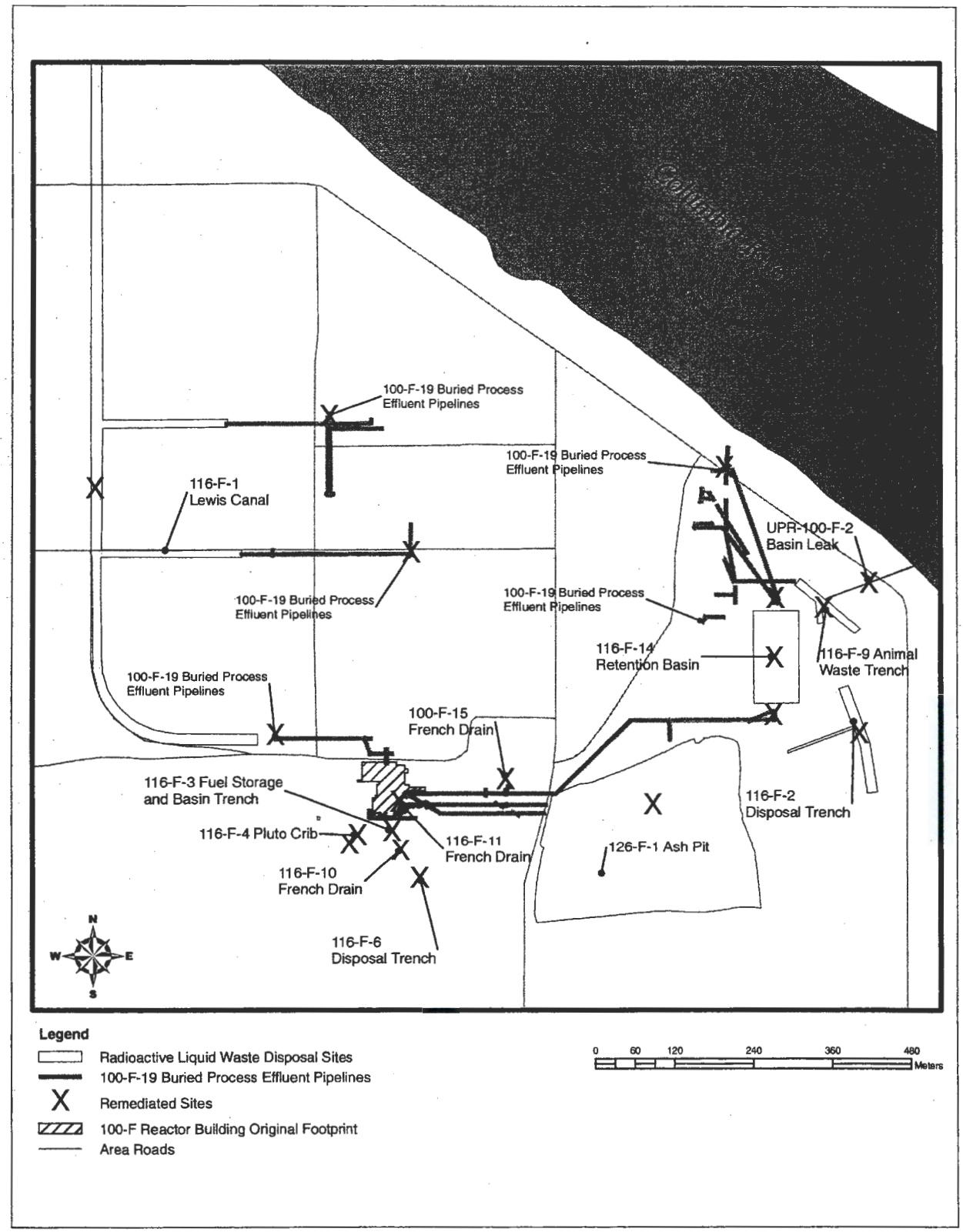


Figure 1-5. 100-K Area Radioactive Liquid Effluent Waste Sites.

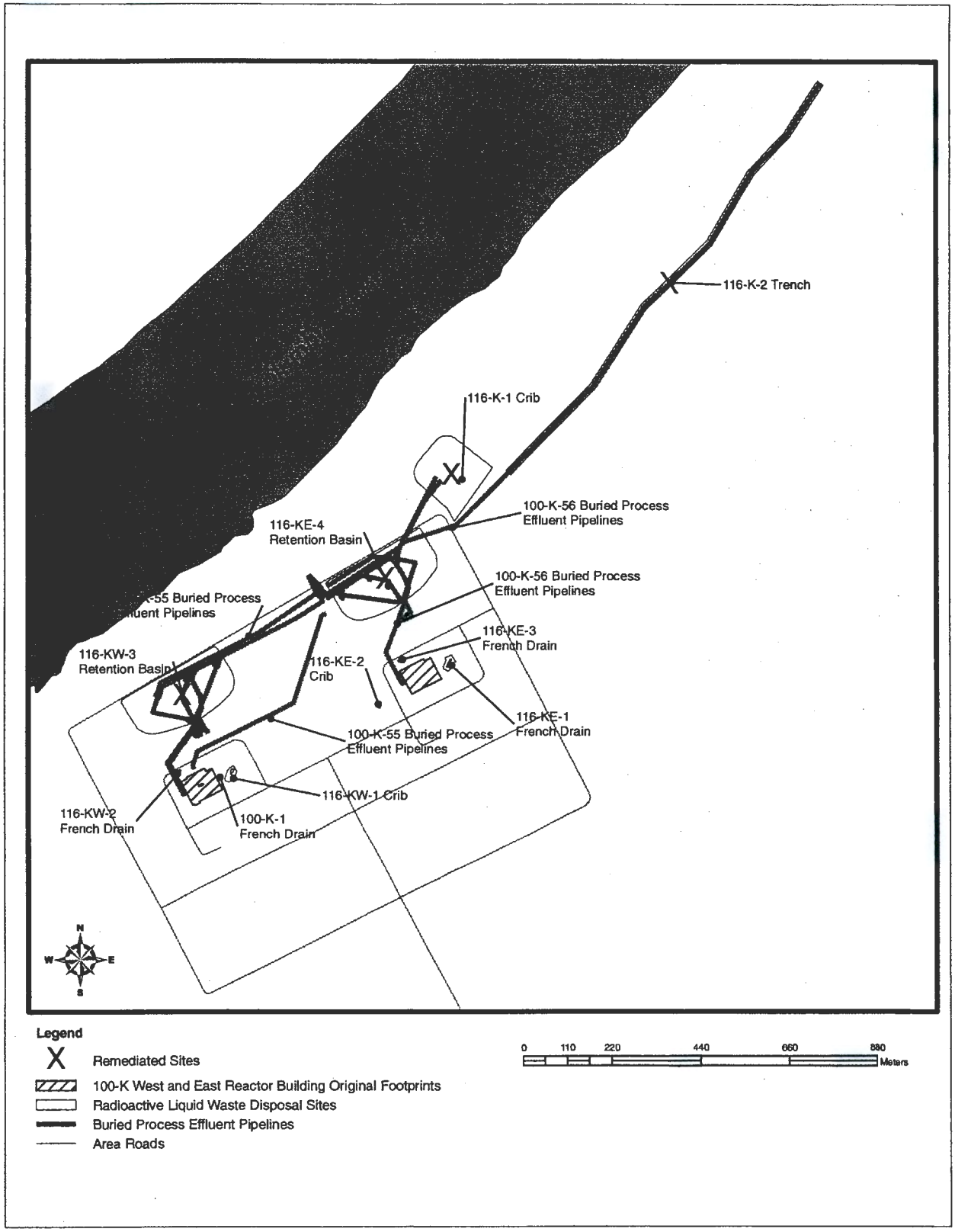


Figure 1-6. 100-B/C Area Remaining Sites.

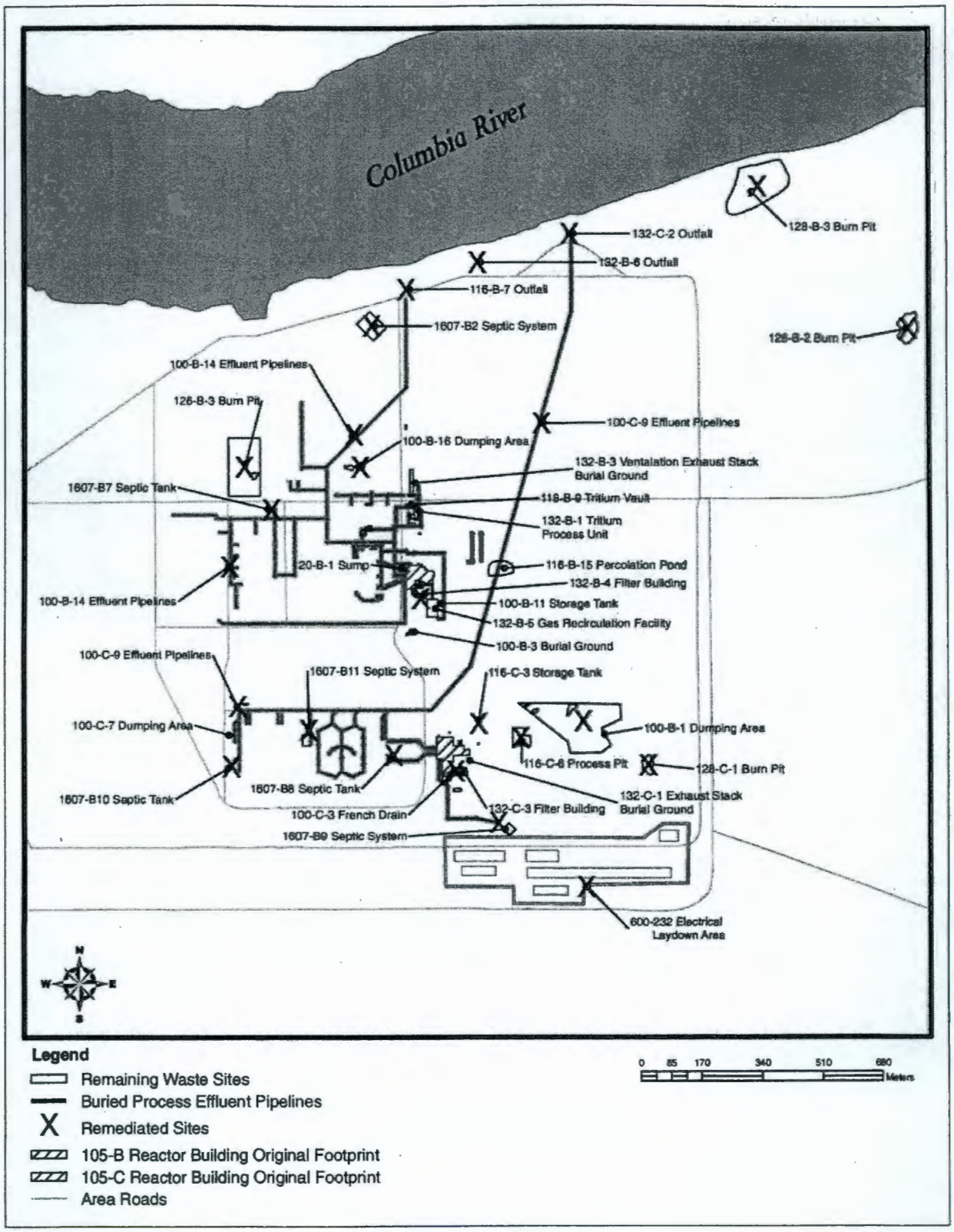


Figure 1-7. 100-D Area Remaining Sites.

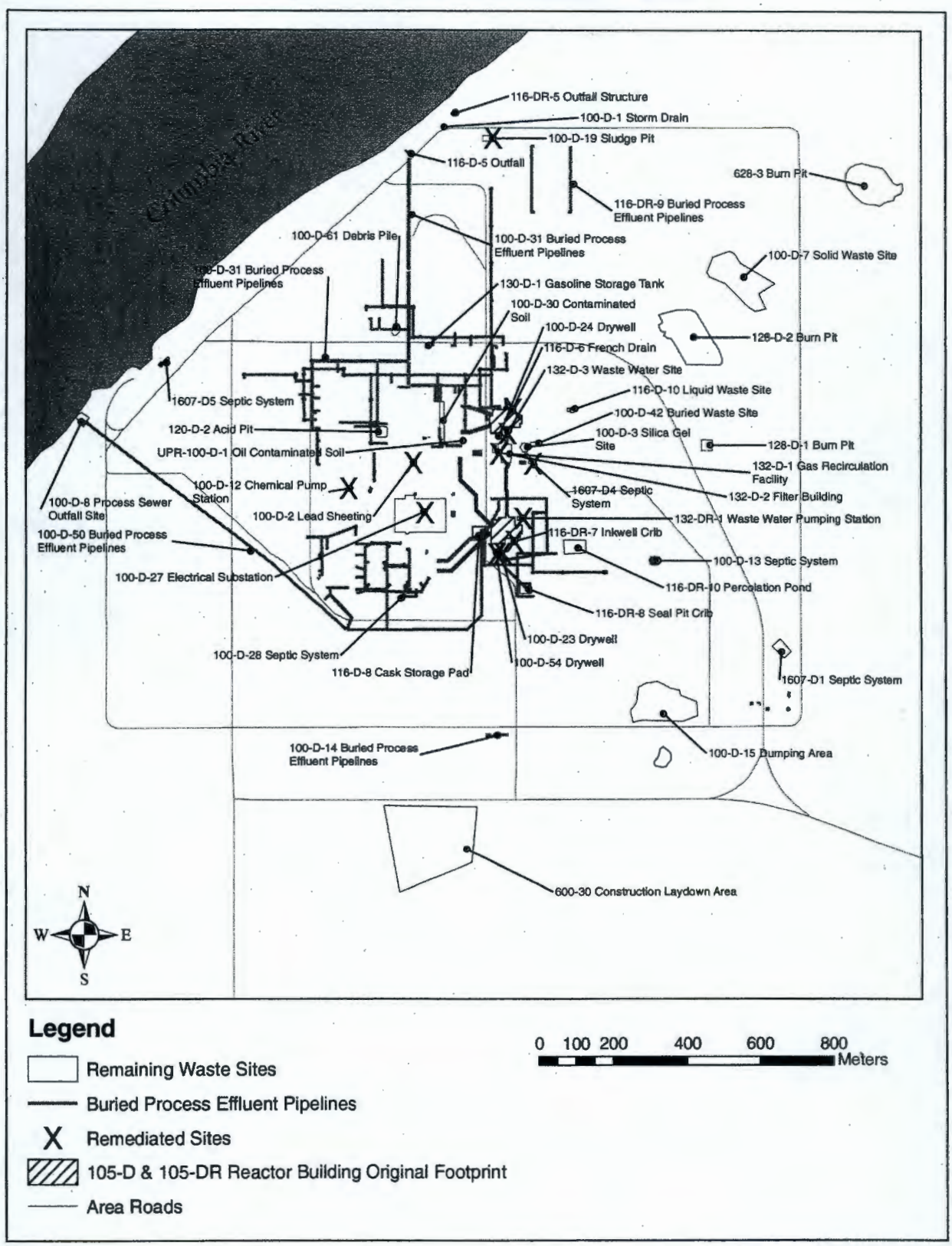


Figure 1-8. 100-F Area Remaining Sites.

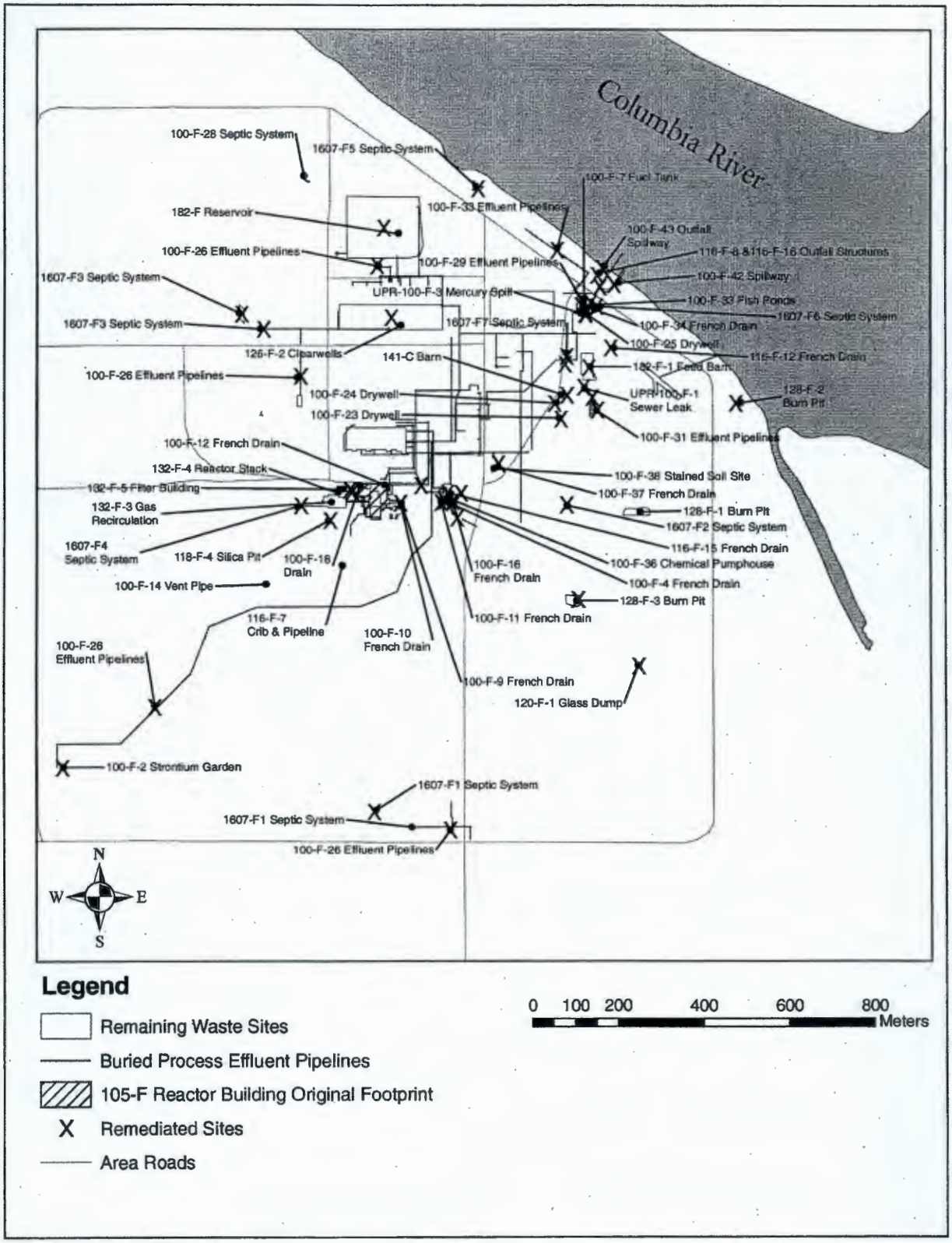


Figure 1-9. 100-H Area Remaining Sites.

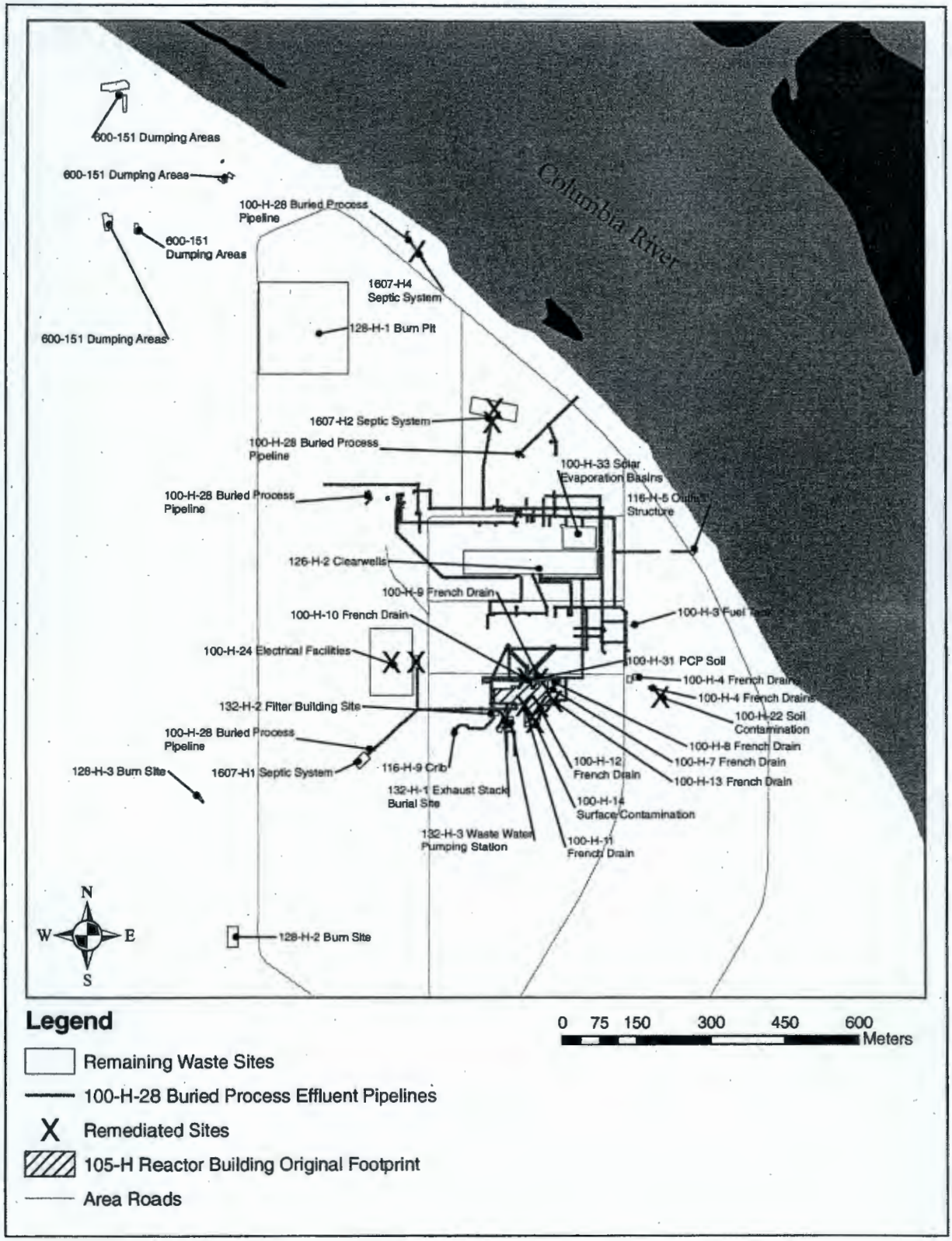


Figure 1-10. 100-K Area Remaining Sites.

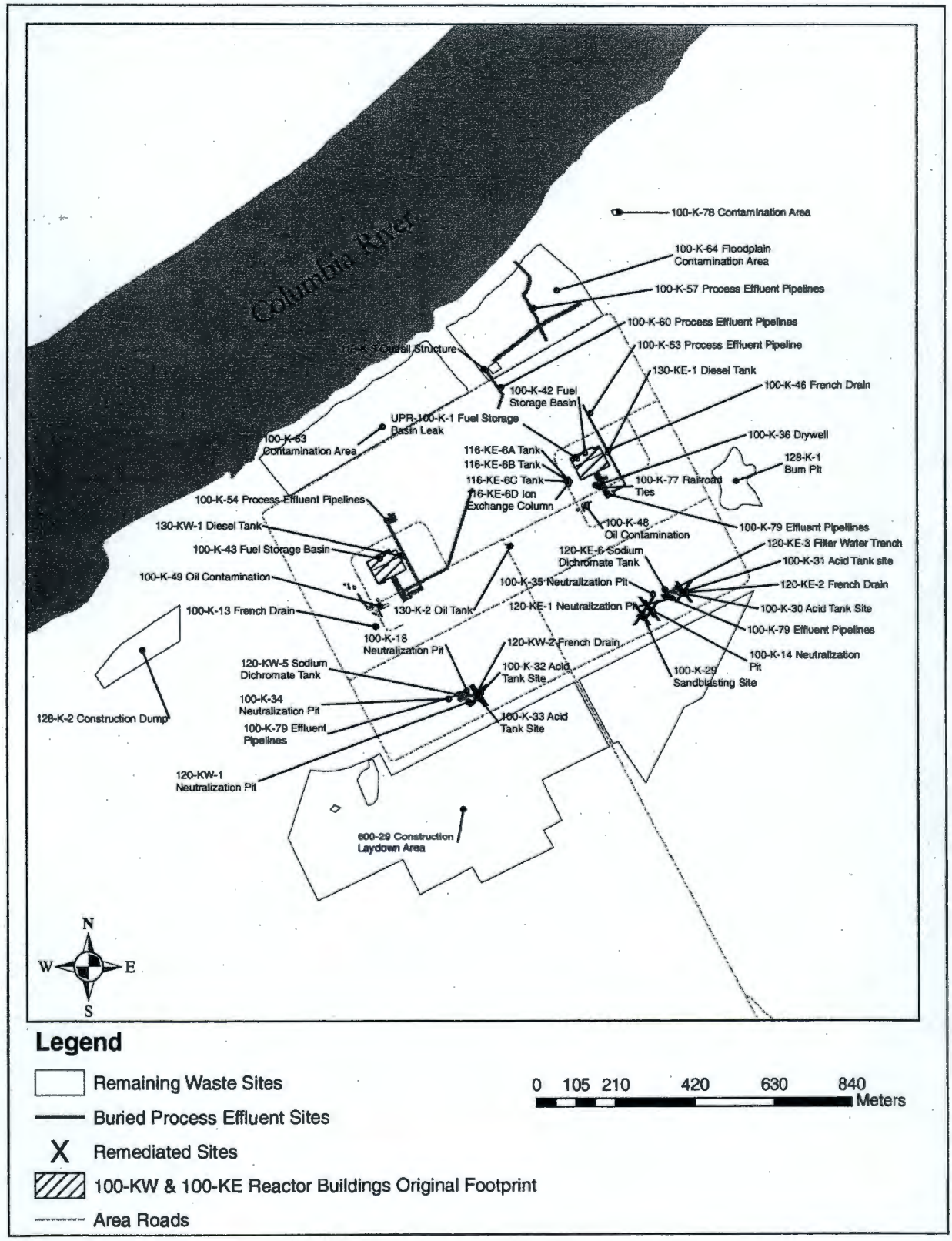


Figure 1-11. 100-IU-2 and 100-IU-6 Operable Unit Remaining Sites.

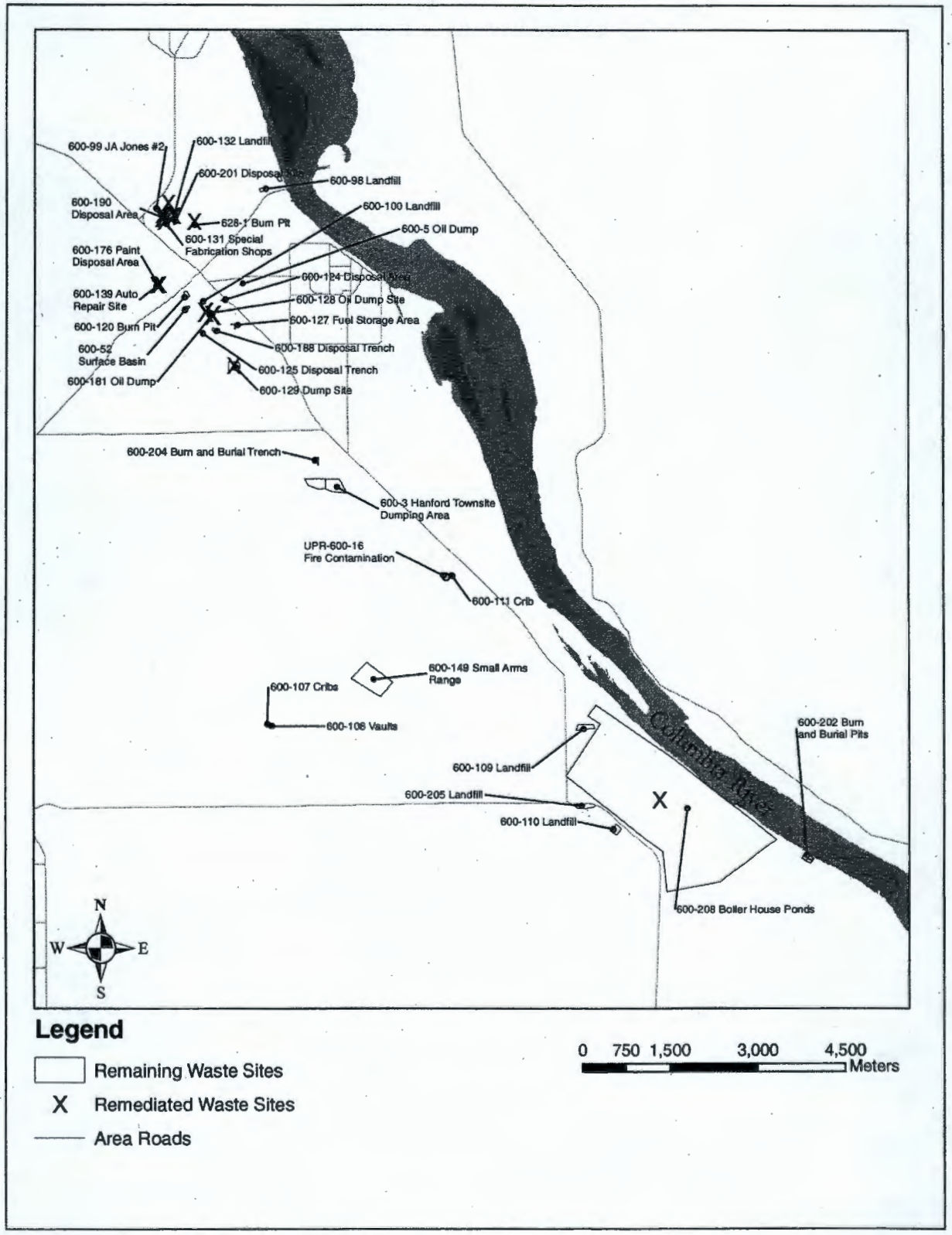


Figure 1-12. Burial Grounds at the 100-B/C Area.

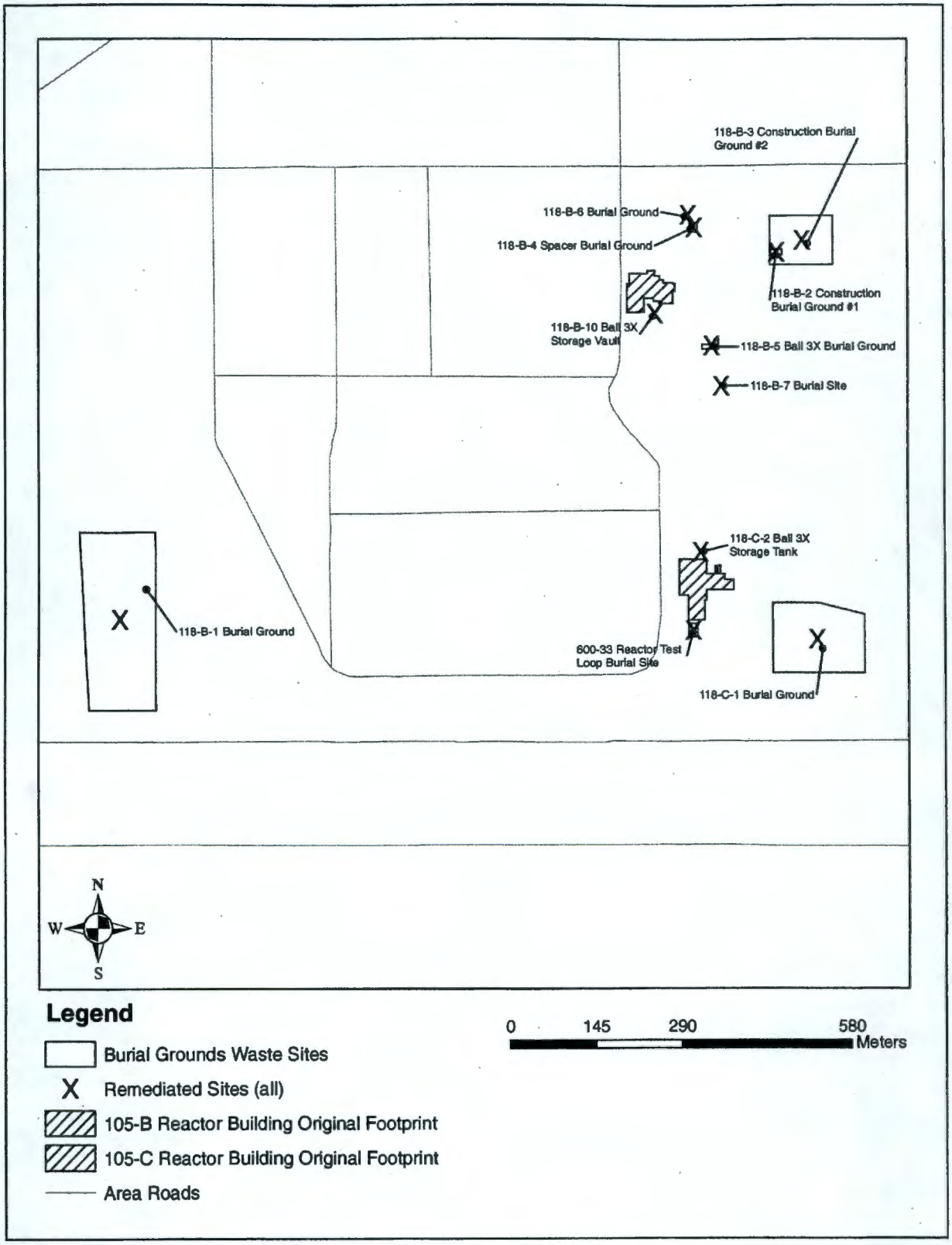


Figure 1-13. Burial Grounds at the 100-K Area.

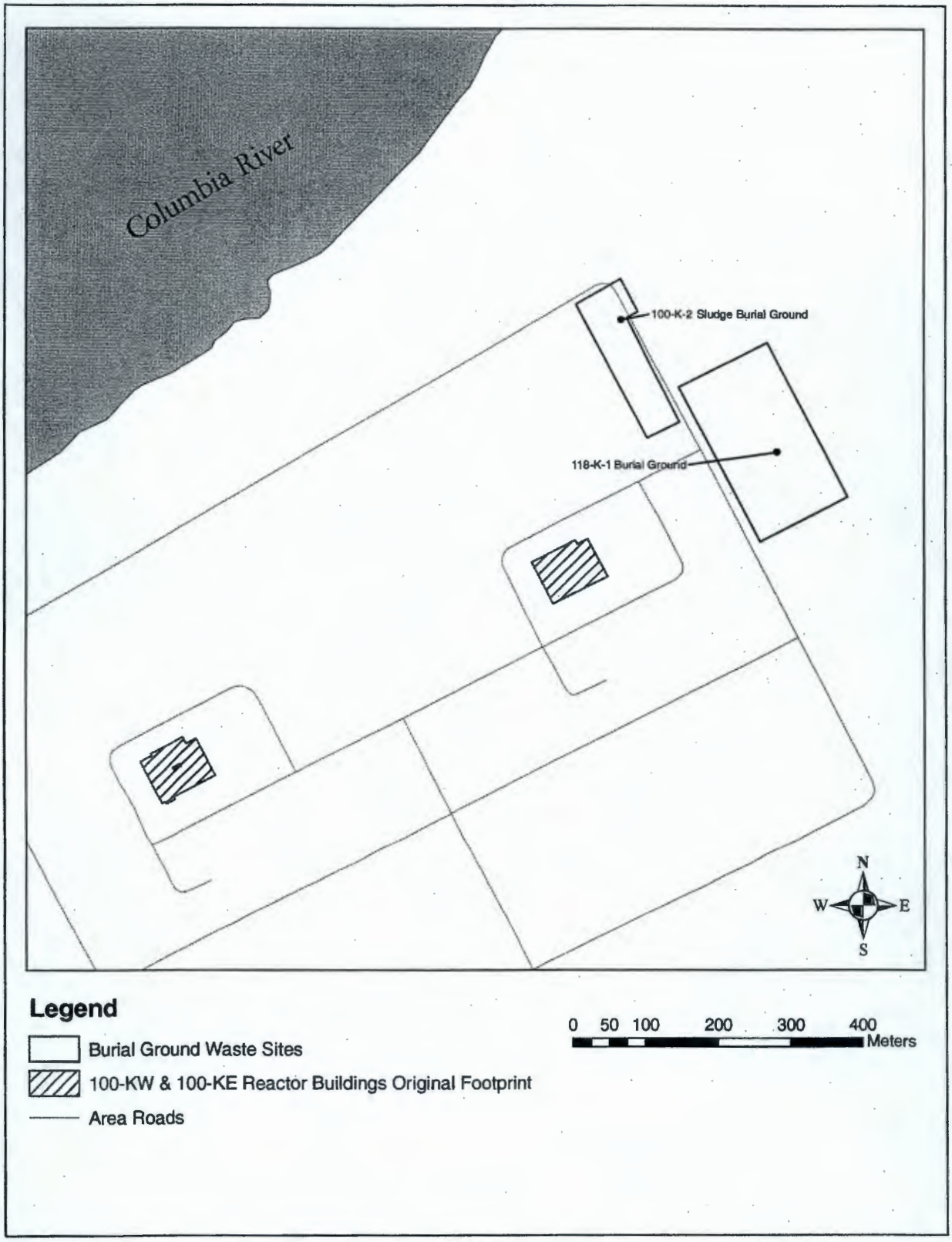


Figure 1-14. Burial Grounds at the 100-D Area.

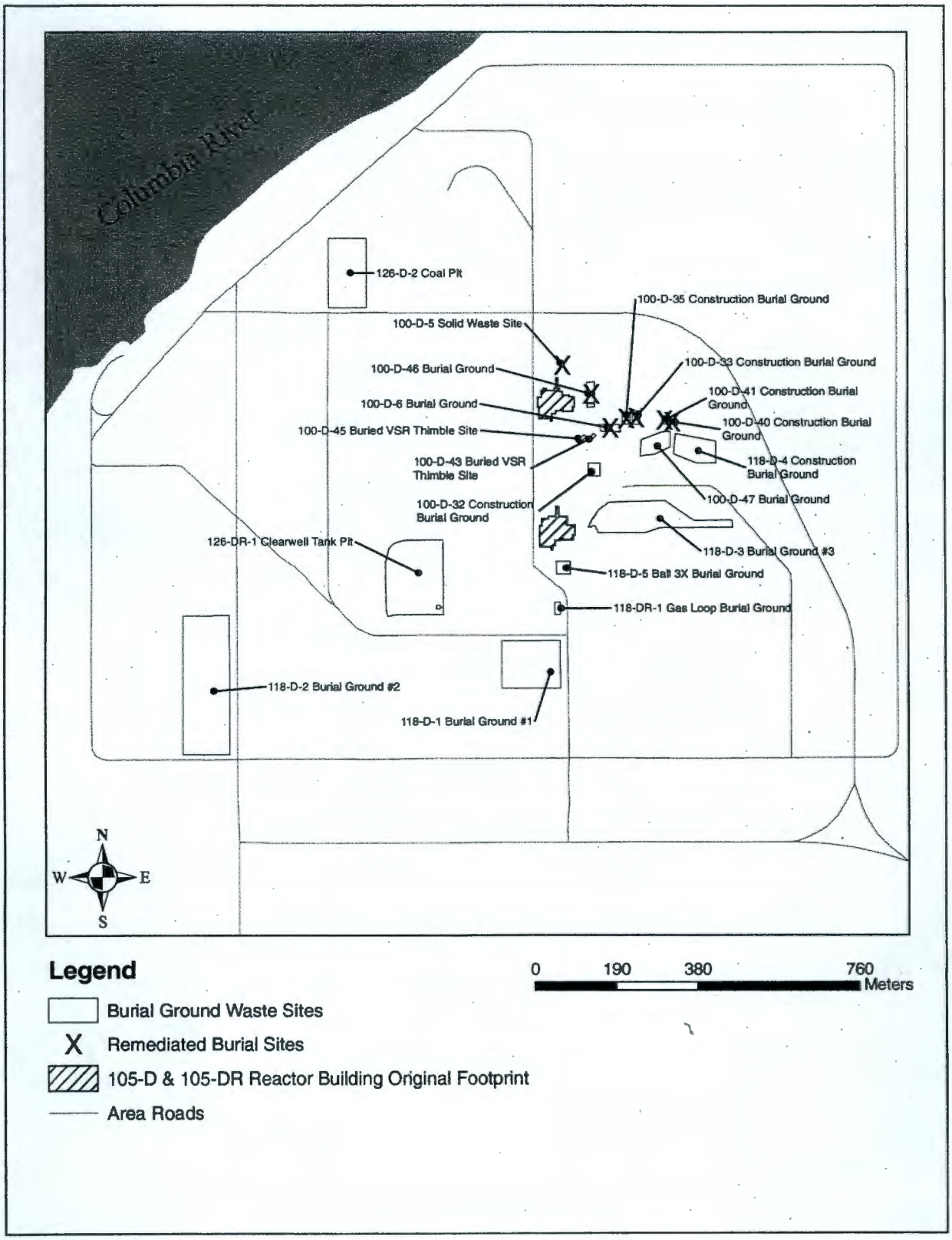


Figure 1-15. Burial Grounds at the 100-H Area.

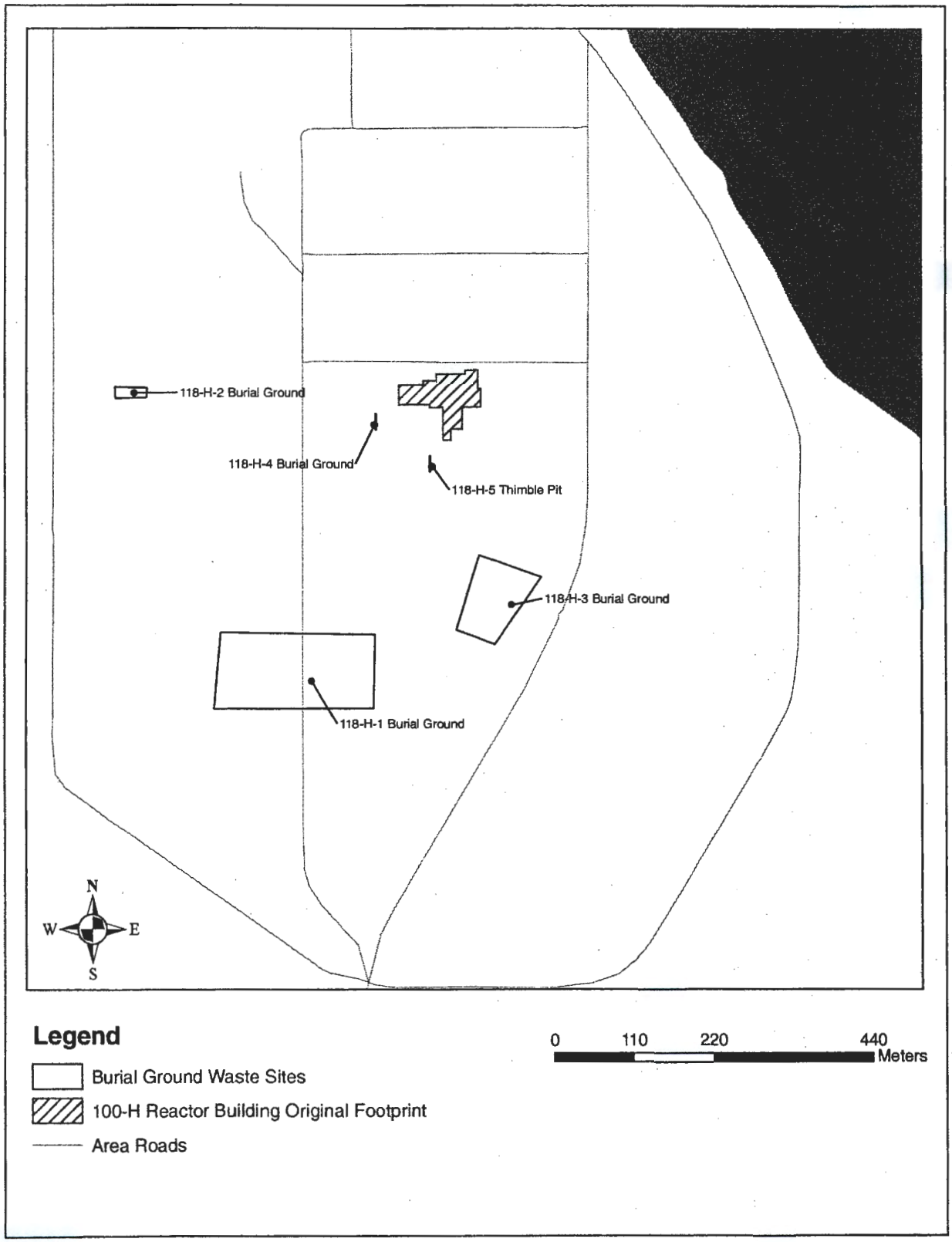
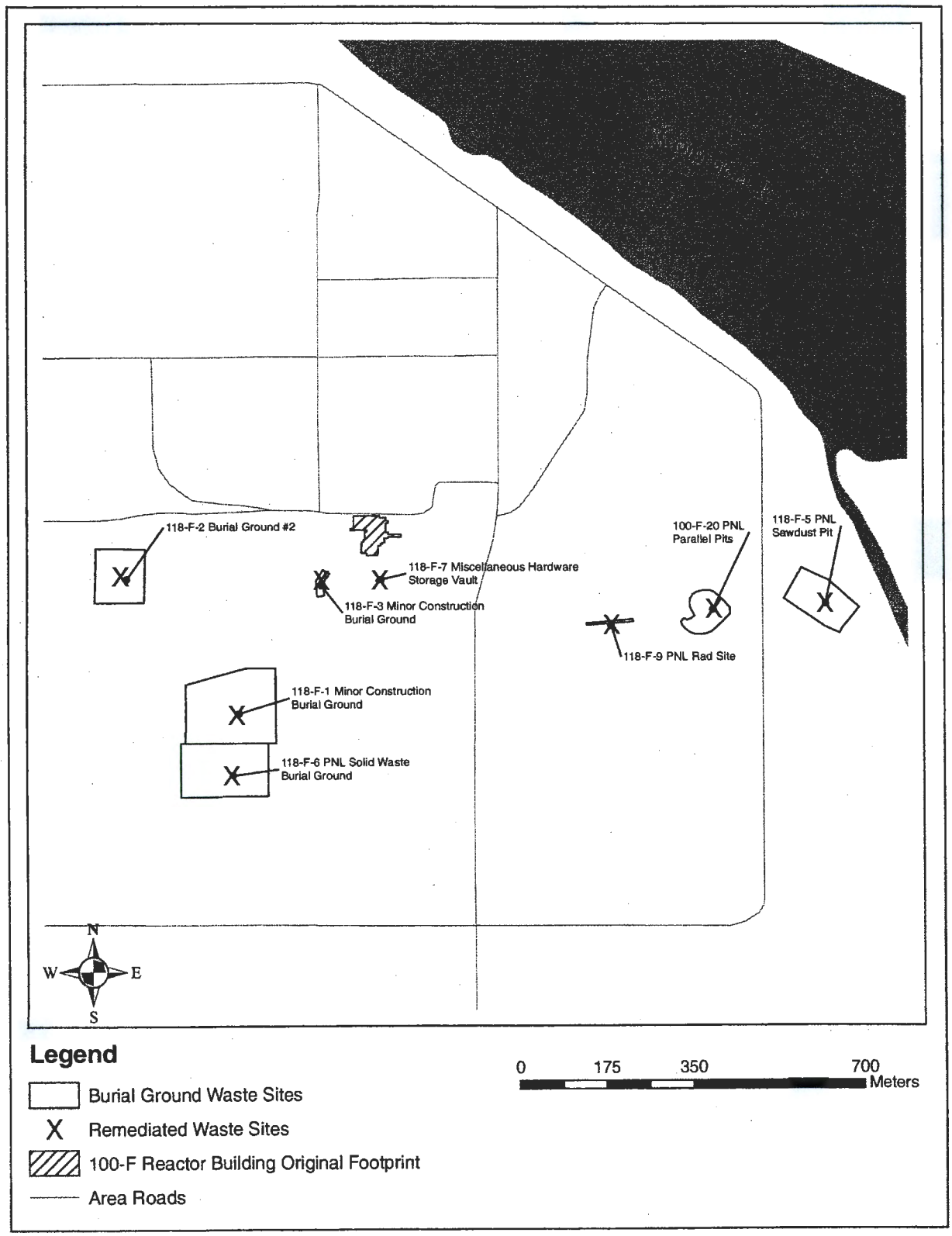


Figure 1-16. Burial Grounds at the 100-F Area.



2.0 BASIS FOR REMEDIAL ACTION

2.1 RECORD OF DECISION SUMMARY AND DECISION DEFINITION

2.1.1 Remedial Action Objectives

The RAOs set forth in the RODs (EPA 1995, 1997a, 1999, 2000a, 2000b) are narrative statements that define the extent to which the waste sites require cleanup to protect human health and the environment. The RAOs identified in the RODs apply to contaminants in soils, structures, and debris. The Interim Action ROD specifically defines three RAOs. The Remaining Sites ROD specifically defines two RAOs, which are the same as the first two RAOs in the Interim Action ROD. The 100 Area Burial Grounds ROD also specifically defines two RAOs, which are the same as the first two RAOs in the Interim Action ROD. The RAOs cited below are taken directly from the RODs (in italics). Following each citation is a brief description of the intent of each RAO and a discussion of the point of compliance.

1. "*Protect human and ecological receptors from exposure to contaminants in soils, structures, and debris by dermal exposure, inhalation, or ingestion of radionuclides, inorganics or organics*" (EPA 1995, page 25; EPA 1999, page 26; and EPA 2000b, page 19).

   The Interim Action ROD elaborates, saying "This RAO will be achieved through excavation to the State of Washington Model Toxics Control Act (MTCA) (WAC 173-340, 1996) levels for organic and inorganic chemical constituents in soil to support unrestricted (residential) use, and the draft [U.S. Environmental Protection Agency] (EPA) (40 CFR 196) and the draft Nuclear Regulatory Commission (10 CFR 20) proposed protection of human health standards of 15 mrem/yr in soils above background for radionuclides" (EPA 1995, page 25). The draft U.S. Nuclear Regulatory Commission regulation (10 *Code of Federal Regulations* [CFR] 20) was withdrawn and is no longer applicable.

   Subsequent to the Interim Action ROD being issued, the proposed EPA regulation (40 CFR 196) was withdrawn. However, the 100 Area Burial Grounds ROD states "Protection will be achieved by reducing concentrations of contaminants in the upper 4.6 meters (15 ft) of soil exposure scenario. The levels of reduction will be such that for radionuclides the EPA CERCLA risk range of 10^{-4} to 10^{-6} increased cancer risk will be achieved. To address this objective, the total dose for radionuclides shall not exceed 15 mrem/yr above Hanford site background for 1,000 years following remediation also, State of Washington MTCA method B limits for inorganics and organics (See Table 2)" (EPA 2000b, page 19). Cleanup values are shown in Table 2 on pages 20 and 21 of EPA (2000b). If a waste site is an engineered structure, protection will be achieved by reducing concentrations of contaminants within the shallow zone (i.e., surface to 4.6 m [15ft] deep) to shallow zone cleanup standards. Direct exposure, groundwater protection, and river protection remedial action goals (RAGs) are applicable to soils within 4.6 m [15 ft] of the ground surface and by reducing concentrations of contaminants within the deep zone (i.e., greater than 4.6 m [15ft] below the ground surface) to deep zone cleanup standards (groundwater protection and river protection RAGs are applicable to soils greater than 4.6 m [15 ft] below the ground surface).

Washington Administrative Code (WAC) 173-340 (1996) defines the point of compliance for soil cleanup levels as follows:

"For soil cleanup levels based on human exposure via direct contact, the point of compliance shall be established in the soils throughout the site from the ground surface to 15 ft 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" (WAC 173-340-740[6][c]) (1996).

2. "*Control the sources of groundwater contamination to minimize the impacts to groundwater resources, protect the Columbia River from further adverse impacts, and reduce the degree of groundwater cleanup that may be required under future actions.*" (EPA 1995, page 25; EPA 1999, page 26; and EPA 2000b, page 22).

   The Interim Action ROD states "This RAO will be achieved by protection of groundwater that has not been impacted such that contaminants remaining in the soil after remediation do not result in an adverse impact to groundwater that could exceed maximum contaminant levels (MCL) and nonzero [maximum contamination level goals] MCLGs under the Safe Drinking Water Act (SDWA). Another consideration for achievement of this RAO is protection of the Columbia River such that contaminants remaining in the soil after remediation do not result in an impact to groundwater, and therefore the Columbia River, that could exceed the Ambient Water Quality Criteria (AWQC) under the Clean Water Act for protection of fish. Since there are no AWQC for radionuclides, MCLs will be used" (EPA 1995, pages 25 and 26).

   The Interim Action ROD defines the point of compliance for soil cleanup levels protective of groundwater as a designated point of compliance beneath or adjacent to the waste site in groundwater. Measurement of compliance for protection of the river will be at a near-shore well, in the downgradient plume. The location and measurement of the point of compliance is to be defined by EPA and the Washington State Department of Ecology (Ecology). Monitoring for compliance will be performed at the defined point (EPA 1995, page 25).

   The 100 Area Burial Grounds ROD states "Protection will be such that contaminants remaining in the soil after remediation do not result in an adverse impact to groundwater underneath the site that could exceed Maximum Contaminant Levels (MCLs) under the Safe Drinking Water Act (SDWA)" (EPA 2000b, page 22).

   Further, "Protection of the Columbia River from adverse impacts such that contaminants remaining in the soil after remediation do not result in an impact to groundwater and, therefore, the Columbia River that could exceed the Ambient Water Quality Criteria (AWQC) under the Clean Water Act for protection of fish. Since there are no AWQC for radionuclides, MCLs will be used. The protection of receptors (aquatic species, with emphasis on salmon) in surface waters will be achieved by reducing or eliminating further contaminant loadings to groundwater such that receptors at the groundwater discharge in the Columbia River are not subject to additional adverse risks. Each of the reactor areas has an extensive well network and monitoring plans that have been approved by the lead regulatory agency for each reactor Area. Data from the networks is reviewed periodically to assure

adequate information is collected. Any changes to the monitoring plans will require approval of the lead regulatory agency" (EPA 2000b, page 22).

3. "*To the extent practicable, return soil concentrations to levels that allow for unlimited future use and exposure. Where it is not practicable to remediate to levels that will allow for unrestricted use in all areas, institutional controls and long-term monitoring will be required*" (EPA 1995, page 26).

   This RAO would be achieved by (1) meeting the first two objectives as defined above; (2) removing waste sites to the bottom of the engineered structure; and (3) providing institutional controls, as required (see Section 2.1.2).

   The Interim Action ROD also indicates that for establishing numerical RAGs protective of human health, the RAOs will be met by using the residential exposure scenario. Removal of soil and debris exceeding human health based goals and replacement (i.e., backfilling) with clean material also will meet the objective of protection of ecological receptors. Note that the top 4.6 m (15 ft) of soil is defined from the ground surface at the time of disposal.

4. "*Provide conditions suitable for future land use of the 100 Areas*" (EPA 2000b, page 22).

   According to the 100 Area Burial Grounds ROD, "This RAO would be achieved by meeting the first two objectives as defined above" (EPA 2000b, page 22).

Once RAOs have been identified, it is necessary to develop numerical RAGs for use in remedial design and to verify that remedial action has achieved the RAOs. The RAO framework involves the following:

- Calculating contaminant-specific concentrations in soil that correspond to the RAGs for use in remedial design (see Section 2.1.4)

- Developing a verification methodology for use in remedial action to determine if residual concentrations in soil achieve the RAGs (see Section 3.6).

2.1.2 Remedial Action Goals

RAGs are the contaminant-specific numerical cleanup criteria developed to ensure that the remedial actions to be implemented will meet the RAOs set forth in Section 2.1.1 and the RODs (EPA 1995, 1997a, 1999, 2000a, 2000b). The RAGs are based on applicable or relevant and appropriate requirements (ARARs), to-be-considered (TBC) information, points of compliance, and assumed land use for the remedial action identified in the RODs (EPA 1995, 1997a, 1999, 2000a, 2000b).

The first RAO will be achieved by meeting the following requirements:

- WAC 173-340-740 (1996) is currently the basis of the RAGs for nonradioactive constituents since the interim action RODs predate WAC-173-340-740, 2001 (Section 2.1.2.1)

- The EPA proposed standards for radionuclides (Section 2.1.2.2).

The second RAO will be achieved by meeting the following requirement:

- Protection of groundwater and the Columbia River (Sections 2.1.2.3, 2.1.2.4, and 2.1.2.5).

The third RAO will be achieved by:

- Meeting the requirements to achieve the first two RAOs
- Removing waste to the bottom of the engineered structure when the engineered structure exceeds the first RAO
- Providing institutional controls, as required, while RL controls the site and in the future in the event that RL relinquishes control of the site (see Section 2.1.5).

The fourth RAO will be achieved by:

- Meeting the requirements to achieve the first two RAOs.

2.1.2.1 Remedial Action Goals for Nonradioactive Contaminants in Soil. Cleanup standards for nonradioactive (i.e., inorganic and organic) contaminants in near-surface soil (to a depth of 4.6 m [15 ft] from the ground surface defined as the grade at the time of disposal) are specified under the 1996 version of the WAC 173-340 (1996) cleanup regulations that were in effect at the time the September 1995 Interim Action Record of Decision (EPA 1995) was approved. Method B (WAC 173-340-705) (1996) describes cleanup levels for groundwater, surface water, soil, and air, assuming a residential exposure scenario.[1] Cleanup levels for individual hazardous substances are established using applicable state and federal laws and the risk equations specified in the 1996 WAC 173-340-720 through 750 (1996). Cleanup levels for individual carcinogens are based on the upper bound of the estimated excess lifetime cancer risk of one in one million (1×10^{-6}). Cleanup levels for individual noncarcinogenic substances are set at concentrations that are anticipated to result in no acute or chronic toxic effects on human health and the environment; this level corresponds to a hazard quotient of less than one. Cleanup levels are calculated using carcinogenic potency factors and noncarcinogenic reference doses available through the EPA Integrated Risk Information System (IRIS) database or other EPA sources as described in WAC 173-340-708 (1996). As EPA updates the carcinogenic potency factors and noncarcinogenic reference doses in the IRIS database or other EPA sources, the RAGs and updated cleanup standards will be included in the applicable verification packages.

The Hanford Site background for arsenic is approximately 6.5 mg/kg and was determined to be the cleanup level for the 100 Areas at the start of remediation. Additionally, the statewide

1 Method B is based on a residential land use scenario, including the potential for a residential basement. It is assumed that deed restrictions or other institutional controls would be applied at waste sites as necessary to preclude direct exposure to residual contaminants in deep soils that might remain onsite.

arsenic background is approximately 7.0 mg/kg (Ecology 1994). However, due to the elevated concentrations of arsenic in the 100 Area surface soil because of pre-Hanford farming uses of lead arsenate pesticides (Yokel and Delistraty 2003), the Tri-Parties (EPA, Ecology, and RL) agreed in May 2000 to revise the cleanup level in the 100 Areas from 6.5 mg/kg to 20 mg/kg. The 20 mg/kg cleanup level is the WAC 173-340 (1996) Method A value used for sites in the State of Washington that contain a small number of hazardous substances, and should not otherwise be used for Hanford Site waste sites.

If a waste site involves multiple contaminants and/or multiple pathways of exposure, WAC 173-340-705 (1996) Method B cleanup levels for individual substances must be modified in accordance with the human health risk assessment procedures outlined in WAC 173-340-708 (1996). This modification of cleanup levels, if necessary, would take place during the verification of site cleanup following remediation. Under this method, the total excess lifetime cancer risk for a site shall not exceed one in one hundred thousand (1×10^{-5}), and the hazard index for substances with similar noncarcinogenic toxic effects shall not exceed one (WAC 173-340-705[4]) (1996).

Cleanup levels for some contaminants may be less than area background values or required detection limits (RDLs). Where WAC 173-340 (1996) Method B cleanup levels are less than area background concentrations, cleanup levels may be set at concentrations that are equal to the agreed-upon site or area background concentrations (WAC 173-340-700(4)(d)) (1996). Area background for nonradioactive contaminants in soil was characterized for the Hanford Site in *Hanford Site Background: Part 1, Soil Background for Nonradioactive Analytes* (DOE-RL 2001b). Similarly, where WAC 173-340 (1996) Method B cleanup levels are less than practical quantitation limits for nonradioactive contaminants, cleanup levels will default to the practical quantitation limits, which are considered equivalent to RDLs in this RDR/RAWP (WAC 173-340-707[2]) (1996). Therefore, the cleanup level for an individual inorganic or organic contaminant in soil reflects the greatest value among the WAC 173-340 (1996) Method B cleanup level, the area background concentration, and the RDLs; but in no case shall cleanup levels be greater than concentrations specified under WAC 173-340 (1996) Method C (WAC 173-340-706 [1][a]) (1996). The WAC 173-340 (1996) cleanup levels, Hanford Site-specific background concentrations, RDLs, and RAGs for nonradioactive contaminants in near-surface soil are presented in Appendix B.

In addition to the cleanup levels for a rural-residential land-use scenario set forth by WAC 173-340-740(3) (1996), alternative human exposure scenarios, including Native American and avid recreationalist exposure scenarios, are being evaluated by other programs. Results of these evaluations will support development of a final ROD.

2.1.2.2 Remedial Action Goals for Radionuclide Contaminants in Soil. The RAGs for radionuclide contaminants in soil are based on the EPA draft proposed radionuclide soil cleanup standards. These proposed standards, as described in the "Notice of Proposed Rulemaking for Radiation Site Cleanup Regulations" (40 CFR 196), would limit radiation doses from contaminated sites to 15 mrem/yr above site background levels for 1,000 years following the completion of a remedial action. The 1,000-year requirement ensures that the proposed standard accounts for the decay of radionuclides to daughter products that are more radioactive.

The development of cleanup standards for the 100 Area will not be affected because the principal radionuclides of concern in the 100 Area (e.g., cobalt-60, cesium-137, europium-152, and europium-154) do not decay to daughter products that are more radioactive.

The 15 mrem/yr proposed standard corresponds to a lifetime increased cancer risk of 3×10^{-4}, based on the following assumptions:

- The future land use will be residential (includes irrigation).
- Future residents are potentially exposed for 30 years.
- Potential exposure pathways are considered in assessing exposure to future residents. (The exposure pathways considered are external exposure, inhalation, crop ingestion, meat ingestion, fish ingestion, drinking water ingestion, and soil ingestion.)

The 15 mrem/yr standard falls within the range of other radiation protection standards promulgated by the EPA; for example, standards employed under the *Uranium Mill Tailings Radiation Control Act of 1978* and the "National Emissions Standards for Hazardous Air Pollutants" (NESHAP) (40 CFR 61).

Limiting exposure levels to 15 mrem/yr above background acknowledges that background varies from site to site. Radionuclide measurement techniques must distinguish site contamination from naturally occurring radionuclides. The radionuclides of concern in the 100 Area (e.g., americium-241, cobalt-60, cesium-137, europium-152, europium-154, strontium-90, and plutonium-239/240) are present at very low concentrations in background soils. Background concentrations of radionuclides in soils at the Hanford Site were published in *Hanford Site Background: Part 2, Soil Background for Radioactive Analytes* (DOE-RL 1996b).

To determine when remedial action has achieved the 15 mrem/yr cleanup level, radionuclide concentrations (pCi/g) in soil must be converted to a dose rate (mrem/yr) using a dose assessment model. The RESidual RADioactivity (RESRAD) model was selected as the dose assessment model for generating RAGs for radionuclide contaminants in soil and for verifying that concentrations remaining after remedial action achieve the 15 mrem/yr cleanup level. The RESRAD model was developed by Argonne National Laboratory (ANL 2001) to implement DOE guidelines for residual radioactive material in soil. The RESRAD model has been accepted by EPA and Ecology for performing dose assessments to support the 15 mrem/yr standard. The most current version of RESRAD will be used for conducting dose assessments (ANL 2007).

The use of a dose assessment model requires specification of pathways of exposure to a hypothetical receptor of radionuclides present in the soil, and development of assumptions and input parameters for estimating exposures and doses to the receptor from radionuclides in the soil. Specific RESRAD input parameters used to calculate the RAGs for radionuclide contaminants in soil are listed in Table B-8 in Appendix B.

The RESRAD model was used to calculate concentrations of individual radionuclides in soil that correspond to a dose rate of 15 mrem/yr. Single radionuclide soil concentrations corresponding

to a 15 mrem/yr dose, Hanford Site-specific background concentrations, RDLs, and RAGs for radionuclides in near-surface soil are presented in Appendix B. As was the case for nonradioactive contaminants in soil, the cleanup level for an individual radionuclide contaminant in soil reflects the greatest value among the single radionuclide soil concentration corresponding to a 15 mrem/yr dose, the area background concentration, and the RDLs.

The values in Appendix B assume that a single radionuclide contributes the entire dose and were calculated using generic site model input parameters; therefore, these values are intended for use in estimating contamination volumes, screening field sampling and analytical data, and guiding remediation. They are not intended to represent final cleanup concentrations to be achieved by remedial action at a particular site. The expectation is that most sites will have multiple radionuclides driving the cleanup; therefore, a cumulative dose of 15 mrem/yr would potentially result in individual radionuclide concentrations that are lower than the values presented in Appendix B. During the verification process, site-specific input parameters will be used in the RESRAD model to verify that residual radionuclide concentrations achieve the cleanup standard. Section 3.6 describes the goals attainment process in detail.

2.1.2.3 Remedial Action Goals for Nonradioactive Contaminants in Water – Protection of Groundwater/Columbia River. RAGs for nonradioactive contaminants in water, protective of groundwater, are based on MCLs and WAC 173-340-720(3)(1996) levels. For each nonradioactive contaminant, protection of groundwater is achieved by identifying the most restrictive contaminant-specific value from these standards as the cleanup level.

RAGs for nonradioactive contaminants in water that are protective of the Columbia River are based on MCLs, WAC 173-340-730(3) (1996) levels, AWQC, and "Water Quality Standards for Surface Waters of the State of Washington" (WAC 173-201A). For each nonradioactive contaminant, protection of the Columbia River is achieved by identifying the most restrictive contaminant-specific value from these standards as the cleanup level. Future revisions will optimize the RDLs for specific contaminants based on data quality assessment results and improved analytical technology.

2.1.2.4 Remedial Action Goals for Radionuclide Contaminants in Water – Protection of Groundwater/Columbia River. As amended in 1986, the SDWA seeks to protect public water supply systems through the protection of groundwater. Any radioactive substances that may be found in water are regulated under the SDWA. The "National Primary Drinking Water Regulations" (40 CFR 141) specify MCLs for radionuclide contaminants in drinking water. In addition, DOE Order 5400.5 establishes derived concentration guidelines (DCGs) for radionuclides. RAGs for radionuclide contaminants in water, protective of both surface water and groundwater, are based on achieving the MCLs. Although some of the following information is not applicable to the current contaminants of concern (COCs), a complete discussion of the MCLs for radionuclides in water is presented.

Current MCLs for radionuclides are set at 4 mrem/yr for the sum of the doses from beta particles and photon emitters, 15 pCi/L for gross alpha particle activity (including radium-226, but excluding uranium and radon), and 5 pCi/L for combined radium-226 and radium-228 (40 CFR 141.66). The MCLs for strontium-90 and tritium are 8 pCi/L and 20,000 pCi/L, respectively (40 CFR 141.66).

The MCL for total uranium is 30 μg/L (40 CFR 141.66). The current MCLs for beta emitters specify that the MCLs are to be calculated based on an annual dose equivalent of 4 mrem to the total body or any internal organ. It is further specified (40 CFR 141.66) that the calculation is to be performed on the basis of a 2-L/day (0.5-gal/day) drinking water intake using the 168-hour data listed in *Maximum Permissible Body Burdens and Maximum Permissible Concentrations of Radionuclides in Air or Water for Occupational Exposure* (NBS 1963). For the following radionuclides, 1/25th of the DOE DCG published in the Interim Action ROD (EPA 1995) is the most stringent applicable standard for drinking water: americium-241, plutonium-238, and plutonium-239/240. In these cases, 1/25th of the DCG is adopted as the RAG in water rather than the MCLs promulgated in 40 CFR 141.66.

RAGs for groundwater and those protective of the Columbia River are presented in Tables B-2 and B-3 of Appendix B, respectively.

2.1.2.5 Remedial Action Goals for Residual Contaminants in Soil – Protection of Groundwater/Columbia River. Residual contaminants remaining in soil after remediation must be at levels such that concentrations of contaminants reaching the unconfined aquifer and, eventually, the Columbia River, by migration through the soil column do not exceed RAGs considered protective of groundwater and the Columbia River (Sections 2.1.2.3 and 2.1.2.4).

Groundwater Protection – Nonradioactive Contaminants. For nonradioactive contaminants, WAC 173-340-740(3)(a)(ii)(A)(1996) specifies that concentrations of residual contaminants are considered protective of groundwater at levels equal to or less than 100 times the groundwater cleanup levels established in accordance with WAC 173-340-720 (1996) (i.e., the RAGs presented in Appendix B), unless it can be demonstrated that a higher soil concentration is protective of groundwater at the site. This approach is applied to nonradioactive contaminants as the first step in calculating residual soil concentrations that are protective of groundwater. If residual concentrations exceed cleanup levels calculated using this approach, site-specific modeling will be performed to provide a refinement on contaminants found to simulate actual conditions at the waste site. Future revisions will review the RDLs to determine if they should be lowered as a result of improved analytical technology.

Groundwater Protection – Radionuclide Contaminants. For radionuclides, groundwater protection is demonstrated through technical evaluation using RESRAD. The RESRAD model is used to demonstrate whether specific radionuclides will reach the groundwater within 1,000 years (the time period specified in the EPA proposed rule for radionuclide cleanup) and, if so, what groundwater concentrations would occur. The RESRAD input parameters used in the modeling are presented in Table B-8, Appendix B. A description of the modeling methodology is presented in Appendix C. The RESRAD model is used in conjunction with a contaminant-at-depth profile to calculate values protective of groundwater. Tables in Appendix B list contaminant-specific concentrations in soil that achieve protection of groundwater (i.e., that achieve groundwater RAGs) for those residual soil contaminants that the RESRAD model predicted will reach groundwater. The values in Appendix B tables are based on the generic site model illustrated in Figure C-1 of Appendix C. Site-specific RAGs that achieve protection of groundwater will be calculated using site-specific information.

Columbia River Protection – Nonradioactive and Radionuclide Contaminants. To achieve protection of the Columbia River, the calculation of RAGs for residual soil contamination must consider two additional contaminant transport steps beyond the migration of contaminants through the soil column and their subsequent leaching into groundwater. The additional contaminant transport steps are (1) the transportation, from beneath the waste site to near-river wells (the point of compliance), of contaminants that have leached to groundwater; and (2) the mixing of groundwater contaminant concentrations with river water within the substrate at the groundwater/river interface. The model that addresses these two steps is the dilution attenuation factor (DAF) model, summarized in Appendix D. This model accounts for the time required for a contaminant to travel through the groundwater underlying a site to the river, radionuclide decay during that travel time period, and a 1:1 dilution factor applied to contaminant concentrations measured in near-river wells (to account for the difference in concentration between the near-river well and the substrate at the groundwater/river interface). In evaluating contaminant transport time, the model uses a 1,000-year period (starting from site closeout) and considers the effect of retardation as contaminants move from under the waste site to the river. As appropriate, dilution factors other than 1:1 will be evaluated on a constituent-specific basis using Hanford Site data. Future revisions will review the RDLs and minimum detectable activities to determine if they should be lowered as a result of improved analytical technology.

To be consistent, the same methodology applied to residual soil contamination to ensure protection of the groundwater was applied to ensure protection of the Columbia River. For residual nonradioactive contaminants, protection of the river is achieved by reducing concentrations remaining in soil after remediation to concentrations less than or equal to 100 times the RAG after the DAF has been applied. If residual contaminant concentrations exceed river protection cleanup levels calculated using this approach, site-specific modeling will be performed to provide a refinement on contaminants found to simulate actual conditions at the waste site.

For residual radionuclide contaminants that reach groundwater within 1,000 years, as demonstrated by RESRAD modeling, protection of the river is achieved by reducing concentrations remaining in soil after remediation to concentrations less than or equal to the value calculated by RESRAD to achieve the RAG after the DAF has been applied. Table B-6 of Appendix B lists the RAGs after the DAF has been applied and the contaminant-specific concentrations in soil that achieve protection of the Columbia River for those residual soil contaminants that the RESRAD model predicted will reach groundwater. The values in Table B-6 of Appendix B are based on the generic site model illustrated in Figure C-1 of Appendix C. Site-specific RAGs that achieve protection of groundwater will be calculated using a site-specific contaminant-at-depth profile.

2.1.2.6 Ecological Risk Evaluations. When evaluating data for the closeout of waste sites, RL will compare the radionuclide and nonradionuclide data against DOE's RESRAD-BIOTA, EPA's ecological soil screening values at www.epa.gov/ecotox.ecossl, and the WAC 173-340 table 749-3 ecological screening values at http://www.ecy.wa.gov/programs/tcp/policies/terrestrial/ table_749-3.htm.

- Ecological protectiveness will be presumed when ecological screening values are not exceeded.

- When ecological screening levels are exceeded and concentrations are less than background, ecological protectiveness will be presumed.

- Ecology, EPA, and DOE guidance allow the use of additional lines of evidence to determine ecological protectiveness when screening and background levels are exceeded. After consideration of additional lines of evidence, there is a Scientific/Management Decisions Point.

The potential significance of any exceedances will be evaluated and discussed between RL and the lead regulatory agency. The conclusion of the ecological risk evaluation will be documented in the relevant cleanup verification package or remaining sites verification package. These actions are interim until the final RODs for the 100 and 300 Areas are issued and placed in the Administrative Record[100N1].

2.1.3 Application of Remedial Action Goals

The decision process for determining the extent of remediation of the waste sites will incorporate site-specific factors. The waste sites are represented by the following three general categories. The application of RAGs to meet RAOs for each site category is discussed below.

- **Shallow sites:** For shallow sites, where the entire engineered structure, soil, or debris contamination is present within the top 4.6 m (15 ft), RAOs will be achieved when (1) contaminant concentrations are demonstrated to be at or below RAGs based on WAC 173-340-740(3) (1996) and the 15 mrem/yr standard assuming no land-use restrictions (i.e., residential scenario), and (2) contaminant concentrations meet RAGs that provide protection of groundwater and the Columbia River.

- **Intermediate sites:** For sites where the engineered structure and/or contaminated soil and debris begin above 4.6 m (15 ft) and extend to below 4.6 m (15 ft), the engineered structure, at a minimum, will be remediated to achieve RAOs. RAOs will be achieved when (1) contaminant concentrations are demonstrated to be at or below RAGs based on WAC 173-340-740(3) (1996) and the 15 mrem/yr standard assuming no land-use restrictions (i.e., residential scenario), and (2) contaminant concentrations meet RAGs that provide protection of groundwater and the Columbia River. Any residual contamination present below the engineered structure shall be subject to the same evaluation as that used for deep sites.

- **Deep sites:** For deep sites, where contamination begins at 4.6 m (15 ft) below the surface, RAGs protective of groundwater and the Columbia River must be met. The extent of remediation will be determined by evaluating several factors. These factors include the reduction of risk by decay of short-lived (half-life of less than 30.2 years) radionuclides, protection of human health and the environment, remediation costs, sizing of the

Environmental Restoration Disposal Facility (ERDF), worker safety, presence of ecological and cultural resources, the use of institutional controls, and long-term monitoring costs. These "balancing factors" are discussed further in Section 2.1.5. The contaminant levels remaining at these sites must be protective of groundwater and the Columbia River.

2.1.4 Contaminant-Specific Concentrations in Soil

As discussed in Section 2.1.1, representative contaminant-specific concentrations in soil have been calculated that correspond to the RAGs described in Section 2.1.2. These contaminant-specific concentrations are used as follows:

- To identify target volumes in soil that require remediation for purposes of remedial design
- To identify minimum quantitation limits for contaminants in soil that must be achieved by analytical systems used during remedial action
- To provide "lookup" values for use in the field to rapidly evaluate analytical data collected during remedial action.

These contaminant-specific concentrations correspond to the RAGs, but are not intended for use in verifying that remedial action is complete at a site. The concentrations represent values that individually equate to WAC 173-340 (1996) values or 15 mrem/yr dose rate. For radionuclides, the expectation is that most sites will have multiple radionuclides driving the cleanup; therefore, a cumulative dose of 15 mrem/yr would potentially result in individual radionuclide concentrations that are lower than these "lookup" values. The process for developing and using these contaminant-specific concentrations is presented in Figure 2-1. The verification process is further defined in Section 3.6. A summary of all representative lookup values can be found in Table 2-1.

2.1.5 Balancing Factors

Based on existing knowledge, it is possible that residual wastes may remain in place at sites where (1) contamination begins at depths below 4.6 m (15 ft), (2) residual soil contamination is present below 4.6 m (15 ft) or the engineered structure, or (3) marginally contaminated material is present. The Interim Action ROD (EPA 1995) provides a decision framework to evaluate leaving some contamination in place:

> "The decision to leave wastes in place at such sites will be a site-specific determination made during remedial design and remedial action activities that will balance the extent of remediation with protection of human health and the environment, disturbance of ecological and cultural resources, worker health and safety, remediation costs, operation and maintenance costs, and radioactive decay of short-lived (half life less than 30.2 years [e.g., Cs-137] radionuclides). The application of the criteria for the balancing factors, the process for determining the extent of remediation at deep sites, and the public

involvement process during such determinations shall be specified further in the Remedial Design Report."

In addition to the seven balancing factors identified above, the section of the Interim Action ROD titled "Scope and Role of Response Action Within Site Strategy" identifies three additional factors: sizing of the ERDF, the use of institutional controls, and long-term monitoring costs.

The balancing factors can be divided into two categories: (1) factors affecting the size of the excavation and (2) factors associated with cost. Three of the balancing factors – minimizing disturbance of cultural or ecological resources, minimizing the size of ERDF (minimize waste volume), and protecting worker health and safety – weigh in favor of minimizing excavation size. The other balancing factors suggest that the extent of remediation and associated costs be weighed against the reliability and cost of institutional controls. The two categories, when weighed with protection of human health and the environment, lead to the following conclusions.

- Contaminant concentrations below 4.6 m (15 ft) or below the engineered structure will be required to meet the criteria for protection of the groundwater and the Columbia River, as stated in RAO # 2 in Section 2.1. For residual contamination below 4.6 m (15 ft) or below the engineered structure shown to impact groundwater or the Columbia River, the balancing factors may be invoked.

- Radioactive contaminants present below the 4.6-m (15-ft) level will be required to be equal to or below concentrations so that the external radiation to a potential receptor in a basement (in combination with radiation exposure from other contaminant pathways) is below 15 mrem/yr when determined as described in Section 3.6.6.

- In the event that RL relinquishes full control of the site, deed restrictions will be applied, as necessary, to prohibit excavation and drilling below the 4.6-m (15-ft) level in those cases where contaminants meet the required groundwater/river protection cleanup goals but exceed concentrations that are protective for direct exposure.

- For areas where lateral movement of contaminants, low radionuclide levels, or small quantities of disposed waste would generate marginally contaminated material to be disposed of at ERDF, or where it can be demonstrated that radionuclide concentrations will result in achieving an acceptable risk range within a reasonable period of time, the balancing factors may be invoked.

In the event that the consideration of balancing factors results in a recommendation to leave contaminated soils or debris in place at a waste site at levels that exceed the RAOs, the Interim Action ROD (EPA 1995) states that the Tri-Parties will initiate public involvement prior to making a decision to leave contamination in place. The process will be as described for an ESD in the *Community Relations Plan for the Hanford Federal Facility Agreement and Consent Order* (Ecology et al. 1997).

Deed/lease restrictions or other institutional controls and long-term monitoring may be required to prevent human exposure to groundwater and/or contaminated soils or interference with the integrity of the cleanup action for any site. Potential deed restrictions could prohibit the drilling of any well to groundwater or any activity that would result in soil disturbance greater than 3.7 m (12 ft) below the surface. The requirement for deed/lease restrictions will be documented in the site cleanup verification package or remaining sites verification package (see Section 3.7, CERCLA Cleanup Documentation") and executed in accordance with DOE land release policy (see Section 3.8, "Site Release"). Public comment would not be sought for deed/lease restrictions deemed necessary to prevent interference with the integrity of the cleanup action.

2.1.6 Applicable or Relevant and Appropriate Requirements

The "National Oil and Hazardous Substances Contingency Plan" (NCP) (40 CFR 300) and the RODs (EPA 1995, 1997a, 1999, 2000a, 2000b) require that the remedial actions described in this document comply with the ARARs established in the RODs. The purpose of this section is to discuss how each of the ARARs identified in the RODs will be met during remedial action. The discussions of ARAR compliance in this section apply to all waste sites in the RODs because these waste sites are currently the only sites for which detailed remedial action plans and specifications have been prepared. As detailed plans and specifications are prepared for subsequent groups of sites, compliance with ARARs will be evaluated, and this section may be revised, as necessary, to incorporate any new activities that are subject to the ARARs.

All activities associated with the remedial action for the source area sites covered under the RODs will occur onsite, as that term is defined under the NCP. As a result, the remedial actions described in this document need only meet the substantive requirements of the ARARs established in the RODs.

If any requirement that would be applicable or relevant and appropriate for the selected remedial action is promulgated subsequent to the RODs (EPA 1995, 1997a, 1999, 2000a, 2000b) being signed, the Tri-Parties will review the requirement and determine whether the selected remedy is still protective in light of the new requirement. This determination will be documented in the Administrative Record.

2.1.6.1 Chemical-Specific ARARs. Chemical-specific ARARs are typically health- or risk-based numerical regulatory values or methodologies that are applied to site-specific media and used to establish remedial action cleanup criteria. As discussed in Section 2.1.1, the chemical-specific ARARs identified in the RODs are as follows:

- WAC 173-340 (WAC 173-340-360 and WAC 173-340-700 through 760) (1996)

- Nonzero MCL goals and MCLs promulgated under the SDWA (40 CFR 141) and/or by the state of Washington (WAC 246-290) (the Interim Action ROD does not include the state of Washington's drinking water regulations as an ARAR; however, since the authority to implement the SDWA has been delegated to the state by the EPA, the state's regulations are considered to be an ARAR for the purpose of this RDR/RAWP)

- The AWQC developed under the *Clean Water Act* (Section 304) and/or promulgated by the state of Washington (WAC 173-200 and 201)

- The *Toxic Substances Control Act* (implemented via 40 CFR 761).

The application of these ARARs for establishing the contaminant-specific RAGs for the source area sites covered under the RODs (EPA 1995, 1997a, 1999, 2000a, 2000b) is described in Section 2.1.1.

The RODs identify two chemical-specific ARARs in addition to those listed above:

- "National Primary and Secondary Ambient Air Quality Standards" (40 CFR 50)
- "National Emissions Standards for Hazardous Air Pollutants" (40 CFR 61).

"National Emissions Standards for Hazardous Air Pollutants" (40 CFR 61) and "Radiation Protection – Air Emissions" (WAC 246-247). The NESHAPs documentation specifies that airborne emissions from all combined operations at the Hanford Site may not exceed 10 mrem/yr (**40 CFR 61.92**) effective dose equivalent to the hypothetical offsite maximally exposed individual. The radionuclide emission standards apply to any fugitive, diffuse, and point-source air emissions of radionuclides generated during excavation or treatment of contaminated soil. **Compliance with the standard is determined on a Hanford Site-wide basis and is documented in the annual radionuclide air emissions report for the Hanford Site. WAC 246-247(1), (3), and (8) requires monitoring for point sources, non-point sources, and fugitive emissions of radioactive material. WAC 246-247-040(3) also requires the application of best available radionuclide control technology if the potential exists to control radioactive air emissions. Standard construction techniques such as using water spray to control fugitive emissions of contaminated dust and particulates will be used.**

Asbestos containing material may be encountered during excavation of waste sites that require remediation. The no visible emission standard, and the packaging, labeling and transportation requirements of 40 CFR 61.150 will be met. Additionally, removal of asbestos on pipelines or other structures that are excavated as part of the remedial actions will be handled consistent with applicable portions of the procedures for asbestos emission control described in 40 CFR 61.145(c).

"National Primary and Secondary Ambient Air Quality Standards" (40 CFR 50). Authority to implement the national air quality standards has been delegated to the state of Washington and is implemented in WAC 173-400. It establishes standards and control requirements for air contaminants including particulates, lead, and dust. WAC 173-400-**040** requires that as long as emissions do not impact any nonattainment areas, control consists only of reasonable precautions to prevent the release of air contaminants. The standard construction techniques that will be employed during excavation and treatment are reasonable precautions.

2.1.6.2 Action-Specific ARARs. Action-specific ARARs typically are technology- or activity-based regulatory requirements or limitations that are triggered by a particular action such as excavation, transport, and/or disposal of hazardous waste. The action-specific ARARs

established in the RODs are identified below, along with a discussion explaining how the ARARs will be met during remedial action implementation.

WAC 173-340 (1996) Cleanup Regulations. Although WAC 173-340 (1996) is primarily a chemical-specific ARAR because it establishes numerical concentration values and methodologies used for deriving cleanup goals, the regulation does include requirements that cleanup of, and residual contamination remaining in, one site medium (e.g., soils and groundwater) do not impact other media either onsite or offsite (WAC 173-340-700[4][b] and [7][h] [1996]). These requirements will be met by establishing soil cleanup levels that are protective of groundwater and the Columbia River (see Section 2.1.1) by monitoring air emissions during remediation, and by implementing dust-control measures, as necessary, based on air emissions monitoring.

State of Washington "Dangerous Waste Regulations" (WAC 173-303). The EPA has delegated the authority to implement the *Resource Conservation and Recovery Act of 1976* (RCRA) to the state of Washington. As a result, the regulations promulgated by the state to implement RCRA (the "Dangerous Waste Regulations") are the primary ARARs for hazardous and dangerous waste generated during the remedial action. Activities performed to comply with the state regulations will also comply with the federal RCRA regulations specified in the RODs.

- **"Designation of Dangerous Waste" (WAC 173-303-070).** This section of Washington State's waste regulations specifies that the procedures will be used to determine if wastes generated during the remedial action classify as dangerous or extremely hazardous wastes. The designation procedures cover both RCRA hazardous wastes (i.e., ignitability, corrosivity, reactivity, toxicity characteristic wastes, and listed wastes) and state-only dangerous wastes (i.e., wastes that meet the criteria for toxic or persistent dangerous wastes). Based on a reasonable search of historical documents and an evaluation of analytical data, it has been concluded that the waste sites contain no listed hazardous wastes or state-only dangerous wastes. However, certain sites may contain effluent sludges and debris with metal concentrations high enough that they would "fail" the toxicity characteristic leachate procedure (TCLP) test and would be classified as toxicity characteristic wastes. In addition, based on experience at some waste sites, solid metals such as lead bricks might be encountered that would fail the TCLP test and would be designated as dangerous waste.

- **"Land Disposal Restrictions" (WAC 173-303-140).** Washington State's land disposal restriction (LDR) regulations incorporate the federal RCRA LDR requirements set forth in 40 CFR 268, and also establishes LDRs for certain state-only dangerous wastes such as wastes that are classified as extremely hazardous and carbonaceous/organic wastes. As discussed above, it currently is anticipated that the only wastes generated during the remedial actions that would be subject to LDRs would be toxicity characteristic wastes. When LDR wastes are encountered, the requirements of 40 CFR 268 will be applied. A contingency plan addressing how LDR wastes will be handled during the remedial action has been prepared (Mueller 1996).

- **"Use and Management of Containers" (WAC 173-303-63).** The LDR regulations contained in 40 CFR 268.50 require that wastes that have been taken out of the area of contamination (AOC) and are subject to LDRs be stored only in containers, tanks, or buildings. Of these three storage options, container storage would be the only practical method for storing toxicity characteristic soil and debris. The LDR contingency plan describes how the storage requirements will be met (Mueller 1996).

- **"Tank Systems" (WAC 173-303-640) and "RCRA Standards for Tank Systems Units" (40 CFR 264, Subpart J).** The remedial actions described in this report will not require the use of tanks to store or treat hazardous wastes.

- **"Miscellaneous Units" (WAC 173-303-680) and "RCRA Standards for Miscellaneous Treatment Units" (40 CFR 264, Subpart X).** As explained in Section 2.1.7, treatment for volume reduction is not anticipated at this time. As a consequence, the remedial actions described in this report are not envisioned to require the use of miscellaneous units to store or treat hazardous wastes.

***Hazardous Materials Transportation Act* and "Requirements for the Transportation of Hazardous Materials" (49 CFR Parts 100 to 179).** The RODs establish the U.S. Department of Transportation (DOT) requirements for the transportation of hazardous materials as an ARAR for offsite shipments of hazardous wastes. Currently, all hazardous waste shipments are anticipated to be onsite (from the source area sites to ERDF).

"Minimum Standards for Construction and Maintenance of Wells" (WAC 173-160) and "Regulation and Licensing of Well Contractors and Operators" (WAC 173-162). Washington State's "Minimum Standards for Construction and Maintenance of Wells" specifies standards for the construction, operation, and abandonment of resource protection (i.e., monitoring) wells. Groundwater monitoring and remediation are addressed under a separate OU from the source area sites covered under the RODs. Because of this, the remedial actions described in this report currently do not include source area, site-specific monitoring well installation. However, if hazardous substances are left in place through application of the balancing factors, and groundwater monitoring at the specific site is required as a consequence, a well installation and monitoring plan will be prepared, as required, to meet the ARAR.

2.1.6.3 Location-Specific ARARs. Location-specific ARARs are restrictions placed on hazardous substance concentrations or remedial actions based on the specific location of the substance or action. The location-specific ARARs established in the RODs (EPA 1995, 1997a, 1999, 2000a, 2000b) and ESD (EPA 2004) are discussed below.

Archaeological and Historical Preservation Act. The *Archaeological and Historical Preservation Act* requires that remedial actions at the source area sites do not cause the loss of any archaeological or historic data and that any archaeological or historic data must be preserved. If any are encountered during excavation, the appropriate authorities will be notified and the artifacts will be preserved. Consideration of archaeological and historic data is included in the balancing factors that will be evaluated if excavations need to be extended beyond those currently planned.

***National Historic Preservation Act* and "Protection of Historic Properties" (36 CFR 800).** The *National Historic Preservation Act* requires that agencies undertaking projects must evaluate impacts to properties that are listed in, or are eligible for inclusion in, the National Register of Historic Places. Consideration of historically significant properties is included in the balancing factors that will be evaluated if excavations need to be extended beyond those currently planned.

***Historic Migratory Bird Treaty Act* and "Wildlife and Fisheries" (50 CFR Parts 10-24).** These requirements are applicable to the protection of migratory bird species associated with the 100 Area. The remedial action will comply with these requirements by following guidance prescribed in the *Mitigation Action Plan for the 100 and 600 Areas of the Hanford Site* (DOE-RL 2001c) and through the performance of site-specific ecological resource reviews prior to remedial action as prescribed in this RDR/RAWP.

"Compliance With Floodplain and Wetland Environmental Review Requirements" (10 CFR 1022) and "Procedures for Implementing the Requirements of the Council on Environmental Quality on the National Environmental Policy Act" (40 CFR 6, Appendix A). These requirements address floodplain protection and are applicable to 100 Area sites located within the Columbia River floodplain. Actions taken within a floodplain must be conducted in a manner that avoids adverse impacts, minimizes potential harm, and restores and preserves natural and beneficial values. Actions required by the RODs (backfilling, revegetation, resource protection, and mitigation) are expected to satisfy these requirements.

***Endangered Species Act of 1973* and "Interagency Cooperation -- Endangered Species Act of 1973" (50 CFR 402).** The *Endangered Species Act* requires that federal agencies consult with the Department of Interior to ensure that actions they authorize, fund, or implement do not jeopardize the continued existence of endangered or threatened species or adversely affect their critical habitat. Because several listed and candidate endangered or threatened species have been identified in and around the Hanford Site, the remedial actions described in this document will be managed so that these species existence will not be jeopardized, or will their habitat be adversely affected.

Native American Graves Protection and Repatriation Act. The *Native American Graves Protection and Repatriation Act* is applicable to any sites should Native American remains be found.

2.1.6.4 Other Criteria, Advisories, or Guidance to Be Considered. TBC information generally consists of federal, state, and local criteria, advisories, and proposed standards that are not legally binding (i.e., are not promulgated regulations), but that may be useful in establishing cleanup goals or remedial alternatives that are protective of human health and the environment. The TBCs identified in the RODs (EPA 1995, 1997a, 1999, 2000a, 2000b) are discussed below.

Ecology has promulgated terrestrial ecological evaluation procedures as part of its continuing revisions to the WAC 173-340 (1996) cleanup regulation (WAC 173-340-7490 [1996]). These procedures, along with the DOE Technical Standard *A Graded Approach for Evaluating Radiation Doses to Aquatic and Terrestrial Biota* (DOE 2002) and the *Ecological Risk*

Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments (EPA 1997b), will be considered as part of river corridor risk assessment studies that are now in progress.

"Notice of Proposed Rulemaking for Radiation Site Cleanup Regulations" (40 CFR 196). The soil cleanup standard of 15 mrem/yr above natural background proposed by the EPA has been specified in the Interim Action ROD (EPA 1995) as the RAG for soil cleanup that is protective of human health from exposure to radionuclides. Subsequent to this ROD being issued, the draft regulation was withdrawn. See Section 2.1.1 for further discussion.

ERDF Waste Acceptance Criteria. Waste acceptance criteria (e.g., concentration limits and waste form limitations) have been developed for ERDF and are provided in *Environmental Restoration Disposal Facility Waste Acceptance Criteria* (WCH 2008). This document provides the primary requirements that must be met in order for waste to be accepted at ERDF. It also cites specific regulations to direct the user to the level of detail necessary for criteria implementation.

"EPA Radiation Protection Guidance for Exposure to the General Public" (59 *Federal Register* [FR] 66414). The EPA has issued guidance recommending that nonmedical radiation doses to the general public from all sources and pathways not exceed 100 mrem/yr above background. The guidance also recommends that radiation doses from individual sources or pathways be lower. Cleanup to the 15 mrem/yr RAG will meet these recommendations.

***The Future for Hanford: Uses and Cleanup, the Final Report of the Hanford Future Site Uses Working Group* (Drummond 1992).** The RAO of cleanup to an "unrestricted status" is based on the recommendations in this document.

"Record of Decision: Hanford Comprehensive Land-Use Plan Environmental Impact Statement (HCP EIS)" (64 FR 61615). The final selected land uses for the 100 Areas are recreation, conservation, and preservation. The 100 Area cleanup scenario is consistent with the land-use plan.

2.1.7 Alternative Description

The selected remedy specified in the RODs (EPA 1995, 1997a, 1999, 2000a, 2000b) is remove and dispose at ERDF, with treatment, as appropriate or required.

Appropriate treatment, as described in the Interim Action ROD (EPA 1995), is soil washing or thermal desorption to "minimize the amount of material to be transported to the ERDF for disposal." However, as described in the following paragraphs, evaluations of existing historical and analytical data and technology demonstrations have resulted in the conclusions that soil treatment for volume reduction will not be appropriate at this time.

Required treatment is any treatment required to comply with legal requirements. Of primary concern are LDR-related treatment requirements.

- **Thermal desorption:** The Interim Action ROD requires that, as appropriate, wastes contaminated with organic chemicals be treated using thermal desorption to reduce volumes requiring disposal at ERDF. The ERDF ROD Amendment (EPA 2002) allows for treatment at ERDF. Also, if concentrations of organic chemicals exceed ERDF waste acceptance criteria (WCH 2008) or LDR criteria, then thermal desorption would be required. However, evaluation of existing historical and analytical data indicates that organic chemicals are not expected at the 100 Area waste sites nor are concentrations likely to be in excess of ERDF waste acceptance criteria. Therefore, thermal desorption will not be included in the detailed design for remedial action.

- **Soil washing:** The Interim Action ROD requires that, as appropriate, contaminated soils be treated using soil washing to reduce volumes requiring disposal at ERDF. A soil washing pilot plant was constructed in the 100-DR-1 OU, and a treatability test was performed to investigate the feasibility of soil washing (DOE-RL 1995b). Using data from the test, RL performed a comprehensive economic analysis to compare the relative costs of soil removal and direct disposal in ERDF with soil removal, soil washing, and disposal of the contaminated fraction in ERDF. The report documenting the analysis (BHI 1995) concluded that removal and disposal is less expensive than removal, soil washing, and disposal, although the difference between the two alternatives is small and within the estimated margin of error of the estimate. Fundamentally, the projected reduction in volumes requiring disposal at ERDF (and associated cost savings) do not offset the extra costs of constructing and operating the soil washing facility. The report recommended that soil washing not be included in remedial action plans at this time, and that actual remedial action costs be monitored and incorporated into a future update of the economic model. The ROD Amendment (EPA 1997a) also recognizes the results of the soil volume reduction treatability studies that indicate soil washing for volume reduction is not cost effective. Therefore, this treatment step will no longer be retained as an option for the 100 Area radioactive liquid effluent disposal sites.

- **Required treatment:** Treatment will be required for LDR material unless a treatability variance or ARAR waiver is requested by RL and approved by the regulatory agencies. The expected condition is that toxicity characteristic suspect waste may exist. If LDR wastes are encountered, the requirements of 40 CFR 268 will be applied. A contingency plan addressing how LDR wastes are handled has been prepared (WAC 173-303, Mueller 1996). When LDR material is encountered, it is temporarily stored within the AOC and disposed of in accordance with applicable regulations (Section 2.1.6.2). The contingency plan is implemented when LDR wastes are detected. If treatment is required to address LDR wastes, RL obtains regulatory agency approval.

The Interim Action ROD presented the selected interim remedial actions for 37 high-priority waste sites that received liquid radioactive effluent discharges in the 100-BC-1, 100-DR-1, and 100-HR-1 OUs. This document introduced the "observational approach" and "plug-in approach" as innovative means to remediation of the individual waste sites and an enhancement to the selected remedy. The observational approach allowed for remediation of waste sites with limited information, using a "test as you go" approach to determine the nature and extent of contamination until cleanup goals have been met. The plug-in approach allowed the analogous

site approach to be used for selection of the same remedy at multiple sites having similar circumstances without expenditure of resources to initially characterize individual sites.

The ROD Amendment (EPA 1997a) increased the scope of the selected remedy in the Interim Action ROD (EPA 1995) to include an additional 34 sites within the 100-BC-2, 100-DR-1, 100-DR-2, 100-FR-1, 100-HR-1, 100-KR-1, and 100-KR-2 OUs. This amendment also recognized the results of the soil volume reduction treatability studies that indicate soil washing for volume reduction is not cost effective and removed it as a treatment option for the 100 Area radioactive liquid effluent disposal sites. Clarification regarding backfill and revegetation of remediated waste sites is included as guidance provided in the current mitigation action plan (DOE-RL 2001c).

The Remaining Sites ROD (EPA 1999) was issued to address the selected remedy of RTD for 46 additional waste sites in the 100 Area and waste sites in the 200-CW-3 OU located in the 200 West Area. An additional 161 sites were identified for use of the plug-in approach for remedy selection. These sites were identified as candidate sites needing further evaluation to support a no-action or remedial action decision. Because they are similar to the 46 sites proposed for RTD, they will "plug-in" to this same remedy if a remedial action is warranted. In addition to these sites, the Remaining Sites ROD also presents the mechanism to include any newly discovered sites that are similar to the 100 Area remaining sites as candidate sites to be "plugged-in" to the RTD remedy. Periodic publication of ESDs will serve as Tri-Party notification to the public of these additions.

The Remaining Sites ESD (EPA 2000a) provided notice of the decision to address two waste sites (600-23 and JA Jones No. 1) that were formerly included in the 300 Area remedial process to the 100 Area remedial action, and to remediate the sites following the RTD approach. An ESD issued in January 2004 (EPA 2004) added 28 newly discovered sites to the list of candidate sites. An upcoming ESD is expected to add additional waste sites for confirmatory sampling and/or RTD to the Remaining Sites ROD and, potentially, address other administrative cleanup issues.

The 100 Area Burial Grounds ROD (EPA 2000b) was issued to address the selected remedy of RTD for 45 burial grounds located in the 100 Areas. This document carried forward the selected remedy used in previous documents of RTD and backfill followed by revegetation. The specific waste sites are located in the 100-B/C, 100-D, 100-H, 100-F, and 100-K Areas, and are anticipated to rely heavily on the observational approach for remediation combined with a "characterize and remediate in one step" methodology.

2.2 REMEDIAL DESIGN

2.2.1 General Design Approach

Remedial design groupings are prepared based on a phased approach by reactor area geographic location. Each design group is initiated so that remedial actions can be maintained. The leading remedial design task consists of preparing documentation and defining concepts so they will be

readily transferable to the sequential remedial design tasks. This concept streamlines the design process. The first series of designs (Group 1 through Group 4 listed in Section 2.2.3) included waste sites in the 100-BC-1, 100-DR-1, 100 FR-1, 100-HR-1, and 100-KR-1 OUs identified in the Interim Action ROD (1995) and associated Interim Action ROD Amendment (1997). Remedial design groupings were also phased based on the timing of issuance of the Interim Action ROD Amendment that added waste sites.

The next series of design groupings followed issuance of the Remaining Sites ROD (EPA 1999) and Remaining Sites ESDs (EPA 2000, 2004) for remaining waste sites in the 100-BC-1, 100-BC-2, 100-DR-1, 100-DR-2, 100-FR-1, 100-FR-2, 100-HR-1, 100-HR-2, 100-KR-1, 100-KR-2, 100-IU-2, 100-IU-6, and 200-CW-3 OUs and issuance of the 100 Area Burial Grounds ROD (EPA 2000b) for burial ground sites in the 100-BC-1, 100-BC-2, 100-DR-1, 100-DR-2, 100-FR-2, 100-HR-2, and 100-KR-2 OUs. This series of design groupings integrate remaining and burial ground sites by geographical locations

The remaining sites design groupings listed in Section 2.2.4 include all RTD remaining sites. Candidate remaining sites that have been determined to require RTD via the Remaining Sites ROD "Plug-In" approach are also listed. Candidate remaining sites documented to meet ROD cleanup criteria without remediation do not require remedial design and are not listed herein. Remediation or closeout decisions have not been completed for all candidate sites. Use of the "Plug-In" approach facilitates streamlining design and remediation processes.

2.2.2 Design Scope

Remediation of waste sites requires soil removal, segregation, storage, transportation, disposal, and backfilling. Remedial design addresses these remediation activities. Key upfront design activities include development of design basis and criteria documents; historical waste site research and field investigation tasks including site walkdowns and geophysical and civil surveys; preparation of safety basis documents; and material at risk, air monitoring, and volume calculations, all as applicable. Data from these activities are used to develop remedial action subcontract design documents termed "exhibits" that describe waste site remediation. Design exhibits include scope of work, drawings, and technical specifications. These design exhibits are incorporated into the request for proposal (RFP) that includes commercial and other technical exhibits that fully describe remedial action subcontractor requirements to implement waste site remediation. Typically, the detailed design for facility layout and excavation processes are completed by the remedial action subcontractor.

The first technical performance specifications were prepared for the types of waste sites found in Group 1 as listed below. As field experience, lessons learned, and waste site types have changed, the technical specifications have also been and continue to be revised, deleted, or combined, as required for subsequent design groupings. Each technical specification establishes quality and workmanship requirements and defines how quality is measured. Generally, each specification includes a list of Hanford Site-specific references; a list of codes, standards, laws, and regulations; definitions of applicable terms; and a discussion of materials, equipment, and associated testing. The list of technical specifications follows:

- Earthwork and excavated material handling
- Survey and decontamination station
- Waste profile station
- Basic electrical materials and methods
- Lighting.

2.2.3 Interim Action ROD Design Groupings

Group 1: The Group 1 remedial design task includes sites within the 100-BC-1, 100-DR-1, and 100-HR-1 OUs. The waste sites are defined as the 116-C-1 Process Effluent Trench, 116-B-1 Process Effluent Trench, 116-B-11 Retention Basin, 116-C-5 Retention Basin, 116-B-13 Sludge Trench, 116-B-14 Sludge Trench, 100-B/C pipelines north of B Avenue, 116-H-1 Process Effluent Trench, and 116-D-1A/1B Fuel Storage Basin Trenches.

Group 2: The Group 2 remedial design task includes sites within the 100-DR-1 OU. The waste sites are defined as the 116-D-7 Retention Basin, 116-DR-9 Retention Basin, 116-DR-1 Process Effluent Trench, 116-DR-2 Process Effluent Trench, five 107-D/DR sludge trenches, 100-D/DR Process Effluent Pipelines north of the road, and the 1607-D2 Septic System. The septic system is included because of its proximity to the Interim Action ROD (EPA 1995) waste sites, and is considered a "no action" site pending additional sampling. The design effort consists of gathering the additional engineering data. Any additional activities for the septic system are based on these data.

Group 3: The Group 3 remedial design task includes sites within the 100-B/C Area and 100-D Area. The waste sites are defined as the 116-B-9 French Drain, 116-B-10 Dry Well, 116-B-3 Pluto Crib, 116-B-2 Fuel Storage Basin Trench, 116-B-6A and B Cribs, 116-B-12 Seal Pit Crib, 100-B South Process Effluent Pipelines, 116-C-2A Pluto Crib Sand Filter, 116-C-2B Pluto Crib Pumping Station, 116-C-2C Pluto Crib, 100-C South Process Effluent Pipelines, 116-D-4 Crib, 116-D-1A and B Fuel Storage Basin Trenches, 116-D-6 French Drain, 116-D-2 Crib, 116-DR-3 Storage Basin Trench, 116-DR-4 Pluto Crib, 116-DR-6 Liquid Disposal Trench, 116-DR-7 Inkwell Crib, 100-DR South Process Effluent Pipelines, 116-D-3 French Drain, 116-D-9 Crib, and 100-D South Process Effluent Pipelines.

Group 4: The Group 4 remedial design task includes sites within the 100-F, 100-H, and 100-K Areas. The waste sites are defined as the 100-F-15 (108-F) French Drain, 100-F-19 Process Effluent Piping, 116-F-1 Lewis Canal Trench, 116-F-2 Trench, 116-F-3 Fuel Storage Basin Trench, 116-F-4 Pluto Crib, 116-F-5 Ball Washer Crib, 116-F-6 Liquid Waste Disposal Trench, 116-F-9 Trench, 116-F-10 French Drain, 116-F-11 French Drain, 116-F-14 Retention Basin, 126-F-1 Ash Pit, UPR-100-F-2 Basin Leak Ditch, 100-H-5 Sludge Burial Trench, 100-H-17 (116-H-2, 100-H-2) Trench, 100-H-21 Process Effluent Pipelines, 116-H-1 Process Effluent Trench, 116-H-3 Dummy Decontamination French Drain, 116-H-4 Pluto Crib, 116-H-7 Retention Basin, 100-K Process Effluent Piping, 116-K-1 Crib, 116-K-2 Effluent Trench, 116-KE-4 Retention Basins, and 116-KW-3 Retention Basins.

2.2.4 100 Area Remaining Sites and 100 Area Burial Grounds Design Groupings

2.2.4.1 100-B/C Area Operable Units

100-B/C Burial Grounds and Remaining Sites Group: This remedial design task includes the 118-B-1, 118-B-2, 118-B-3, 118-B-4, 118-B-5, 118-B-6, 118-B-7, 118-C-1, 118-C-2, and 600-33 Burial Grounds and the 128-B-3, 126-B-3, 128-B-2, 128-C-1, 100-B-16, 118-B-9, 100-B-11, 600-232, 116-C-3, 100-B-1, 120-B-1, 100-C-9:2, 100-B-18, 100-B-21, 100-B-27, 1607-B4, and 1607-B5 Remaining Sites.

Remedial Action for the 100-B/C Area Remaining Pipelines and Sewers (RPAS): This remedial design task includes 100-B-14, 100-C-9, 100-C-7, 100-C-7:1, 1607-B2, and 1607-B9.

Remedial Action for 100-B/C Area Remaining Sites: This remedial design task includes 100-B-17, 100-B-19, 100-B-21:4, 100-B-23, 100-B-25, 100-B-27, 100-B-28, and 100-C-7. Note that 100-C-7 and 100-B-27 designs are for the greater than 4.6 m (15 ft) deep chromium contamination remediation.

2.2.4.2 100-D Area Operable Units

100-D Area Burial Grounds and Remaining Sites Group: This remedial design task includes the 100-D-32, 100-D-33, 100-D-35, 100-D-40, 100-D-41, 100-D-43, 100-D-45, 100-D-47, 118-D-1, 118-D-2, 118-D-3, 118-D-4, 118-D-5, 118-DR-1, 126-D-2, and 126-DR-1 Burial Grounds and the 100-D-1, 100-D-2, 100-D-3, 100-D-31, 116-D-5, 116-DR-5, 120-D-2, 116-D-8, 116-DR-8, 116-DR-10, 100-D-29, UPR-100-D-5, 1607-D2 , 100-D-30, 100-D-56, 100-D-15, 100-D-42, 100-D-61, 116-D-10, 118-D-6:4, 600-30, 628-3, 100-D-13, 100-D-28:1, 100-D-50:4, 100-D-50:6, 100-D-50:8, 100-D-50:9, 100-D-58, 100-D-65, 100-D-66, 100-D-7, 100-D-8, 116-DR-3, 128-D-2, 130-D-1, 1607-D1, and 1607-D5 Remaining Sites.

2.2.4.3 100-F Area Operable Units

100-F Area Burial Grounds and Remaining Sites Group: This remedial design task includes the 118-F-1, 118-F-2, 118-F-3, 118-F-5, 118-F-6, 118-F-7, and 100-F-20 Burial Grounds and the 100-F-26, 116-F-8, 116-F-15, 116-F-16, 128-F-3, 100-F-10, 100-F-31, 100-F-33, 100-F-38, 120-F-1, 126-F-1, 128-F-2, 126-F-2, 132-F-1, 141-C, 182-F, 1607-F1, 1607-F3, 1607-F4, 1607-F5, 118-F-8:4.and 1607-F7 Remaining Sites.

2.2.4.4 100-H Area Operable Units

100-H Area Burial Grounds and Remaining Sites Group: This remedial design task includes the 118-H-1, 118-H-2, 118-H-3, 118-H-4, and 118-H-5 Burial Grounds and the 100-H-33, 116-H-5, 116-H-9, 600-152, and 100-H-37 Remaining Sites.

2.2.4.5 100-K Area Operable Units

118-K-1 Burial Ground: The 118-K-1 Burial Ground is a single waste site design group.

2.2.4.6 100-IU Area Operable Units

100-IU Area Remaining Sites Group: This remedial design task includes the 600-3, 600-5, 600-100, 600-108, 600-109, 600-111/UPR-600-16, 600-120, 600-124, 600-125, 600-127, 600-176, 600-182, 600-188, 600-202, 600-205, 600-149, 600-178, 600-186, 600-213, 600-267, 600-239, 600-146, and 600-280 Remaining Sites.

2.2.5 Future Remedial Design Groupings

As listed in the previous sections, design has been completed for waste sites that required RTD per the cited RODs, ROD Amendments, and/or ESDs. The remediate or closeout decision for most candidate sites listed in the Remaining Sites ROD and associated ESDs (except for 100-K Area) have been made and associated remedial designs completed. However, future remedial design is required for candidate sites determined to require RTD. The same applies to discovery sites that are identified and accepted by the Tri-Parties. These sites may be designed in preparation for RTD via the remaining sites ROD "Plug-In" approach, followed by an ESD or ROD Amendment. Future remedial design tasks will be defined based on the schedule for interim remedial actions (see Section 3.2.2).

Figure 2-1. Calculation of Contaminant-Specific Cleanup Levels.

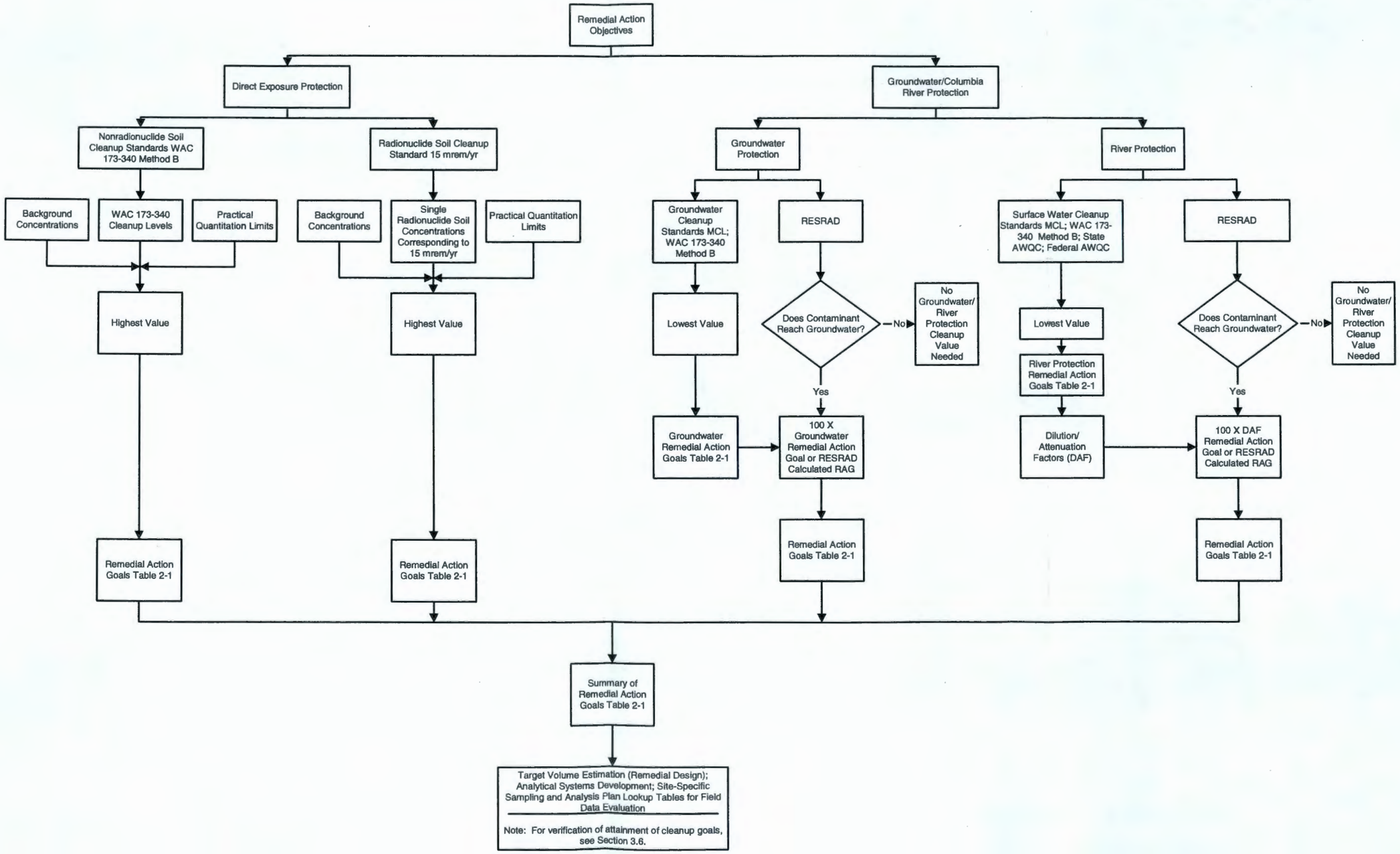


Table 2-1. Soil Lookup Value Summary: Contaminant-Specific Concentrations. (5 Pages)

Contaminant	Kd Value (mL/g)	Back-ground (pCi/g)	Soil Lookup Values (pCi/g) [a]		
			Direct Exposure	Protective of Groundwater	Protective of the River
Radionuclides					
Ag (silver)-108m	90	--	2.38	--	--
Americium-241	200	--	31.1	--	--
Carbon-14	200	--	8.69	--	--
Cesium-137	50	1.1	6.2	364	728
Cobalt-60	50	0.008	1.4	3,440	6,880
Europium-152	200	--	3.3	--	--
Europium-154	200	0.033	3.0	--	--
Europium-155	200	0.054	125	--	--
Nickel-63	30	--	4,026	30	60
Plutonium-238	200	0.004	37.4	--	--
Plutonium-239/240	200	0.025	33.9	--	--
Strontium-90	25	0.18	4.5	10.4	20.8
Technetium-99	0	--	15 [i]	15 [i]	15 [i]
Thorium-232	200	1.3	1.3	--	--
Tritium (H-3) [b]	0	--	406	10	13.4
Uranium-233/234	2	1.1	1.1 [c]	1.1 [c]	1.1 [c]
Uranium-235	2	0.11	0.84	0.5 [i]	0.5 [i]
Uranium-238	2	1.1	1.1 [c]	1.1 [c]	1.1 [c]
Contaminant	**Kd Value (mL/g)**	**Back-ground (mg/kg)**	**Soil Cleanup Levels (mg/kg) [a]**		
			Direct Exposure	**Protective of Groundwater**	**Protective of the River**
Metals					
Antimony	45	5	32	5 [c]	5 [c]
Arsenic	3	20	20	20	20
Barium	25	132	16,000	200	400
Beryllium	790	1.51	10.4 [d]	1.51 [c]	1.51 [c]
Boron [e]	3	--	16,000	320	--
Cadmium	30	0.81 [f]	13.9 [d]	0.81 [c]	0.81 [c]
Chromium, Total	200	18.5	120,000	18.5 [c]	18.5 [c]
Chromium VI [e]	0	--	2.1 [d]	4.8	2
Cobalt	50	15.7	1,600	32	--
Copper	22	22.0	2,960	59.2	22.0 [c]
Lead	30	10.2	353	10.2 [c]	10.2 [c]
Lithium	50	33.5	1,600	33.5 [c]	--
Manganese	50	512	11,200	512 [c]	512 [c]
Mercury	30	0.33	24	0.33 [c]	0.33 [c]
Methyl Mercury	--	--	8	0.16	0.16
Molybdenum [d]	20	--	400	8	--
Nickel	65	19.1	1,600	19.1 [c]	27.4

Table 2-1. Soil Lookup Value Summary: Contaminant-Specific Concentrations. (5 Pages)

Contaminant	Kd Value (mL/g)	Back-ground (mg/kg)	Soil Cleanup Levels (mg/kg) [a]		
			Direct Exposure	Protective of Groundwater	Protective of the River
Selenium	150	0.78 [f]	400	5	1
Silver	90	0.73	400	8	0.73 [c]
Strontium	25	--	48,000	960	--
Tin	130	--	48,000	960	--
Uranium (soluble salts)	2	3.21	240	3.21	3.21
Vanadium	1,000	85.1	560	85.1 [c]	--
Zinc	30	67.8	24,000	480	67.8 [c]
Inorganic Anions and Total Petroleum Hydrocarbons					
Cyanide	0	--	1,600	20	1.04
Fluoride	0.0143	2.81	4,800	960	400
Nitrate (as Nitrogen)	0	11.8	128,000	1,000	2,000
Nitrite (as Nitrogen)	0	--	8,000	100	200
Sulfate	2	237	--	25,000	50,000
Sulfide	0	--	--	--	--
TPH	50	--	--	200	200
Volatiles					
Acetone [g]	0.0006	--	72,000	720	--
Carbon Tetrachloride [g]	0.152	--	7.69	0.0337	0.05
Methylene Chloride [g]	0.01	--	133	0.5	0.94
Toluene [g]	0.14	--	6,400	64	1,360
Xylene [g]	0.233	--	16,000	160	--
Semivolatiles					
Acenapthene	4.9	--	4,800	96	129
Acenapthylene [h]	6.12	--	4,800	96	129
Anthracene	23.5	--	24,000	240	1,920
Benzo(a)anthracene	360	--	1.37	0.015 [i]	0.015 [i]
Benzo(a)pyrene	5,500	--	0.137	0.015 [i]	0.015 [i]
Benzo(b)fluoranthene	880	--	1.37	0.015 [i]	0.015 [i]
Benzo(k)fluoranthene	2,020	--	13.7	0.015 [i]	0.015 [i]
Benzo(g,h,i)perylene [h]	2,680	--	2,400	48	192
Bis(2-chloro-1-methylethyl) ether	0.0392	--	14.3	0.33 [i]	7.50
Bis(2-chloroethoxy)methane [h]	0.00277	--	0.909	0.33 [i]	0.33 [i]
Bis(2-chloroethyl) ether	0.0760	--	0.909	0.33 [i]	0.33 [i]
Bis(2-ethylhexyl)phthalate	110	--	71.4	0.6	0.36
Bromophenylphenyl ether; 4-	4.16	--	--	--	--
Butylbenzylphthalate	13.8	--	16,000	320	250
Carbazole	200	--	50	0.437	--
Chloro-3-methylphenol; 4- [h]	--	--	4,000	80.0	--
Chloroanilene; 4-	0.0725	--	320	6.4	--

Table 2-1. Soil Lookup Value Summary: Contaminant-Specific Concentrations. (5 Pages)

Contaminant	Kd Value (mL/g)	Back-ground (mg/kg)	Soil Cleanup Levels (mg/kg) [a]		
			Direct Exposure	Protective of Groundwater	Protective of the River
Chloronaphthalene; 2-	2.98	--	6,400	64	206
Chlorophenol;2-	0.388	--	400	4.00	19.34
Chlorophenylphenyl ether; 4-	--	--	--	--	--
Chrysene	200	--	137	1.2	0.1 [i]
Dibenzo(a,h)anthracene	1,790	--	0.137	0.03 [i]	0.03 [i]
Dibenzofuran	11.3	--	160	3.20	--
Dichlorobenzene; 1,2-	0.379	--	7,200	60.0	540
Dichlorobenzene; 1,3-	0.434	--	2,400	24.0	80
Dichlorobenzene; 1,4-	0.616	--	41.7	0.33 [i]	0.972
Dichlorobenzidine; 3,3-	0.724	--	2.22	0.33 [i]	0.33 [i]
Dichlorophenol; 2,4-	0.147	--	240	4.80	18.6
Diethylphthalate	0.0820	--	64,000	1,280	4,600
Dimethylphthalate	0.0371	--	80,000	1,600	14,400
Dimethylphenol; 2,4-	0.209	--	1,600	32.0	110.6
Di-n-butylphthalate	1.57	--	8,000	160	540
Di-n-octylphthalate	83,200	--	1,600	32	--
Dinitro-2-methylphenol; 4,6-	0.6015	--	8.00	0.2 [i]	--
Dinitrophenol; 2,4-	0.00001	--	160	3.20	14
Dinitrotoluene; 2,4-	0.0955	--	160	3.20	0.013 [i]
Dinitrotoluene; 2,6-	0.0692	--	80.0	1.60	136
Ethylene glycol	0.001	--	160,000	3,200	--
Fluoranthene	49.1	--	3,200	64	18.0
Fluorene	7.71	--	3,200	64	260
Hexachlorobenzene	80	--	0.625	0.013 [i]	0.013 [i]
Hexachlorobutadiene	53.7	--	12.8	0.05 [i]	0.05 [i]
Hexachlorocyclopentadiene	200	--	480	5	48
Hexachloroethane	1.78	--	71.4	0.313	0.38
Hydrazine	0.0143	--	0.333	0.33 [i]	--
Indeno(1,2,3-cd) pyrene	3,470	--	1.37	0.03 [i]	0.03 [i]
Isophorone	0.0468	--	1,050	9.21	1.68
Methylnaphthalene; 2-	2.98	--	320	3.2	--
Methylphenol; 2- (cresol;o-)	0.434	--	4,000	80.0	--
Methylphenol; 4- (cresol;p-)	0.434	--	400	8.00	--
Naphthalene	1.19	--	1,600	16.0	988
Nitroaniline; 2-	0.0527	--	240	2.4	--
Nitroaniline; 3-	0.0516	--	24	0.33 [i]	--
Nitroaniline; 4-	0.0516	--	47.6	0.33 [i]	--
Nitrobenzene	0.119	--	40.0	0.40	3.40
Nitrophenol; 2-	--	--	--	--	--

Table 2-1. Soil Lookup Value Summary: Contaminant-Specific Concentrations. (5 Pages)

Contaminant	Kd Value (mL/g)	Back-ground (mg/kg)	Soil Cleanup Levels (mg/kg) [a]		
			Direct Exposure	Protective of Groundwater	Protective of the River
Nitrophenol; 4-	0.309	--	640	12.8	1,254
Nitroso-di-n-propylamine;N-	0.0240	--	0.33	0.33 [i]	0.33 [i]
Nitrosodiphenylamine;N-	1.29	--	204	1.79	1.946
Pentachlorophenol	0.592	--	8.33	0.2 [i]	0.2 [i]
Phenanthrene [h]	23.5	--	24,000	240	1,920
Phenol	0.0288	--	24,000	480	4,200
Pyrene	68	--	2,400	48	192
Tributyl Phosphate	1.89	--	185	3.3 [i]	--
Trichlorobenzene; 1,2,4-	1.66	--	800	7	45.4
Trichlorophenol; 2,4,5-	1.60	--	8,000	160	--
Trichlorophenol; 2,4,6-	0.381	--	90.9	0.795	0.42
Pesticides and PCBs					
Aldrin	48.7	--	0.0588	0.002 [i]	0.002 [i]
BHC, alpha	1.76	--	0.159	0.002 [i]	0.002 [i]
BHC, beta	2.14	--	0.556	0.00486	0.00554
BHC, delta	3.38	--	--	--	--
BHC, gamma (Lindane)	1.35	--	0.769	0.00673	0.0038
Chlordane (alpha, gamma)	51	--	2.86	0.025	0.02 [i]
Dalapon	0.00274	--	2,400	20	--
Db; 2,4-	0.1	--	640	12.8	--
DDD, 4,4'-	45.8	--	4.17	0.0365	0.0033 [i]
DDE, 4,4'-	86.4	--	2.94	0.0257	0.0033 [i]
DDT, 4,4'-	678	--	2.94	0.0257	0.0033 [i]
Dicambra	0.0288	--	2,400	48	--
Dichlorophenoxyacetic acid; 2,4-	0.0294	--	800	7	--
Dichloroprop [h]	0.0294	--	800	7	--
Dieldrin	25.6	--	0.0625	0.0033 [i]	0.0033 [i]
Dinoseb (DNBP)	3.54	--	80	0.7	--
Endosulfan (I, II, sulfate)	2.04	--	480	9.6	0.0112
Endrin (and ketone, aldehyde)	10.8	--	24	0.2	0.039
Heptachlor	9.53	--	0.222	0.002 [i]	0.002 [i]
Heptachlor epoxide	83.2	--	0.11	0.002 [i]	0.002 [i]
Methoxychlor	80	--	400	4	1.67
Polychlorinated Biphenyls	530	--	0.5 [j]	0.017 [i]	0.017 [i]
PCB Aroclor-1016	107	--	0.5	0.017 [i]	0.017 [i]
PCB Aroclor-1221	10.3	--	0.5	0.017 [i]	0.017 [i]
PCB Aroclor-1232	10.3	--	0.5	0.017 [i]	0.017 [i]
PCB Aroclor-1242	44.8	--	0.5	0.017 [i]	0.017 [i]
PCB Aroclor-1248	43.9	--	0.5	0.017 [i]	0.017 [i]

Table 2-1. Soil Lookup Value Summary: Contaminant-Specific Concentrations. (5 Pages)

Contaminant	Kd Value (mL/g)	Back-ground (mg/kg)	Soil Cleanup Levels (mg/kg) [a]		
			Direct Exposure	Protective of Groundwater	Protective of the River
PCB Aroclor-1254	75.6	--	0.5	0.017 [i]	0.017 [i]
PCB Aroclor-1260	530	--	0.5	0.017 [i]	0.017 [i]
Silvex (tp;2,4,5-)	0.08	--	640	5	--
Toxaphene	95.8	--	0.909	0.2 [i]	0.2 [i]
Trichlorophenoxyacetic acid;2,4,5-	0.049	--	800	16	--

[a] Radionuclide soil activities protective of groundwater and the river were calculated using RESRAD Version 6.4 (ANL 2007) assuming that no uncontaminated vadose zone exists between contamination and groundwater. Nonradionuclide soil concentrations protective of groundwater and the river are based upon application of the "100 times" rule (Ecology 1996).

[b] Tritium samples will be taken 15.2 cm (6 in.) below the excavation surface. If tritium is detected, a path forward will be developed with the lead regulatory agency for appropriate cleanup verification sampling (per TPA-CN-177).

[c] Where cleanup levels are less than background, cleanup levels default to background per WAC 173-340-700[4][d] (1996).

[d] Carcinogenic cleanup level calculated based on the inhalation exposure pathway (WAC 173-340-750[3], 1996) using an airborne particulate mass-loading rate of 0.0001 g/m^3 (WDOH 1997).

[e] No Hanford Site-specific or Washington State background value available.

[f] Hanford Site-specific background not available. Value is from Ecology (1994).

[g] Common laboratory contaminant unlikely to be found in soil. If detected in soil, all analyses of blanks, duplicates, and splits should be checked and the original soil sample reanalyzed.

[h] Toxicity data for this chemical are not available. Cleanup levels are based on surrogate chemicals:
Contaminant: acenapthylene; surrogate: acenapthene
Contaminant: benzo(g,h,i)perylene; surrogate: pyrene
Contaminant: bis(2-chloroethoxy)methane; surrogate: bis(2-chloroethyl)ether
Contaminant: chloro-3-methylphenol; 4-; surrogate: methylphenol; 3-
Contaminant: dichloroprop (pesticide); surrogate: dichlorophenoxyacetic acid; 2,4-; (2,4-D)
Contaminant: phenathrene; surrogate: anthracene

[i] Where cleanup levels are less than RDLs, cleanup levels default to RDLs per WAC 173-340-707(2) (Ecology 1996). The cited RDLs are based on analytical method numbers that may not be available for rapid turnaround analyses. Prior notification and concurrence with the laboratory may be necessary to analyze to meet this RDL. Actual detection limits may differ from any RDL.

[j] The soil cleanup value for PCBs is based on the formula presented in WAC 173-340-740(3)(a)(iii)(B) (1996), and the cancer potency factor for ingestion of PCBs of 2.0 kg-day/mg (soils) from the EPA Integrated Risk Information System (IRIS) on the internet at < http://www.epa.gov/iris >.

-- = not available
Kd = Distribution coefficient discussed in Appendix E. Kd values also found in the Ecology CLARC Database at < http://www.ecy.wa.gov > or from the Risk Assessment Information System database maintained by the Oak Ridge National Laboratory at < http://risk.lsd.ornl.gov >.
PCB = polychlorinated biphenyl
RDL = required detection limit
RESRAD = RESidual RADioactivity
TPH = total petroleum hydrocarbon

3.0 REMEDIAL ACTION APPROACH AND MANAGEMENT

Initiation of full-scale remedial action to accomplish the goals set forth in the RODs (EPA 1995, 1997a, 1999, 2000a, 2000b) requires completion of numerous interdependent tasks. Key tasks are illustrated in the flowchart presented in Figure 3-1. Activities or documents requiring regulatory agency approval are specifically identified in this document[jwg2].

3.1 REMEDIAL ACTION OPERATING SYSTEM

Remediation, in accordance with the RODs (EPA 1995, 1997a, 1999, 2000a, 2000b), requires soil excavation, treatment as appropriate or required, disposal, backfilling, and revegetation. Clean overburden can be segregated and stockpiled onsite for backfill purposes. For the purpose of this discussion, the system design is divided into five subsystems: pre-excavation, excavation, material handling and transportation, soil characterization and analysis, and decontamination. These subsystems merge to become the operating remediation system.

3.1.1 Pre-Excavation

Site setup involves stripping the existing overburden material; establishing site utility services, as required; and constructing roads, field support facilities, and survey and decontamination stations (where loaded containers are surveyed for radioactive contamination and decontaminated, if necessary). Stripping removes surface and near-surface materials (including roots, organic materials, vegetation, cobbles, and boulders) that will be stockpiled and used later as a top dressing and planting medium for revegetation. After backfill of cleanup sites, revegetation will be conducted as discussed in Appendix H. Hanford Site roadways are constructed of existing site materials, except the surface course, which is imported. Field support facilities provide a changing area, lunchroom, and offices at individual sites. The changing area includes lockers, benches, and storage for both clean and contaminated personal protection equipment.

3.1.2 Excavation

Excavation begins when sufficient analytical data have been obtained to characterize the site's initial conditions and the excavation subcontractor receives notification to begin work. Excavation of the designated work site involves removing clean and contaminated soils, debris, and anomalous waste present within the sites boundaries. The soils exposed during excavation are monitored for radiological and hazardous constituents as defined in the 100 Area SAP (DOE-RL 2008) and the 100 Area Burial Grounds SAP (DOE-RL 2001a).

Materials are excavated using standard equipment and construction methods for both shallow lifts and deep excavations. Containers (described in Section 3.1.3) are relocated from the container staging area to the excavation site and are prepared with a plastic liner. Excavated materials are placed in the lined containers and, depending on the material composition, are designated for transport to ERDF, a clean material storage area, or a soil treatment storage area.

The containers are inspected for the presence of water prior to placing a liner or waste into the container. When water is found in a container with an estimated volume of 151 L (40 gal) or less (less than a depth of 1.3 cm [0.5 in.] in the bottom of the container), the water will be used as an aid for dust suppression in the adjacent radiological excavation, staging pile, or radiological debris piles in a manner that is consistent with regulator-approved work plans. When water is found in the container with an estimated volume greater than 151 L (40 gal), lead regulatory agency approval will be sought to use the water as an aid for dust suppression in the adjacent radiological excavation, staging pile, or radiological debris pile, or direction from the agency to process the water through other means[jwg3].

For all burial grounds and dump sites, materials will be excavated with standard construction equipment using one or more of the following techniques to sort and disposition waste:

- **Mechanical Grizzly or Power Screen.** Material will be excavated using heavy equipment and passed through a large sieve-type apparatus (grizzly) or power screen with 15-cm (6-in.) openings. Observation, sorting, and radiological surveys of the material may be performed at the dig face, on material retained by the grizzly or power screen, and on material passing through the grizzly or power screen.

- **0.3-m (1-ft)-Horizontal Lifts.** The exposed surface of each lift will be visually observed, radiologically screened, sorted (as necessary) to remove anomalous material and large debris, and then excavated using heavy equipment and stockpiled. Material will also be observed as it is being stockpiled for any additional sorting that is appropriate.

- **0.3-m (1-ft)-Diagonal (Sloping) Lifts.** The exposed surface of each lift will be visually observed as it is raked down the face of an excavation slope using heavy equipment. Material will be radiologically surveyed at the bottom of the slope, sorted as necessary, and stockpiled. Material will also be observed as it is being stockpiled for any additional sorting that is appropriate.

- **Bulk Excavate and Spread.** Material will be bulk excavated using heavy equipment, and then spread onto the ground in approximately 0.3-m (1-ft) layers. The shallow layer of material will then be radiologically screened and sorted.

- **0.2-m (0.5-ft)-Loader Lifts.** The surface of each lift will be visually observed, radiologically screened, sorted as necessary, and then excavated using the front-end loader. This technique is best suited for areas with little visible debris.

In excavation areas where there are large quantities of observed lead containing materials (e.g., lead bricks, lead slag) intermixed with the soil, a variation of these excavation/sorting methods may be used. Observation, sorting, and radiological surveys for removal of the large materials and nonlead anomalous materials will be performed using one or more of the methods described above. The remaining materials may then be identified as meeting the RCRA definition of "soil" per 40 CFR 268.2, and considered hazardous/dangerous due to lead contamination. In such cases, the soil will be sampled in accordance with the 100 Area SAP or

100 Area Burial Ground SAP as appropriate (DOE-RL 2008, 2001a) and transported to ERDF or other approved facility for treatment (stabilization) and subsequent disposal.

For sites where the potential for spent nuclear fuel (SNF) has been identified, it must be managed as high-level waste and is not eligible for disposal in ERDF. Shielded bunkers will be used for interim storage of the suspect SNF with minimum specifications of (1) a 1.8-m (6-ft)-tall security fence, and (2) a bunker constructed of concrete shielding blocks including a heavy metal lid or concrete shielding block cover. Suspect SNF will be characterized for shipment to the 100-K facility or stored on the Hanford Site until an offsite storage or disposal facility authorized to manage high-level waste becomes available (DOE-RL et al. 2005b).

Sluicing (use of water) is not an acceptable excavation method. Excavation operations in areas where there is known drummed waste will be performed using horizontal lifts (as described above). In all other cases, selection of the excavation/sorting method will be made by the remedial action subcontractor, and the method may be changed to another approved method based on the type of material being excavated. Alternate excavation/sorting methods (e.g., vacuum systems, metal detectors) may be proposed by the project on a case-by-case basis and implemented with concurrence from the RL and lead regulatory agency representatives. During the excavation process, care will be taken to prevent the breakage or puncture of pipelines or unopened or sealed cans, jars, and containers.

Material that has been excavated using one of the approved sorting techniques will be directed in one of the following ways:

- Radiologically contaminated material that is above cleanup levels and within ERDF waste acceptance criteria (WCH 2008) will be loaded into plastic-lined, roll-off containers on project haul trucks at the excavation site. Asbestos-containing material will be double bagged or put into roll-off containers that are double lined. The loaded containers will be covered (i.e., by folding and securing the liner over the load) and surveyed prior to being transported to a container transfer facility (CTF) using the project haul trucks. If contamination is found on a container exterior, the container will be decontaminated using standard equipment and techniques. In the unlikely event that a container cannot be decontaminated using standard methods, advanced techniques will be implemented, as necessary. Released containers will be off-loaded and staged in the CTF until applicable shipping papers are completed. When the shipping papers have been completed, ERDF transport vehicles will enter the CTF, pick up the full containers, and haul them to ERDF.

- Anomalous waste (e.g., drums, intact containers, elemental lead, unknown materials) and/or above cleanup level material that is not within ERDF waste acceptance criteria (WCH 2008) will be set aside within the AOC or within designated staging piles for further characterization and final disposition (see Section 4.0). LDR wastes stored outside of the AOC shall only be returned to the AOC, and removed from the container with lead regulator approval[jwg4]. As needed, appropriate inerting materials may be added to drums that contain waste with pyrophoric properties. Waste that is subsequently identified for ERDF disposal or staging will be directed as described previously, with the exception that drummed waste will be transported on flatbed trailers. Excavated material that must be sent to facilities other than

ERDF for treatment and/or disposal will be stockpiled or drummed and staged within the AOC until loaded for offsite shipment. Identification of an appropriate treatment and/or disposal facility, and arrangements for loading and transporting excavated material to facilities other than ERDF will be made on a case-by-case basis by the project in coordination with Washington Closure Hanford (WCH) waste management representatives. Prior to shipment, an offsite determination must be obtained from the EPA for receipt, storage, treatment, and disposal of CERCLA waste at the identified treatment/disposal facility.

- Material that is free of anomalous waste and below cleanup levels may be stockpiled onsite for use as backfill material.

- In certain situations, soil may be placed over material excavated within a waste site or discovered within a staging pile as a temporary measure. Such action may be undertaken to minimize an imminent threat to the worker, for example, a high dose item is uncovered, and a temporary soil cover is appropriate to control worker exposure. Temporary covering with soil may also be undertaken to prevent windborne dispersal of excavated material or highly contaminated soil and to maintain segregation from other waste site materials. These temporary measures may be undertaken while plans are developed for safe reexcavation and removal of waste site materials. In these instances lead regulator notification will be made[jwg5].

- Excavated material that has been packaged may be returned to an excavation area or staging pile area in situations where the dose rates, contamination levels, free liquids, or other abnormalities have subsequently been determined to exceed normal transport requirements. In these situations, when repackaging is necessary, the previously excavated material will be reloaded into the transportation container. Notification to the lead regulatory agency is generally not required for these actions. The exception is LDR waste, which shall be managed in accordance with the second bullet of this section (Section 3.1.2[jwg6]).

- An approved LDR treatment method for radioactively contaminated cadmium-, silver-, and mercury-containing batteries allows for macroencapsulation prior to disposal. However, lead-acid batteries are not covered by this standard and require initial treatment (draining corrosive liquids, treating separately prior to disposal) (DOE-RL et al. 2005c).

Containers destined for ERDF are surveyed (if required) and decontaminated (if required) prior to entering the clean work area. Survey stations provide sheltered work areas where loaded containers are covered (i.e., by folding and securing the liner over the load) and surveyed for radioactive contamination. If contamination is found on a container's exterior, contamination is removed at the survey and decontamination stations. In the unlikely event that a container cannot be decontaminated with the normal equipment and techniques available at the survey and decontamination station, an evaluation will be made of the advanced and appropriate techniques, and these will be implemented.

After containers are released, they are relocated to a clean container transfer area. When the shipping papers have been completed and a transport vehicle is available, the containers are

placed onto clean trailers for hauling to ERDF. The trucks and trailers used for hauling within the excavation site remain in the contaminated area and do not require decontamination. Empty containers being returned from ERDF are loaded onto excavation site trailers for refilling.

Activities are guided during excavation from data obtained by the in situ analytical system or in-process sampling using quick-turnaround laboratory analyses working concurrently with excavation. Additional information on characterization during excavation are presented in the 100 Area SAP and 100 Area Burial Ground SAP (DOE-RL 2008, 2001a).

Dust control is maintained on the haul roads, at the excavation site, and at the clean soil storage area, as well as at the contingency storage area for soils potentially requiring treatment. Use of water for dust control at the excavation site will be minimized. All material being transported from the excavation site is covered, contained, or has moisture content adequate for inhibiting dust without being covered or contained during transport and disposal. The moisture content of bulk contaminated material destined for ERDF disposal is in accordance with ERDF waste acceptance criteria (WCH 2008). Dust fixative is applied to open excavation sites when potential concerns arise about health issues or the spread of contamination.

Excavated material will be surveyed and characterized for appropriate disposition prior to undertaking disposal of materials. When excavation of a waste site is complete, exposed dig faces will be evaluated to verify that remedial action goals have been met. When remedial action goals have been met and backfill concurrence is obtained from the lead regulatory agency, site backfill will be authorized. (Note: Unless specified otherwise, the term "backfill" as used in this document refers to filling in the excavation once post-waste site remediation sampling has demonstrated that remedial action goals have been met.) Clean backfill material is obtained from clean material storage areas, approved/clean rubble, and local borrow sites. Excavations are backfilled so the sites conform to local topography[jwg7].

3.1.3 Material Handling and Transportation

All contaminated materials, including excavated soils, debris, disposable protective clothing, air filters, and trash, whether stored or transported to ERDF, require proper packaging, handling, and transporting. The design of the packaging, handling, and transportation systems involves an efficient method of transporting bulk contaminated materials from each contaminated area to a clean work area.

The containers for hauling radiologically contaminated excavated materials are open-top, roll-off boxes with varying dimensions, Maximum capacity includes 18.1 metric tons (20 tons) and 22.7 metric tons (25 tons). The steel containers have approximately 0.6-cm (0.25-in.)- thick floors, 0.5-cm (0.18-in.)-thick walls, and hinged locking rear gates. Other features include steel construction, a single top-hinged or side-hinged end gate, approximately 20.3-cm (8-in.)-diameter wheels at gate end, painted identification number, a heavy duty top-edge side rail, and fork pockets to accommodate lifting by forklift. A sufficient number of containers are available to ensure uninterrupted excavation operations. The open-top construction allows for top loading, and the top-hinged end gate allows the contents to be emptied by dump-bed trailers.

Shuttle trucks are used to transport the containers from the excavation area to the CTF, as well as to ERDF. The containers are transported on roll-on/roll-off trailers towed by conventional tractor units. The trailers and tractors are suitable for operating on sloped excavation access ramps and other off-road ramps, and also meet applicable DOT requirements. The wheel wells of the tractors tires are constructed to prevent soils from being thrown onto the trailer and its containers.

Containers are transported over existing Hanford Site roadways to ERDF. Empty containers returning from ERDF are unloaded and stored at the container transfer area until ready for refilling. A queue, maintained near the end of the container transfer area, provides temporary storage for full and/or empty containers if a backlog of containers develops or is required. The queue helps to maintain a continuous flow of materials through the transportation system by allowing excavation to continue for a limited time if the trucks running to ERDF are not operating, or it allows ERDF trucks to continue to run for a limited time if the excavators are not operating.

An alternative to transporting loaded containers from the excavation area to the CTF, then from the CTF to ERDF, is to load excavated material directly into material handling vehicles. These vehicles proceed directly to ERDF and the CTF is not used. The advantages of this method are that material handling vehicles can transport larger quantities and duplicate handling of excavated material is eliminated. Excavated material must meet stringent conditions, however, including nonradiologically contaminated material.

3.1.4 Soil and Debris Characterization and Analysis

Soil and debris characterization and analysis is based on the observational approach. This approach relies on recorded information from historical process operations, including effluent discharges and waste disposal records, and information from limited field investigations on the nature and extent of existing contamination combined with a "characterize-and-remediate-in-one-step" methodology. The latter methodology consists of site excavation, field screening, and in-process sampling for contaminants at sites where remedial action and cleanup goals have been selected. Remediation proceeds until it can be demonstrated through a combination of field screening, in-process sampling, and verification sampling that cleanup goals have been achieved.

During excavation, soils are monitored for both radiological and chemical constituents. For the radioactive liquid effluent sites, gamma-emitting radiological constituents are used as the primary "indicator" contaminants to guide excavation for the following reasons:

- Data indicate, in general, that when gamma-emitting radionuclide concentrations are less than cleanup criteria, concentrations of nonradiological constituents are also less than cleanup criteria.

- Gamma-emitting radionuclide contaminants are readily detected with field instruments at levels specified for cleanup, whereas alpha- and beta-emitting radionuclides and chemical constituents are not readily detected.

At other sites, monitoring methods depend on the anticipated contaminants. If field screening methodologies are not available for the primary or indicator contaminants, in-process samples may be collected for quick-turnaround laboratory analysis to guide excavation.

On initial completion of excavation at each waste site, cleanup verification sampling and analysis will be performed to confirm attainment of cleanup criteria for all COCs. If analytical results indicate that cleanup criteria have not been achieved, then excavation will resume with appropriate analyses as guidance.

Each shipment of soil/debris transported to ERDF is referenced to a waste profile that is representative of the material found at the site. The waste profile is "in effect" until the characteristics of the excavation site have changed significantly. A large increase in radioactivity levels exceeding waste profile limits, or the detection of previously unknown contaminants, would require an update to the waste profile.

3.1.5 Decontamination

Decontamination to support excavation activities is provided primarily by the following two methods: (1) wet methods using pressure washers and steam cleaners, and (2) dry methods using wiping and high-efficiency particulate air-filtered vacuum cleaners.

The following are best management practices (BMPs) for the wet cleaning and/or decontamination of heavy equipment and vehicles working directly in contaminated areas, when cleaning and/or decontamination water is not collected.

General BMP. This applies to all equipment cleaning/decontamination activities within a waste site.

- Decontamination should be conducted within the waste site to prevent the spread of contaminants.
- The amount of water used to clean equipment should be minimized.
- Raw or potable water should only be used.
- Soaps, detergents, or other cleaning agents **that would regulate as a hazardous waste** should not be added to wash water.
- Pressure washing will normally use cold water (hot water may be used to avoid icing).
- Steam cleaning may be used only after other decontamination methods prove to be ineffective.
- Decontamination practices will be documented in the daily log.
- Personnel responsible for equipment decontamination will be trained to this BMP.

Ongoing Remediation Site BMP. This applies to equipment being washed and/or decontaminated within sites that have ongoing remediation.

- Equipment washing/decontamination will be located in areas with ongoing waste removal.
- Spent wash water and associated contamination will be kept within the AOC.
- Pre- and post-washing/decontamination contaminant surveys are not required.
- The project may opt to collect wash water for reuse in the excavation or to be sent for treatment.

Completed Remediation Site BMP. This applies to equipment being washed and/or decontaminated within sites that have achieved preliminary remediation goals.

- At the "completion" of excavation activities at a site, the project may opt to transport the equipment to a nearby site that is being remediated (by excavation) to perform equipment washing/decontamination (as described above).
- Equipment washing/decontamination to be performed at the site will be physically located within the remediated site.
- A pre- and post-survey will be performed on the washing/decontamination area to assess and remediate (if required) areas affected by the activity.
- When the washing/decontamination is set up in an area of a site that has apparently attained the preliminary remediation goals, sampling of the area will be performed per the 100 Area and 100 Area Burial Grounds SAP (DOE-RL 2008, 2001a), as applicable.
- The project may opt to perform other methods of equipment washing and/or decontamination for a completed site (e.g., wrap the equipment for transfer to a decontamination pad, provide for a temporary facility at the site to collect wash water, fix the contamination to the equipment).

3.2 PROJECT SCHEDULE AND COST

Project schedules are developed in accordance with the River Corridor Closure Contractor's procedure manual PI-1, *Project Integration*, at several different levels consistent with the project work breakdown structure (WBS). The WBS-based schedules promote complete and consistent compliance with DOE Order 4700.1, *Project Management System*, and cost and schedule control systems criteria. Large-scale (multi-year) projects encompassing multiple smaller projects (e.g., each waste site remediation can be considered a single project, while the entire project is to remediate all waste sites) are generally planned and scheduled using a phased approach. Near-term (less than 1 year) work is usually planned and scheduled at a detail activity level using logic ties to establish and maintain a true critical-path schedule. Logic-driven, critical-path schedules,

commonly referred to as the critical-path method, are used to manage and control the daily progress of the work and provide early warning of problem areas. Forecast planning and scheduling (1 to 2 years) can be performed at the task-package level, and long-range planning and scheduling (greater than 2 years) is performed at the work package or cost account levels.

3.2.1 Remediation Scheduling

Post-ROD planning and scheduling for remediation projects follows a distinct pattern consistent with the work package level of the WBS. Planning elements at this level include, but are not limited to or bound by, remedial design, procurement, remedial actions, and site closures.

3.2.1.1 Remedial Design. Remedial design includes all design work, project plans, project procedures, remediation cost estimating, drawings, and specifications required to procure a remediation subcontractor to perform the remediation. Project plans will define the data-gathering requirements to ensure worker health and safety and to eventually prove the waste sites meet remediation goals and standards. Project procedures will define the "how to" of obtaining data and controlling the site activities. Planning documentation is discussed further in Section 3.4. Scope of work, design drawings, and specifications will provide the necessary technical tools to procure a subcontractor.

3.2.1.2 Procurement. Procurement includes soliciting qualified subcontractors, preparing RFPs, awarding the subcontract, coordinating submittals, negotiating change orders, and receiving and controlling subcontractor request for payments. The RFP documents are prepared as part of the remedial design. Procurement must assemble the RFP and contract documents.

3.2.1.3 Remedial Actions. Remedial action includes implementing the remedial design and project plans. The implementation will include, but will not be limited to, subcontractor oversight, excavation, material handling, analytical system operations, worker health and safety, radiological controls, data gathering, and overall daily conduct of operations. Subcontractor oversight occurs through administration of subcontract documents. Project specifications and procedures define the "how to" of excavation, material handling, analytical system operation, data gathering, and overall daily conduct of operations. Worker health and safety and radiological control requirements are included in site health and safety plans and permits.

3.2.1.4 Site Verification and Closeout. Site verification and closeout includes, but is not limited to, data collection (including samples and photos), data evaluation, data interpretation, preparation of documentation, Tri-Party approval that the RAOs have been met, and updating the WCH End States and Final Closure Project files and the Hanford Site Waste Information Data System (WIDS).

3.2.2 100 Area Interim Remedial Action Schedule

With the signing of the Interim Action ROD (EPA 1995) in September 1995, RL committed to perform remedial actions over the next several years on 37 waste sites within the 100 Area. In a 1997 ROD Amendment (EPA 1997a), RL committed to perform remedial actions at an additional 34 waste sites. In the July 1999 Remaining Sites ROD (EPA 1999), RL committed to

perform remedial actions at 46 remaining waste sites and use the plug-in approach at 161 other remaining sites. In the September 2000 100 Area Burial Grounds ROD (EPA 2000b), RL committed to perform remedial actions at 45 burial grounds. Three of these sites (i.e., 100-D-5, 100-D-6, and 100-D-46) were remediated during remediation of liquid waste disposal sites with which they were associated. A schedule for all Interim Action ROD, ROD Amendment, Remaining Sites ROD, and 100 Area Burial Grounds ROD milestones is provided in Figure 3-2. The schedule is based on factors defined by the Tri-Parties with public involvement (Appendix F). These factors include the following:

- Remedial actions shall occur concurrently in two reactor areas within 15 months of issuance of the Interim Action ROD. The initial two reactor areas are 100-B/C and 100-D/DR. (Completed)

- Remedial actions will be initiated in the 100-H Area on completion of remedial actions in either the 100-B/C or the 100-D/DR Area (see the *Richland Environmental Restoration Project Fiscal Year 2001-2003 Detailed Work Plan* [DOE-RL 2000]). (Completed)

- The methodology for prioritizing waste sites is summarized as initiating at the waste sites closest to the Columbia River and moving south toward the reactor buildings. This methodology incorporates the four factors defined by the Tri-Parties: (1) waste site impacts or impacts to groundwater, primarily due to chromium; (2) waste site proximity to the Columbia River; (3) waste site is a large contributor to surface radiation exposure; and (4) waste site follows logical construction management practices. (Ongoing)

- If waste sites are added, upon regulatory agency review and approval, the schedule will be updated and the additional waste sites will be integrated into the remedial action. (Ongoing)

- In accordance with an ESD to the ERDF ROD (EPA 1996) to authorize disposal of Environmental Restoration Program investigation-derived waste (IDW) in ERDF, RL developed an integrated schedule for disposal of these wastes. The schedule presented in the *Richland Environmental Restoration Project Fiscal Year 2001-2003 Detailed Work Plan* (DOE-RL 2000) identifies this activity (i.e., for those wastes associated with the 100 Area RODs). (Completed)

The remedial action schedules for cleanup of the 100 Area are driven by a set of milestones that have been established as part of the Tri-Party Agreement (Ecology et al. 1998), a number of which have been renegotiated. Schedule commitments associated with all Interim Action ROD, ROD Amendment, Remaining Sites ROD, and 100 Area Burial Grounds waste sites are summarized in Table 3-1 and are shown in Figure 3-2.

3.2.3 Project Cost

Cost estimates for remediation of waste sites listed in this document were prepared as part of their respective feasibility studies and subsequently carried forward into their proposed plans and RODs. Cost estimates were prepared with an accuracy of -30% and +50% to support evaluation

and remedial alternative and selection of a remedy. Cost estimates are updated based on design work.

3.3 PROJECT TEAM

The term project team, in the strictest sense, means all individuals working to accomplish a particular project. According to this definition, there are numerous members of the project team. For the purpose of this discussion, the project team is WCH, RL, EPA, and Ecology.

3.3.1 Regulatory Agencies

The regulatory agencies for the CERCLA remediation activities in the 100 Area of the Hanford Site are EPA and Ecology. The lead regulatory agency will depend on the OU area where the remediation activities are taking place (e.g., the EPA is currently the lead regulatory agency for 100-B/C, 100-F, and 100-KE/KW, and Ecology is the lead regulatory agency for 100-D/DR, 100-H, and 100-N). The lead regulatory agency may request support from the nonlead agency, if necessary. The lead regulatory agency is responsible for overseeing the activities to ensure that all applicable regulatory requirements are met.

3.3.2 U.S. Department of Energy, Richland Operations Office

RL is the government agency responsible for the remedial actions throughout the 100 Area and the remaining Hanford Site. RL has assigned project managers to each major area and task involved with remediation activities.

RL project managers are responsible for the management of their assigned activities, including scope, budget, schedule, quality, personnel, communication, risk/safety, contracts, and regulatory interface.

3.3.3 River Corridor Closure Contractor

WCH is the River Corridor Closure Contractor responsible for cleanup of the 100 Area waste sites along the Columbia River. Under the direction of the field remediation director, project managers are assigned areas consistent with the project management assignments of RL to promote a single point-of-contact management philosophy. Each WCH project manager must develop, maintain, and oversee individual project teams. The project team will include all required disciplines to accomplish the remedial actions in a safe, efficient, and compliant manner.

3.4 PLANNING DOCUMENTATION

Planning documentation to implement remedial actions includes the preparation of a set of field documents required to guide the work being performed. Examples include analytical system work instructions, site support systems work instructions, and radiation work permits. Some documentation requires the review and concurrence of RL and the regulatory agencies. In accordance with the 100 Area RODs, SAPs are already identified as primary documents. Other tiered documents (e.g., remedial designs, air monitoring plans [AMPs]) may require approval by the lead regulatory agency, if requested, and will follow the processes identified below.

3.4.1 Field Procedures

Field procedures provide guidance to the site workers during field work execution. The procedures define the scope, operations, progression of field work, personnel control requirements, radiological posting requirements, and analytical system guidance. The procedures also provide contingency plans should unexpected conditions arise. The site superintendent must execute the field operations in compliance with the field procedure.

3.4.2 Sampling and Analysis Plans

The 100 Area SAP (DOE-RL 2008) and the 100 Area Burial Grounds SAP (DOE-RL 2001a) provide guidance to field samplers during the field work specific to a remediation site or group of sites. The relationship between this RDR/RAWP and the SAPs is illustrated in Figure 3-3. Sampling is performed to meet five objectives: excavation guidance, waste profile verification, worker health and safety, site cleanup verification, and overburden soil and backfill material verification.

The 100 Area SAP also defines the decision-making process for the remaining sites. The remaining sites encompass a variety of miscellaneous liquid and nonliquid disposal sites, dump sites, burn pits, debris piles, french drains and unplanned releases. The decision-making process for the remaining sites is performed on a site-specific basis. Because of the diversity of characteristics among the remaining sites, an agreement was made with the regulators to provide the details of the sample design for each site in a site-specific work instruction.

The 100 Area SAP and the 100 Area Burial Grounds SAP include quality assurance project plans. The quality assurance project plans define the chain of custody and analysis strategy to control the quality and reliability of the analytical data. The field analytical team must perform all sampling and analysis efforts in strict compliance with the SAPs. The SAPs are primary documents and are provided to RL and regulatory agencies for review and approval.

Protocols for managing analytical data developed to support remedial action are specified in Section II.3.10 of the 100 Area SAP (DOE-RL 2008). The data management process starts with using the project's past-practice data as input to the data quality objective process and tracks the remedial action project sample data flow through collection, analysis, verification/validation, and storage in site data management databases. Both the past-practice and remedial action project

data are managed under documented configuration control procedures. Procedures are in place for the integrated sample data management processes.

3.4.3 Safety and Health Plan

Safety and health (S&H) plans are prepared in conjunction with the activity hazards classification. These plans provide guidance to the site superintendent and all personnel on the site for safety and health concerns specific to the remediation site and action. The WCH site-specific S&H plan is prepared by the project S&H officer and is reviewed by all project staff and WCH functional organizations. The site superintendent must comply with the S&H plan at all times. All project field staff must understand the S&H plan. All unescorted site visitors are required to read and sign the S&H plan before entering the construction area. Escorted visitors are briefed on the S&H plan and must be escorted by the site superintendent or designee at all times when in the construction area. The S&H plan is prepared and revised in accordance with SH-1, *Safety and Health*. The excavation subcontractor may prepare a separate S&H plan.

3.4.4 Mitigation Action Plan

The *Mitigation Action Plan for the 100 and 600 Areas of the Hanford Site* (DOE-RL 2001c) provides guidance to the design and field staff to ensure that natural and cultural resources are protected during field activities. The plan also includes avoidance and minimization steps for mitigation.

3.4.5 Remedial Action Design

RL shall provide the lead regulatory agency remedial designs for review and approval, if requested. Summary briefings and discussions may be held at Unit Manager's Meetings (UMM) or other forums, as agreed. Issues will be identified and resolved in a timely manner to prevent or minimize impacts to schedules for issuing RFPs.

The following process will be followed to implement the requirement above, and may be modified and documented at the 100 Area UMM:

Remedial Design Reviews:

- If requested, RL shall provide the draft remedial design package and design schedule to the lead regulatory agency at the UMM, or deliver to the local field office.
- Lead regulatory agency shall provide notice to RL within a timely manner, if approval is warranted.
- Lead regulatory agency review period is generally two weeks. If additional review time is necessary, the review period can be increased up to 45 calendar days. To minimize impacts to the schedule, additional review time should be communicated early in the process.

- Review comments and issues shall be identified and resolved in a timely manner. Review comments and issues, including responses or resolutions, shall be documented in the UMM, letters, or other forums, as agreed.

- RL shall provide a copy of the final remedial design package, which has comments incorporated, to the lead regulatory agency at the UMM, deliver to the local field office, or transmit.

Remedial Design Approval:

- An approval letter should be provided by the lead regulatory agency to RL within a reasonable timeframe. The approval letter should reference the specific design, and reference that approval by the lead regulatory agency was warranted.

3.4.6 Air Monitoring Plans

The substantive requirements applicable to radioactive air emissions resulting from remediation activities are to quantify potential emissions, monitor the emissions, and identify and employ best available radionuclide control technology. Exemption from these requirements may be requested if the potential-to-emit for the activity or emission unit would result in a total effective dose equivalent of less than 0.1 mrem/yr. Implementation of these elements fulfills the ARARs identified in the 100 Area RODS. The use of best available radionuclide control technology includes, but is not limited to, dust suppression (e.g., water, water sprays, fixatives) and the use of other standard engineering controls (e.g., high-efficiency particulate air filter vacuum cleaners). An AMP for the remedial action activity will be developed to incorporate the above requirements and will be provided to the lead regulatory agency for review and approval, if requested. Summary briefings and discussions may be held at UMMs or other forums, as agreed. Issues will be identified and resolved in a timely manner to prevent or minimize impacts to schedules.

The following process will be followed to implement the requirement above, and may be modified at the 100 Area UMM.

Air Monitoring Plan Reviews:

- RL shall provide the draft AMP and schedule to the lead regulatory agency at the UMM, deliver to the local field office, or other forums (as agreed).

- Lead regulatory agency shall provide documented notice to RL within a timely manner, if approval is warranted.

- Lead regulatory agency review period is generally two weeks. If additional review time is necessary, the review period can be increased up to 45 calendar days. To minimize impacts to the schedule, additional review time should be communicated early in the process.

- Review comments and issues shall be identified and resolved in a timely manner. Review comments and issues, including responses or resolutions, shall be documented in the UMM, letters, or other forums (as agreed).

- RL shall provide a copy of the final AMP, which has comments incorporated, to the lead regulatory agency at the UMM, deliver to the local field office, or transmit.

Air Monitoring Plan Approval:

- RL shall transmit the final AMP to the lead regulatory agency for approval.

- The lead regulatory agency should provide an approval letter to RL within a reasonable timeframe. The approval letter should reference the specific AMP, and reference that approval by the lead regulatory agency was warranted.

3.5 REMEDIAL ACTION CHANGE MANAGEMENT

Three types of changes in the 100 Area remedial actions are possible that affect compliance with the requirements in the RODs (EPA 1995, 1997a, 1999, 2000a, 2000b): (1) a nonsignificant or minor change, (2) a significant change to a component of the remedy, and (3) fundamental changes to the overall remedy.

A nonsignificant or minor change falls within the normal scope of changes occurring during the remedial design and remedial action processes. These minor changes should be documented in the appropriate post-decision project file. Nonsignificant changes shall not impact the requirements of the RODs nor will they impact the functional requirements. Examples of nonsignificant changes include, but are not limited to, the following:

- The addition of waste sites that are adjacent to and within the area required for remediation of sites addressed in the RODs

- Modifications to the remedial action schedule that do not impact agreed-upon milestones

- The addition of IDW associated with the sites listed in this document for remediation in a manner that is consistent with the scope and role of action as described in the RODs. The minor change to manage IDW associated with the waste sites addressed by the RODs is included in the WCH planned work schedule

- The granting of a treatability variance if it is technically impractical to meet the LDR treatment standard.

It may be determined that a significant change to the selected remedy as described in the RODs (EPA 1995, 1997a, 1999, 2000a, 2000b) is necessary after the RODs have been signed. Significant changes are defined as changes that significantly modify the scope, performance, or component cost for the remedy as presented in the RODs. All significant changes will be

addressed in an ESD. An example outline for an ESD can be found in the Interim Action ROD, Exhibit 8-3 (EPA 1995). Examples of significant changes will include, but are not limited to, the following:

- A 50% increase in the total cost of site remediation addressed in the RODs
- A delay in the point in time when the remedial action or objectives are met
- The addition of 100 Area IDW not associated with the sites in this document
- The addition of waste sites for remediation in a manner that is consistent with the scope and role of action as described in the RODs.

A fundamental change is a change that does not meet the requirements set forth in the RODs (EPA 1995, 1997a, 1999, 2000a, 2000b) or that incorporates remedial activities not defined in the scope of the RODs. In few cases are there fundamental changes to a ROD. Should the situation arise, the RODs must be amended. Examples of significant changes that fundamentally alter the remedy are as follows:

- Waste remains in place above cleanup objectives due to cultural resources
- A final land use is defined that is not compatible with the RODs
- Stabilization of waste remaining in place in the 100 Area rather than excavating and disposing the soil at ERDF.

The project manager is responsible for tracking all changes and obtaining appropriate reviews by WCH staff. The project manager will discuss the change with RL, and RL will then discuss the type of change that is necessary with the EPA and Ecology. The lead regulatory agency's responsibility is to determine the significance of the change. Appropriate documentation will follow based on the type of change.

3.6 ATTAINMENT OF REMEDIAL ACTION OBJECTIVES

This section describes the approach for verifying attainment of cleanup of soils in accordance with the RAOs identified in the RODs (EPA 1995, 1997a, 1999, 2000a, 2000b) and presents the supporting calculations. Because candidate sites are subject to compliance with RAOs prior to rejection as waste sites, they too are subject to verification with the RAGs in accordance with the approach below.

The analytical results used to verify attainment of RAOs will be derived from one of three types of sampling designs: focused sampling; random or statistical sampling; or a combination of both. In focused sampling, process knowledge and professional judgment are used to limit the number of samples from a site and focus sample collection on locations that are expected to have the highest contamination levels. The subsequent evaluation is based on maximum values.

Statistical sampling uses composite values and summary statistics for decision making. Based on experience to date, focused sampling is often appropriate for confirmatory sampling at remaining candidate sites, whereas statistical sampling is most often used at radioactive liquid effluent sites and remaining sites that require remedial action. The site-specific work instructions (sampling designs) are reviewed and approved by RL and the lead regulatory agency. Based on this review, these work instructions may be modified, as appropriate, prior to approval.

The general approach for verifying attainment of RAOs is presented in Figure 3-4 and involves the following steps.

- Identify the unit(s) within a site for cleanup verification.
- Calculate the summary statistics for the identified unit(s) (statistical sampling design) or maximum values (focused sampling).
- Identify the appropriate RAGs to be applied to the unit(s).
- Evaluate the summary statistics or maximum values, as appropriate, for the identified unit(s) against the decision rules for achieving the appropriate RAGs.
- Verify that radionuclide soil concentrations are less than the 15 mrem/yr radionuclide soil cleanup standard for direct exposure.
- Verify the attainment of the nonradionuclide soil concentrations corresponding to WAC 173-340-740(3) (1996) soil cleanup standards for direct contact.
- Verify that radionuclide soil concentrations are less than the radionuclide groundwater protection standard.
- Verify the attainment of the nonradionuclide contaminant concentrations in soil less than or equal to 100 times the groundwater RAGs for protection of groundwater.
- Verify that radionuclide soil concentrations are less than the radionuclide Columbia River protection standard after the DAF has been applied.
- Verify the attainment of the nonradionuclide contaminant concentrations in soil less than or equal to 100 times the RAGs for protection of the Columbia River after the DAF has been applied.
- Report the results of evaluations against ecological soil screening values as discussed in Section 2.1.2.6.

Details regarding verification sampling and analysis may be found in the 100 Area SAP (DOE-RL 2008) and the 100 Area Burial Grounds SAP (DOE-RL 2001a).

3.6.1 Identify the Unit(s) Within a Site for Cleanup Verification

In this step, the site is divided into units for purposes of collecting verification samples. Summary statistics (e.g., arithmetic mean and 95% upper confidence limit [UCL]) or maximum values are calculated for verification samples from a particular unit. Verification sampling and analysis data will be evaluated against the decision rules (see Section 3.6.4) on a unit-by-unit basis. Generally, a site will be divided into the following units: (1) stockpiled "clean" soil that will be returned to the excavation, (2) soil from the bottom of the excavation when excavation is from 0 to 4.6 m (0 to 15 ft) below ground surface, and (3) soil from the bottom of the excavation when excavation is greater than 4.6 m (15 ft) below ground surface. Additional units may be defined, as needed, for large sites or other specific needs. Overburden (stockpiled) "clean" soil from multiple waste sites may be combined into a single common overburden pile or multiple common overburden piles. These units will be identified in instructions prepared for confirmatory sampling. Details regarding verification sampling and analysis can be found in the 100 Area SAP (DOE-RL 2008) and the 100 Area Burial Grounds SAP (DOE-RL 2001a).

For candidate sites, confirmatory sampling may be performed to determine whether or not a site exceeds applicable RAGs. Factors such as site construction and purpose, contaminants of potential concern, process history, waste form, and contaminant dispersion mechanisms are considered so that the applicable sampling design may be chosen. The confirmatory sampling data will be evaluated against the decision rules (Section 3.6.5) on a unit-by-unit basis. Generally, a confirmatory sampling effort site will consist of just one unit, soil/material from the engineered structure from 0 to 4.6 m (15 ft) below grade level. Additional units may be defined, as needed, for large sites or other specific needs. These units will be identified in site-specific work instructions prepared for confirmatory sampling, which are submitted to the lead regulatory agency for review and approval. Details regarding verification sampling and analysis can be found in the 100 Area SAP (DOE-RL 2008) and site-specific work instructions for verification sampling.

3.6.2 Calculate the Summary Statistics for the Identified Unit(s) (Statistical Sampling Design)

The summary statistics needed for each unit (Section 3.6.1) are arithmetic mean, standard deviation, single-sided 95% UCL, and the total number of samples collected from the unit. The number of samples with concentrations exceeding the WAC 173-340 (1996) cleanup level and two times the WAC 173-340 (1996) cleanup level must also be determined from the sampling and analytical data.

The 95% UCL for the mean will be calculated for each COC, with adjustments for censored data in accordance with *Statistical Guidance for Ecology Site Managers* (Ecology 1992) and *Statistical Guidance for Ecology Site Managers, Supplement S-6, Analyzing Site or Background Data with Below-Detection Limit or Below-PQL Values (Censored Data Sets)* (Ecology 1993). For the nonradionuclides, the 95% UCL will be compared to the WAC 173-340 (1996) Method B limit in addition to the comparison of the raw data to twice the WAC 173-340 (1996) Method B limit and the proportion of raw data exceeding that WAC 173-340 (1996) Method B limit.

The 95% UCL for each of the COCs will be used as the basis for RESRAD modeling, as necessary.

Examination of the distribution of large nonradionuclide data sets (10 or more data points per component) will be done per guidelines presented in the Ecology guidance documents (Ecology 1992, 1993), and will typically be performed using the WAC 173-340 (1996) Microsoft® Excel module. Small data sets (less than 10 data points per component) will be evaluated in accordance with Section 5.2.1.4 of Ecology (1992) (refer to Figure 3-5).

3.6.3 Determine the Maximum Values for the Identified Unit(s) (Focused Sampling Design)

The maximum values for each unit (Section 3.6.1) must be determined from the data set. The number of samples with concentrations exceeding the WAC 173-340 (1996) cleanup level and two times the WAC 173-340 (1996) cleanup level must also be determined from the sampling and analytical data.

3.6.4 Identify the Appropriate Remedial Action Goals to be Applied to the Unit(s)

The RAG or RAGs that apply to a site must be identified to verify that remedial action has attained the RAOs. A review of Section 2.1.2 provides the necessary information to identify the appropriate RAGs. One or more of these goals may apply to any particular unit. Compound-specific RAGs (e.g., hydrocarbons, pesticides, volatile organic analytes, and semivolatile organic compounds) will be calculated, as needed, for site verification.

3.6.5 Evaluate the Data Against the Decision Rules for Achieving the Appropriate Remedial Action Goals

For the RAGs identified in the previous step, decision rules are defined that will be used to test verification sampling and analysis data. For statistical sampling designs, these decision rules are as follows:

- WAC 173-340-740(7)(e) (1996) standards are achieved under the following conditions:
  - The 95% UCL on the arithmetic mean from verification samples collected is less than the cleanup standard for each COC
  - No single sample concentration is greater than two times the cleanup standard
  - Less than 10% of the sample concentrations exceed the cleanup standard.
- Radionuclide soil cleanup standards are achieved under the following conditions: The dose calculated from the 95% UCL on the arithmetic mean for the sum of all radioactive COCs

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from verification samples collected from the sides of the excavation and from soil 0 to 4.6 m (0 to 15 ft) below grade is less than 15 mrem/yr above background. The dose is calculated assuming exposure during a portion of the individual's lifetime through inhalation, soil ingestion, crop ingestion, meat and milk ingestion, aquatic foods ingestion, drinking water ingestion, and external gamma exposure pathways using residential exposure assumptions (specific assumptions for dose calculations are presented in Appendix B). Figure 3-5 illustrates this scenario.

- For nonradioactive contaminants, cleanup of soils for groundwater protection will have been achieved when the 95% UCL on the arithmetic mean concentration in soil of each COC is less than 100 times the groundwater RAG as presented in Table B-5 of Appendix B or when site-specific modeling or other appropriate methods indicate that the residual contaminant concentrations will not impact groundwater at levels above the groundwater RAG for 1,000 years.

- For radionuclide contaminants, cleanup of soils for groundwater protection will have been achieved when the 95% UCL on the arithmetic mean concentration in soil of each COC is less than the value, as calculated by RESRAD, that meets the groundwater RAG as presented in Table B-5 (Appendix B).

- For nonradioactive contaminants, cleanup of soils for protection of the Columbia River will have been achieved when the 95% UCL on the arithmetic mean concentration in soil of each COC is less than 100 times the RAG after the DAF has been applied as presented in Table B-6 (Appendix B), or when site-specific modeling or other appropriate methods indicate that the residual contaminant concentrations will not impact the river at levels above the surface water RAG after the DAF has been applied for 1,000 years (EPA 2000b).

- For radionuclide contaminants, cleanup of soils for protection of the Columbia River will have been achieved when the 95% UCL on the arithmetic mean concentration in soil of each COC is less than the value, as calculated by RESRAD, that meets the RAG after the DAF has been applied as presented in Table B-6 (Appendix B).

For focused sampling designs, the decision rules are the same except that maximum values are used in lieu of the 95% UCL on the arithmetic mean concentration.

3.6.6 Verify the Attainment of the Radionuclide Soil Cleanup Standard

Determining when a remedial action has achieved the cleanup level (15 mrem/yr above background) involves converting radionuclide concentrations (in pCi/g) in soil into dose rates (in mrem/yr) using a dose assessment model. Use of a model requires an exposure scenario that specifies (1) a hypothetical receptor, (2) pathways of exposure from radionuclides in soil to the receptor, and (3) assumptions and parameters for estimating exposures and doses to the receptor from radionuclides in soil.

Unrestricted future use in the 100 Area is represented by an individual resident in a rural-residential setting. This resident is assumed to consume crops raised in a backyard garden,

meat and milk from locally raised livestock, and meat from game animals and fish, and to live in a residence with a basement 3.7 m (12 ft) below grade. The following exposure pathways are considered when estimating doses from radionuclides in soil: inhalation; soil ingestion; ingestion of crops, meat, fish, drinking water, and milk; and external gamma exposure. External gamma exposure is assumed to be the only exposure pathway from contaminants at the bottom of the excavation and is assumed to occur only when an individual is in the basement. (Wastes left in place at depths greater than 4.6 m [15 ft] and that are protective of groundwater and the Columbia River will have institutional controls applied [e.g., deed restrictions for well drilling and deep excavation].) This individual is conservatively assumed to spend 25% of his/her lifetime in the basement. Therefore, doses are calculated separately in fill soil from 0 to 4.6 m (0 to 15 ft) below grade and for residual contaminants at the bottom of the excavation. These doses are then summed to obtain the total dose associated with radionuclides in soil. A list of the assumptions and model parameters used in RESRAD is presented in Appendix B.

3.6.7 Verify the Attainment of the WAC 173-340-740(3) (1996) Cleanup Standards

Verifying the attainment of WAC 173-340-740(3) (1996) cleanup standards involves comparing the appropriate summary statistics or maximum values with the RAGs presented in Table 2-1, or conducting a site-specific assessment using models or other appropriate methods to demonstrate that residual site contamination does not pose an unacceptable risk. The decision rules for WAC 173-340 (1996) standards presented in Section 3.6.4 are also used for this verification.

3.6.8 Verify the Attainment of the Contaminant Concentrations in Soil for Protection of the Groundwater

Verifying the attainment of groundwater protection RAGS for radionuclides involves using the RESRAD model with site-specific and 100 Area-specific parameters to assess the groundwater impact from residual site contamination. The RESRAD estimated groundwater concentrations (as effected by post-remediation residual contamination) are used to calculate a dose based on groundwater used as drinking water or are directly compared to radionuclide drinking water maximum contaminant levels. For nonradionuclides, the summary statistical values are compared to the groundwater protection soil RAGs developed in Table B-5 of Appendix B. The groundwater protection RAG is attained if the statistical values are less than the Table B-5 RAGs and each sample data set meets the requirements of the WAC 173-340-740(7)(e) (1996) three-part test. If this is not the case, a more detailed assessment using RESRAD or other appropriate methods (e.g., leach tests) is used to assess the potential of residual site contaminants to impact groundwater. If this assessment indicates that the residual contamination at the site will not impact groundwater at concentrations above the groundwater RAGs, then the groundwater protection RAG has been attained.

3.6.9 Verify the Attainment of the Contaminant Concentrations in Soil for Protection of the Columbia River

The Columbia River radionuclide protection RAGs are identical to the groundwater protection RAGs; therefore, showing groundwater protection as discussed above also shows protection of the Columbia River. For nonradionuclides, the summary statistical values are compared to the

Columbia River protection soil RAGs developed in Table B-6 of Appendix B. The river protection RAG is attained if the statistical values are less than the Table B-6 RAGs and each sample data set meets the requirements of the WAC 173-340-740(7)(e) (1996) three-part test. If this is not the case, a more detailed assessment using RESRAD or other appropriate methods (e.g., leach tests) is used to assess the potential of residual site contaminants to impact groundwater and the river. If this assessment indicates that the residual contamination at the site will not impact groundwater (and therefore the river) at concentrations above the river RAGs, then the Columbia River protection RAG has been attained.

3.7 CERCLA CLEANUP DOCUMENTATION

Subsequent to remedial action, cleanup verification reports will be prepared. The reports will provide the needed documentation for verification of interim remedial action at a site and to support the eventual deletion of the OU from the NPL. Cleanup verification reports will be prepared for groups of sites or individual sites, as needed. Guidance found in Appendix G is one method to satisfy this requirement. Less complex sites require less complex verification reports. At a minimum, the following is required for each waste site:

- Description of current waste site condition
- Basis for reclassification
- Analytic data or data references (if applicable).

Candidate sites confirmed not to exceed the RAGs for any constituents will be reclassified as no action per the waste site reclassification guideline TPA-MP-14, "Maintenance of the Waste Information Data System (WIDS)" (DOE-RL2007). Regulator approval will be documented on a Waste Site Reclassification Form, which is accompanied by a regulator-reviewed site-specific informal report. Supporting documentation (e.g., calculations, memorandum to file explaining field investigation effort) will be held in records retention for retrieval, if ever required. The WIDS database will serve as formal notification to the public that the site is no longer a candidate for remedial action and does not exceed RAOs established in the Remaining Sites ROD (EPA 1999).

3.8 SITE RELEASE

RL will continue to manage the land in the 100 Area of the Hanford Site as long as necessary to support remedial actions and other missions. The release of land areas for other uses will depend on the following: (1) release of the individual waste sites, and (2) the completion of other work in the OU such as decontamination and decommissioning of facilities as well as final cleanup verification under CERCLA.

It is unknown at this time when a final ROD will be recorded for the 100 Area NPL site, but the final ROD will contain operation and maintenance requirements. The RL will provide institutional controls (e.g., site monitoring and access restrictions) to meet all project missions until such time that they are deemed unnecessary.

Institutional controls are designed to prevent exposure to contamination by limiting land or resource uses. Continuing existing institutional controls during the interim action include access controls, water-use and land-use restrictions, and signs. Restrictions on certain land uses (e.g., restricting drilling or excavation) are administered through the onsite excavation permit process. Access control is ensured through Hanford Site badging requirements and the use of signs posted along the Columbia River shoreline for restricted uses. RL is responsible for establishing and maintaining land-use and access restrictions until the RAOs are achieved. RL will notify EPA and Ecology upon discovering any trespassing incident and will report the incident to the Benton County Sheriff's Office.

Where deed restrictions or other institutional controls are used in accordance with this RDR/RAWP and the RODs (EPA 1995, 1997a, 1999, 2000a, 2000b), RL will not allow any activities that would interfere with the remedial action prior to EPA and Ecology approval. Additionally, RL will take necessary measures, such as filing the deed restrictions in appropriate county offices, to ensure the continuation of these restrictions prior to any transfer or lease of the property. A copy of a notification of any restrictions will be given to any prospective purchaser/transferee before any transfer or lease by RL. RL will provide EPA and Ecology with written verification that these restrictions have been put in place.

A plan for implementing current and post-remedial action institutional controls as specified in the RODs is presented in the *Sitewide Institutional Controls Plan for Hanford CERCLA Response Actions* (DOE-RL 2002). The institutional controls defined in this plan will be enforced during and after cleanup, as appropriate. The plan describes the types of institutional controls used and how each type of control is, or will be, implemented. The institutional controls are grouped into five main types: warning notices, entry restrictions, land-use management, groundwater-use management, and waste site information management. In addition, the plan includes the following:

- A tracking mechanism defining restricted land areas and changes to these areas
- Notification requirements for activities that are inconsistent with the institutional control objectives for the site
- A point of contact for institutional control compliance on the Hanford Site
- Evaluation of the implementation and effectiveness of institutional controls on an annual basis with a report issued each year to EPA and Ecology by September 30.

The following institutional controls will be implemented:

- Warning notices:
  - Appropriate signage is posted at various locations around the perimeter of the Hanford Site. Additionally: One sign is located along the Columbia River at each reactor area (100-B/C, 100-K, 100-N, 100-D/DR, 100-H, and 100-F). The signs will consist of one

each in Spanish and English. The signs will be located so that the distance for viewing from the Columbia River will be approximately 150 m (500 ft). No signs will be placed between reactor areas. Another sign will be placed at the major road entrance to the areas (100-B/C, 100-K, 100-N, 100-D/DR, 100-H, and 100-F). Location of the signs have been coordinated with the regulators. The English sign along the river reads as follows:

WARNING: HAZARDOUS AREA
DO NOT ENTER
Area May Contain Hazardous Soil and Water Seeps
For Information Call: 509-376-7501

The Spanish sign reads as follows:

ADVERTENCIA: AREA DE PELIGRO
NO ENTRES
Esta area puede contener tierra y fuentes de agua que son peligrosas.
Para Informacion Usted Puede Llamar a (509) 376-7501

- Along access roads, one large sign is located at the entrance to the active remediation area. The sign reads as follows:

WARNING: HAZARDOUS AREA
Area May Contain Hazardous Soil
Only Authorized Personnel Allowed
For Information Call: 509-376-7501

- Entry restrictions: Site access is restricted and security badges must be worn by employees, contractors, and visitors. Before receiving a badge, all must receive the level of training required to access the site or perform work.

- Land-use management: Excavation permits are required for excavations in the areas to prevent unplanned disturbances, spread of contamination, or infiltration.

- Groundwater-use management: Groundwater use is restricted, except for the purpose of monitoring and treatment, as approved by EPA or Ecology or as authorized in EPA-approved documents. Groundwater use is also controlled through excavation permits.

- Waste site-specific institutional controls: The site-specific institutional control requirements and information on the location and nature of any remaining contamination documented in the cleanup verification package (in Section 8.0, "Statement of Protectiveness") is maintained in WIDS.

Figure 3-1. Remedial Action Process Overview.

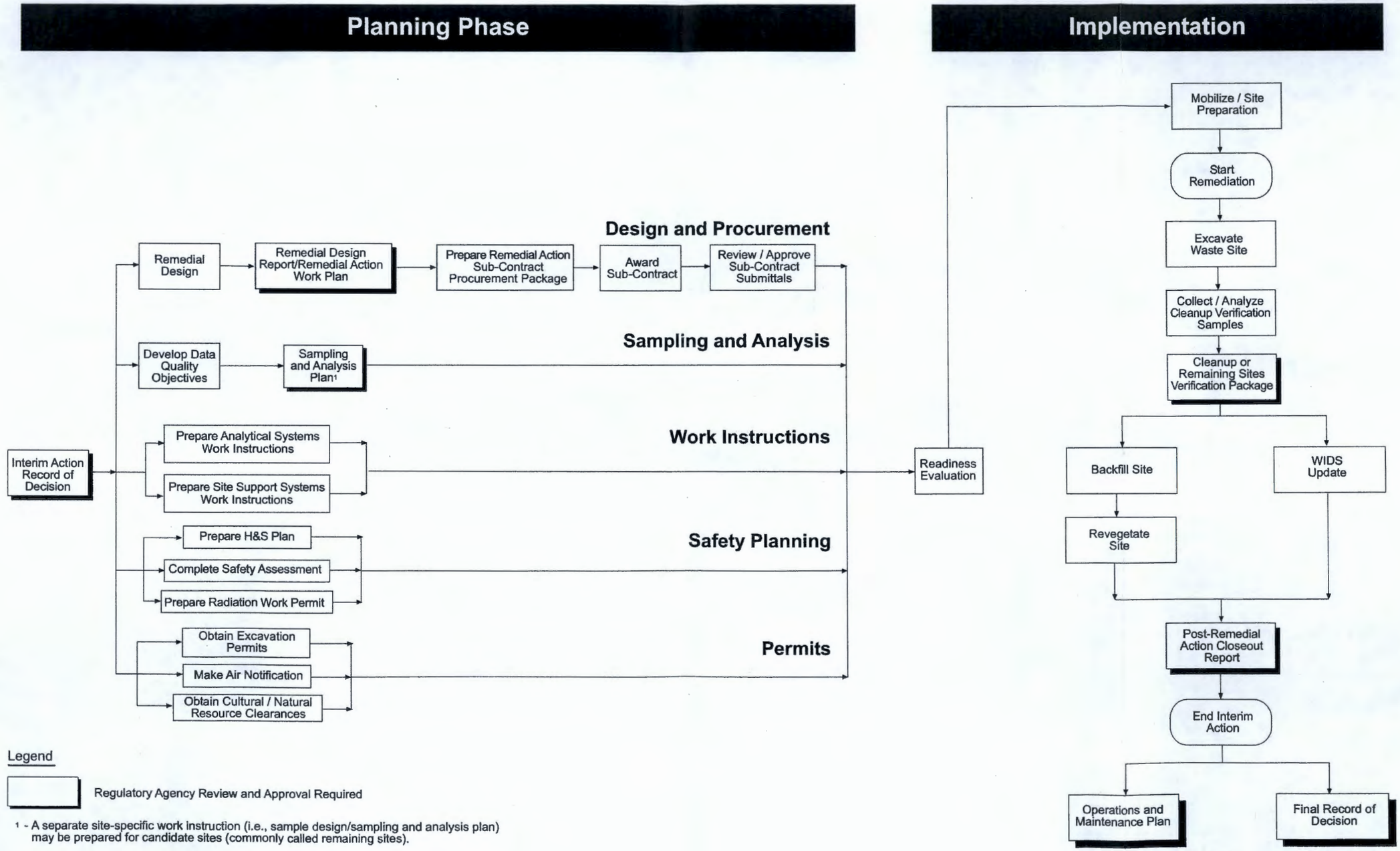


Figure 3-2. Tri-Party Agreement Milestones for 100 Area CERCLA Cleanup.

M-16 MILESTONES	Fiscal Year 2002	Fiscal Year 2003	Fiscal Year 2004	Fiscal Year 2005	Fiscal Year 2006	Fiscal Year 2007	Fiscal Year 2008	Fiscal Year 2009	Fiscal Year 2010	Fiscal Year 2011	Fiscal Year 2012	Fiscal Year 2013
M-016-10A		▲	Initiate remedial actions in the 100-KR-1 Operable Unit (8/1/03)									
M-016-13B				▲	Complete remediation and backfill of 16 liquid waste sites and process effluent pipelines in the 100-FR-1 and 100-FR-2 Operable Units (10/29/04)							
M-016-26B	▲	Complete remediation and backfill of 51 liquid waste sites and complete revegetation of 36 liquid waste sites (03/31/02)										
M-016-26E				▲	Complete excavation and removal of 100-B/C process effluent pipelines (09/30/04)							
M-016-26F					▲	Complete backfill of 100-BC process effluent pipelines and excavations (02/28/05)						
M-016-00A										Complete all interim response actions for the 100 Areas (12/31/12)		△
M-016-45							▲	Complete interim remedial action for 100-B/C Area (12/31/07)				
M-016-46						▲	Initiate remedial actions for remaining waste sites for 100-D Area (07/31/06)					
M-016-47								Complete interim remedial actions for 100-D Area (12/31/11)			△	
M-016-48					▲	Initiate remedial actions for remaining waste sites for 100-F Area (7/31/05)						
M-016-49								△	Complete interim remedial actions for 100-F Area (12/31/08)			
M-016-50								▲	Initiate remedial actions for remaining waste sites for 100-H Area (10/31/08)			
M-016-51								Complete interim remedial actions for the 100-H Area (12/31/11)	△			
M-016-51-T01									△	Complete excavation of 1 of 5 100-H Area Burial Grounds (12/31/09)		
M-016-51-T02										△	Complete excavation of a total of 3 of 5 100-H Area Burial Grounds (12/31/10)	
M-016-52								△	Initiate response actions for remaining waste sites for 100-K Area including closure of 1706-KE waste treatment system (7/31/09)			
M-016-53									Complete interim response actions for 100-K Area (12/31/12)			△
M-016-56								△	Complete interim remedial actions for 100-IU-2 and 100-IU-6 (12/31/08)			
M-016-57									△	Initiate K-East Basin soil remediation (10/31/09)		
M-016-58								△	Initiate soil remediation at K-West Basin (4/30/09)			
M-016-94									△	Complete interim remedial actions at 100-B/C Area (not covered by M-016-45) (12/31/09)		
COMMITMENTS	C-16-06A	● Submit the B/C Risk Assessment Pilot Study to EPA & Ecology										
	C-16-06B	● Submit an Engineering Evaluation of the final disposition of the river pipelines and outfall structures to EPA & Ecology (07/31/05)										

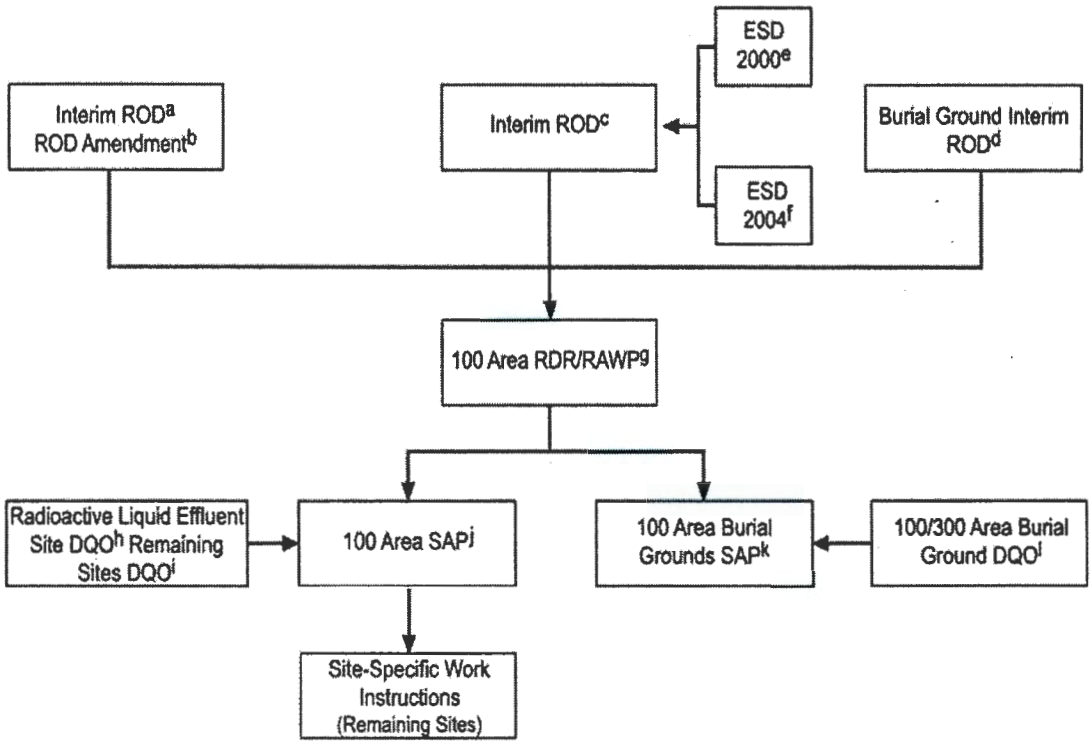
LEGEND

△ **TPA Milestone**

▲ **Completed TPA Milestone**

● **Completed Commitment**

Figure 3-3. 100 Area Record of Decisions and Implementing Documents



NOTE: The 100-N Area is not included in these documents.

[a] *Interim Action Record of Decision for the 100-BC-1, 100-DR-1, and 100-HR-1 Operable Units, Hanford Site, Benton County, Washington* (EPA 1995).

[b] *Amendment to the Interim Action Record of Decision for the 100-BC-1, 100-DR-1, and 100-HR-1 Operable Units* (EPA 1997a).

[c] *Interim Action Record of Decision for the 100-BC-1, 100-BC-2, 100-DR-1, 100-DR-2, 100-FR-1, 100-FR-2, 100-HR-1, 100-HR-2, 100-KR-1, 100-KR-2, 100-IU-2, 100-IU-6, and 200-CW-3 Operable Units, Hanford Site, Benton County, Washington* (EPA 1999b).

[d] *Record of Decision for the 100-BC-1, 100-BC-2, 100-DR-1, 100-DR-2, 100-FR-2, 100-HR-2, and 100-KR-2 Operable Units (100 Area Burial Grounds), Hanford Site, Benton County, Washington* (EPA 2000b).

[e] *Explanation of Significant Difference for the 100 Area Remaining Sites ROD* (EPA 2000a).

[f] *Explanation of Significant Differences for the 100 Area Remaining Sites Interim Remedial Action ROD* (EPA 2004).

[g] *Remedial Design Report/Remedial Action Work Plan for the 100 Area* (this document).

[h] *Data Quality Objectives Summary Report for the 100-FR-1, 100-FR-2, 100-HR-1, 100-KR-1, and 100-KR-2 Group 4 Waste Sites* (DOE-RL 1997b); *Data Quality Objectives Summary Report for the 100-BC-1, 100-BC-2, 100-DR-1, and 100-DR-2 Group 3 Waste Sites* (DOE-RL 1997a); *Data Quality Objectives for the 100-D Group 2 Waste Sites* (DOE-RL 1996c).

[i] *Data Quality Objectives Summary Report for the 100 Area Remaining Confirmatory Sampling Effort Sites* (BHI 2003).

[j] *100 Area Remedial Action Sampling and Analysis Plan* (DOE-RL 2008).

[k] *100 Area Burial Grounds Remedial Action Sampling and Analysis Plan* (DOE-RL 2001a).

[l] *Data Quality Objective Summary Report for the 100 Area Burial Grounds and 300-FF-2 Operable Unit Waste Sites* (BHI 2003).

Figure 3-4. Verification of Soil Cleanup.

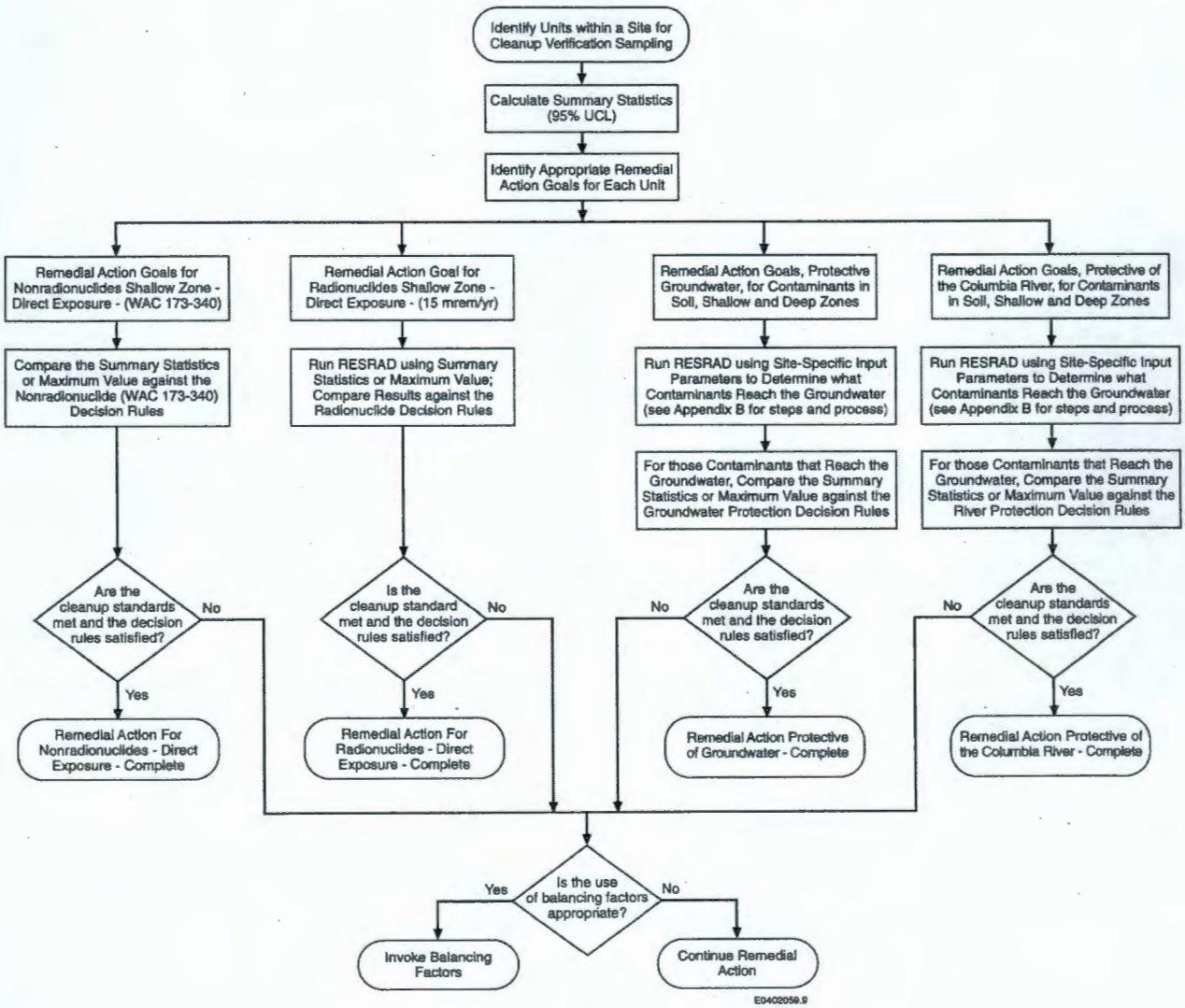


Figure 3-5. Human Exposure Scenario.

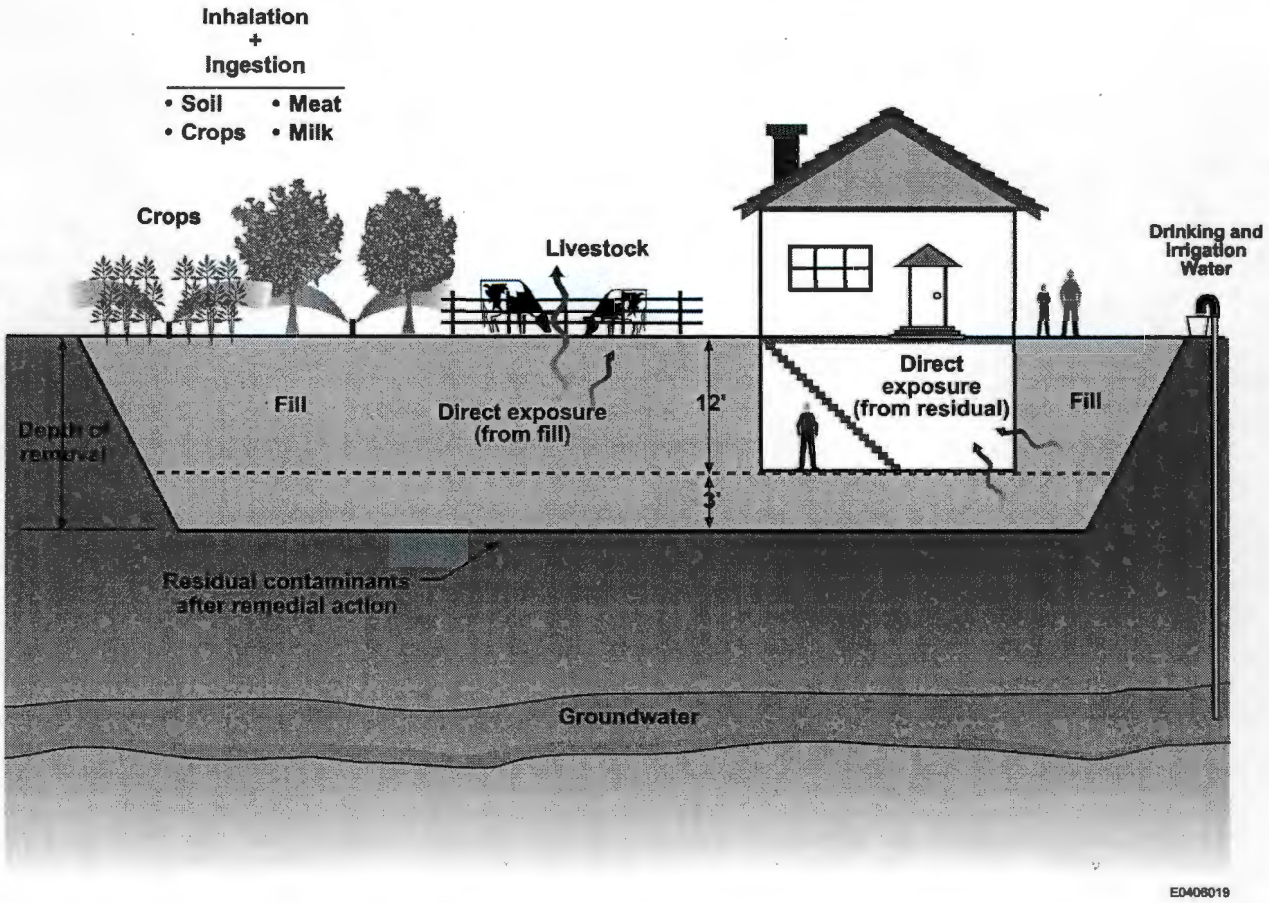


Table 3-1. Summary of Relevant Tri-Party Agreement Milestones. (2 Pages)

Milestone	Description	Due Date/ Complete Date
	General 100 Area Milestones	
M-016-10A	Initiate remedial actions in the 100-KR-1 OU.	August 01, 2003 Completed Dec. 11, 2002
M-016-13B	Complete remediation and backfill of 16 liquid waste sites and process effluent pipelines in the 100-FR-1 and 100-FR-2 OUs	October 29, 2004 Completed May 20, 2003
M-016-26B	Complete remediation and backfill of 51 liquid waste sites in the 100-BC-1, 100-BC-2, 100-DR-1, 100-DR-2, and 100-HR-1 OUs. Complete revegetation of 36 liquid waste sites in the 100-BC-1, 100-DR-1, 100-DR-2, and 100-HR-1 OUs.	March 31, 2002 Completed Dec. 11, 2001
M-016-26E	Complete excavation and removal of 100-B/C process effluent pipelines.	September 30, 2004 Completed Nov. 5, 2003
M-016-26F[a]	Complete backfill of 100-B/C process effluent pipelines and excavations.	February 28, 2005 Completed May 7, 2004
M-016-00A	Complete all interim response actions for the 100 Area. Completion of interim response actions is defined as the completion of the Interim ROD or Action Memorandum requirements in accordance with an approved RDR/RAWP or Removal Action Work Plan and obtain EPA and/or Ecology approval of the appropriate project closeout documents.	December 31, 2012
M-016-45	Complete the interim remedial action for the 100-B/C Area.	December 31, 2007 Completed Dec. 30, 2007
M-016-46	Initiate remedial actions for remaining waste sites for the 100-D Area.	July 31, 2006 Completed June 13, 2006
M-016-47	Complete the interim remedial actions for the 100-D Area.	December 31, 2011
M-016-48	Initiate remedial actions for the remaining waste sites for the 100-F Area.	July 31, 2005 Completed March 29, 2005
M-016-49	Complete the interim remedial actions for the 100-F Area.	December 31, 2008
M-016-50	Initiate remedial actions for the remaining waste sites for the 100-H Area.	October 31, 2008 Completed July 22, 2008
M-016-51	Complete the interim remedial actions for the 100-H Area.	December 31, 2011
M-016-51-T01	Complete excavation of 1 of 5 100-H Burial Grounds (118-H-1, 118-H-2, 118-H-3, 118-H-4, or 118-H-5).	December 31, 2009
M-016-51-T02	Complete excavation of a total of 3 of 5 100-H Burial Grounds (118-H-1, 118-H-2, 118-H-3, 118-H-4, or 118-H-5).	December 31, 2010
M-016-52	Initiate response actions for the remaining waste sites from the 100-K Area including closure of the 1706-KE Waste Treatment System in accordance with Section 5.5 of the Agreement Action Plan.	July 31, 2009

Table 3-1. Summary of Relevant Tri-Party Agreement Milestones. (2 Pages)

Milestone	Description	Due Date/ Complete Date
M-016-53	Complete the interim response actions for the 100-K Area.	December 31, 2012
M-016-56	Complete the interim remedial actions for the 100-IU-2 and 100-IU-6 OUs.	December 31, 2008
M-016-57	Initiate K-East Basin soil remediation.	October 31, 2009
M-016-58	Initiate soil remediation at K-West Basin.	April 30, 2009
M-016-94	Complete the interim remedial actions at 100-B/C (not covered by M-16-45).	December 21, 2009
Additional Commitments		
C-16-06A	Submit the 100-B/C risk assessment pilot study to EPA and Ecology.	July 31, 2005 Completed July 13, 2005
C-16-06B	Submit an engineering evaluation of the final disposition of the river pipelines and outfall structures to EPA and Ecology.	July 31, 2005 Completed April 19, 2005

[a] Tri-Party Agreement Milestone M-016-26F has an associated commitment to submit the 100-B/C risk assessment pilot study to EPA and Ecology (completed July 13, 2005).

Definitions for Tri-Party Agreement Milestones M-016-45 through M-016-94:

Initiate Remedial Actions: This is the initiation of excavation of waste sites.

Remaining Waste Sites: This includes all waste sites that have been designated for response actions including liquid disposal sites, solid waste burial grounds, unplanned releases, miscellaneous pipelines, and other miscellaneous waste sites.

Complete Interim Remedial Actions: This includes the completion of the excavation, backfill, and revegetation of the waste sites. It also includes the completion of the decontamination and decommissioning of ancillary facilities. EPA/Ecology approval of the waste site reclassification form for cleanup verification packages must also be done.

4.0 WASTE MANAGEMENT

This waste management plan establishes the requirements and describes the activities for the management and disposal of waste associated with the remedial actions as stipulated in the Interim Action ROD (EPA 1995), the ROD Amendment (EPA 1997a), the Remaining Sites ROD (EPA 1999), and the 100 Area Burial Grounds ROD (EPA 2000b).

Waste management activities will be performed in accordance with waste management ARARs identified in Section 2.1.6 of each ROD. The requirements specified by the ARARs and other applicable guidance and contractor procedures will address waste storage, transportation, packaging, handling, and labeling as they specifically apply to waste streams from each waste site.

4.1 PROJECTED WASTE STREAMS

In conducting the remedial action, various waste steams will be encountered. Each waste stream will require specific processing and disposal. Similar types of OU-specific waste will be managed uniformly. Assignment of waste to the appropriate waste stream depends on knowing the designation of the waste and appropriate disposal facility. Projected waste streams include, but are not limited to, the following:

- Nonhazardous, nondangerous miscellaneous solid waste
  - Filter paper, wipes, personal protective equipment, cloth, plastic, equipment, tools, pumps, wire, metal and plastic piping, and materials from cleanup of unplanned releases
  - "Demolition waste," which means solid waste, largely inert waste, resulting from the demolition or razing of buildings, roads, or other man-made structures
- Low-level radioactive waste, including soil and associated miscellaneous solid waste. Decommissioning debris includes such materials as concrete, wood, rebar, metal/plastic pipe and screens, wire, liners, equipment, pumps, and tanks
- Mixed waste (i.e., waste that is both low-level radioactive waste and hazardous waste)
- Liquids including, but not limited to, the following:
  - Water from unplanned releases (i.e., spills)
    - Decontamination/cleaning fluids
    - Unknown (i.e., liquid in pipes).
- Used oil/hydraulic fluids

- Returned sample waste associated with these waste sites
- Nonradioactive waste (e.g., asbestos, PCBs, TPH)
- Hazardous or dangerous waste
- Spent nuclear fuel.

4.1.1 Waste Characterization, Designation, and Disposal

Miscellaneous solid waste and demolition debris that has contacted contaminated media, and/or is designated as contaminated by process knowledge or other information, may be disposed of at ERDF as described above. Waste will be characterized and designated in accordance with requirements of the receiving facility and in accordance with the approved 100 Area SAP (DOE-RL 2008) and the 100 Area Burial Grounds SAP (DOE-RL 2001a). The sorting process is observational and is performed to identify the nonconforming waste forms. Waste will be designated using process knowledge, historical analytical data, engineering calculations, and/or analyses of samples identified in the referenced documents or SAPs, as appropriate. Anomalous wastes are defined as waste materials that must be sorted out of the burial ground dig face or by a mechanical sorting process because they require special handling and/or treatment prior to disposal. This anomalous material may or may not require additional characterization prior to disposal. Every effort will be made to minimize waste volume for disposal at ERDF through recycling and reuse, as appropriate.

ERDF is the preferred disposal location, provided that the waste acceptance criteria (WCH 2008) are met. As necessary, waste will be stored within the AOC, in staging piles, or at ERDF as described in the following subsections.

Miscellaneous solid waste and demolition debris that has contacted contaminated media may be disposed of at ERDF as described above. Miscellaneous solid waste or demolition debris that is nondangerous and has been radiologically released may be disposed of at an offsite permitted disposal facility or a limited purpose inert landfill, or recycled, as appropriate. On a case-by-case basis, and as allowed by the lead regulatory agency, such waste forms may be used as waste site backfill provided that general size and/or placement requirements are met. These case-by-case agreements will be documented in UMMs or other forums agreed to by the lead regulatory agency. Uncontaminated soils will be placed on the ground near the point of origin. Waste handling and disposal options are further described in Section 4.3.

SNF was discovered during burial ground excavation in 2004. SNF must be managed as high-level waste and is not eligible for disposal in ERDF. SNF will be stored on the Hanford Site until an offsite storage or disposal facility authorized to manage high-level waste becomes available (DOE-RL et al. 2005b).

Small volumes of liquid that have been solidified may also be disposed of at ERDF if the waste meets ERDF waste acceptance criteria. Liquid waste that does not meet the ERDF acceptance criteria will be shipped to the Effluent Treatment Facility (ETF) or an appropriate offsite facility.

Offsite facilities that receive contaminated waste must be deemed acceptable by the EPA in accordance with 40 CFR 300.440. Used nonradioactive oil will be sent offsite for recycling or disposal. Spent or unusable chemicals/reagents may also be generated during field sampling and analysis, and would require disposal based on the designation.

The ETF is an approved noncontiguous onsite facility pursuant to CERCLA Section 104(d)(4) to store and treat liquid waste generated from removal actions, provided the waste acceptance criteria are met.

Three categories of waste exist from a designation standpoint: (1) wastes that do not require additional characterization or special handling, (2) wastes that do not require additional characterization but do require special handling, and (3) wastes that require additional characterization.

4.1.1.1 Wastes That Do Not Require Additional Characterization or Special Handling. Wastes that do not require additional characterization or special handling include untreated wastes that conform to the conceptual waste form models (CWFMs) (and/or process soil) that may be designated without characterization, and do not require special handling for human exposure or waste acceptance.

4.1.1.2 Wastes That Do Not Require Additional Characterization, But Do Require Special Handling. Wastes that do not require additional characterization but do require special handling are untreated wastes that conform to the CWFMs (and/or process soil) that may be designated without characterization, but do require special handling for human exposure or waste acceptance. Waste types in this category include, but are not limited to, the following:

- Lead bricks
- Cadmium shielding
- Friable asbestos-containing materials
- High-dose, highly contaminated components that do not contain dangerous/hazardous materials
- Spend nuclear fuel.

4.1.1.3 Wastes That Require Additional Characterization. Wastes that require additional characterization include untreated and/or treated wastes that cannot be designated without characterization, and may also require special handling for human exposure protection or waste acceptance. Unknown anomalous materials are included in this category.

4.1.2 Waste Designation Methods

Wastes will be designated for waste disposition based on one of several methods, including historical data, process knowledge, engineering calculations, and sampling and analysis. This is presented for information purposes only and the generator is responsible for proper waste designation. Each of these methods and their applications is described as follows:

- Historical data may be used to designate waste forms that have previously been characterized (e.g., 100 Area Reactor Interim Safe Storage Project, general housekeeping activities, the

100 Area Excavation Treatability Study Report [DOE-RL 1996a]). In addition, previous and current 300 Area burial ground remediation projects have designated significant quantities of buried solid waste. The waste forms in this category are readily identified and are known for their hazardous material content.

- Process knowledge will be used to designate wastes for which process knowledge provides sufficient information. Waste forms such as asbestos-containing floor tiles and pipe lagging do not require sampling and analysis because these will be designated as asbestos-containing materials based on visual observation.

- Engineering calculations may be performed to determine the weight or volume of a hazardous waste in a certain matrix (e.g., calculating lead-based paint content on pump housings).

- Field screening and sampling and analysis will be used for designation of wastes when the other methods are not appropriate. Sampling and analysis is required for liquids and most of the anomalous waste forms.

Visual observations combined with historical data, process knowledge, and engineering calculations can result in a cost-effective and expeditious waste designation. The observational designation process is based on the assumption that the buried waste did not change after disposal; however, it is recognized that containers of liquids may have leaked, causing dangerous/hazardous materials to come into contact with buried solid wastes, or contaminated soils may have been disposed in the burial grounds. It is therefore necessary to screen the co-mingled soil during excavation, as determined by the project.

Specific types of anomalous wastes that are repeatedly discovered during remediation should become new CWFMs. This would be a field decision based on concurrence by the WCH Waste Management representative, safety engineer, project environmental lead, and analytical lead (or task lead, as appropriate), and is documented in the project files.

After the anomalous waste forms are removed, the co-mingled soil will be referred to as "process soil," consistent with current 300 Area burial ground remediation terminology. Process soil will be field screened on a frequency basis in addition to field observations.

In addition to the frequency-based field screening, visual observations made in the dig face or process soil piles will be used to trigger field screening. This is based on visual observations of color changes, odors, the presence of leaking containers, significant radiological detector readings, large accumulations of dangerous/hazardous solid materials (e.g., lead bricks), or other anomalous conditions.

Depending on the volume of anomalous soil and the detected values, additional sampling may be initiated for laboratory analysis, or project Waste Services personnel may assign the appropriate waste code and ship the anomalous soil for treatment and disposal. If the project elects to sample for laboratory analysis, one sample should be collected from the location with the highest field screening readings. The results of the laboratory analysis will be used to determine if the soil is

designated as dangerous/hazardous waste. Figure 4-1 provides a logic flow diagram for disposition of anomalous waste forms. Figure 4-2 provides a logic flow diagram for disposition of soil.

4.2 INITIAL WASTE DESIGNATIONS

Waste designation for the 100 Area burial grounds will initially be based on analytical data obtained from the 118-B-1 Burial Ground as described in the *118-B-1 Burial Ground Excavation Treatability Test Report* (DOE-RL 1995a), *Estimates of Solid Waste Buried in 100 Area Burial Grounds* (Miller and Wahlen 1987), and *Radiological Characterization of the Retired 100 Areas* (Dorian and Richards 1978). These initial waste designations will be applied to analogous 100 Area burial ground sites and their waste forms. These data will also be used to develop initial waste profiles. This enables remediation to start without hindering production to satisfy initial waste designation requirements. However, undesignated anomalous media must be characterized as they are discovered.

When asbestos in nonfriable form (e.g., asbestos in the pipe matrix, asbestos impregnated in tar paper-wrapped water pipes) is encountered in the shallow zone, as in pipelines, and no other CERCLA hazardous waste is associated with the pipelines other than asbestos in nonfriable form, remediation of such pipelines is not required (DOE-RL et al. 2005d).

4.3 WASTE STREAM-SPECIFIC MANAGEMENT

The following sections describe how the various waste streams will be managed.

4.3.1 Miscellaneous Solid Wastes

This is nonhazardous, nonradioactive waste that is expected to consist of paper, debris, and other solid waste that will be collected during the remediation activities. Miscellaneous solid waste that has contacted potentially contaminated materials will be segregated from other materials. Miscellaneous solid waste will be placed in containers that are appropriate for the material and the disposal facility. Miscellaneous solid waste that has not contacted contaminated media, and miscellaneous solid waste that has contacted contaminated media but is nondangerous and has been radiologically released, may be disposed offsite at a permitted disposal facility, disposed in an inert landfill, or recycled, as appropriate. Only waste meeting the inert waste criteria of WAC 173-350-990 may be disposed in an inert waste landfill.

4.3.2 Low-Level Radioactive Waste

Low-level radioactive waste including soil, concrete, debris, and structures will be removed during excavation. Low-level radioactive debris (e.g., concrete, wood, rebar, metal/plastic pipe and screens, wire, liners, bentonite/sand/gravel, equipment, pumps, tanks) will be generated during the decommissioning of wells. Plastic, paper, and other compactible waste will also be generated as part of the remediation activities. Debris that has contacted contaminated media

may be disposed of at ERDF after meeting ERDF waste acceptance criteria (WCH 2008). If the waste acceptance criteria cannot be met, the waste will be shipped to an appropriate offsite facility, depending on the waste designation. Offsite facilities that receive CERCLA waste must be deemed acceptable by the EPA in accordance with 40 CFR 300.440. Material that can be radiologically released may be disposed in an onsite inert landfill if the waste meets the criteria for being "inert," or recycled, as appropriate.

4.3.3 Spent Nuclear Fuel

Waste identified as suspect SNF will be evaluated against the criteria in applicable DOE orders and guides to determine if the material is, in fact, SNF subject to management as high-level waste. Waste categorized as SNF is not eligible for disposal at the Hanford Site. SNF will normally be transported to the 105-K facility for storage and packaging, after which the material will be placed in storage at the Canister Storage Building in the 200 Area until an offsite facility capable of managing high-level waste becomes available. In accordance with 40 CFR 300.440, EPA will approve the receiving facilities for SNF prior to shipment. Should the 105-K facility and Canister Storage Building not be available, other locations may be approved by EPA on a case-by-case basis (DOE-RL et al. 2005b).

4.3.4 Hazardous/Dangerous and/or Mixed Waste (Both Radioactive and Dangerous/Hazardous)

Hazardous/dangerous and/or mixed waste that meets the LDR treatment standards and the most current ERDF waste acceptance criteria may be disposed of at ERDF. Wastes that do not meet the acceptance criteria may be temporarily stored until they can be treated to meet the criteria and will be handled on a case-by-case basis. Depending on the waste designation, the waste may be shipped to an appropriate offsite facility. Offsite facilities that receive CERCLA waste must be deemed acceptable by the EPA in accordance with 40 CFR 300.440.

4.3.5 Liquid

4.3.5.1 Liquids from Unplanned Releases. If a release occurs, the notification of WCH Spill Release Support is required. The reporting requirements will be met as required by DOE O 232.1A. The WCH spill reporting point of contact will determine the actions required to address the spill. The lead regulatory agency will be notified of significant spills.

4.3.5.2 Decontamination Fluids. Decontamination fluids (i.e., water and/or nonhazardous cleaning solutions) from cleaning equipment and tools used in the OUs will be discharged to the ground (if appropriate) **as discussed in Section 3.1.5**. If decontamination fluids are collected and they are above the collection criteria, they will be designated and transported to ETF (if the waste acceptance criteria can be met), or other facility as authorized by the lead regulatory agency. Small volumes of decontamination fluids may be stabilized to eliminate free liquids and then disposed of at ERDF after meeting the waste acceptance criteria (WCH 2008).

4.3.5.3 Liquid Remaining In Pipes. Liquids that may remain in pipelines to be remediated will be collected to the extent reasonably practicable, designated, and transported to the ETF or other facility as authorized by the lead regulatory agency. If the liquid is water and contains contaminants in levels below those listed in WAC 173-200, or groundwater cleanup standards in WAC 173-340-720, it may be used as dust suppressant. Water above the WAC 173-200 limits and the WAC 173-340-720 groundwater cleanup standards may be used as dust suppressant following approval by the lead regulatory agency.

Pipeline removal may be a planned remedial action or an activity made necessary by an unplanned discovery. Projects perform historical research to locate buried pipelines and learn as much as possible about their past functions and what liquids they may currently hold. Based upon that research, and observations and data gathered during remedial action, a graded approach will be taken to spill control practices implemented during pipeline removal. The most stringent efforts will be used for pipes containing or expected to contain dangerous waste liquids. Those pipelines will be hot tapped and liquids drained, containerized and properly disposed.

Mitigative measures required in most cases will lie somewhere between those extremes. Spill control practices (spill kits, absorbents, liners, catch basins, etc.) will be used to minimize the quantities of non-dangerous waste liquids that may be released to the soil. Pipelines will not be deliberately breached unless their contents are known or measures are in place to positively contain any liquids that may be discharged. Proposed pipeline remediation will be discussed with the regulators so they understand the approach to be used, spill controls that will be employed, and uncertainties or risks of unknown liquids or inadvertent discharges.

4.3.6 Used Oil and Hydraulic Fluids

Used oil and hydraulic fluids are generated during the operation of the machinery at the waste sites and will be sent offsite for recycling or disposal, as appropriate, or may be stabilized in accordance with the ERDF waste acceptance criteria (WCH 2008) and disposed to ERDF if fluid contacted contaminated media associated with the waste site.

4.3.7 Returned Sample Waste

Screening and analysis of both solids and liquids may be conducted at the waste sites, offsite or onsite laboratories, and/or the Radiological Counting Facility. Samples from these laboratories are authorized for return to the OU. Unused samples and associated laboratory waste from offsite analyses will be dispositioned in accordance with the laboratory contract and agreements for return of the waste to the Hanford Site. Waste from field screening and onsite laboratories will be managed depending on whether it has been altered. Altered samples will be contained and disposed of at ETF, ERDF, or other appropriate facility as authorized by the lead regulatory agency, depending on waste designation. Unaltered liquid waste generated during sample screening and analysis may be discharged to the ground near the point of generation (if it is below the collection criteria limits) or disposed of at ETF, ERDF, or other appropriate facility if it meets the collection criteria. Some liquids may be neutralized and/or stabilized to meet the

disposal facility's waste acceptance criteria. Pursuant to 40 CFR 300.440, remedial project manager approval will be obtained before returning unused samples or waste from onsite or offsite laboratories. Approval of this RDR/RAWP constitutes remedial project manager approval for shipment of offsite and onsite laboratory sample waste back to the waste site of origin.

Spills (unplanned releases) that occur in clean areas that are being used in support of a CERCLA remediation are appropriate for disposal at the ERDF, when the following conditions exist:

1. The spill occurred from equipment supporting the CERCLA activity.
2. The waste meets the ERDF waste acceptance criteria (WCH 2008).
3. The spill occurred within the CERCLA OU boundary or onsite area.

A "clean area" is defined as an area supporting a CERCLA remediation activity that is not contaminated with the COCs found in the active remediation areas (DOE-RL et al. 2007).

4.3.8 Radiological Counting Facility Sample Wastes

Samples from CERCLA activities may be counted in a radiological counting facility (currently located in M0-870 at 100-D Area). Counting capabilities include, but are not limited to, liquid scintillation, gross alpha/beta gamma, gamma ray spectroscopy, and alpha spectroscopy. This facility will be operated as a CERCLA facility to support counting of CERCLA samples from the Hanford Site. Various types of sample media will be prepared and counted such as smears, swipes, air filters, soil, liquids, and miscellaneous waste streams (e.g., concrete, cloth, etc.). Sample preparation activities prior to sample counting will typically involve physical processes (e.g., mounting of air filters and smears on planchets) prior to counting rather than radiochemistry.

The primary waste material generated from radiological counting includes samples, sample residues, and secondary waste (e.g., personnel protective equipment such as gloves and wipes). Laboratory calibration standard wastes or inter-laboratory comparison waste may be generated. Some waste may be generated from maintenance or calibration of sample equipment.

Sample counting wastes, including any associated secondary waste, may routinely be sent back to the operable unit of origin for disposition. Alternatively, sample counting waste may be sent directly to ERDF for disposal if the waste meets the ERDF waste acceptance criteria. Other sample-related waste, such as inter-laboratory comparison samples and maintenance/calibration waste, may also be sent to ERDF for disposal if it contains CERCLA hazardous substances (including potentially radiologically contaminated wastes) and meets the waste acceptance criteria. Otherwise, the waste will be handled as solid waste that may be sent offsite for disposal at a municipal/industrial landfill or recycled as appropriate (e.g., used oils, batteries, or aerosol containers).

Disposal of CERLCA waste at any disposal facility other than ERDF requires EPA approval in accordance with 40 CFR 330.440. Disposal of material containing no or de minimis levels of CERCLA hazardous substances would not require an offsite acceptability

determination per 40 CFR 300.440. Waste will be designated as described elsewhere in Section 4.0 of this document.

Materials requiring collection will be placed in containers appropriate for the material and the receiving facility, and will be appropriately marked, labeled, stored, and transported consistent with the requirements described elsewhere in Section 4.0 of this document. Containerized hazardous/dangerous waste, if any, will meet the substantive requirements of WAC 173-303.

The radiological counting facility currently located in M0-870 at 100-D Area is authorized as an noncontiguous onsite facility pursuant to CERCLA Section 104(d)(4) to receive and analyze CERCLA samples associated with 100 Area and 300 Area CERCLA actions, and ERDF. This radiological counting facility may be relocated within the 100-Area with prior notification of the regulatory agencies.

4.4 WASTE HANDLING, PACKAGING, AND LABELING

Materials requiring collection will be placed in containers appropriate for the material and the receiving facility. Although ERDF containers will be used for most wastes, an alternative "truck and pup" style of container may be used for nonradionuclide-contaminated waste.

Waste moved outside the AOC must meet all substantive requirements of WAC 173-303 and DOT requirements, as applicable. In addition, PCB wastes will be managed in accordance with substantive provisions of 40 CFR 761, and asbestos waste will be managed in accordance with 40 CFR 61. Waste will be packaged, marked, and labeled in accordance with ARARs.

4.5 STORAGE

The amount of waste stored at the site will be kept to a minimum. Full containers will be prepared for disposal as quickly as feasible. Radioactive waste will be managed separately from nonradioactive waste. In general, disposal of waste recovered in support of this RDR/RAWP will either be disposed of at ERDF, or other approved onsite or offsite facility. As necessary, waste will be stored within the AOC, in staging piles in the OU, or at ERDF as described in the following subsections.

4.5.1 Area of Contamination

Waste from the 100 Area sites and their connecting pipelines that are excavated and held for further analysis, treatment, or any other reason (not immediately transported to ERDF) will be temporarily stored in the AOC. Waste managed within the AOC is not subject to substantive provisions of 40 CFR 264.554. The AOC approach was discussed in the NCP (55 FR 8666) with regards to remedial actions under CERCLA. The guidance states that the AOC can be equated to an RCRA landfill where movement within the area would not be considered land disposal and would not trigger the requirements of Subtitle C; such as 90-day storage or LDRs. Any

movement of soil outside of the AOC but within the CERCLA onsite area will trigger compliance with all ARARs, such as RCRA provisions for management of hazardous waste. The AOC for each waste site will be delineated in the project drawings. These drawings will be provided to the lead regulatory agency for review and approval, if requested.

4.5.2 Staging Piles

As an alternative to storage within the AOC, waste that is not immediately transported to ERDF or other EPA-approved disposal facility may be stored in staging piles. Staging piles must be designed so as to prevent or minimize releases of hazardous wastes and hazardous constituents into the environment, and minimize or adequately control cross-media transfer. Staging piles must be closed by removing or decontaminating all remediation waste; contaminated containment system components, structures, and equipment contaminated with waste; and leachate. A map outlining the AOC and staging piles will be developed for each excavation area. The map will be posted at the construction office and will be updated in the field, as needed, if plumes or other areas of contamination are discovered that change the AOC or staging pile areas.

The staging piles must be operated in accordance with the substantive standards and design criteria prescribed in 40 CFR 264.554, paragraphs (d) through (k). General requirements for the staging piles include the following.

- Staging piles are used only during remedial operations for temporary storage at a facility, and must be located within the contiguous property where the wastes to be managed in the staging piles originated.

- Staging piles cannot be used for flowing (i.e., liquid) waste storage.

- The staging pile must be designed so as to prevent or minimize releases of hazardous wastes and hazardous constituents into the environment, and minimize or adequately control cross-media transfer. To protect human health and the environment, this can include installation of berms, dust control practices, or using liners/covers, as appropriate. A release of a hazardous substance outside the staging pile confines into the underlying soil or ambient air will be considered a release into the environment, and immediate notification under CERCLA will be pursued in accordance with 40 CFR 302 if the quantity involved exceeds a reportable quantity over a 24-hour period. However, if hazardous substances are discovered within the confines of an approved staging pile it is not considered a release (DOE-RL et al. 2005a).

- The staging pile must not operate for more than 2 years (measured from the first time remediation waste is placed into the pile), except when the EPA grants an operating term extension. A record of the date when remediation waste was first placed in the staging pile must be maintained until final closeout of the site is achieved.

- Ignitable or reactive waste must not be placed in a staging pile unless it has been treated or mixed before being placed in the pile so that the waste no longer meets the definition of ignitable or reactive waste, or the waste is managed to protect it from exposure to any material or condition that may cause it to ignite or react.

- Incompatible wastes may not be placed in the same staging pile unless the requirements in 40 CFR 264.17(b) have been met. The incompatible materials must be separated or they must be protected from each other with a dike, berm, wall, or other device. Remediation waste may not be piled on the same base where incompatible wastes or materials were previously piled, unless the base has been decontaminated sufficiently to comply with 40 CFR 264.17(b).

- Within 180 days after the operating term of the staging pile located in a previously uncontaminated area expires, the staging pile must be closed in accordance with substantive provisions of 40 CFR 264.258(a) and 40 CFR 264.111, or 40 CFR 265.258(a) and 40 CFR 265.111. This includes removing all remediation waste, contaminated containment system components, contaminated structures and equipment, and leachate.

Approval of this RDR/RAWP by the regulators constitutes general authorization to operate staging piles during remediation of the 100 Area. Specific staging pile locations will be identified on project drawings and approved by the lead regulatory agency in UMMs or other forums agreed to by the lead regulatory agency. Field operation of staging piles within the referenced regulatory provisions will be accomplished through the following controls:

- The staging pile area will be surrounded with a minimum of a 15-cm (6-in.) berm to control run-on/run-off control prior to use.

- Dust control practices will be deployed consistent with soil piles managed in the AOC, including the use of crusting agents, as necessary, to minimize migration/leaching or contaminants into underlying soil. Application of water for dust control will prevent contamination spread beyond the boundaries of the AOC.

- Surveys of the staging pile area will be performed prior to placement to ensure that no cross-media transfer or staging of waste on previous contaminated areas.

- Gross sorting of waste will be performed within the AOC to identify and remove anomalous waste, including drums or other containers from the bulk soil. Additional sorting may be required on bulk soil prior to moving the soil to the staging pile area. Any dangerous or unknown waste identified will be packaged and managed appropriately (drums) within the staging pile area and within close proximity to the specific staging pile. Drums will be properly labeled, managed, and inspected, and must be inspected weekly or as described in WMT-1, *Waste Management and Transportation.*

Once characterization and designation of the material is completed, the waste will be loaded into containers for transport to ERDF or shipped offsite for treatment and/or disposal, as appropriate. To close out the staging pile areas after the waste has been removed, samples of the residual soil

will be collected in accordance with the 100 Area SAP or 100 Area Burial Grounds SAP (DOE-RL 2008, 2001a), as appropriate. The sample results will be evaluated with the soil cleanup levels in Table 2-1 to demonstrate attainment of the RAOs.

4.5.3 Environmental Restoration Disposal Facility Waste Staging Area

On a case-by-case basis, a staging area is available at ERDF for wastes from the 100 Area remedial action sites that require special handling and/or treatment, such as thermal treatment of a mixed radioactive/dangerous waste. Waste will be characterized at the site prior to transport to the ERDF staging area. All waste sent to the ERDF staging area will be stored in accordance with requirements prescribed by the ERDF ROD Amendment (EPA 2002) and implementing documents.

4.6 WASTE TRANSPORTATION

Packaging, marking, and labeling for transportation will be in accordance with DOT 49 CFR requirements, ARARs and procedures, as appropriate. With appropriate documentation (e.g., safety analysis report for packaging or risk-based exemption), packaging exceptions to DOT requirements that provide an equivalent degree of safety during transportation may be used for waste shipments. Coordination and preparation of these documents will be approved by RL with the assistance of the Waste Management and Transportation group. ERDF roll-off-type containers will be used for most bulk wastes. Tractor-trailer flatbed units will be used for transportation of containerized waste. Containers will be shipped to the identified disposal facility as quickly as economically feasible.

4.7 WASTE TREATMENT

The selected remedy specified in the RODs (EPA 1995, 1997a, 1999, 2000a, 2000b) is remove and dispose to an authorized facility such as ERDF. Treatment, as appropriate or required, may be conducted at ERDF or the OU. Required treatment is any treatment required to comply with ARARs. However, as described in Section 2.0 of this RDR/RAWP, evaluations of existing historical and analytical data and technology demonstrations have resulted in the conclusions that soil treatment for volume reduction will not be appropriate at this time.

Treatment will be required for LDR material unless a treatability variance or ARAR waiver is requested by RL and approved by the regulatory agencies. If LDR wastes are encountered, the requirements of 40 CFR 268 will be applied. Should LDR material be encountered, it will be temporarily stored within the AOC or staging piles and disposed in accordance with applicable regulations. If treatment is required to address LDR wastes, RL will obtain regulatory agency approval.

An approved LDR treatment method for radioactively contaminated cadmium-, silver-, and mercury-containing batteries allows for macroencapsulation prior to disposal. However, lead-

acid batteries are not covered by this standard and require initial treatment (draining corrosive liquids, treating separately prior to disposal) (DOE-RL et al. 2005c).

Figure 4-1. Logic Flow Diagram for Disposition of Buried Waste and Co-Mingled Soil.

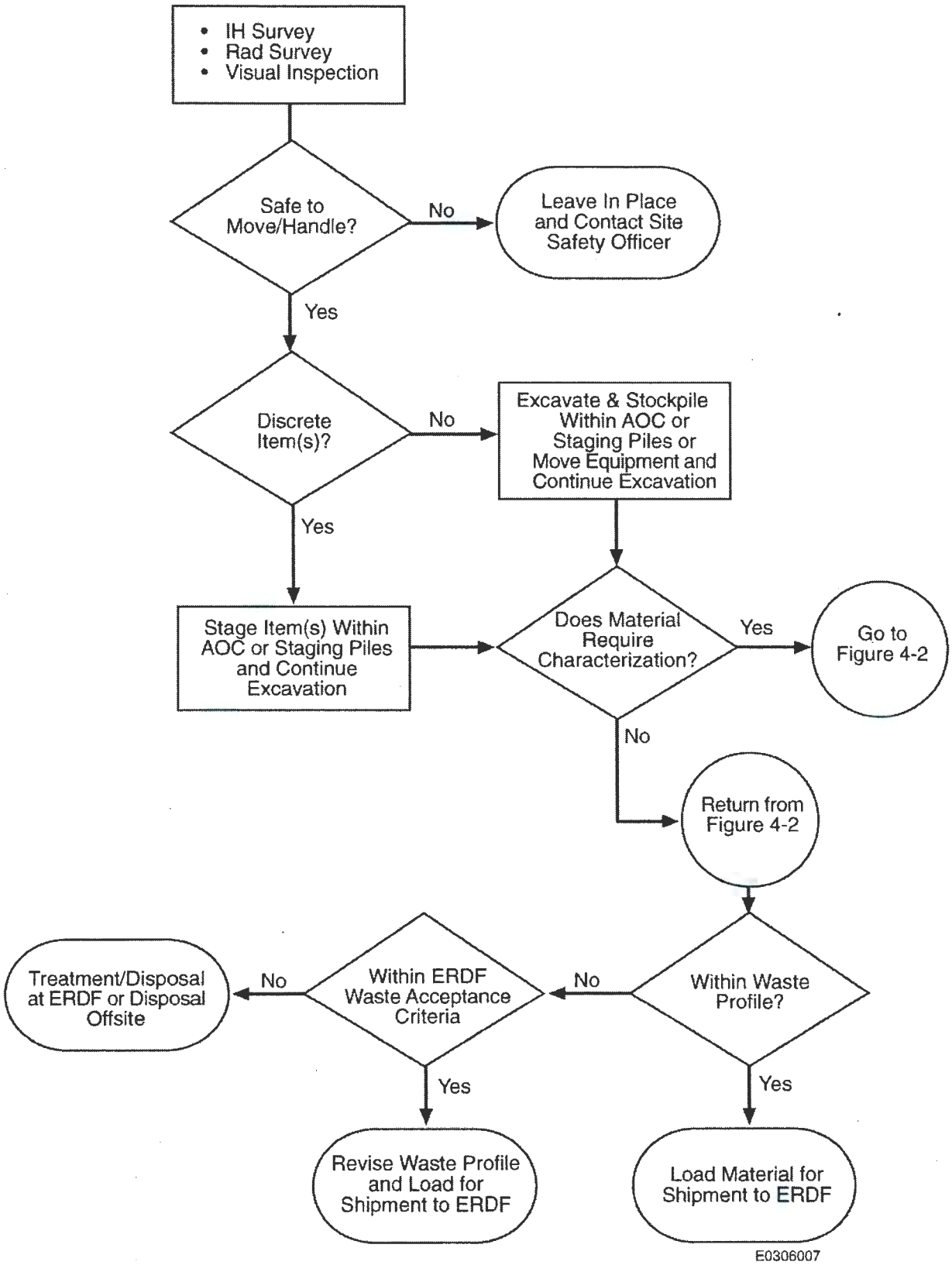
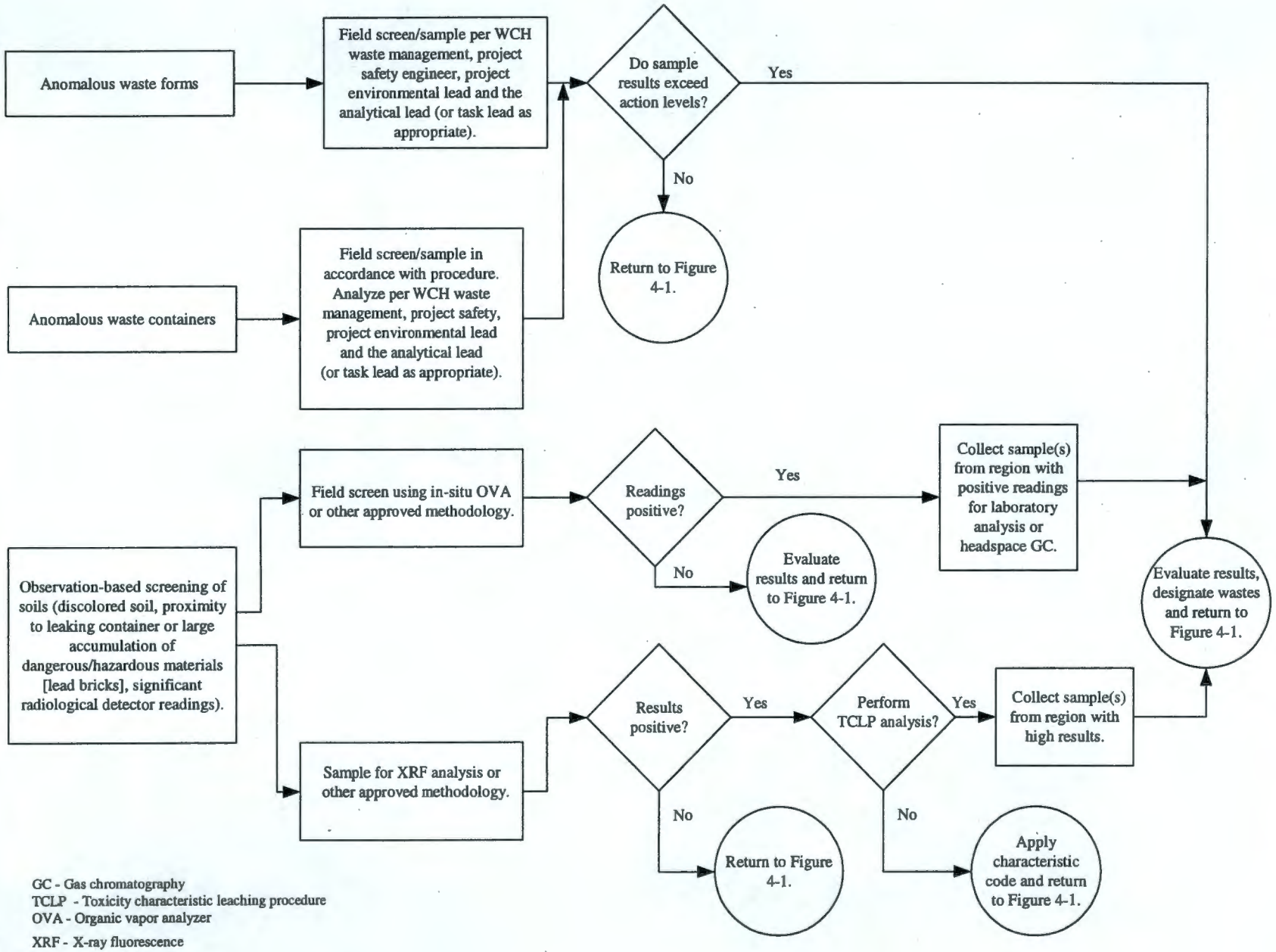


Figure 4-2. Logic Flow Diagram for Disposition of Anomalous Waste Forms.



GC - Gas chromatography
TCLP - Toxicity characteristic leaching procedure
OVA - Organic vapor analyzer
XRF - X-ray fluorescence

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APPENDIX A

WASTE SITE INFORMATION

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WASTE SITE INFORMATION

This appendix contains a list of all the waste sites identified in the following Records of Decision and Explanation of Significant Differences. Remediation and interim closure and/or reclassification status are also provided.

- *Interim Action Record of Decision for the 100-BC-1, 100-DR-1, and 100-HR-1 Operable Units, Hanford Site, Benton County, Washington* (EPA 1995)
- *Amendment to the Interim Action Record of Decision for the 100-BC-1, 100-DR-1, and 100-HR-1 Operable Units* (EPA 1997)
- *Interim Action Record of Decision for the 100-BC-1, 100-BC-2, 100-DR-1, 100-DR-2, 100-FR-1, 100-FR-2, 100-HR-1, 100-HR-2, 100-KR-1, 100-KR-2, 100-IU-2, 100-IU-6, and 200-CW-3 Operable Units, Hanford Site, Benton County, Washington* (EPA 1999)
- *Explanation of Significant Difference for the 100 Area Remaining Sites ROD* (EPA 2000a)
- *Record of Decision for the 100-BC-1, 100-BC-2, 100-DR-1, 100-DR-2, 100-FR-2, 100-HR-2, and 100-KR-2 Operable Units, Hanford Site (100 Area Burial Grounds)* (EPA 2000b)
- *Explanation of Significant Differences for the 100 Area Remaining Sites Interim Remedial Action ROD* (EPA 2004).

Table A-1. 100-B/C Area Waste Site Information and Status. (9 Pages)

Site Name	Site Information	Site Status
100-B-1, Surface Chemical Dumping Area	Undocumented solid and liquid waste site and laydown yard. Approximately 61 m (200 ft) x 18.3 m (60 ft) containing several surface dump sites. Site smelled of oil and other petrochemicals. Affected soils were vegetation-free. Operation years unknown. Contaminants of potential concern were miscellaneous hydrocarbons and inorganic chemicals.	EPA 1999. Site has been remediated and interim closed. See WSRF 2006-003.
100-B-2, 181-B Backwash Trench	The site was a trench constructed to receive filtered backwash water from the 181-B Pumphouse. The trench was fed by a single 30 cm (12 in.) pipeline that originated at the backwash filter. The pipe is approximately 0.9 m (3 ft) below grade and enters the trench from the west. Before construction of the trench, the backflush water was returned directly to the Columbia River.	Site has been reclassified as no action. See WSRF 2004-101.
100-B-3, Former Hot Thimble Burial Ground	Undocumented solid waste site. A highly contaminated vertical thimble was removed from the 105-B Reactor Building in 1952 and temporarily buried in a trench at this site. The thimble was later removed and taken to another burial ground. Trench measured approximately 30.5 m (100 ft) x 7.6 m (25 ft) x 6.1 m (20 ft) deep.	EPA 1999. Site has been reclassified as no action. See WSRF 2003-008.
100-B-5, Effluent Vent Disposal Trench	Undocumented waste site. Trench of undetermined dimensions appears on historical drawings. No records of the type or volume of waste deposited (if any) have been found. Operation years unknown (trench may not have been built).	EPA 1999. Site has been remediated and interim closed. See CVP-2003-00014.
100-B-8, Process Effluent Pipelines	100-B Reactor cooling water process effluent underground pipelines. Divided into two subsites--the north section and the south section—for remediation and closeout purposes.	EPA 1995. Site has been remediated and interim closed. See CVP-2003-00019 and CVP-2003-00022.
100-B-10, 107-B Basin Leak and Warm Springs	Springs observed along the Columbia River below the B-Area retention basin (116-B-11) in 1949.	EPA 1999. Site has been remediated and interim closed. See CVP-2004-00004.
100-B-11, 115-B/C Caisson Site	Steel pipe (caisson) about 1.4 m (4 ft) diameter and 1.5 m (5 ft) deep located next to the 115-B/C Gas Recirculation Facility.	EPA 2004. Site has been reclassified as no action. See WSRF 2004-003.
100-B-12, Filter Box Radiological Materials Area (RMA)	This site was a Radiological Materials Area (RMA) with four metal boxes containing filters and filter frames with fixed contamination from 100-N Area.	Site has been remediated and closed. See WSRF 2001-016, and CCN 089130.

Table A-1. 100-B/C Area Waste Site Information and Status. (9 Pages)

Site Name	Site Information	Site Status
100-B-14, 100-B Area Process and Sanitary Sewer Underground Pipelines	Abandoned underground process sewers associated with 100-B Area operations, mostly north and west of B-Reactor and joining to empty into the 116-B-7 Outfall. Also, the pipelines feeding the 1607-B7 septic systems, the sodium dichromate pipelines from the 108-B Building to the 190-B Building, and the treated water pipelines from the 190-B Building to B Reactor. Pipelines carried nonradioactive waste fluids, sodium dichromate, pre-reactor treated cooling water, and septage. This site was divided into seven subsites as follows: 100-B-14:1, Main Process Collection Pipes 100-B-14:2, Sanitary Sewer Pipelines 100-B-14:3, West Process Sewer Pipeline 100-B-14:4, Cooling Water Pipe Tunnels 100-B-14:5, Sodium Dichromate and Sodium Silicate Pipelines 100-B-14:6, 184-B Powerhouse Piping 100-B-14:7, 185-B/190-B Sump/Pipeline.	EPA 2004. 100-B-14:1, remediated and interim closed. See WSRF 2004-005. 100-B-14:2, remediated and interim closed. See WSRF 2004-006. 100-B-14:3, reclassified as no action. See WSRF 2004-007. 100-B-14:4, reclassified as no action. See WSRF 2004-008. 100-B-14:5, reclassified as no action. See WSRF 2004-009. 100-B-14:6, reclassified as no action. See WSRF 2004-010. 100-B-14:7, reclassified as no action. See WSRF 2004-011.
100-B-16, Utility Poles and Fixtures Debris Pile	Two piles of debris from teardown of utility poles, including treated wood; lead-tipped bolts; dry transformers; and miscellaneous metal, wood, and wiring. Main pile located northwest of B Reactor. Second pile (poles only) located south of main pile. No sign of leakage at site.	EPA 2004. Site has been remediated and interim closed. See WSRF 2005-009.
100-B-17, Transite on Columbia River Shoreline	The site is an old dumping area. It is below the high water mark and is visible only at very low river flow. The waste is a mixture of material ranging from corrugated transite, fire brick, milk bottles, concrete form fittings, small rebar, pipe fittings, chunks of vitrified clay, nuts and bolts.	No decision document
100-B-18, 184-B Powerhouse Debris Pile	The site consisted of a debris pile containing miscellaneous demolition waste from the decommissioning activities of the 184-B Building and the 184-B Power House. Material included numerous concrete blocks, mixed aggregate/concrete slabs, stone rubble, rusted metal piping and plumbing, traces of tar/coal and paint, broken fluorescent lights, creosote timbers, brick chimney remnants, and rubber hoses.	Site has been remediated and interim closed. See WSRF 2007-020.
100-B-19, 100-B/C Stained Soil	The waste site consists of several areas of disturbed soil with little or no vegetation. The soil sites have a visible yellow or red to purple surface color seen at analogous sites in the 100 Area.	No decision document.
100-B-20, 1716-B Maintenance Garage Underground Tank	Site consisted of an underground gas and/or oil tanks near the 1716-B Maintenance Garage. The garage was used for maintenance of 100-B Area vehicles.	No decision document. Site has been remediated and interim closed. See WSRF 2006-019.
100-B-21, 100-B/C Misc. Pipelines	A variety of underground pipeline segments uncovered during removal of 100-B/C Reactor effluent pipelines and soils. Contains four subsites: (1) pipeline segments (-016 and -020); (2) pipeline segment (-002); (3) pipeline segment (-019); and (4) pipeline segment (-044).	No decision document. 100-B-21:1, reclassified as no action. See WSRF 2005-052.

Table A-1. 100-B/C Area Waste Site Information and Status. (9 Pages)

Site Name	Site Information	Site Status
100-B-22, 100-B Water Treatment Facilities	This site consists of the 190-B Pump House, the 183-B Filter Plant, underground transfer piping that interconnected the facilities, as well as any associated soil. The facilities were demolished during the 1980s and 1990s to 1 m (3 ft) below grade. Chromium contamination is suspected in associated soils. The underground lines are up to 600 m (1,968 ft) long and include reinforced concrete, cast iron, and steel pipes up to 137 cm (54 in.) in diameter. Contains three subsites: (1) pipeline; (2) water treatment facility; and (3) pumphouse.	No decision document. 100-B-22:1, reclassified as no action. See WSRF 2005-042.
100-B-23, 100-B/C Surface Debris	The site consists of various sizes and forms of surface debris in the 100-B/C Area created during construction, operation, decontamination and decommissioning, and remedial action, including suspected asbestos-containing material, lead, oil and oil filters, and treated wood.	No decision document
100-B-24, 1904-B1 Spillway	The site was a concrete spillway (also referred to as a flume) that led from the 116-B-7 outfall structure and terminated at the river shoreline. Decommissioning projects in the 1980s removed the above-grade portion and backfilled the below-grade portion with soil. Some of the spillway structure was removed in 2001 during remediation of the 116-B-7 outfall structure.	Site has been reclassified as no action. See WSRF 2006-051.
100-B-25, 1904-B2 Spillway	The site consists of a spillway (also referred to as a flume) constructed of concrete and led from the 132-B-6 outfall structure, via a heavy riprap extension on the end of the concrete spillway, to the river shoreline. During decommissioning projects in the 1980s, the spillway walls were collapsed and the structure covered with clean soil.	No decision document
100-B-26, 1904-C Spillway	The site consisted of a spillway (also referred to as a flume) constructed of concrete and led from the 132-C-2 outfall structure, via a heavy riprap extension on the end of the concrete spillway, to the river shoreline. During decommissioning projects in the 1980s, the spillway walls were collapsed and the structure was covered with clean soil.	Site has been reclassified as no action. See WSRF 2006-052.
100-B-27, Sodium Dichromate Spill	Unplanned release of sodium dichromate discovered during remedial action at the 126-B-3 waste site. The current site dimensions are 130 m (426 ft) long by 70 m (230 ft) wide. Additional contamination is possible.	No decision document
100-B-28, Sodium Dichromate Transfer Pipeline	This site is a sodium dichromate transfer pipeline. The pipeline is an 8-cm (3-in.) steel line for supplying soft water from the 184-B Power House to the 183-C Head House. However, in 1962 the line from the 184-B Power House was removed from service and blanked (capped off) and a new line was run to the 183-B Filter Plant to allow the use of the southern extent of the 8-cm (3-in.) line as a sodium dichromate transfer line from the 183-C Head House to the 183-B Filter Plant.	No decision document
116-B-1, Process Effluent Trench	Trench was dug to receive effluent routed from the 116-B-11 (107-B) Retention Basin at times of high activity due to fuel element failures.	EPA 1995. Site has been remediated and interim closed. See CVP-99-00012.
116-B-2, Fuel Storage Basin Trench	Received contaminated fuel storage basin water one time after a fuel element was accidentally cut in half.	EPA 1995. Site has been remediated and interim closed. See CVP-99-00015.
116-B-3, Pluto Crib	Received effluent from reactor process tubes containing ruptured fuel elements. Wooden vault 3 x 3 x 3 m deep.	EPA 1995. Site has been remediated and interim closed. See CVP-99-00013.

Table A-1. 100-B/C Area Waste Site Information and Status. (9 Pages)

Site Name	Site Information	Site Status
116-B-4, French Drain	The site was excavated in 1995 as part of the 100-B/C Demonstration Project (DOE/RL-95-102). Contaminated material was stored for later transport to ERDF, the site was backfilled and closure was initiated.	EPA 1995. Site has been remediated and interim closed. See CVP-99-00014.
116-B-5, Crib	The site was excavated in 1995 as part of the 100-B/C Demonstration Project (DOE/RL-95-102). No contamination above cleanup criteria was found and the site was backfilled and closed.	EPA 1995. Site has been excavated and closed out. See WSRF 1998-064.
116-B-6A, Crib	Vitrified in situ as a treatability test in 1990. Formerly an unlined crib 3.7 m x 2.4 m x 4.6 m (12 x 8 x 15 ft) deep. Received radioactive liquid wastes from decontamination of equipment and fuel element spacers.	EPA 1995. Site has been remediated and interim closed. See CVP-99-00011.
116-B-6B, Crib	Received radioactive liquid wastes from decontamination of equipment and fuel element spacers in the 111-B Building. Unlined crib 3.7 m x 2.4 m x 4.6 m (12 x 8 x 15 ft) deep.	EPA 1995. Site has been remediated and interim closed. See CVP-99-00017.
116-B-7, 1904-B1 Outfall Structure	Used to dispose of wastes from the 100-BC Area water treatment plant and reactor coolant water from the 116-B-11 retention basin. Intact outfall structure consisting of an open concrete sump, spillway, and effluent line extending into the Columbia River.	EPA 1999. Site has been remediated and interim closed. See CVP-2002-00003.
116-B-9, French Drain	Received waste water from the P-10 tritium production project storage building drain. Tile drain 1.2 m (4 ft) diameter x 1 m (3 ft) deep associated with the 118-B-9 Storage Building.	EPA 1995. Site has been remediated and interim closed. See CVP-99-00009.
116-B-10, Dry Well/Quench Tank	Collection tank for process and storm drain wastes. Drained to process sewer. Vitrified clay pipe 0.6 m (2 ft) diameter resting vertically on a concrete slab. Incorrectly registered as an injection well.	EPA 1995. Site has been remediated and interim closed. See CVP-99-00010.
116-B-11, Retention Basin	This site consisted of a retention basin and effluent pipes and was constructed to hold cooling water effluent from the 105-B Reactor to allow for thermal cooling and radioactive decay prior to release to the Columbia River.	EPA 1995. Site has been remediated and interim closed. See CVP-99-00001.
116-B-12, Seal Pit Crib	A crib that received drainage from the confinement system seal pits in the 132-B-4 Air Filtration Ventilation Building. The crib measured 6.1 x 5.2 m (20 x 50 ft).	EPA 1995. Site has been remediated and interim closed. See CVP-99-00008.
116-B-13, Sludge Trench	The trench was dug to receive sludge from the bottom of the 107-B Retention Basin.	EPA 1995. Site has been remediated and interim closed. See CVP-99-00002.
116-B-14, Sludge Trench	The trench was dug to receive sludge from the bottom of the 107-B Retention Basin.	EPA 1995. Site has been remediated and interim closed. See CVP-99-00003.
116-B-15, 105-B Fuel Storage Basin Cleanout Percolation Pit	Received treated water from the 105-B Fuel Storage Basin cleanup project. Open excavated pit 30.5 m (100 ft) x 15.2 m (50 ft) x 1.8 m (6 ft) deep with cobble and soil walls. Contaminated water was processed through filters and an ion exchange system before discharge.	EPA 1999. Site has been reclassified as no action. See WSRF 2003-052.
116-B-16, 111-B Fuel Examination Tank	Received liquid wastes from decontamination of fuel element spacers and other equipment. Site is a below ground concrete tank 3.3 x 1.8 x 2.7 m (11 x 6 x 9 ft) deep. Tank was cleaned and filled with sand or concrete during D&D of 111-B Building.	No decision document. Proximity Site. Site has been remediated and interim closed. See CVP-99-00011.
118-B-1, 105-B Burial Ground	Formerly the primary burial ground for general wastes from the operation of 100-B Reactor plus wastes from operation of the P-10 tritium separation project. Operated from 1944 to 1973. Site contained 22 burial trenches in an area approximately 1,000 ft x 321 ft x 20 ft deep; 3,000 ft west of the 105-C Reactor. Remediated 2004-2007.	EPA 2000b. Site has been remediated and interim closed. See CVP-2007-00006. WSRF 2007-032.

Table A-1. 100-B/C Area Waste Site Information and Status. (9 Pages)

Site Name	Site Information	Site Status
118-B-2, Minor Construction Burial Ground No. 1	Remediated with the 118-B-3 Burial Ground in 2004.	EPA 2000b. Site has been remediated and interim closed. See CVP-2005-00001. WSRF 2005-002.
118-B-3, Minor Construction Burial Ground No. 2	Remediated with the 118-B-2 Burial Ground in 2004. Received solid wastes generated by modifications to the effluent lines and other 100-B Reactor alterations. Operated from 1952 to 1960.	EPA 2000b. Site has been remediated and interim closed. See CVP-2005-00001. WSRF 2005-001.
118-B-4, 105-B Spacer Burial Ground	Excavation found 5 wooden and 3 metal caissons. Aluminum fuel spacers, splines, and Cd/Pb poison pieces were found inside the caissons. The total amount of solid waste was less than 60 cubic meters. Operated from 1956-1958. Was located 300 ft northeast of the 100-B Reactor Building.	EPA 2000b. Site has been remediated and interim closed. See CVP-2004-00002. WSRF 2004-016.
118-B-5, Ball 3X Burial Ground	Excavation found only construction waste. Historical information had said the site received irradiated equipment and metallic wastes removed from 100-B Reactor during the Ball 3X Project in 1953.	EPA 2000b. Site has been remediated and interim closed. See CVP-2004-00003. WSRF 2004-017.
118-B-6, 108-B Solid Waste Burial Ground	Site contained two vertical concrete pipes 18 ft long and 6 ft in diameter capped with a concrete pad with two steel lids. Site operated from 1950-1953. Used for the disposal of tritium recovery process wastes.	EPA 2000b. Site has been remediated and interim closed. See CVP-2006-00002.
118-B-7, Solid Waste Burial Site	Site was located in an area remediated with C-reactor effluent pipelines in 2004 but specific site waste could not be identified. Site was believed to have received waste and assorted equipment from the 111-B decontamination facility and workshop from 1951-1968 and was said to be 2.4 m (8 ft) x 2.4 m (8 ft) x 2.4 m (8 ft) deep.	EPA 2000b. Site has been rejected. See WSRF 2004-099.
118-B-8, 105-B Reactor Building	Site consists of the 105-B Reactor block, irradiated fuel storage basin, work areas, and B Reactor control room. Operated from 1944-1968. Decommissioning is discussed in a final environmental impact statement dated December 1992 (DOE/EIS-0119F). National Historical Preservation Act. This site includes french drains that were designed to receive nonradioactive liquids from the 105-B Reactor Building via above-ground and/or underground piping. Subsites are (1) 105-B Reactor Building, (2) French Drains, and (3) Miscellaneous Pipeline Segments.	The french drains are within 7.6 m (25 ft) of the B Reactor and deferred until reactor dispositioned. See CCN 124802.
118-B-9, 104-B-1 Tritium Vault, 104-B-2 Tritium Laboratory	Operated 1948-1965 for storage of tritium flasks prior to use.	EPA 2004. Site has been reclassified as no action. WSRF 2004-004.
118-B-10, Caisson Site; Ball 3X Storage Vault	Excavation found only boron steel balls mixed with soil. Former location of a chromate-contaminated steel caisson which was removed with the 115-B/C Gas Recirculation Facility in 1986. Operation dates unknown.	EPA 2000b. Site has been remediated and interim closed. See CVP-2004-00004.
120-B-1, Battery Acid Sump	Used for disposal of waste battery acid, solvents and ethylene glycol. Site was a concrete-lined sump immediately adjacent to 105-B Reactor Building, which was cleaned in 1986. Operated 1944-1969.	EPA 1999. Site has been remediated and interim closed. See WSRF 2006-057.

Table A-1. 100-B/C Area Waste Site Information and Status. (9 Pages)

Site Name	Site Information	Site Status
126-B-2, 183-B Clearwells	Consists of two underground concrete reservoirs (or clearwells) separated in the center by the remains of a demolished pump room. The remaining portion of the pump house contained debris from the demolition of the above-ground portion. The clearwells were once intended for disposal of demolition debris, but were never used for that purpose and remained empty.	Site has been reclassified as no action. See WSRF 2007-004.
126-B-3, 184-B Coal Pit	Former coal storage pit 122 x 68.6 x 6.1 m (400 x 225 x 20 ft) deep. Operated 1943-1968. Subsequently used for disposal of nonhazardous, nonradioactive solid waste and demolition debris.	EPA 1999. Site has been remediated and interim closed. See WSRF 2005-028.
128-B-2, 100-B Burn Pit No. 2	Used for burning of nonradioactive, combustible wastes, including office wastes, paint, and chemical solvents. Unlined pit 137.2 m (450 ft) x 15.2 m (60 ft) x 9.1 m (30 ft) deep. Operated 1948-1968.	EPA 1999. Site has been remediated and interim closed. See WSRF 2005-038.
128-B-3, Coal Ash and Demolition Waste Site	Used for burning nonradioactive, combustible wastes and disposal of solid building demolition waste. Chemical-stained soil and stressed vegetation visible along the river banks. Site was a vegetation-covered depression 137.2 m (450 ft) x 18.3 m (60 ft). Operated 1944-1968.	EPA 1999. Site has been remediated and interim closed. See WSRF 2006-058.
132-B-1, 108-B Tritium Separation Facility Site	Site of a former 45.1 m x 9.8 m x 12.5 m tall steel-frame and concrete-block building. Building was decontaminated, decommissioned, and demolished. Operated 1944 to early 1970.	EPA 1999. Site has been reclassified as no action. See WSRF 2003-044.
132-B-2, 116-B Reactor Exhaust Stack	Existing concrete stack 61 m tall x 4.9 m base diameter. Part of the 105-B Reactor gas and exhaust air system. Received low-level radioactive contamination from the 100-B Reactor. Operated 1944-1968. National Historical Preservation Act. Stack will remain as part of the B Reactor.	No decision document
132-B-3, 108-B Ventilation Exhaust Stack Burial Ground	Unlined trench 76.2 x 9.1 x 5.5 m deep. Stack containing low-level radioactive contamination was demolished with explosives and buried in the trench. Operated approximately 1950-1968.	EPA 1999. Site has been reclassified as no action. See WSRF 2003-011.
132-B-4, 117-B Filter Building	Site of a former 18 x 11.9 x 10.7 m tall steel-frame and concrete-block building. Building was decontaminated, decommissioned, and demolished in situ. Operated 1961-1968.	EPA 1999. Site has been reclassified as no action. See WSRF 2003-010.
132-B-5, 115-B/C Gas Recirculation Facility Site	Formerly a steel-frame and concrete-block building on a 51.2 m x 29.9 m site. Building was decontaminated, decommissioned, and demolished in situ. Operated 1952-1968.	EPA 1999. Site has been reclassified as no action. See WSRF 2003-027.
132-B-6, 1904-B2 Outfall	Concrete outfall structure and spillway built to supplement the 116-B-7 Outfall. Received discharged 105-B Reactor effluent via 100-B-14 and 100-B-8 pipelines. Operated 1954-1968.	EPA 1999. Site has been remediated and interim closed. See CVP-2002-00003.
1607-B1, Septic Tank and Drain Field (124-B-1)	Inactive below-ground concrete septic tank 4.3 m x 2.1 m x 3.4 m deep with drain field. Sanitary sewage from the Patrol Change Room and Fire Station considered nonhazardous and nonradioactive. Operated 1944-1960.	Site has been reclassified as no action. See WSRF 2007-015.
1607-B2, Septic Tank and Drain Field (124-B-2)	Below-ground concrete septic tank 7.6 m x 3.5 m x 4.0 m deep with drain field. Sanitary sewage from the 105-B Reactor Building and offices considered nonhazardous and nonradioactive.	EPA 1999. Site has been remediated and interim closed. See WSRF 2006-055.
1607-B3, Septic Tank and Drain Field	Tank Pumped dry and demolished in December 1987. Formerly a below-ground concrete septic tank 2.9 m x 1.4 m x 3.2 m deep with drain field. Sanitary sewage from the 184-B Powerhouse. Considered nonhazardous and nonradioactive. Operated 1944-1974.	Site has been closed out. See WSRF 2001-015.

Table A-1. 100-B/C Area Waste Site Information and Status. (9 Pages)

Site Name	Site Information	Site Status
1607-B5, Septic Tank and Drain Field (124-B-4)	Site consists of an underground septic tank and drain field that received sanitary sewage from the 181-BC Pump House. In January 2001, residue in the septic tank was sampled and low levels of radionuclides were identified. Based on analogous data from similar septic systems, the site is targeted for remediation because of expected concentrations of contaminants above cleanup levels.	Fluor Hanford facility.
1607-B7, Septic Tank and Drain Field	Inactive below-ground concrete septic tank 1.8 m x 0.9 m x 2.5 m deep with drain field. Sanitary sewage from the 183-B Water Treatment Plant considered nonhazardous/nonradioactive. Operated 1951-1969.	EPA 1999. Site has been remediated and interim closed. See CVP-2003-00004.
1607-B8, Septic Tank and Drain Field (124-C-2)	Inactive below-ground vertical steel septic tank, 1,325-L (350-gal) capacity, with drain field. Sanitary sewage from the 190-C Pump House considered nonhazardous/nonradioactive. Operated 1951-1969.	EPA 1999. Site has been remediated and interim closed. See CVP-2003-00005.
1607-B9, Septic Tank and Drain Field (124-C-3)	Inactive below-ground vertical steel septic tank, 9,085-L (2,400-gal) capacity, with drain field. Sanitary sewage from the 105-C Reactor Building considered nonhazardous and nonradioactive. Operated 1952-1969.	EPA 1999. Site has been remediated and interim closed. See CVP-2003-00006.
1607-B10, Septic Tank and Drain Field	Inactive below-ground vertical steel septic tank, 1,325-L (350-gal) capacity, with drain field. Sanitary sewage from the 183-C Water Treatment Plant considered nonhazardous and nonradioactive. Operated 1952-1969.	EPA 1999. Site has been remediated and interim closed. See CVP-2003-00007.
1607-B11, Septic Tank and Drain Field	Inactive below-ground vertical steel septic tank, 1,325-L (350-gal) capacity, with drain field. Sanitary sewage from the 183-C Filter Building considered nonhazardous and nonradioactive. Operated 1952-1969.	EPA 1999. Site has been remediated and interim closed. See CVP-2003-00008.
100-C-3, 119-C French Drain	Received water coolant from the heat exchanger for the air sampler, water from the building swamp cooler, and floor drain effluent. Site is a small French drain or dry well associated with the 119-C Sample Building. Operated 1960 to 1968.	EPA 1999. Site has been remediated and interim closed. See CVP-2003-00009.
100-C-6, Process Effluent Pipelines	100-C Reactor Cooling Water Effluent Underground Pipelines. Site consists of five subsites, all closed out but one subsite (100-C-6:5), which is a 33.5-m (110-ft) section under an active export waterline.	EPA 1995. See CVP-2003-00019 and CVP-2003-00022 for closeout information on four of the five subsites.
100-C-7, Former 183-C Water Filter Building	Former 183-C water filter building demolished in 1996. Structures deeper than 0.9 m (3 ft) remain in place, including concrete and soil contaminated with sodium dichromate.	EPA 1999.
100-C-9, 100-C Area Process and Sanitary Sewer Underground Pipelines	The site consists of approximately 3,000 m (9,843 ft) of 100-C Area miscellaneous underground pipelines separated into four subsites as follows: 100-C-9:1, Main Process Sewer 100-C-9:2, Sanitary Sewer Lines 100-C-9:3, 183-C Clearwell Pipelines 100-C-9:4, Cooling Water Lines.	EPA 2004. 100-C-9:1, remediated and interim closed. See WSRF 2004-012. 100-C-9:2, remediated and interim closed. See WSRF 2004-013. 100-C-9:3, reclassified as no action. See WSRF 2004-014. 100-C-9:4, reclassified as no action. See WSRF 2004-015.
116-C-1, Process Effluent Trench	Received contaminated cooling water from the 100-B/C Area Retention Basin.	EPA 1995. Site has been remediated and interim closed. See CVP-98-00006.
116-C-2A, Pluto Crib	Received radioactively contaminated effluent from 116-C-2C Pluto Crib Sand Filter.	EPA 1997. Site has been remediated and interim closed. See CVP-99-00019.

Table A-1. 100-B/C Area Waste Site Information and Status. (9 Pages)

Site Name	Site Information	Site Status
116-C-2B, Pluto Crib Pump Station	Received process effluent from C Reactor contaminated during fuel element cladding failures.	EPA 1997. Site has been remediated and interim closed. See CVP-99-00019.
116-C-2C, Sand Filter	Received process effluent from C Reactor contaminated during fuel element cladding failures.	EPA 1997. Site has been remediated and interim closed. See CVP-99-00019.
116-C-3, Chemical Waste Tanks	Two below ground storage tanks installed to receive caustic waste from the metal examination facility and may be filled with water. Both tanks measured 3.7 m (12 ft) diameter x 3.7 m (12 ft) deep.	EPA 1999. Site has been remediated and interim closed. See WSRF 2008-002.
116-C-5, Retention Basin	Received cooling water effluent from 105-C Reactor to allow for thermal cooling and radioactive decay.	EPA 1995. Site has been remediated and interim closed. See CVP-99-00004.
116-C-6, Percolation Pit	Received treated water from the 105-C Fuel Storage Basin cleanup project. Contaminated water was processed through filters and an ion-exchange system before discharge into the percolation pit. Operated 1984-1985.	EPA 1999. Site has been remediated and interim closed. See WSRF 2003-034.
118-C-1, 105-C Solid Waste Burial Ground	Formerly the primary burial ground for general wastes from the operation of C Reactor. Consisted of several trenches and pits in a trapezoidal area 155 x 122 x 6.1 m (510 x 400 x 20 ft) deep. Received reactor hardware and soft wastes from the 105-C Reactor Building from 1953-1969.	EPA 2000b. Site has been remediated and interim closed. See CVP-2006-00011. WSRF 2006-063.
118-C-2, 105-C Ball Storage Tank	Remediated 2003. Excavation found a storage tank containing boron steel balls. Historical information stated that this site was used in 1969 for disposal of 9,000 kg (20000 lb) of highly activated boron steel and carbon steel balls in their storage tank.	EPA 2000b. Site has been remediated and interim closed. See CVP-2003-00015. WSRF 2004-019.
118-C-3, 105-C Reactor Building	Concrete building included the reactor block, irradiated fuel storage basin, work areas, and Reactor Control Room. Operated 1952-1969. Underwent decontamination and decommissioning of ancillary facilities to put the reactor core in interim safe storage in 1998. Site consists of three subsites: (1) 105-C Reactor core, (2) 105-C Reactor Building below-grade structures and underlying soils, and (3) 105-C french drains.	Action memorandum. 118-C-3:1, Interim Safe Storage. 118-C-3:2, remediated and closed out. See CVP-98-00009. 118-C-3:3, remediated and closed out. See WSRF 2006-016.
118-C-4, Horizontal Control Rod Storage Cave	Reinforced concrete bunker used to store radiologically contaminated control rod tips. Decision Document: *Approved Action Memorandum for the 100 B/C Area Ancillary Facilities and the 108-F Building Removal Action*, CCN 042276, letter, D. Faulk (EPA) to J. M. Bruggeman (RL), January 29, 1997, U.S. Environmental Protection Agency, Richland, Washington.	Action memorandum. Site has been remediated and closed out. See CVP-2003-00015.
128-C-1, 100-C Burning Pit	Used for burning nonradioactive, combustible wastes and disposal of noncontaminated equipment and other solid waste. Ashes and miscellaneous debris were visible. Site measured 68.6 m (225 ft) x 38.1 m (125 ft).	EPA 1999. Site has been remediated and closed out. See WSRF 2005-019.
132-C-1, 105-C Reactor Stack Burial Ground	Site contains concrete rubble from demolition of the 105-C (116-C) Reactor Stack. The stack was used to exhaust confinement air from the work areas of the 105-C Reactor Building from 1952-1969 and was demolished in 1983. The stack and its foundation were demolished with explosives and buried in a trench 61 x 9 x 4 m (200 x 30 x 12 ft) deep.	EPA 1999. Site has been reclassified as no action. See WSRF 2003-026.

Table A-1. 100-B/C Area Waste Site Information and Status. (9 Pages)

Site Name	Site Information	Site Status
132-C-2, 1904-C Outfall (Alias 116-C-4 Outfall)	Concrete outfall structure and spillway reduced to grade and covered with clean soil. Underground effluent discharge lines remain in place. Discharged C Reactor effluent and process sewer effluent near the bottom center of the Columbia River. Operated 1952-1969.	EPA 1999. Site has been remediated and interim closed. See CVP-2002-00003.
132-C-3, 117-C Filter Building Site	This site contains rubble from the 1988 demolition of the 117-C exhaust air filtration facility for C Reactor. Building was used from 1961-1969. Housed the filtration system for the ventilation of air prior to its release into the atmosphere through the stack.	EPA 1999. Site has been reclassified as no action. See WSRF 2003-024.
600-33, 105-C Reactor Test Loop Burial Site	Inactive solid waste burial site operated in 1963 as a single use site. A highly irradiated test loop was removed from C Reactor and buried in a single trench. Subsequently the test loop was removed and disposed in the 118-C-1 Burial Ground.	EPA 2000b. Site has been reclassified as rejected. See WSRF 2004-132
600-230, Dumping Area	The area appears to have been used as a dumping area for domestic waste before the Manhattan Project.	Site has been reclassified as no action. See WSRF 2006-041.
600-232, 100B Electrical Laydown Area	Undocumented solid waste site. Open area with various nonhazardous, nonradioactive materials (incandescent light bulbs, power poles, metal debris) on the surface.	EPA 2004. Site has been remediated and interim closed. See WSRF 2004-066.
600-233, Vertical Pipe Near 100B Electrical Laydown Area	This site was a steel pipe near the 100-B electrical laydown area that measured 6.4 cm (2.5 in.) in diameter and extended 1.7 m (4.92 ft) vertically above the ground surface with an elbow and valve at the top.	No decision document. Site has been remediated and interim closed. See WSRF 2005-041.

CCN = chronological control number
CVP = cleanup verification package
D&D = decontamination and decommission
WSRF = Waste Site Reclassification Form

Table A-2. 100-D Area Waste Site Information and Status. (10 Pages)

Site Name	Site Information	Site Status
100-D-1, Contaminated Storm Drain	Located just north of the patrol road between the 1904-D and 1904-DR outfall structures. Small concrete storm drain system, box covered with steel plate. Posted with surface radioactive contamination signs. Provided drainage via underground piping from the south side of the patrol road to the river shoreline.	EPA 1999.
100-D-2, Lead Sheeting	Small lead sheet covering a concrete pad southwest of the 185-D Building. Purpose unknown. Contaminant of potential concern is lead.	EPA 1999. Site has been remediated and interim closed. See WSRF 2007-030.
100-D-3, Silica Gel	Small covered trench with concrete marker and brass cap. Disposal of silica gel from the 115-D/DR drying towers. Potentially contaminated with radioactive and hazardous materials.	EPA 1999.
100-D-4, 107-D Sludge Trench #5	Trench excavated in 1955 near the 107-D retention basin. Received effluent containing radioactive and hazardous materials from 116-D-7 (107-D/DR) retention basins during fuel cladding failures.	EPA 1995. Site has been remediated and interim closed. See CVP-98-00004.
100-D-5, Solid Waste Site near 103-D	Burial ground located just north of the 105-D and east of the 103-D Building. Operated 1950. Received contaminated soil and pipe from the "D" and "DR" effluent line tie-in.	EPA 2000b. Site has been remediated and interim closed. See CVP-2000-00033
100-D-6, 118-D-4D Buried VSR Thimble Site 4D	Received contaminated vertical safety rod thimbles, guides, and miscellaneous waste removed from 105-D Reactor during the Ball 3X project in 1953.	EPA 2000b. Site has been remediated and interim closed. See CVP-2000-00034
100-D-7, Solid Waste Site	Solid waste dumping area containing nonradioactive, nonhazardous waste including vitrified clay pipe, concrete cores, metal paint cans, and wood debris.	EPA 1999.
100-D-8, 1907-DR Outfall, 105-DR Process Sewer Outfall Site	Constructed in 1949 as a spillway for an emergency discharge for the DR reactor. Consisted of a 1.8-m (72-in.)-diameter reinforced concrete pipe. The pipe discharged into a concrete box flume that spilled onto a grouted riprap surface and extended about 13.1 m (43 ft) beyond the low water level of the Columbia River.	EPA 1999.
100-D-9, 184-DA Boiler Oil Tank	Former location of an underground storage tank for fuel oil for the 184-DA boiler house. Site was excavated in 1994 to confirm tank removal and determine that no soil contamination existed. Additional confirmatory sampling on January 4, 2006 found no contamination.	Site has been remediated and interim closed. See WSRF 2006-030.
100-D-12, Sodium Dichromate Pump Station	Received sodium dichromate and sulfuric acid solutions in water from flushing and draining of hoses and pipelines connected to railcars and trucks for unloading.	EPA 1999. Site has been remediated and interim closed. See CVP-2000-00016.
100-D-13, Septic System	Septic system installed for use during construction of 105-DR Reactor. Consisted of an IMHOFF tank, a chlorinated house, a dosing tank, a filter bed, and associated piping.	EPA 1999.

Table A-2. 100-D Area Waste Site Information and Status. (10 Pages)

Site Name	Site Information	Site Status
100-D-14, Unnumbered Septic System	Concrete tank with drain field. Received sanitary sewage from 105-DR Reactor construction badgehouse before relocation. The site appears as a vegetation-covered field. A small depression may indicate the presence of the tank. A 10-cm (4-in.) cement pipe is likely to be a vent pipe to the drain field. The site is adjacent to a small soil pile.	No decision document.
100-D-15, Dumping Area	Received debris and miscellaneous waste described as nonradioactive and nonhazardous, including paint cans, solvent cans, and construction materials. Waste material has been dumped at two locations in a large borrow pit southeast of the 100-DR reactor facilities (Gravel Pit #21).	EPA 1999.
100-D-18, Sludge Trench	Received sludge from 107-D retention basin to facilitate repairs to the retention basin.	EPA 1995. Site has been remediated and interim closed. See CVP-2000-00001.
100-D-19, Sludge Trench	Received sludge from 107-D retention basin to facilitate repairs to the retention basin.	EPA 1999. Site has been remediated and interim closed. See CVP-2000-00003.
100-D-20, Sludge Trench	Received sludge from 107-D retention basin to facilitate repairs to the retention basin.	EPA 1995. Site has been remediated and interim closed. See CVP-98-00003.
100-D-21, Sludge Trench	Received sludge from 107-DR retention basin to facilitate repairs to the retention basin.	EPA 1995. Site has been remediated and interim closed. See CVP-98-00002.
100-D-22, Sludge Trench	Received sludge from 107-DR retention basin to facilitate repairs to the retention basin.	EPA 1995. Site has been remediated and interim closed. See CVP-98-00001.
100-D-23, 119-DR Sample Building Drywell	Site was a drywell that received drainage from a floor drain in the 119-DR Sample Building.	EPA 1999. Site has been remediated and interim closed. See CVP-2003-00018.
100-D-24, 119-D Sample Building Drywell	Site was a drywell that received drainage from a floor drain in the 119-D Sample Building.	EPA 1999. Site has been reclassified no action. See WSRF 2006-004.
100-D-25, 107-DR Basin Leaks	Site is located beneath the 107-DR Retention Basin and consisted of basin leaks.	No decision document. Proximity Site. Site has been remediated and interim closed. See CVP-99-00006.
100-D-27, 151-D Substation	Site consisted of an unplanned release within the 151-D electrical substation. The transformer was repaired, facility was power washed, all contaminated material was shoveled into seven 208-L (55-gal) drums, and the site backfilled with clean gravel.	EPA 1999. Site has been remediated and Closed Out. See WSRF 2005-014.

Table A-2. 100-D Area Waste Site Information and Status. (10 Pages)

Site Name	Site Information	Site Status
100-D-28, 190-DR Building Septic System	Site consists of two septic systems; the original and the replacement. 100-D-28:1 is the replacement system and consists of a 2,730 L (720 gal) steel septic tank and vitrified clay pipe drainfield. 100-D-28:2 is the original system and consists of a 2,839 L (750 gal) septic tank and drainfield.	EPA 1999. 100-D-28:2, reclassified as rejected. See WSRF 2005-015.
100-D-29, Effluent Line Leak No. 2	This site is an unplanned release of effluent water from the reactor cooling water (effluent line leak #2) and is located southeast of the 107-DR basin (116-DR-9).	
100-D-30, Sodium Dichromate Contaminated Soil	Sodium dichromate contamination was discovered in the soil along the entire length of the 185-D Sodium Dichromate Trench.	EPA 1999.
100-D-31, 100-D Water Treatment Facility Underground Pipelines	Reinforced concrete piping system from 100-D/DR water treatment facility buildings 182-D, 183-D, 186-D, 185/189/190-D, 105-D, 108-D, 182-DR, and 183-DR. Carried process sewer waste and rain runoff to process effluent outfall (116-D-5) until 1977. The process sewer drainage was diverted to the 120-D-1 D Ponds from 1977 to 1994.	EPA 1999.
100-D-32, Minor Construction Burial Ground	Received contaminated materials and equipment from D/DR-Reactor effluent system modifications. Operated 1956.	EPA 2000b.
100-D-33, Minor Construction Burial Ground	Used for the disposal of low level reactor wastes. The site was 30 x 15 x 7.6 m (100 x 50 x 25 ft), with a cover depth of 1.5 m (5 ft). Short-lived radionuclides were present at the site.	EPA 2000b.
100-D-35, Minor Construction Burial Ground	Used for the disposal of D-Reactor thimbles, rod guides, and miscellaneous waste during the Ball 3X conversion. Burial ground measured 0 x 15 x 7.9 m (100 x 50 x 26 ft) deep.	EPA 2000b.
100-D-40, Minor Construction Burial Ground	Burial ground #5 hole (pit) that received solid wastes from D/DR-Reactor alterations. Site is described as a 12-m (40-ft)-diameter pit. Operated 1956.	EPA 2000b.
100-D-41, 118-D-18 Construction Burial Ground	Exact location of this solid waste site uncertain. Both radioactive and nonradioactive materials from the D/DR-Reactor were disposed of at the site. Site was 12 x 12 x 7.6 m (40 x 40 x 25 ft) deep and covered with 1.5 m (5 ft) of material.	EPA 2000b.
100-D-42, Buried VSR Thimble Site	Consists of a solid waste burial ground that contains vertical safety rod (VSR) thimbles. Located east of the two reactor effluent pipelines in the 100-D Area.	EPA 2004.
100-D-43, Buried VSR Thimble Site	118-D-4C; Buried VSR Thimble Site 4C. Vertical safety rod thimble removed from the D Reactor. Two trenches in an area 30 x 15 x 6.1 m (100 x 50 x 20 ft) deep with overburden 1.5 m (5 ft) deep.	EPA 2000b.
100-D-45, 118-D-4B Burial Ground 4B	Solid Wastes from D/DR Reactor Alternations. Exact location of burial site is uncertain. References indicate it was part of the 118-D-4 site. Site was used as a thimble pit burial for radioactive and nonradioactive solid wastes and was 24.7 x 7.3 x 5.2 m (81 x 24 x 17 ft) deep.	EPA 2000b.
100-D-46, 118-D-4A Burial Ground 4A	Solid wastes from D/DR Reactor alternations. Exact location of burial site is uncertain. References indicate it was part of the 118-D-4 site and under the 116-D-1A and 116-D-1B Trenches. Site received thimble wastes and was 45.7 x 6.1 x 7.6 m (150 x 20 x 25 ft) deep. The principal radionuclide is short-lived cobalt-60.	EPA 2000b.

Table A-2. 100-D Area Waste Site Information and Status. (10 Pages)

Site Name	Site Information	Site Status
100-D-47, Burial Ground 4E, 118-D-4E	Received solid wastes from D/DR Reactor alterations. Site is 228 ft x 187 ft x 25 ft deep. Operation dates unknown.	EPA 2000b.
100-D-48, 100-D Reactor Cooling Water Effluent Pipelines	Site consisted of underground pipelines that transported radioactive treated and untreated waste water from the 105-D Reactor Building to the 107-D Retention Basin and the 116-D-5 Outfall. Consists of four subsites as follows: 100-D-48:1, North Pipelines from 116-D-7 to Outfalls 100-D-48:2, West Pipelines from D Avenue to 116-D-7 100-D-48:3, Effluent Pipelines from D Avenue to 105-D Reactor 100-D-48:4, Effluent Pipelines at 105-D Reactor.	EPA 1995. 100-D-48:1, remediated and interim closed. See CVP-2000-00003. 100-D-48:2, remediated and interim closed. See CVP-2000-00005. 100-D-48:3, remediated and interim closed. See CVP-2000-00034 100-D-48:4, remediated and interim closed. See CVP-2000-00033.
100-D-49, 100-DR Reactor Cooling Water Effluent Pipelines	Site consisted of underground pipelines that transported radioactive treated and untreated waste water from the 105-DR Reactor Building and the 1608-DR Building to the 107-DR Retention Basin and the Outfalls. Consists of four subsites as follows: 100-D-49:1, North Pipelines from 116-DR-9 to Outfalls 100-D-49:2, East Pipelines from D Avenue to 116-DR-9 100-D-49:3, Effluent Pipelines from D Avenue to Near 105-DR Reactor 100-D-49:4, Effluent Pipelines at 105-DR Reactor.	EPA 1995. 100-D-49:1, remediated and interim closed. See CVP-2000-00003. 100-D-49:2, remediated and interim closed. See CVP-2000-00005. 100-D-49:3, remediated and interim closed. See CVP-2000-00034 100-D-49:4, remediated and interim closed. See CVP-2003-00016.
100-D-50, 100-DR Water Treatment Facilities Underground Pipelines	Abandoned underground pipelines that carried treated and untreated wastewater from the 183-DR Building, the 183-DR Clearwells, and the 105-DR Reactor to the 100-D-8 Outfall. Consists of ten subsites.	EPA 2004. 100-D-50:10, reclassified as no action. See WSRF 2005-016.
100-D-52, 105-D Downcomer Drywell	Consisted of a 1-m (3-ft)-diameter by 6.9 m (22 ft) deep french drain (drywell). Received condensate or cooling water leakage from the concrete enclosure for the 105-D Downcomer.	No decision document. Proximity site. Site has been remediated and interim closed. See CVP-2000-00018.
100-D-53, 117-DR Filter Building	The ventilation exhaust filter building housed blowers and particulate filters used to treat the ventilation exhaust from the 105-DR Reactor Building. Decision document: *Action Memorandum for the 105-F and 105-DR Reactor Buildings and Ancillary Facilities*, July 19, 1998, CCN 059850, EPA, Ecology, and DOE-RL, Richland, WA.	Action memorandum. Site has been remediated and interim closed. See CVP-2003-00018. WSRF 2003-053, CCN 0557039
100-D-54, Drywell	Drywell near sodium fire facility gravel scrubber. Consisted of a 56-cm (28-in.) drywell constructed of concrete pipe with a steel cover. Approximately 1.5 m (4.9 ft) deep with a 5-cm (2-in.) pipe entering near the bottom.	EPA 2004. Site has been remediated and interim closed. See CVP-2003-00018.
100-D-56, 100-D Area Sodium Dichromate Underground Pipeline	Consists of two abandoned 7.6-cm (3-in.) underground supply lines that carried concentrated sodium dichromate between the 108-D, 185-D, 189-D, 190-D, and 183-DR Buildings and the 100-D Sodium Dichromate Transfer Station.	EPA 2004. Additional candidate pipeline site.

Table A-2. 100-D Area Waste Site Information and Status. (10 Pages)

Site Name	Site Information	Site Status
100-D-58, 100-DR On-Site Sewage System	Site includes a septic tank, drain field, two compartment tank, and associated risers supporting portable office MO980.	No decision document
100-D-61, Utility Pole and Fixture Debris Piles	Site is a debris pile which includes treated wood and lead-tipped bolts, and miscellaneous other debris from tearing down electrical utility poles.	EPA 2004.
100-D-62, 183-DR Headhouse Septic Tank	Site includes a septic tank with a capacity of 2,271 L (600 gal), a drain field, and related piping.	No decision document
100-D-63, 100-D/DR Service Water Pipelines	The site encompasses the clean water pipelines upstream of the 100-D and 100-DR Reactors, including underground pipelines used to transport raw, fire, export, and sanitary water from the river pumphouse, to the water treatment facilities and to 100-D Area facilities and fire hydrants.	No decision document
100-D-64, 119-DR Sample Building,	105-DR Reactor Exhaust Stack Sampling Building. Decision document: *Action Memorandum for the 105-F and 105-DR Reactor Buildings and Ancillary Facilities*, July 19, 1998, CCN 059850, EPA, Ecology, and DOE-RL, Richland, WA	Action memorandum. Site has been remediated and interim closed. See CVP-2003-00018. WSRF 2003-053, CCN 0557039.
100-D-65, 1904-D Spillway	The site is the concrete spillway (also referred to as a flume) that led from the 116-D-5 outfall structure and terminated at the river shoreline.	No decision document
100-D-66, 1904-DR Spillway	The site is the concrete spillway (also referred to as a flume) that led from the 116-DR-5 outfall structure and terminated at the river shoreline.	No decision document
100-D-67, D Island Contamination	Contamination spread from vent risers that extended from the buried river effluent pipelines (100-D-60).	No decision document
100-D-68, 190-DR Process Water Pump House	The pump house provided high volume treated water to the 105-DR Reactor for cooling.	Site has been reclassified as no action. See WSRF 2005-034.
100-D-70, 184-DA French Drain	Site consists of a 122 cm (48 in.) diameter drywell located on the south side of the former 184-DA Building. It received steam separator discharge from equipment within the former 184-DA (demolished) Building.	No decision document
100-D-71, Vertical Safety Rod Tower Components	Site is components of the 195-D Vertical Safety Rod Tower. It is unknown if the components remain in the ground. The site had a 1.2-m (4-ft)-diameter by 2.2-m (7-ft)-deep concrete drywell, a below grade pit approximately 30.5 cm (12 in.) square, and a 7.6 cm (3 in.) diameter underground cast iron.	No decision document
100-D-72, 183-D Acid Facility	The waste site consists of multiple components on the south side of the 183-D Head House. All activities associated with the waste site are related to the unloading, storage, and use of acid to support water treatment in the 183-D Head House.	No decision document
100-D-73, 108-D Chemical Pump House	Soil and possibly the demolition debris under the former 108-D Building. This building was used to store and mix sodium dichromate.	No decision document
100-D-74, Dry Well North Side of 105-D	A french drain located on the north side of 105-D Reactor footprint.	No decision document

Table A-2. 100-D Area Waste Site Information and Status. (10 Pages)

Site Name	Site Information	Site Status
100-D-75, Electrical Substations	Site is the 151-D primary and the 152-CI-D secondary electrical substations.	No decision document
100-D-76, Crib	The waste site is either a french drain or crib formerly known as 116-D-3. Historical documentation, a construction drawing, and GPR results indicate that waste site 116-D-3 probably remains near the southeast corner of the 108-D Building.	No decision document
100-D-77, 183-DR Acid Facility	The waste site consists of the 183-DR Acid Facility, 183-DR Head House, the six 183-DR Flocculation Basins, the six 183-DR Sedimentation Basins, and the 183-DR Filter Building, all of which were components of the cooling water treatment system that supported the 105-DR Reactor. These components are of interest because they stored, mixed, or processed liquid contaminants of concern, especially sodium dichromate and sulfuric acid.	No decision document
100-D-78, 100-D Yellow Stained Soil	Site consists of four areas of yellow-stained soils within the 100-D Area.	No decision document
100-D-79, Posted SCA	Posted soil contamination areas within the 100-D Area.	No decision document
100-D-80, Stained Soil	Patches of tar-stained soil scattered throughout the 100-D Area.	No decision document
100-D-81, Dump Area	Site consists of burned areas and other stained soil areas throughout the 100-D Area.	No decision document
100-D-82, Garnet Sand	Site consists of garnet sand areas throughout the 100-D Area.	No decision document
100-D-83, Pipelines	100-D Area water treatment pipelines not included in 100-D-63.	No decision document
100-D-84, Pipelines	Sanitary sewer pipelines that carried sewage to various septic systems within 100-D Area.	No decision document
100-D-85, Pipelines	Reactor effluent pipelines from the 105-D and 105-DR Reactors not included in 100-D-48 and 100-D-49 sites.	No decision document
100-D-86, Pipelines	Site consists of the process sewer pipelines not included in other sites within 100-D Area.	No decision document
100-D-88, Pipelines	Site consists of various miscellaneous pipeline segments.	No decision document
116-D-1A, 116-D-1B, 105-D Fuel Storage Basin Trenches	Trench measuring 40 x 3 x 1.8 m (130 x 10 x 6 ft) that received contaminated water and sludge from the 118-D-6 Fuel Storage Basin from 1947 to 1952. The 116-D-1B Trench was constructed in 1953 to replace the 116-D-1A Trench.	EPA 1995. Both sites have been remediated and interim close. See CVP-2000-00010.
116-D-2, 105-D Pluto Crib	Site was used to isolate coolant flow from process tubes containing ruptured fuel elements.	EPA 1995. Site has been remediated and interim closed. See CVP-2000-00013.
116-D-3, 108-D Crib	It was determined that this site is a duplicate number for 116-D-4.	EPA 1997. Site has been reclassified as no action. See WSRF 2002-060.
116-D-4, 108-D Crib	French Drain that received low-lever fission product wastes.	EPA 1995. Site has been remediated and interim closed. See CVP-2000-00008.
116-D-5, 1904-D Outfall Structure	Structure was an open concrete compartmentalized weir structure located at the top of the river bank west of the 107-D retention basin. Discharged effluent from the retention basins to the Columbia River from 1944-1975.	EPA 1999.

Table A-2. 100-D Area Waste Site Information and Status. (10 Pages)

Site Name	Site Information	Site Status
116-D-6, 105-D Cushion Corridor French Drain	French drain that received domestic waste water from the change room and mask decontamination station.	EPA 1995. Site has been remediated and interim closed. See CVP-2000-00009.
116-D-7, 105-D Retention Basin	Site was an open concrete basin that retained cooling water effluent from the 105-D Reactor for radioactive decay and thermal cooling prior to release to the Columbia River.	EPA 1995. Site has been remediated and closed out. See CVP-99-00007.
116-D-8, 100-D Cask Storage Pad	Concrete pad with two drains that stored shipping and handling casks and is covered with grey grout. Site operated from 1946-1975.	EPA 1999.
116-D-9, Seal Pit Crib	Site was the seal pit crib that received drainage from the confinement system 117 Building seal pits.	EPA 1995. Site has been remediated and closed out. See CVP-2000-00012.
116-D-10, Fuel Storage Basin Percolation Pit	Site consists of two open excavation pits that received process water from the 105-D Fuel Storage Basin cleanout activities. Operated during 1984.	EPA 1999.
116-DR-1&2, 107-DR Liquid Waste Disposal Trench	Sites consisted of two trenches that were later joined together to form a single trench. Received effluent from the retention basins when cooling water was contaminated due to ruptured fuel elements.	EPA 1995. Site has been remediated and closed out. See CVP-2000-00002.
116-DR-3, 105-DR Storage Basin Trench	Site consists of a trench that received water and sludge pumped from the fuel storage basin via an overground pipeline. Used in 1955.	EPA 1997.
116-DR-4, 105-DR Pluto Crib	The crib was a wooden structure with 3 x 3 m (10 x 10 ft) bottom dimensions and gravel filled and covered with 3 m (10 ft) of soil.	EPA 1997. Site has been remediated and closed out. See CVP-2000-00015.
116-DR-5, 1904-DR Outfall Structure	Structure was an open concrete compartmentalized weir structure located at the top of the river bank west of the 107-D retention basin. It operated from 1956-1967. Received effluent from the retention basins prior to release to the Columbia River.	EPA 1999.
116-DR-6, 1608-DR Liquid Disposal Trench	Received 105-DR Reactor cooling water effluent during upgrade of the reactor emergency shutdown system.	EPA 1997. Site has been remediated and closed out. See CVP-2000-00014.
116-DR-7, Inkwell Crib	This crib was used to receive the liquid potassium borate solution that was drained from the 3X system before the Ball 3X upgrade. It operated during 1953. Marked with single concrete marker. The crib is also described as a tank of unknown size buried under 1.8 m (6 ft) of soil.	EPA 1999. Site has been remediated and closed out. See CVP-2000-00019.
116-DR-8, Seal Pit Crib	A crib with a large steel vent cap surrounded by red steel posts. Operated 1960-1964. Received radioactive wastes consisting of beta-gamma from the 117-DR Building seal pits.	EPA 1999.
116-DR-9, 107-DR Retention Basin	Site was an open concrete basin that retained cooling water effluent from the 105-DR Reactor for radioactive decay and thermal cooling prior to release to the Columbia River.	EPA 1995. Site has been remediated and closed out. See CVP-99-00006.
116-DR-10, Fuel Storage Basin Cleanout Percolation Pond	Site operated during 1984 to receive radioactive shielding water from the 105-DR fuel storage basin.	EPA 1999.

Table A-2. 100-D Area Waste Site Information and Status. (10 Pages)

Site Name	Site Information	Site Status
118-D-1, 100-D Burial Ground No. 1	Burial ground for the disposal of irradiated reactor parts, dummies, thimbles, rods, gun barrels, and other contaminated solid wastes. Operated from 1944-1967. Received 10,000 cubic meters of wastes.	EPA 2000b.
118-D-2, 100-D Burial Ground No. 2	Burial ground for the disposal of various contaminated solid wastes including irradiated dummies, splines, rods, thimbles, and gun barrels. Operated from 1949-1970. Site was divided into four sections and measured 305 x 109 x 6.1 m (1,000 x 357 x 20 ft) deep. Contains east-west trenches and five disposal pits. Contaminated soil is possible beneath the site because of large quantities of water used to extinguish a fire in the 1960s.	EPA 2000b.
118-D-3, 100-D Burial Ground No. 3	Burial ground for the disposal of contaminated solid waste and irradiated dummies, splines, rods, thimbles, and gun barrels. Operated from 1956-1973. Site also contains a burning pit used for the disposal of low level radioactive combustible materials. Site was divided into five sections with several unequally spaced trenches.	EPA 2000b.
118-D-4, Construction Burial Ground	Burial ground received primarily reactor components and hardware. Operated from 1953-1967. Site contained several nonuniform trenches and was 183 x 61 x 6.1 m (600 x 200 x 20 ft) deep.	EPA 2000b.
118-D-5, Ball 3X Burial Ground	Burial ground received thimbles from the 105-DR Reactor during the Ball 3X Project in 1954. Site contained two parallel trenches 12 x 6.1 x 3 m (40 x 20 x 10 ft) deep.	EPA 2000b.
118-D-6, 105-D Reactor Building	Concrete building included the 105-D reactor block, irradiated fuel storage basin, work areas, and reactor control room. Operated from 1944-1967. Underwent decontamination and decommissioning of ancillary facilities in 2001-2004 to put the reactor core in interim safe storage. Site consists of four subsites: (1) concrete facility with reactor block, (2) ancillary support areas, below-grade structures and underlying soils, (3) fuel storage basin and underlying soils, and (4) 105-D fuel storage basin side slope soils.	Action memorandum. 118-D-6:1, Interim Safe Storage. 118-D-6:2, remediated and interim closed. See CVP-2005-00003. 118-D-6:3, remediated and interim closed. See CVP-2005-00003.
118-DR-1, 105-DR Gas Loop Burial Ground	The test loop burial ground was originally a gunnite-lined trench used to perform examination and sectioning of test assemblies pulled from the 105-DR Reactor. Operated from 1963-1964. Later, used for the disposal of irradiated metal assemblies from the 105-DR gas loop. The principal radionuclide is short-lived cobalt-60.	EPA 2000b.
118-DR-2, 105-DR Reactor Building	Concrete building included the 105-DR reactor block, irradiated fuel storage basin, work areas, and reactor control room. Operated 1950-1964. Underwent decontamination and decommissioning of ancillary facilities to put the reactor core in interim safe storage in 2002. Site consists of two subsites: (1) 105-DR Reactor core, and (2) 105-DR Reactor below-grade structures and underlying soils. Decision document: *Action Memorandum for the 105-F and 105-DR Reactor Buildings and Ancillary Facilities*, July 19, 1998, CCN 059850, EPA, Ecology, and DOE-RL, Richland, WA	Action memorandum. 118-DR-2:1, Interim Safe Storage. 118-DR-2:2, remediated and interim closed. See CVP-2003-00016.
120-D-2, 186-D Waste Acid Reservoir	Constructed of acid-proof brick, waterproof membrane, vitrified pipe, #8 lead flashing, and gunnite. Facility never used (no records found to document use). Structure demolished in place in 1979. Designated as a waste site because the lead flashing was not removed.	EPA 1999.
126-D-2, 184-D Coal Pit (Solid Waste Burial Ground)	Site was originally a coal storage facility for the powerhouse. From the 1970s-1986 it was operated as a burial ground receiving solid wastes from demolition activities.	EPA 2000b.

Table A-2. 100-D Area Waste Site Information and Status. (10 Pages)

Site Name	Site Information	Site Status
126-DR-1, 190-DR Clearwell Tank Pit	Originally contained four 3,750,000-gal water tanks which were removed in 1970s The site became a D&D burial ground and received rubble including pipe insulation containing asbestos. Suspected to contain soil and solid waste contaminated with paint, solvents, oil, sodium dichromate, creosote, herbicides, and miscellaneous materials.	EPA 2000b.
128-D-1, 100-D/DR Burning Pit	Site was used from 1944-1967 for disposal of nonradioactive combustible materials such as paint waste, office waste, and chemical solvents.	EPA 1999. Site has been reclassified as no action. See WSRF 2003-009.
128-D-2, Burning Pit	Large landfill area that shows evidence of surface burning. Some pieces of uncontaminated reactor hardware were found at the site.	EPA 1999.
130-D-1, Gasoline Storage Tank Site	Site of a steel underground storage tank used for storage of leaded gasoline with a capacity of 15,140 L (4,000 gal). Tank was removed in 1989. Operated 1944-1968. Site was contaminated with petroleum hydrocarbons. Site was backfilled with clean soil without removal of contaminated soil.	EPA 1999.
132-D-1, 115-D/DR Gas Recirculating Facility	The facility was built in 1943 to house the equipment used to recirculate, filter, dry, and inject the cover gases for the 105-D and 105-DR reactor cores. The concrete facility was demolished in place in 1986. Operated 1944-1967.	EPA 1999.
132-D-2, 117-D Filter Building	Concrete structure built to receive exhaust discharges from the 105-D Reactor Building and filter the exhaust prior to the exhaust stack release into the atmosphere. Operated 1961-1967. The facility was decontaminated and decommissioned in situ in 1986.	EPA 1999. Interim closed out. See WSRF 2005-024.
132-D-3, Waste Water Pumping Station	Received liquid waste from reactor drains containing low-level radionuclides, sodium fluoride, oxalic acid, and citric acid. Concrete structure that extended 9.8 m (32 ft) below grade and 1.2 m (4 ft) above grade. Operated 1944-1965. Demolished in place in 1986 and 1987.	EPA 1999. Interim closed out. See WSRF 2005-033.
132-D-4, 105-D Reactor Exhaust Stack	105-D Reactor Bldg. Stack demolished August 19, 1999. Debris disposed at ERDF. Operated from 1944-1967. Received exhaust air from 105-D reactor work areas known to contain low level radioactive materials. Decision document: *Action Memorandum for the 105-F and 105-DR Reactor Buildings and Ancillary Facilities*, EPA, Ecology, and DOE-RL, July 19, 1998, CCN 059850	Action Memorandum. Site has been remediated and interim closed. See CVP-2005-00003.
132-DR-1, 1608-DR Waste Water Pumping Station	Former concrete structure which contained pumps, sumps, and accumulation chambers. Operated 1950-1964. Demolished in place in 1987. Received liquid waste from reactor drains containing low-level radionuclides, sodium fluoride, oxalic acid, and citric acid.	EPA 1999. Interim closed out. See WSRF 2005-035
132-DR-2, 116-DR Reactor Exhaust Stack	105-DR Reactor Bldg. Stack demolished August 14, 1999. Debris disposed at ERDF. Operated 1950-1986. Received exhaust air from 105-DR reactor work areas known to contain low level radioactive materials. Decision document: *Action Memorandum for the 105-F and 105-DR Reactor Buildings and Ancillary Facilities*, July 19, 1998, CCN 059850, EPA, Ecology, and DOE-RL, Richland, WA	Action Memorandum. Site has been remediated and interim closed. See CVP-2003-00018.
1607-D1, Septic System	This site is a concrete tank (capacity of 130 L [35 gal]) with drain field that received sanitary sewage from 1701-D Badgehouse and 1709-D Fire Headquarters Building. This septic system is not known to have received hazardous or radioactive wastes.	No decision document.

Table A-2. 100-D Area Waste Site Information and Status. (10 Pages)

Site Name	Site Information	Site Status
1607-D2, Septic System	This site was a concrete tank with drain field that received sanitary waste from the 190-DA, 189-D, 185-D, 182-D, 183-D, 1700-D Administration & Services buildings, and the 105-D Reactor. The site has been divided into four subsites: (1) 1607-D2:1 Abandoned Tile Field; (2) 1607-D2:2 Replacement Tile Field; (3) 1607-D2:3 Septic Pipelines, and (4) 1607-D2:4 Septic Tank. Sites 1, 3, and 4 are interim closed.	No decision document. Proximity site. 1607-D2:1, remediated and interim closed. See CVP-98-00005. 1607-D2:2, pending 1607-D2:3, remediated and interim closed. See CVP-2000-00004. 1607-D2:4, remediated and interim closed. See CVP-99-00005.
1607-D3, Septic System	This site is a concrete tank with drain field. Received sanitary sewage from the 151-D Electrical Distribution Substation.	Closed out by Fluor. See WSRF 2000-122.
1607-D4, Septic System	This site is a concrete tank with drain field. Received sanitary sewage from 115-D/DR Gas Recirculation Building.	EPA 1999. Site has been remediated and interim closed. See WSRF 2005-036.
1607-D5, Septic System	This site is a concrete tank (capacity of 130 L [35 gal]) with drain field. Received sanitary sewage from the 181-D Pump House.	EPA 1999.
600-30, 100-DR Construction Laydown Area	Site is approximately 4 hectares (10 acres) scattered with construction related debris.	EPA 1999.
628-3, Burn Pit	Site littered with burned wood, nails, metal pipes, rebar, and glass debris. Depression in center shows signs of severe plant stress and soil discoloration.	EPA 1999.
UPR-100-D-1, Oil Soaked Soil	Site was an unplanned release that appeared as a small depression located east of 190-D facility. Contained small amount of oil-contaminated soil. Site was demolished with the 190-D facility.	EPA 1999. Site has been reclassified as no action. See WSRF 2005-020.
UPR-100-D-2, Effluent Line Leak #1	Site was an unplanned release from pipelines 100-D-48 and 100-D-49.	No decision document. Proximity site. Site has been remediated and interim closed. See CVP-2000-00005.
UPR-100-D-3, Effluent Line Leak #3	Site was an unplanned release from pipelines 100-D-48 and 100-D-49.	No decision document. Proximity site. Site has been remediated and interim closed. See CVP-2000-00005.
UPR-100-D-4, 107-D Basin Leaks	Site was an unplanned release from pipelines 100-D-48 and 100-D-49.	No decision document. Proximity site. Site has been remediated and interim closed. See CVP-2000-00003.
UPR-100-D-5, Effluent Line Leak #4	This site is an unplanned release of effluent water from the reactor cooling water (effluent line leak #4) and is located southeast of 116-DR-9 (107-DR Retention Basin).	No decision document. Proximity site.

CVP = cleanup verification package
GPR = ground-penetrating radar
WSRF = Waste Site Reclassification Form

Table A-3. 100-F Area Waste Site Information and Status. (10 Pages)

Site Name	Site Information	Site Status
100-F-2, Strontium Garden	PNL ecological study garden formerly used for growing cereal grains, alfalfa, and other crops in soils containing Sr-90 and Cs-137.	EPA 1999. Site has been remediated and interim closed. See CVP-2001-00001.
100-F-4, 108-F Building 12-Inch French Drain	Site was a 0.3-m (12-in.)-diameter vitrified clay pipe adjacent to the former 108-F Building. Removed during D&D of 108-F Building.	EPA 1999. Site has been remediated and interim closed. See CVP-2002-00001.
100-F-7, Underground Fuel Tank	Underground 3,785 L (1,000 gal) fuel oil tank that supplied oil to the 1705-F Building Heater Room. The lab has been decommissioned with no trace of location.	EPA 1999. Site has been reclassified as no action. See WSRF 2004-124.
100-F-9, French Drain	French drain at east end of 105-F storage room. Likely removed during D&D activities.	EPA 1999. Site has been reclassified as no action. See WSRF 2004-125.
100-F-10, French Drain	Site was a 91-cm (36-in.)-diameter concrete pipe buried to unknown depth at the east end of the 105-F storage room.	EPA 1999. Site has been remediated and interim closed. See CVP-2003-00017.
100-F-11, 108-F Building 18-Inch French Drain	Site was a 0.5-m (18-in.)-diameter concrete pipe (length unknown) adjacent to the northwest corner of the electrical substation on the west wall of 108-F Building. Removed during D&D of 108-F Building.	EPA 1999. Site has been remediated and interim closed. See CVP-2002-00001.
100-F-12, 36-Inch French Drain at 105-F Building	Site was a 91-cm (36-in.)-diameter concrete pipe of unknown length with a steel lid. Located at northeast corner of the 105-F Reactor	EPA 1999. Site has been reclassified as no action. See WSRF 2004-126.
100-F-14, Vent Pipe	Site is a steel vent pipe extending above grade. The above grade portion is 10 cm (4 in.) in diameter with a 90-degree bend at the top.	EPA 1999. Site has been reclassified as no action. See WSRF 2004-127.
100-F-15, 108-F Building French Drain	Site was a 1.2-m (36-in.)-diameter gravel-filled concrete pipe extending to an unknown depth located adjacent to the east wall of the 108-F Building. Removed during D&D of 108-F Building.	EPA 1997. Site has been remediated and interim closed. See CVP-2002-00001.
100-F-16, 108-F Building French Drain	Site was a 0.8-m (30-in.)-diameter steel pipe of unknown length adjacent to the 108-F Building, which was removed during D&D of 108-F Building.	EPA 1999. Site has been remediated and interim closed. See CVP-2002-00001.
100-F-18, Condensate Drain	Former 91-cm (36-in.)-diameter steel pipe located near the northwest corner of the 105-F Reactor adjacent to the north wall of the fan house. Removed during D&D activities.	EPA 1999. Site has been reclassified as no action. See WSRF 2004-137.
100-F-19, Process Effluent Pipelines	Numerous underground pipelines radioactively and/or chemically contaminated. These include process sewer lines, effluent lines to and from the retention basins, and numerous others left in place upon D&D activities. Consists of three subsites: (1) north group, (2) south group, and (3) west group.	EPA 1997. Site has been remediated and interim closed. See CVP-2001-00002 and CVP-2001-00003.

Table A-3. 100-F Area Waste Site Information and Status. (10 Pages)

Site Name	Site Information	Site Status
100-F-23, 141-C Drywell	French drain that received liquid waste for animal pens and 141-C Building research laboratories.	EPA 1999. Site has been remediated and interim closed. See CVP-2003-00011.
100-F-24, 145-F Drywell	French Drain that received waste from the 145-F Animal Monitoring Laboratory.	EPA 1999. Site has been remediated and interim closed. See CVP-2003-00012.
100-F-25, 146-F Drywells	French Drains that received waste from the 146-F and 146-FR Buildings.	EPA 1999. Site has been remediated and interim closed. See CVP-2003-00010.

Table A-3. 100-F Area Waste Site Information and Status. (10 Pages)

Site Name	Site Information	Site Status
100-F-26, Underground Pipelines	100-F Water treatment facility underground pipelines; process sewer. Consists of 16 subsites as follows: 1) North Process Sewer Collection Pipelines 2) Process Water Pipelines to Aquatic Biology and Strontium Gardens 3) 184-F Powerhouse Pipelines 4) South Process Pipelines 5) 190-F Bypass Process Sewer Pipelines 6) 190-F Reservoir Pipeline 7) Sodium Dichromate and Sodium Silicate Pipelines 8) 1607-F1 Sanitary Sewer Pipelines 9) 1607-F2 Sanitary Sewer Pipelines 10) 1607-F3 Sanitary Sewer Pipelines 11) 1607-F4 Sanitary Sewer Pipelines 12) Main Process Sewer 13) 108-F Drain Pipelines 14) 116-F-5 Influent Pipelines 15) Miscellaneous Pipelines Associated with 1608-F Sump 16) Reactor Cooling Water Pipelines.	EPA 2004. 100-F-26:1, reclassified as no action. See WSRF 2005-008. 100-F-26:2, reclassified as no action. See WSRF 2005-005. 100-F-26:3, reclassified as no action. See WSRF 2004-118. 100-F-26:4, WSRF pending 6/18/08. 100-F-26:5, reclassified as no action. See WSRF 2005-007. 100-F-26:6, reclassified as no action. See WSRF 2004-119. 100-F-26:7, interim closed. See WSRF 2005-010. 100-F-26:8, remediated and interim closed. See WSRF 2005-004. 100-F-26:9, WSRF pending 6/18/08. 100-F-26:10, remediated and interim closed. See WSRF 2007-028. 100-F-26:11, reclassified as no action. See WSRF 2005-003. 100-F-26:12, remediated and interim closed. See WSRF 2007-034. 100-F-26:13, remediated and interim closed. See WSRF 2005-011. 100-F-26:14, remediated and interim closed. See WSRF 2007-029. 100-F-26:15, remediated and interim closed. See WSRF 2007-031. 100-F-26:16, reclassified as no action. See WSRF 2004-120.
100-F-28, Septic System	Septic tank and drain field thought to support a single, isolated office building.	EPA 1999. Site has been reclassified as rejected. See WSRF 2001-030.
100-F-29, Process Sewer Pipeline	Site consisted of contaminated pipelines that existed at the 100-F Experimental Animal Farm.	EPA 1999. Site has been remediated and interim closed. See CVP-2001-00003.
100-F-31, 144-F Sanitary Sewer System	Site consisted of a septic tank and drain field that supported the 144-F Building.	EPA 1999. Site has been remediated and interim closed. See WSRF 2006-033

Table A-3. 100-F Area Waste Site Information and Status. (10 Pages)

Site Name	Site Information	Site Status
100-F-33, 146-F Aquatic Biology Fish Ponds	The fish ponds were constructed unlined reinforced concrete used to support testing on fish.	EPA 1999. Site has been remediated and interim closed. See WSRF 2006-021.
100-F-34, Biology Facility French Drain	Site was believed to have supported the 1705-F Experimental Gardens.	EPA 1999. Site has been remediated and interim closed. See CVP-2001-00002.
100-F-35, Soil Contamination Area	Site was a soil contamination area inside the 105-F exclusion area.	No decision document. Site has been remediated and interim closed. See CVP-2002-00007.
100-F-36, 108-F Chemical Pumphouse	Site was the 108-F Chemical Pumphouse, but was remodeled into the Biological Laboratory for plant and animal experiments, then decontaminated and demolished.	EPA 2004. Site has been reclassified as no action. See WSFR 2007-002.
100-F-37, French Drain	Site consisted of an abandoned french drain near hydrant F-2.	EPA 2004. Site has been reclassified as no action. See WSFR 2004-095.
100-F-38, Yellow-Stained Soil	Sites consisted of yellow-stained soil near hydrant F-2.	EPA 2004. Site has been remediated and interim closed. See WSFR 2004-093.
100-F-41, 100-F Service Water Pipelines	The site includes underground pipelines used to transport raw, fire, export, filtered, and sanitary water from the river pump house to 100-F Area facilities, including the water treatment facilities and fire hydrants.	Site has been reclassified as rejected. See WSRF 2006-064.
100-F-42, 1904-F Spillway	Site consisted of a reinforced concrete flume that extended from the 116-F-8 Outfall to the Columbia River shoreline.	EPA 1999. Site has been remediated and interim closed. See WSRF 2006-045.
100-F-43, PNL Outfall Spillway	Site consisted of a reinforced concrete flume that extended from the 116-F-16 Outfall to the Columbia River shoreline.	EPA 1999. Site has been remediated and interim closed. See WSRF 2006-046.

Table A-3. 100-F Area Waste Site Information and Status. (10 Pages)

Site Name	Site Information	Site Status
100-F-44, 100-F Miscellaneous Pipelines	Site consists of a compilation of pipeline segments not previously addressed in any closure documents. Subsites are: 1) Pipeline Near 182-F Reservoir 2) Pipeline Near 108-F Building 3) 1607-F3 Sewer System Pipeline 4) Pipeline in Silica Gel Pit 5) Process Sewer Pipeline 6) 189-F Refrigeration Pipeline 7) 1717-F Blowdown Pipeline 8) 1717-F Fuel Oil Supply and Return Pipelines 9) 105-F Process Sewer Pipelines 10) 141-C Sewer Pipeline.	No decision document. 100-F-44:1, reclassified as no action. See WSRF 2007-005. 100-F-44:2, reclassified as no action. See WSRF 2007-006. 100-F-44:3, reclassified as rejected. See WSRF 2007-010. 100-F-44:4, WSRF pending. 100-F-44:5, WSRF pending. 100-F-44:6, reclassified as rejected. See WSRF 2007-007. 100-F-44:7, reclassified as rejected. See WSRF 2007-012. 100-F-44:10, reclassified as rejected. See WSRF 2007-011.
100-F-45, Buried Effluent Pipelines	The site consists of a piece of pipeline that was buried in the river bank after it floated loose from the river effluent pipeline.	No decision document.
100-F-46, French Drain	Site consisted of the 119-F french drain, a gravel-filled vertical pipe, and the pipeline from the 119-F Stack Sampling Building to the french drain.	No decision document.
100-F-47, 151-F Substation	The substation consisted of a fenced, gravel-bed yard measuring 92.4 m (303 ft) by 137.2 m (450 ft), with the 151-F Switch House along the eastern fence line. A railroad spur entered the yard from the south and paralleled the east fence line.	No decision document.
100-F-48, 184-F Coal Pit Debris	The site consists of an area of debris that was identified in an aerial photograph and a historical literature search.	No decision document.
100-F-49, 1716-F Maintenance Garage Lubrication Pit	The site consists of components of the 1716-F Maintenance Garage, including the foundation, the lubrication pit, and the contaminated drain(s).	No decision document.
100-F-50, 100-F Railroad French Drain	The site consists of a french drain between two sets of railroad tracks at the first junction in the south center of the 100-F Area.	No decision document. Reclassified as no action. See WSRF 2007-001.
100-F-51, 146-F Fish Laboratory Soil	The site is the soil under and around the former 146-F Fish Laboratory.	No decision document.
100-F-52, 146-FR Radioecology/Aquatic Laboratory Soil	The site consists of the soil under and around the former 146-FR Radioecology and Aquatic Biology Laboratory.	No decision document.

Table A-3. 100-F Area Waste Site Information and Status. (10 Pages)

Site Name	Site Information	Site Status
100-F-53, 108-F Septic System	The site potentially consists of pipelines, a septic tank, the drain field and any contaminated soil around them.	No decision document.
100-F-54, Animal Farm Pastures	This site consists of the remaining soil associated with the former pastures that were used to hold contaminated animals.	No decision document. Reclassified as no action. See WSRF 2008-015.
100-F-55, 1607-F7 Contaminated Ash Layer	The site consists of a contaminated layer of ash located in a trench near the 1607-F7 area.	No decision document.
100-F-56, 100-F Surface Debris/Stains	The site consists of scattered surface debris located throughout the 100-F Area.	No decision document.
100-F-57, 190-F Process Water Pump House Debris	The site consists of the remaining foundation of the demolished 190-F Process Water Pump House.	No decision document.
116-F-1, Lewis Canal	Process Effluent Disposal Trench.	EPA 1997. Site has been remediated and interim closed. See CVP-2002-00009.
116-F-2, 107-F Liquid Waste Disposal Trench	Site was an open liquid waste trench used for disposal of process effluent from 1950 to 1965.	EPA 1997. Site has been remediated and interim closed. See CVP-2001-00005.
116-F-3, 105-F Storage Basin Trench	Site was a trench that received reactor cooling water during the 1947 fuel rupture occurrence. In 1951, the trench received sludge from the 105-F Fuel Basin.	EPA 1997. Site has been remediated and interim closed. See CVP-2002-00008.
116-F-4, Pluto Crib	Site was a wooden crib that received liquid waste from 105-F Reactor during fuel ruptures between 1950-1952.	EPA 1997. Site has been remediated and interim closed. See CVP-2001-00006.
116-F-5, Ball Washer Crib	Site was a wood structure located in the transfer basin area of the 105-F Reactor Building that received decontamination wastes from the 105-F Reactor ball washer assembly.	EPA 1997. Site has been remediated and interim closed. See CVP-2001-00007.
116-F-6, Liquid Waste Disposal Trench	Site was an open excavation used to receive reactor cooling water.	EPA 1997. Site has been remediated and interim closed. See CVP-2002-00010.
116-F-7, 117-F Crib and Pipeline	The site consists of (1) crib, and (2) pipeline that has been filled with gravel and covered with clean soil. A pipeline that has been filled with gravel and covered with clean soil. The pipeline originated at the 117-F Filter Building (132-F-5) and terminated at the crib site.	EPA 1999. Both subsites have been reclassified as no action. See WSRFs 2004-128 and 2005-044.

Table A-3. 100-F Area Waste Site Information and Status. (10 Pages)

Site Name	Site Information	Site Status
116-F-8, 1904-F Outfall Structure	Located on the bank of the Columbia River, the site served as a weir box for 105-F Reactor coolant water ducted to the river via the 100-F-42 Spillway to provide overflow capability in case the outfall lines became plugged.	EPA 1999. Site has been remediated and interim closed. See WSRF 2006-038.
116-F-9, PNL Animal Waste Leach Trench	Site was a leaching trench that received waste water from the cleaning of animal pens in the experimental animal farms.	EPA 1997. Site has been remediated and interim closed. See CVP-2001-00008.
116-F-10, 105-F Dummy Decontamination French Drain	Site consisted of a vitrified clay pipe placed in the ground vertically and used to dispose of fluid from decontamination of the dummy fuel element spacers and other reactor hardware.	EPA 1997. Site has been remediated and interim closed. See CVP-2003-00003.
116-F-11, Cushion Corridor French Drain	Site was a french drain that received liquid decontamination waste from the cushion corridor area of the reactor.	EPA 1997. Site has been remediated and interim closed. See CVP-2001-00003.
116-F-12, 148-F French Drain	Site was a french drain that received effluent pump priming water from lift station during 1944-1964.	EPA 1999. Site has been remediated and interim closed. See CVP-2001-00002.
116-F-14, 107-F Retention Basins	Site was a concrete-lined, open-top reservoir designed to retain reactor cooling water prior to discharge to the Columbia River.	EPA 1997. Site has been remediated and interim closed. See CVP-2001-00009.
116-F-15, 108-F Radiation Crib	Site was a floor drain and sump that emptied into a trench beneath the floor of the 108-F Building.	EPA 1999. Site has been remediated and interim closed. See WSRF 2007-003.
116-F-16, PNL Outfall Structure	Located on the bank of the Columbia River, the site served as a concrete weir box that carried experimental animal farm wastes to the river.	EPA 1999. Site has been remediated and interim closed. See WSRF 2006-039.
118-F-1, Burial Ground	Solid waste burial ground received radioactive material and reactor components from the 100-F Reactor from 1954-1965. Site contained two north /south trenches.	EPA 2000b. Site has been remediated and interim closed. See CVP-2007-00001.
118-F-2, Burial Ground	Received solid waste from the 100-F Reactor and biology facilities. Operated from 1945 to 1965.	EPA 2000b. Site has been remediated and interim closed. See CVP-2007-00002.

Table A-3. 100-F Area Waste Site Information and Status. (10 Pages)

Site Name	Site Information	Site Status
118-F-3, Minor Construction Burial Ground.	Solid waste site received irradiated reactor parts from the 100-F Reactor during the 3X Project in 1952. Waste was primarily vertical safety rod thimbles and step plugs.	EPA 2000b. Site has been remediated and interim closed. See CVP-2006-00008.
118-F-4, 115-F Pit	The site was a small unlined disposal pit used to receive silica gel from the 115-F drying towers.	EPA 1999. Site has been reclassified as no action. See WSRF 2004-129.
118-F-5, PNL Sawdust Pit	Received sawdust containing strontium-90 and plutonium-239 from the animal pens at the Experimental Animal Farm from 1954-1975. Materials were placed in paper boxes or 250-L (55-gal) metal drums for burial. The site was later backfilled and stabilized with 3-4 ft of clean soil.	EPA 2000b. Site has been remediated and interim closed. See CVP-2007-00003
118-F-6, PNL Solid Waste Burial Ground	Received biological waste from animal research studies. Operated from 1965-1973. Site contained two large rail tankcars used for incineration of animal tissue and carcasses and a waste disposal area.	EPA 2000b. Site has been remediated. CVP is pending as of 4/4/2008
118-F-7 Misc. Hardware Storage Vault	Below ground concrete vault south of the 105-F reactor building. Used 1945 – 1965 for temporary storage of contaminated reactor parts and mixed wastes. Remediated and Interim Closed Out in 2006.	EPA 2000b. Site has been remediated and interim closed. See CVP-2006-00007.
118-F-8, 105-F Reactor Building	Inactive plutonium production reactor that operated from 1944 to 1965 and was placed in Interim Safe Storage in 2003. Site consists of four subsites: (1) 105-F Reactor Ancillary Support Areas, Below-Grade Structures, and Underlying Soils, (2) 105-F Reactor Core and ISS Project, (3) 105-F Fuel Storage Basin and Underlying Soils, and (4) 105-F Fuel Storage Basin West Side Adjacent and Side Slope Soils. Decision document: *Action Memorandum for the 105-F and 105-DR Reactor Buildings and Ancillary Facilities*, July 19, 1998, CCN 059850, EPA, Ecology, and DOE-RL, Richland, WA	Action memorandum. 118-F-8:1, remediated and interim closed. See CVP-2003-00017. 118-F-8:2, Interim Safe Storage. 118-F-8:3, remediated and interim closed. See CVP-2003-00017. 118-F-8:4, remediated and interim closed. See CVP-2007-00004.
118-F-9 PNL Rad Site (Burial Ground)	Suspected inactive solid waste burial ground in the southeastern corner of the 126-F-1 Ash Pit.	EPA 2000b. Site has been reclassified as rejected. See WSRF 2006-048.
120-F-1, Glass Dump	Dump site containing surface litter consisting of numerous fluorescent tubes, light bulbs, vacuum tubes, broken tools, small batteries, chemical bottles, and laboratory apparatus.	EPA 1999. Site has been remediated. WSRF 2008-028 pending 6/10/08.
126-F-1, Ash Pit	Solid waste site that received coal ash from the 184-F coal-fired steam plant.	EPA 1999. Site has been remediated and interim closed. See CVP-2002-00004.
126-F-2, 183-F Clearwells	Reinforced concrete water storage basins designed to store river water being processed for reactor coolant. Operated from 1945 to 1965.	EPA 1999. Site has been remediated and interim closed. See WSRF 2006-017.
128-F-1, Burning Pit	Burning pit that operated from 1945 to 1965. Waste included nonradioactive, combustible materials such as paint waste, office waste, and chemical solvents.	EPA 1999. Site has been reclassified as no action. See WSRF 2003-035.

Table A-3. 100-F Area Waste Site Information and Status. (10 Pages)

Site Name	Site Information	Site Status
128-F-2, Burning Pit	Site is an irregularly-shaped depression located on the river bank used for burning of nonhazardous office waste, vegetation, paint, solvents, and other combustibles.	EPA 1999.
128-F-3, PNL Burn Pit	Shallow was a shallow pit used for burning materials from the Experimental Animal Farm. Pit currently filled with coal ash.	EPA 1999. Site has been remediated and interim closed. See WSRF 2006-042.
132-F-1, Chronic Feeding Barn	Site was a concrete block building with concrete animal pens that was used as the main housing facility for sheep and other livestock used in radiological dose studies.	EPA 1999. Site has been remediated and interim closed. See WSRF 2006-029.
132-F-3, Gas Recirculation Facility	Single story concrete building that housed the reactor inert gas processing and recirculation system.	EPA 1999. Site has been reclassified as no action. See WSRF 2003-025.
132-F-4, 116-F Reactor Stack	Site contains concrete rubble from demolition of the 105-F (116-F) Reactor Stack. The stack was used to exhaust confinement air from the work areas of the 105-F Reactor Building from 1944-1965 and was demolished in 1983. The stack and its foundation were demolished with explosives and buried in a trench. Site consists of two subsites: (1) 116-F Reactor Stack, and (2) Reactor Stack Base Burial Site.	EPA 1999. 132-F-4:1, reclassified as no action. See WSRF 2003-023. 132-F-4:2, reclassified as no action. See WSRF 2005-043.
132-F-5, 117-F Filter Building	Building received exhaust fan discharge through an inlet duct from the 105-F Reactor and discharged filtered air through a duct and out the 116-F Stack.	EPA 1999. Site has been reclassified as no action. See WSRF 2003-029.
132-F-6, 1608-F Waste Water Pumping Station	Former concrete building that housed a water pumping station that operated from 1944-1965 and was demolished in situ in 1987. Received waste water from reactor drains and sumps and combined these wastes with reactor effluent.	EPA 1999. Site has been reclassified as no action. See WSRF 2003-032.
141-C, Animal Barn	Site was the location of the large animal barn and biology laboratory, and also referred to as the hog barn.	EPA 1999. Site has been remediated and interim closed. See WSRF 2006-027.
1607-F1, 124-F-1 Septic Tank and Drainfield	Concrete septic tank with a 125-person capacity, a vitrified pipe tile field, and associated piping. Received sanitary sewage form 1701-F badge house, 1709-F Fire Station, and 1720-F Admin. office and change room.	EPA 1999. Site has been remediated and interim closed. See WSRF 2004-130.
1607-F2, Septic System	Site included a septic tank, drainfield, and associated piping that received sanitary wastes from the 184-F, 185-F, 190-F, and 1700 Admin. Services Building. Site operated from 1944 to 1988.	EPA 1999. Site has been remediated and interim closed. See CVP-2002-00005.
1607-F3, 124-F-3 Septic System	Site included a 41-person capacity concrete tank with vitrified pipe tile field. It operated from 1944 to 1965. It received sanitary sewage from 182-F Pump Station, 183-F Water Treatment Plant, and 151-F Substation.	EPA 1999. Site has been remediated and interim closed. See WSRF 2006-047.

Table A-3. 100-F Area Waste Site Information and Status. (10 Pages)

Site Name	Site Information	Site Status
1607-F4, Septic System	Site included a 6-person capacity concrete tank, vitrified pipe tile field, and associated piping. It operated from 1944 to 1965 and received sanitary sewage from the 115-F Gas Recirculation Building.	EPA 1999. Site has been remediated and interim closed. See WSRF 2004-131
1607-F5, Septic System	Site included a 6-person capacity concrete tank with vitrified pipe tile field. It operated from 1944 to 1965 and received sanitary sewage from the 181-F Pump house.	EPA 1999. Site has been remediated and interim closed. See WSRF 2006-043.
1607-F6, Septic System	Site included three tanks, a tile field, and associated pipelines. It operated from 1945 to 1975 and received sanitary wastes from the 1705-F, 146-F, and 146-FR Animal Farm Buildings.	EPA 1999. Site has been remediated and interim closed. See CVP-2001-00010.
1607-F7, Septic System	Site included a septic tank, drainfield, and associated piping that received sanitary sewage from the 141-M Building.	EPA 1999. Site has been remediated and interim closed. See WSRF 2006-040.
182-F, Reservoir	Received raw water from the Columbia River for input to the reactor cooling water system. Operated 1945-1965.	EPA 1999. Site has been remediated and interim closed. See WSRF 2005-025.
UPR-100-F-1, Sewer Line Leak	Spill of 64,352 L (17,000 gal) of animal pens wash water occurred when a process sewer line from the 141-C Hog Barn plugged and overflowed adjacent to the building in 1971.	EPA 1999. Site has been remediated and interim closed. See CVP-2001-00003.
UPR-100-F-2, Basin Leak Ditch	Ditch formed by overflow of the north end of the 107-F Retention Basin during 1955 and enlarged by repeated overflows from an effluent line manhole north of the basin. Ditch ran northeast to the Columbia River	EPA 1997. Site has been remediated and interim closed. See CVP-2001-00011.
UPR-100-F-3, Mercury Spill	Mercury spilled on the floor of the former 146-FR Fish Lab. All material was "squeegeed" out the door of the building and was reported to have been cleaned up and removed.	EPA 1999. Site has been remediated and interim closed. See CVP-2003-00010.

CVP = cleanup verification package
D&D = decontamination and decommission
WSR = Waste Site Reclassification Form

Table A-4. 100-H Area Waste Site Information and Status. (5 Pages)

Site Name	Site Information	Site Status
100-H-1, 105-H Rod Cave	Site was used for temporary storage of horizontal control rods and vertical safety rods as well and tools used in removal and installation. Operated from 1949 to 1965.	No decision document. Site has been remediated and interim closed. See CVP-2000-00029.
100-H-2, Buried Thimble Site	Inactive low-level solid waste burial ground said to consist of two north-south backfilled trenches.	No decision document. Proximity site. Site has been remediated and interim closed. See CVP-2000-00031.
100-H-3, 1716-H Garage Fuel Tank	Site may contain one or more underground storage tanks used to supply fuel to the 1716-H Garage. This building served as an automotive service station from 1949 to 1965. The automotive service area included gas pumps with underground storage tanks and, possibly an oil pit.	EPA 1999.
100-H-4, 1717-H Hot Shop, French Drain	The site is a Hot Shop, French Drain and Contaminated Storage. The french drain was located under additional storage (Butler type) areas that were added to the east side of the 1717-H Building.	EPA 1999.
100-H-5, 107-H Sludge Burial Trench	Site contains sludge removed from the 116-H-7 Retention Basins in 1953.	EPA 1997. Site has been remediated and interim closed. See CVP-2000-00028.
100-H-7, French Drain A	This site is a vertical 76-cm (30-in.)-diameter vitrified concrete pipe with metal lid (at surface grade) suspected to be a french drain.	EPA 1999.
100-H-8, French Drain B	This site is a vertical 91-cm (36-in.)-diameter concrete pipe (filled with gravel) with steel lid (at surface grade) suspected to be a french drain.	EPA 1999.
100-H-9, French Drain C	Site was a vertical 61-cm (24-in.)-diameter concrete pipe with a rusted metal lid suspected to be a french drain.	EPA 1999. Site has been remediated and interim closed. See CVP-2006-00003.
100-H-10, French Drain D	Site was a vertically buried 122-cm (48-in.)-diameter vitrified clay pipe with steel lid.	EPA 1999. Site has been remediated and interim closed. See CVP-2006-00003.
100-H-11, Expansion Box French Drain E	Site was a vertical 76-cm (30-in.)-diameter steel manhole set in concrete that provided access to a french drain at bottom of box.	EPA 1999. Site has been remediated and interim closed. See CVP-2006-00003.
100-H-12, Expansion Box French Drain F	This site is a vertical 76-cm (30-in.)-diameter steel manhole set in concrete that provided access to a french drain at bottom of box.	EPA 1999. Site has been remediated and interim closed. See CVP-2006-00003.

Table A-4. 100-H Area Waste Site Information and Status. (5 Pages)

Site Name	Site Information	Site Status
100-H-13, French Drain G	Site was a french drain constructed of vitrified clay pipe with two metal lids that suggest the possibility of drainage from the reactor building.	EPA 1999. Site has been remediated and interim closed. See CVP-2006-00003.
100-H-14, Surface Contamination Zone H	Surface contamination area located next to the south wall of the 105-H Reactor Building.	EPA 1999. Site has been remediated and interim closed. See CVP-2006-00003.
100-H-17, 116-H-2 Overflow Area	Site was a triangular area that received overflow from the 1608-H Liquid Waste Disposal Trench.	EPA 1997. Site has been remediated and interim closed. See CVP-2000-00031.
100-H-21, 100-H Reactor Cooling Water Effluent Pipelines	Underground pipelines that transported reactor cooling water to the 107-H Retention basin and then to the 1904-H Outfall and/or 116-H-1 Trench.	EPA 1995. Site has been remediated and interim closed. See CVP-2000-00029.
100-H-22, Soil Contamination	Site was soil contaminated by effluent line leakage.	EPA 1999. Site has been remediated and interim closed. See CVP-2000-00029.
100-H-24, 151-H Electrical Facilities	Demolished facility located west of the 105-H Reactor. Supplied all electrical power to the 100-H Area from 1948 to 1965.	EPA 1999. Site has been remediated and interim closed. See CVP-2000-00030.
100-H-28, 100-H Water Treatment Facility Underground Pipelines	Site includes upstream (pre-reactor) process sewers for the 100-H Reactor, including all underground water lines used to transport reactor cooling water between water treatment facilities and the 105-H Reactor Building. Consists of eight subsites: 100-H-28:1, 184-H Power House Ash Sluicing Line 100-H-28:2, South Process Sewers 100-H-28:3, North Process Sewers 100-H-28:4, 1607-H1 Sanitary Sewer 100-H-28:5, 1607-H2 Sanitary Sewer 100-H-28:6, 182-H Reservoir Sump Drains 100-H-28:7, 183-H Process Water Lines 100-H-28:8, 190-H Process Water Lines.	EPA 2004. 100-H-28:8, reclassified as no action. See WSRF 2006-024.
100-H-30, Sanitary Sewer Trench	Site was a sanitary sewer trench and feed pipeline thought to support the demolished 110-H Building.	No decision document. Site has been remediated and interim closed. See CVP-2000-00031.
100-H-31, PCB in Soil	Site was polychlorinated biphenyl (PCB) contamination in soil at the north side of 105-H Reactor building.	EPA 1999. Site has been remediated and interim closed. See With CVP-2006-00003.

Table A-4. 100-H Area Waste Site Information and Status. (5 Pages)

Site Name	Site Information	Site Status
100-H-33, 183-H Solar Evaporation Basins	This site was created to address the radionuclide component of the 183-H Solar Evaporation Basins (116-H-6, which is the TSD component).	EPA 2004.
100-H-36, 1904-H Spillway	The site is the concrete spillway (also referred to as a flume) that led from the 116-H-5 outfall structure and terminated at the river shoreline. The spillway could have received reactor coolant effluent when the 100-H-34 river pipelines were blocked, damaged, or undergoing maintenance.	No decision document.
100-H-37, Mud Dauber Site	This site is contamination from mud dauber wasps. The nests are estimated to cover approximately 10.1 hectares (25 acres) throughout 100-H Area.	No decision document.
116-H-1, Process Effluent Trench	Trench received mixed waste effluent from the 116-H-7 Retention basin during reactor shutdown caused by fuel element ruptures.	EPA 1995. Site has been remediated and interim closed. See CVP-2000-00026.
116-H-2, Effluent Disposal Trench	Open trench fed by a vitrified clay pipe that originated from the 1608-H pumphouse.	EPA 1995. Site has been remediated and interim closed. See CVP-2000-00031.
116-H-3, 105-H Dummy Decontamination French Drain	Received radioactively contaminated water and nitric acid from decontamination of fuel spacers, process tube caps, and other reactor hardware. Consisted of two 0.9-m-diameter gravel-filled clay pipes.	EPA 1997. Site has been remediated and interim closed. See CVP-2000-00032.
116-H-4, 105-H Pluto Crib	Mixed liquid waste site that operated from 1950 to 1952 and received about 1,000 L (254.2 gal) of contaminated cooling water from reactor process tubes containing ruptured fuel elements. After its use was discontinued in 1952, this pluto crib was covered with about 3.1 m (10 ft) of soil and marked with permanent concrete monuments. The pluto crib was uncovered and exhumed in 1960, during construction of the 105-H confinement system, so that the 117-H Filter Building could be constructed at the same location.	EPA 1995.
116-H-5, 1904-H Outfall Structure	Located east of the 105-H Reactor building on the Columbia River shoreline. Operated 1949-1965 as a weir box to discharge 105-H Reactor coolant water to the river. Received effluent from the 107-F retention basins. Concrete structure connected to two 1.5-m (60-in.)-diameter pipelines.	EPA 1999.
116-H-6, 183-H Solar Evaporation Basins	Site was a concrete water and treatment basin divided and subdivided for treatment of liquid waste by solar evaporation. Site has been closed out via modified closure certificate.	EPA 2004 (as 100-H-33). Site has been closed out. See WSRF 99-124.
116-H-7, 107-H Retention Basin	Site was a concrete-lined rectangular structure that received cooling water effluent from the 105-H Reactor Building for radioactive decay and thermal cooling.	EPA 1995. Site has been remediated and interim closed. See CVP-2000-00027.
116-H-9, 117-H Crib	Site was designed to receive drainage from the 117-H filter building seal pits. Operated from 1960 to 1965.	EPA 1999.

Table A-4. 100-H Area Waste Site Information and Status. (5 Pages)

Site Name	Site Information	Site Status
118-H-1, 100-H Burial Ground No. 1	Primary burial ground for 105-H Reactor operation waste. Inactive mixed solid waste area was the primary burial site used for the 100-H Area from 1949-1965. The wastes included process tubing, contaminated lead brick, dummy fuel elements, and miscellaneous hardware. In 1955, the site was enlarged to 213 x 107 x 6.1 m (700 x 350 x 20 ft) deep. The site contained trenches and pits.	EPA 2000b.
118-H-2, 100-H Burial Ground No. 2	Received stainless steel tube removed from the reactor in 1955. Also used for disposal of contaminated pipe. Inactive mixed solid waste burial ground. Received a small quantity of contaminated and activated test material and contaminated pipe. Operated from 1955-1965. Two concrete vaults were placed in the site, one in 1955 and the other in 1958. Currently, both vaults have been filled with gravel.	EPA 2000b.
118-H-3, Construction Burial Ground	Received sections of contaminated pipe used as chutes for removal of thimbles from 105-H Reactor. Mixed solid waste burial ground. Received 3,000 cubic meters of reactor components and hardware from H-Reactor. Operated from 1953-1957.	EPA 2000b.
118-H-4, Ball 3X Burial Ground	Received thimbles and other waste generated during conversion from liquid to Ball 3X safety system in 1953. Site is a single trench. It is believed 55 thimbles were buried at the site along with irradiated materials from the 105-H Reactor Building.	EPA 2000b.
118-H-5, Thimble Pit	Inactive, mixed solid waste burial ground. Received a single experimental thimble assembly in 1953 and was backfilled to grade. Reopened in 1960 and received contaminated soil from the 116-H-4 Pluto Crib site.	EPA 2000b.
118-H-6, 105-H Reactor Building	Inactive plutonium production reactor that operated from 1949 to 1965 and was placed in Interim Safe Storage in 2005. Site consists of six subsites: (1) 105-H Reactor Block and ISS Project, (2) 105-H Reactor Ancillary Support Areas, Below-Grade Structures, and Underlying Soils, (3) 105-H Fuel Storage Basin and Underlying Soils, (4) 105-F Fuel Storage Basin Shallow Zone Side Slope Soils, (5) Three 105-H Decontamination Pads, and 6) Deep Zone Side Slope Soils.	Action memorandum. 118-H-6:1, Interim Safe Storage. 118-H-6:2, :3, and :6 have been remediated and interim closed. See CVP-2006-00003.
126-H-2, 183-H Clearwells	Concrete basins used to store reactor coolant water. Eastern half contains D&D rubble (west half still intact).	EPA 1999.
128-H-1, Burning Pit	Site is a large depression used for burning nonradioactive combustible materials, paint, office waste, solvents. Site also contains surface debris such as wood, metal, chunks of concrete, etc.	EPA 1999.
128-H-2, Burning Ground	The site is in a depression cut into the hillside that appears to be a former borrow area. Evidence of burning is not readily visible, but the following surface debris was observed in 2000: wood, metal cables, cans, lighting fixtures, concrete, and a battery. The visible debris was scattered through the site.	EPA 1999.
128-H-3, Burning Ground	Site is a pit resembling a trench with little to no evidence of burning other than charred rocks.	EPA 1999.

Table A-4. 100-H Area Waste Site Information and Status. (5 Pages)

Site Name	Site Information	Site Status
132-H-1, 116-H Reactor Exhaust Stack Burial Site	Site contains concrete rubble from demolition of the 105-H (116-H) Reactor Stack. The stack was used to exhaust confinement air from the work areas of the 105-H Reactor Building from 1945-1965 and was demolished in 1983. The stack and its foundation were demolished with explosives and buried in a trench.	EPA 1999. Site has been remediated and interim closed. See WSRF 2006-053.
132-H-2, 117-H Filter Building Site	This site was a concrete building that housed reactor exhaust filters. Built over the excavated 116-H-4 Pluto Crib and Operated from 1961 to 1965. It was demolished in 1984.	EPA 1999. Site has been remediated and interim closed. See WSRF 2006-049.
132-H-3, 1608-H Waste Water Pumping Station	Located immediately west of the reactor fuel storage basin. Station operated 1949-1965. Site collected low level contaminated waste water from 105-H sumps and drains and pumped it to either the 1608-H disposal trench or effluent pipelines. Site was a concrete building that was D&D'd in place in 1987.	EPA 1999.
1607-H1, Septic System	Site is a concrete tank with a 50-person capacity and tile field that received sanitary sewage from the 151-H and 105-H Reactor Buildings.	EPA 1999.
1607-H2, Septic System	Site was a concrete tank with a 500-person capacity, tile field, and associated piping that received sanitary sewage from the 182-H, 183-H, 190-H, and other offices and maintenance buildings.	EPA 1999. Site has been remediated and interim closed. See CVP-2000-00024.
1607-H3, Septic System	Site is a concrete tank with a 100-person capacity and tile field. It operated from 1948 to 1968 and received sanitary sewage from 1701-H Badge House, 1709-H Fire Station, and 1720-H Patrol Office.	No decision document.
1607-H4, Septic System	Site was a concrete tank with a 6-person capacity and tile field that received sanitary sewage from 181-H Pump House Building. It operated from 1948 to 1965.	EPA 1999. Site has been remediated and interim closed. See CVP-2000-00025.
600-151, Dumping Areas	Site contains scattered debris and areas of disturbed vegetation remaining from its use as a military camp.	EPA 1999.
600-152, Military Septic Tanks	Site is identified by three separate inline concrete covers and two manholes. It is one or more septic tanks left from a military camp that was once located in this area.	No decision document.

CVP = cleanup verification package
D&D = decontamination and decommission
WSR = Waste Site Reclassification Form

Table A-5. 100-K Area Waste Site Information and Status. (9 Pages)

Site Name	Site Information	Site Status
100-K-1, 119-KW French Drain	The site is a 0.46-m (1.5-ft)-diameter concrete french drain that extends approximately 15 cm (6 in.) above the surrounding grade. It has a blue metal cover that is posted with "Confined Space" and "Surface Contamination" warning signs.	EPA 1997.
100-K-2 (118-K-2) Sludge Burial Ground	Believed to have been a burial site for sludge from the KE and KW retention basins.	EPA 2000b.
100-K-3, 1706-KE Fish Pond Heat Exchanger Pit	This site includes two concrete pits, two concrete manholes, concrete encased pipelines and nonencased pipelines. This site includes those pipelines that were specific to the 1706-KE Water Studies Semi-Works, and does not include the large 0.9-m (36-in.) or 1.8-m (72-in.) 105-KE Reactor effluent pipelines.	No decision document.
100-K-4, 1706-KE Wet Fish Studies Ponds and Valve Pit	The site is identified by two 9.1-m (30-ft)-diameter circular concrete basins separated by a 2.7 x 9.1-m (9 x 30-ft) rectangular pond and valve pit. Operated from 1956 to 1965. Used to conduct fish development experiments in reactor effluent waters.	No decision document.
100-K-5, 1705-KE French Drain	The site is a french drain consisting of a 0.9-m (3-ft)-diameter vitrified clay pipe that protrudes approximately 0.3 m (1 ft) above grade and has a heavy wooden cover.	No decision document.
100-K-6, Vacuum Pit	The vacuum pit contains a cyclone separator in a vertically oriented 3-m (10-ft)-diameter culvert that extends from grade level to 9.2 m (30 ft) below grade, used for reactor maintenance.	No decision document.
100-K-13, French Drain	This site is a french drain that is a 1.5-m (5 ft)-diameter vertical concrete pipe filled with gravel.	EPA 1999.
100-K-14, 183-KE Acid Neutralization Pit	Site is a pit that is 4.6 m (15 ft) deep with associated piping that received overflow and drainage from the 183-KE day-use acid tank.	EPA 1999.
100-K-18, 183-KW Caustic Neutralization Pit	Site is a 0.9-m (3 ft)-deep brick-lined concrete box with a wooden cover that received overflow and transfer waste caustic soda (sodium hydroxide solution) for neutralization before draining to the process sewer system.	EPA 1999.
100-K-19, 183-KW Caustic Soda Storage Tank	The site was originally an above-ground, cylindrical, vertical steel storage tank on a concrete base. The above-ground tank was 7.8 m (25.5 ft) in diameter with a 287,660-L (76,000-gal) capacity. Some time in the past (date unknown) the tank was removed. Today, the site is the 9.1-m (30-ft)-diameter grade-level concrete tank base and the soil surrounding the base.	No decision document.
100-K-25, 183-KE Caustic Neutralization Pits	Site is a 0.9-m (3 ft)-deep brick-lined concrete structure that was used to neutralize sodium hydroxide prior to disposal.	No decision document.
100-K-27, 183-KE Caustic Soda Storage Tank	The site was originally an above-ground, cylindrical, vertical steel storage tank on a concrete base. The above-ground tank was 7.8 m (25.5 ft) in diameter with a 287,660-L (76,000-gal) capacity. Some time in the past (date unknown) the tank was removed. Today, the site is the 9.1-m (30-ft)-diameter grade-level concrete tank base and the soil surrounding the base.	No decision document.
100-K-29, 183-KE Sandblasting Site	Site was a 46 x 27 m (50 x 30 yd) area covered with red/purple garnet. The garnet was used to sandblast steel components prior to being sold for scrap.	EPA 1999. Site has been remediated and interim closed. See WSRF 2004-040.

Table A-5. 100-K Area Waste Site Information and Status. (9 Pages)

Site Name	Site Information	Site Status
100-K-30, 183-KE Sulfuric Acid Tank Site (West)	Site consisted of two above-ground U-shaped concrete bases that supported a cylindrical tank and associated above-ground piping. The tank was used for storage of sulfuric acid for water treatment.	EPA 1999. Site has been remediated and interim closed. See WSRF 2003-036.
100-K-31, 183-KE Sulfuric Acid Tank Site (East)	Site consisted of two above-ground U-shaped concrete bases that supported a cylindrical tank and associated above-ground piping. The tank was used for storage of sulfuric acid for water treatment.	EPA 1999. Site has been remediated and interim closed. See WSRF 2004-038.
100-K-32, 183-KW Sulfuric Acid Tank Site (East)	Site consisted of two above-ground U-shaped concrete bases that supported a cylindrical tank and associated above-ground piping. The tank was used for storage of sulfuric acid for water treatment.	EPA 1999. Site has been remediated and interim closed. See WSRF 2004-039.
100-K-33, 183-KW Sulfuric Acid Tank Site (West)	Site consisted of two above-ground U-shaped concrete bases that supported a cylindrical tank and associated above-ground piping. The tank was used for storage of sulfuric acid for water treatment.	EPA 1999. Site has been remediated and interim closed. See WSRF 2004-041.
100-K-34, 183-KW Acid Neutralization Pit	Site is a 1.5-m (5 ft)-deep brick-lined concrete box that was used to neutralize transfer and overflow waste from sulfuric acid tanks prior to disposal.	EPA 1999.
100-K-35, 183-KE Acid Neutralization Pit	Site is a 1.5-m (5 ft)-deep brick-lined concrete box that was used to neutralize transfer and overflow waste from sulfuric acid tanks prior to disposal.	EPA 1999.
100-K-36, 1706-KE Facility Dry Well	Site is a french drain that was added to the 1706-KE Building as part of the chemical storage facility. Consists of a 0.46-m (18-in.)-diameter, 1.2-m (4-ft)-long vitrified clay pipe.	EPA 1999.
100-K-37, 1706-KE Sulfuric Acid Tank	The site is an above-ground, vertical, storage tank constructed of stainless steel used to store sulfuric acid and/or sodium hydroxide.	
100-K-38, 1706-KE Caustic Soda Tank	Contaminated soil from spills related to a caustic soda storage tank. The tank is above ground, vertical, and constructed of stainless steel. The tank rests on a redwood timber deck. A 5.1 cm (2 in.) fill line for tank truck usage is also located in the same area. Two 5.1 cm (2-in.) drain lines, one for vent and overflow and the other for valve leakage, enter a french drain (100-K-36) that is located (in the service area) between the caustic soda tank and the sulfuric acid tank (100-K-37).	No decision document.
100-K-42, 105-KE Fuel Storage Basin	Site is the concrete fuel storage basin for the 105-KE Reactor Building that served as a collection, storage, and transfer facility for irradiated fuel elements discharged from the reactor.	EPA 1999.
100-K-43, 105-KW Fuel Storage Basin	Site is the concrete fuel storage basin for the 105-KW Reactor Building that served as a collection, storage, and transfer facility for irradiated fuel elements discharged from the reactor.	EPA 1999.
100-K-46, 119-KE French Drain	Site is a french drain that received drainage from the 119-KE Sampling Building.	EPA 1999.
100-K-47, 1904-K Process Sewer	This site includes those underground process sewer pipelines that begin at the 105-KE Reactor, 105-KW Reactor, 165-KE, 190-KE, 1706-KE, and terminate at either the 116-K-3 Outfall or join the 100-K-56 Pipeline south of the outfall.	No decision document.

Table A-5. 100-K Area Waste Site Information and Status. (9 Pages)

Site Name	Site Information	Site Status
100-K-48, 100-KE Oil Contamination Areas	Site of Bunker C fuel oil spillage from rail car off-loading near the 166-KE oil storage tank. The oil has been absorbed by soil and sand forming a hard asphalt-like covering on the surface.	EPA 1999.
100-K-49, 100-KW Oil Contamination Areas	Site of Bunker C fuel oil spillage from rail car off-loading near the 166-KW oil storage tank. The oil has been absorbed by soil and sand forming a hard asphalt-like covering on the surface.	EPA 1999.
100-K-50, 1725-K & 1726-K Sanitary Sewer System Holding Tank	The site is a sanitary sewage holding tank that services the 1725-K and 1726-K mobile offices. The site is marked by eight red concrete posts. The tank is constructed of concrete and has three manholes on top and one hinged hatch cover.	No decision document.
100-K-53, 100-KE Glycol Heat Recovery Underground Pipelines	Underground pipelines that transported ethylene glycol solutions (34%) from the 116-KE-5 (150-KE Heat Recovery Station) to where they entered the 165-KE Powerhouse (Power Control Building).	EPA 1999.
100-K-54, 100-KW Glycol Heat Recovery Underground Pipelines	Underground pipelines that transported ethylene glycol solutions (34%) from the 116-KW-4 (150-KW Heat Recovery Station) to where they entered the 165-KW Powerhouse (Power Control Building).	EPA 1999.
100-K-55, 100-KW Reactor Cooling Water Effluent Underground Pipelines	Transported process effluent from KW Reactor to the river via the retention basins, trenches, and outfall structures. This site consists of two subsites: (1) underground process effluent pipelines located on the north side of 105 KW Reactor, from the outside of the security fence to the 116-K-3 Outfall, the 116-K-1 Crib, the 116-K-2 Trench, and the 116-KW-3 Retention Basins; (2) process effluent underground pipelines from the west side of the reactor north to the security fence. The subsite also includes the 61-cm (24-in.)-process water pipeline connecting the 105-KW and 105-KE Reactors (south side) to the half-way point between them.	EPA 1997. 100-K-55:1, remediated and interim closed. See CVP-2005-00006.
100-K-56, 100-KE Reactor Cooling Water Effluent Underground Pipelines	Transported process effluent from KE Reactor to the river via retention basins, trenches, and outfall structures. This site consists of two subsites: (1) underground process effluent pipelines located on the north side of 105 KE Reactor, from the outside of the security fence to the 116-K-3 Outfall, the 116-K-1 Crib, the 116-K-2 Trench, and the 116-KE-4 Retention Basins; (2) process effluent underground pipelines from the west side of the reactor north to the security fence. The subsite also includes the 61-cm (24-in.)-process water pipeline connecting the 105-KW and 105-KE Reactors (south side) to the half-way point between them.	EPA 1997. 100-K-56:1, remediated and interim closed. See CVP-2005-00006.
100-K-57, 107-KE Drainage Ditch	Consists of a dry, shallow ditch that extends from the 116-K-3 Outfall Structure and the 116-K-1 Crib. A second ditch extends from the culvert to the Columbia River. The culvert conveyed process effluent leakage from the area surrounding the 107-KE Basins to the ditch.	EPA 2004.
100-K-60, 1904-K Process Sewer	Consists of the 1.7-m (66-in.) concrete process sewer that begins at the 165-K water treatment facility and runs to the point of intersection with the pipelines coming from the 105-KW Reactor Building.	EPA 2004.
100-K-61, 117-KW Filter Building	The site is the ventilation exhaust filter building that houses blowers and particulate filters used to treat the ventilation exhausted from the 105-KW Reactor Building. Included in this site are the 117-KW Building, the intake ventilation duct from the 105-KW Reactor Building, and the exhaust ventilation ducts to the 116-KW Reactor Exhaust Stack.	No decision document.

Table A-5. 100-K Area Waste Site Information and Status. (9 Pages)

Site Name	Site Information	Site Status
100-K-62, 117-KE Filter Building	The site is the ventilation exhaust filter building that houses blowers and particulate filters used to treat the ventilation exhausted from the 105-KE Reactor Building. Included in this site are the 117-KE Building, the intake ventilation duct from the 105-KE Reactor Building, and the exhaust ventilation ducts to the 116-KE Reactor Exhaust Stack.	No decision document.
100-K-63, 100-K Flood Plain Contamination Area	This site is a large portion of the flood plain along the shore of the Columbia River that is posted as a radiological contamination area.	EPA 2004.
100-K-64, 100-KE Flood Plain Contamination Area	This site is a large portion of the flood plain along the shore of the Columbia River that is posted as a radiological contamination area.	EPA 2004.
100-K-66, 165-KW Power Control Building	The building is painted a pink color and has three large stacks on the west end of the building. This site is a bomb resistant shelter without windows. All ventilation is supplied by fans. The building is posted Danger- Restricted Area- Asbestos. The purpose is to house the powerhouse, control room, valve pit, and electrical switch gear of the electrical supply system.	No decision document.
100-K-67, 165-KE Power Control Building	The purpose is to house the powerhouse, control room, valve pit, and electrical switch gear of the electrical supply system. It is constructed as a bomb resistant shelter without windows and ventilation is supplied by fans.	No decision document.
100-K-68, 105-KE Pump Gallery	The structure is constructed of a 2.4-m (8-ft)-diameter corrugated steel caisson. A vinyl lined concrete catch tank is located at the bottom of the caisson. Located above the catch tank is a pump gallery containing two sump pumps and a ladder for access. The top of the caisson is covered with a conical 12-gauge sheet metal roof with a hatch for access.	No decision document.
100-K-69, 105-KE Sump C	The structure is a concrete sump that receives water from the 105-KE fuel storage basin floor drains in the transfer area. Two electric powered sump pumps return the drain water to the basin.	No decision document.
100-K-70, 105-KE Waste Storage Tank	Steel storage tank for the 105-KE Spent Fuel Storage Basin radioactive drains. The tank is buried under a 1.8-m (6-ft)-deep earthen berm. An absolute filter is located on the east end of the tank and a gauge is located on the west end of the tank.	No decision document.
100-K-71, 105-KE Collection Box	Collects effluent from nine underground process sewer lines that originate in the 105-KE Reactor Building. The effluent exits via 30- and 41-cm (12- and 16-in.)-diameter cast iron process sewer pipelines.	No decision document.
100-K-72, 105-KW Pump Gallery	The structure is constructed of a 2.4-m (8-ft)-diameter corrugated steel caisson. A vinyl-lined concrete catch tank is located at the bottom of the caisson. Located above the catch tank is a pump gallery containing two sump pumps and a ladder for access.	No decision document.
100-K-73, 105-KW Collection Box	Collects effluent from nine underground process sewer lines that originate in the 105-KW Reactor Building. The effluent exits via 30- and 41-cm (12-in.and 16-in.) cast iron process sewer pipelines.	No decision document.
100-K-74, 105-KW Waste Storage Tank	The site is a steel storage tank for the 105-KW Spent Fuel Storage Basin radioactive drains. The tank is buried under a 1.8-m (6-ft)-deep earth berm. An absolute filter is located on the east end of the tank and a level gauge is located on the west end of the tank.	No decision document.
100-K-75, 105-KW Sump C	The structure is a concrete sump that receives water from the 105-KW fuel storage basin floor drains in the transfer area. Two electric powered sump pumps return the drain water to the basin and/or the underground holding tank.	No decision document.

Table A-5. 100-K Area Waste Site Information and Status. (9 Pages)

Site Name	Site Information	Site Status
100-K-77, Underground Railroad Ties	Site is underground railroad ties discovered at the bottom of an excavation that is located 7 m (23 ft) southeast of 1706-KE Building. The excavation was backfilled.	EPA 2004.
100-K-78, Fenced Contamination Area	Site is enclosed within a post and chain area and posted with Contamination Area signs.	EPA 2004.
100-K-79, Pipelines	Site includes sodium dichromate and sulfuric acid pipelines that run from the railroad offloading area to the dichromate and sulfuric acid storage tanks then to the headhouses at both KE and KW. It also includes the treated water pipelines that run from the 165 Power Control Buildings to the reactors.	EPA 2004.
100-K-81, Contamination Area	The site consists of a large cylindrical piece of equipment surrounded by a rope and posted as Soil Contamination Area west of the 116-K-3 Outfall Structure.	No decision document.
100-K-82, 105-KW Fuel Storage Basin Leak	The storage basin extends from the north wall of the 105-KW Reactor Building to the open area behind the reactor, with its longitudinal axis running parallel to the north wall of the building. Its east-west location is roughly in the center of the building. The leak occurred on the north side of the 105-KW basin. The release is not marked or posted.	No decision document.
100-K-83, 1904-K Spillway	The site is the concrete spillway (also referred to as a "flume") that is associated with the 116-K-3 outfall structure. The spillway was attached to the outfall and could have received reactor coolant effluent when the 100-K-80 river pipelines were blocked, damaged, or undergoing maintenance. Decommissioning projects in the 1980s collapsed the above-grade portion and backfilled the site with soil.	No decision document.
116-K-1, Crib	Site was a structure within a structure that received process effluent from 105-KE and 105-KW Reactors.	EPA 1997. Site has been remediated and interim closed. See CVP-2003-00024.
116-K-2, 100-K Mile Long Trench	Received process effluent from the floor drains of the 105-KE and 105-KW Reactors.	EPA 1997. Site has been remediated and interim closed. See CVP-2006-00001.
116-K-3, 1904-K Outfall Structure	Intact structure. Open reinforced concrete water box that serves as an anchor for the two 2-m (84-in.) discharge lines that carried process effluent from the retention basins to the center of the river. Structure is 11 m (35 ft) long x 10 m (33 ft) wide x 7 m (23 ft) deep.	EPA 1999.
116-KE-1, 115-KE Condensate Crib	Received condensate from 105-KE Reactor gas purification system. Partially remediated in 2004. The crib and pipeline have been removed and the site backfilled with clean soil to the average adjacent grade elevation.	EPA 1997. Partially remediated. See BHI-01737.
116-KE-2, 1706-KER Waste Crib	Received liquid waste from 105-KE Reactor effluent test loop. A wooden crib structure with dimensions of 3 m (10 ft) x 3 m (10 ft) x 3 m (10 ft) that rests 0.9 m (3 ft) above the bottom of an excavation.	EPA 1997.
116-KE-3, 105-KE Storage Basin French Drain	Received overflow from 105-KE Reactor fuel storage basin. The site is part of the sub-basin drainage disposal system for the 105-KE Fuel Storage Basin (100-K-42) and includes the following components: a feed pipe, crib structure, dry well, and test hole.	EPA 1997.
116-KE-4, 107-KE Retention Basins	The site consisted of three open top, carbon-steel tanks with steel bottoms. The circular basins were 6.1 m (20 ft) apart. Received process effluent from 105-KE Reactor.	EPA 1997. Site has been remediated and interim closed. See CVP-2005-00002.

Table A-5. 100-K Area Waste Site Information and Status. (9 Pages)

Site Name	Site Information	Site Status
116-KE-5, 150-KE Heat Recovery Station.	The facility was constructed on a concrete pad and consisted of heat exchangers and associated piping. The heat exchangers had been removed for used elsewhere. Exposed piping had wooden covers installed over the open ends. Heat recovery facility was used to transfer heat from the 105-KE Reactor. Operated from 1955 to 1971.	Site has been remediated and interim closed. See CVP-2005-00006.
116-KE-6A, 1706-KE Collection Tank	Site is a 363-L (96-gal) condensate collection tank that collected steam and condensed it as part of a system to treat radioactive mixed waste from 1706-KE laboratories. The tank and piping remain in place in the basement of 1706-KER Building. Operated from 1984 to 1986.	EPA 2004.
116-KE-6B, 1706-KE Evaporation Tank	Site is a 114-L (30 gal) steel evaporation tank that was used to solidify the radioactive waste. Operated from 1984 to 1986. The tank and piping remain in place in the basement of 1706-KER building.	EPA 2004.
116-KE-6C, 1706-KE Waste Accumulation Tank	This 2,082-L (550-gal) steel tank was used to accumulate the radioactive waste before transferring it to an ion exchange column for continuous recirculation. Operated from 1984 to 1986. The tank and piping remain in place in the basement of 1706-KER Building.	EPA 2004.
116-KE-6D, 1706-KE Ion Exchange Column	This (5 cubic ft) mixed-bed resin ion exchange column was used to remove ionic constituents from the waste stream. Operated from 1984 to 1986. Exchange column believed to have been removed in 1992.	EPA 2004.
116-KW-1, 115-KW Condensate Crib	Received condensate from 105-KW Reactor gas purification system. Before the 2004 partial remediation, the bottom of the crib was 1.8 m (6 ft) in diameter and 7.8 m (25.5 ft) below ground surface. The top of the crib measures 12.2 m (40 ft) in diameter. The bottom of the crib was filled with 3 m (10 ft) of course gravel, then backfilled with dirt to grade. This site includes the feed pipeline from the 115-KW Building.	EPA 1997. Partially remediated. See BHI-01737.
116-KW-2, Fuel Storage Basin French Drain	Received overflow from 105-KW Reactor fuel storage basin. The site is part of the sub-basin drainage disposal system for the 105-KW Fuel Storage Basin (100-K-43) and includes the following components: a feed pipe, crib structure, dry well, and test hole.	EPA 1997.
116-KW-3, Retention Basin	The site consisted of three open top, carbon-steel tanks with steel bottoms. The circular basins were 6.1 m (20 ft) apart. Received process effluent from 105-KW Reactor.	EPA 1997. Site has been remediated and interim closed. See CVP-2004-00001.
116-KW-4, 150-KW Heat Recovery Station	The site consisted of heat exchangers, pumps, and associated piping on a concrete pad. Provided heat recovery from cooling water effluent. Operated from 1955 to 1970.	No decision document. Site has been remediated and interim closed. See CVP-2005-00006.
118-K-1, 100-K Burial Ground	Primary burial ground for 105-KE and 105-KW Reactor operations waste. Received an estimated 10,000 cubic meters of solid waste materials from the K and N Areas. Operated from 1953-1975. Site contains numerous trenches and pits of various sizes to accommodate material being disposed in an area 366 x 183 x 6.1 m (1,200 x 600 x 20 ft) deep. Six vertical silos each 3-m (10-ft)-diameter by 7.6 m (25 ft) deep were used to hold reactor hardware having high dose rates. Site also contains a waste incinerator which was built over an ash pit and later buried in the site. The principal radionuclide is long-lived nickel-63.	EPA 2000b.
118-KE-1, 105-KE Reactor Building	Reinforced-concrete and steel multistory building that consists of: (1) the reactor block, which includes the graphite moderator stack, biological and thermal shields, pressure tubes, and safety and control systems, (2) irradiated fuel storage basin, and (3) contaminated portions of the reactor building and remnant contaminated pipelines connected to the buildings and not removed through other remedial actions. Operated from 1955-1971.	Action memorandum.

Table A-5. 100-K Area Waste Site Information and Status. (9 Pages)

Site Name	Site Information	Site Status
118-KE-2, 105-KE Horizontal Control Rod Storage Cave	The cave was constructed by pouring a concrete slab 18.3 m (60 ft) long by 2.4 m (8 ft) wide. Two sections of 0.61-m (24-in.) pipe were cut in half lengthwise and laid open side down, on the slab. Vertical concrete walls and steel doors were added to the ends of the pipe sections, with the walls forming a wing at each end. The pipe sections were then covered with 1.8 m (6 ft) of clean fill material, forming a 12.2-m (40-ft) long tunnel. The berm width after the fill material was added is about 7.6 m (25 ft). The entire structure is above grade. Operated from 1955 - 1971. Used to temporarily store radioactive rod tips.	No decision document.
118-KW-1, 105-KW Reactor Building	Reinforced-concrete and steel multistory building that consists of: (1) the reactor block, which includes the graphite moderator stack, biological and thermal shields, pressure tubes, and safety and control systems, (2) irradiated fuel storage basin, and (3) contaminated portions of the reactor building and remnant contaminated pipelines connected to the buildings and not removed through other remedial actions. Operated from 1955-1970.	Action memorandum.
118-KW-2, 105-KW Horizontal Control Rod Storage Cave	The cave was constructed by pouring a concrete slab 18.3 m (60 ft) long by 2.4 m (8 ft) wide. Two sections of 0.61-m (24-in.) pipe were cut in half lengthwise and laid open side down, on the slab. Vertical concrete walls and steel doors were added to the ends of the pipe sections, with the walls forming a wing at each end. The pipe sections were then covered with 1.8 m (6 ft) of clean fill material, forming a 12.2-m (40-ft) long tunnel. The berm width after the fill material was added is about 7.6 m (25 ft). The entire structure is above grade. Operated from 1955 - 1971. Used to temporarily store radioactive rod tips.	No decision document.
120-KE-1, Acid Neutralization Pit	The site received nonradioactive sulfuric acid and sulfuric acid sludge for neutralization before transfer to the process sewer system. Site is a subsurface concrete box filled with crushed limestone to neutralize the acid prior to discharge to the process sewer.	EPA 1999.
120-KE-2, 183-KE Filter Waste Facility French Drain	French drain used from 1955 to 1971 for disposal of sulfuric acid sludge removed from sulfuric acid tanks.	EPA 1999.
120-KE-3, 183-KE Filter Water Facility Trench	Trench measuring 12 m (40 ft) long, 0.9 m (3 ft) wide, and 0.9 m (3 ft) deep that received sulfuric acid sludge from sulfuric acid storage tanks. Operated from 1955 to 1970.	EPA 1999.
120-KE-4, 183-KE1 Sulfuric Acid Storage Tank	An above-ground steel tank with a storage capacity of 38,267 L (10,109 gal) is supported on concrete saddles. Tank was used to store sulfuric acid product from 1955 to 1971. It was drained and neutralized.	No decision document.
120-KE-5, 183-KE2 Sulfuric Acid Storage Tank	An above-ground steel tank with a storage capacity of 38,267 L (10,109 gal) is supported on concrete saddles. Tank was used to store sulfuric acid product from 1955 to 1971. It was drained and neutralized. The site is the westernmost of the two original sulfuric acid tanks at the 183-KE Headhouse.	No decision document.
120-KE-6, 183-KE Sodium Dichromate Tank	Site is a foundation where a sodium dichromate storage tank was placed. Tank had a capacity of 159,000 L (42,000 gal) and has been removed; base and piping remain.	EPA 1999.
120-KE-8, 165-KE Brine Pit	Concrete subsurface pit used for mixing salt brine for water softeners for the 165-KE Powerhouse. Operated from 1955 to 1971.	No decision document.
120-KE-9, 183-KE Brine Pit	Concrete subsurface structure consisting of five chambers that provided brine for the 183-KE Water Treatment Facility. Four wooden covers and one metal cover were visible at the surface. The wooden covers were in poor condition. In August of 1998 the ceiling structures were demolished and the open chambers were backfilled to grade. Operated from 1955 to 1971.	No decision document.

Table A-5. 100-K Area Waste Site Information and Status. (9 Pages)

Site Name	Site Information	Site Status
120-KW-1, Acid Neutralization Pit	The site was an underground structure used to neutralize acid wastes prior to disposal. The pit was a concrete box lined with bricks. The pit was also used to dispose of sulfuric acid sludge from sulfuric acid tanks located nearby.	EPA 1999.
120-KW-2, 183-KW Filter Water Facility French Drain	French drain used from 1955 to 1971 for disposal of sulfuric acid sludge removed from sulfuric acid tanks.	EPA 1999.
120-KW-3, 183-KW1 Sulfuric Acid Storage Tank	The site is the westernmost of the two original sulfuric acid tanks at the 183-KW Headhouse. The tank is a horizontal, cylindrical-shaped, steel tank supported above ground on concrete saddles. The tank has a capacity of 38,267 L (10,109 gal). The sulfuric acid was used to activate sodium silicate. During seasons of high turbidity, activated silica solution was fed into the raw water to aid in coagulation.	No decision document.
120-KW-4, 183-KW2 Sulfuric Acid Storage Tank	The site is the easternmost of the two original sulfuric acid tanks at the 183-KW Headhouse. The tank is a horizontal, cylindrical-shaped, steel tank supported above ground on concrete saddles and has a capacity of 38,267 L (10,109 gal).	No decision document.
120-KW-5, 183-KW Sodium Dichromate Storage Tank	Site is a concrete pad, contaminated soil, and any remaining piping from a former steel tank, 6.1 m (20 ft) high by 5.8 m (19 ft) in diameter. Operated 1955-1971. Storage of sodium dichromate.	EPA 1999.
120-KW-6, 165-KW Brine Pit	The unit is a below grade concrete structure that provided brine for the 165-KW Powerhouse. The roof of the structure was approximately 0.3 m (1 ft) above ground level. The opening into the pit was covered by a wooden cover. Just south of the brine pit is a valve pit located within a vertical section of 1.2-m (4-ft)-diameter corrugated galvanized pipe. In August 1998, remaining liquid was removed and the open pit was backfilled to grade.	No decision document.
120-KW-7, 183-KW Brine Pit	The Salt Dissolving Pits and Brine Pump Pit were part of a single below grade concrete structure that provided brine for the 183-KW Water Treatment Facility. Four wooden covers and one metal cover were visible at the surface. The wooden covers are in poor condition. The unit contained salt cake and brine. Operated 1955-1970. In August 1998, remaining liquid was removed and the unit was backfilled to grade	No decision document.
126-K-1, 100-K Gravel Pit	This unit is a gravel pit that resulted from 100-K Area construction. The slope of the southwest corner contains demolition waste. This area is covered with pit run backfill material. Received uncontaminated inert waste, transite (asbestos), and debris from demolition (e.g., concrete, wood, steel pipe, structural steel, conduit, and wire).	No decision document.
126-KE-2, 183-KE Liquid Alum Storage Tank	The site is an above-ground vertical stainless steel storage tank mounted on a concrete base. The tank was part of a system that supplied liquid alum for water treatment. During the winter, the liquid alum was pumped through heat exchangers for purpose of heating and agitating the chemicals.	No decision document.
128-K-1, 100-K Burning Pit	Used for disposal of nonradioactive combustible waste such as paint waste, office waste, and chemical solvents. Site is 30 m (100 ft) long, 30 m (100 ft) wide, and 3 m (10 ft) deep; covered with clean fill. Operated 1955-1971.	EPA 1999. Site has been remediated and interim closed. See WSRF No. 2004-042.
128-K-2, 100-K Construction Dump	Site used for surface burning of construction, laboratory, office and shop waste, and transite (asbestos) burial. The burning pit is 244 m (800 ft) long and 85 m (280 ft) wide.	EPA 1999.
130-K-2, 1717-K Waste Oil Storage Tank	The site was an underground waste oil storage tank used for storing used motor oil. Tank was used from 1955 to 1972, then was removed in 1989	EPA 1999.

Table A-5. 100-K Area Waste Site Information and Status. (9 Pages)

Site Name	Site Information	Site Status
130-KE-1, 105-KE Emergency Diesel Fuel Tank	The site was a diesel fuel storage tank with a capacity of 7,600 L (2,000 gal). Tank was used from 1955 to 1971, and then removed in 1992.	EPA 1999.
130-KE-2, 166-KE Oil Storage Tank	Reinforced concrete structure measuring 42.5 m (139 ft) x 28.5 m (93 ft) x 7.1 m (23 ft) deep, with a storage capacity of 3.04E+06 L (803,000 gal). Operated 1955-1971. Storage and pump facilities for fuel oil for the oil-fired steam plant in the 165-KE buildings. Approximately 7,600 L (2,000 gal) of oil remain as a heel in this reinforced concrete tank.	No decision document.
130-KW-1, 105-KW Emergency Diesel Fuel Tank	Location of two underground diesel storage tanks with a capacity of 7.6 L (2,000gal) each. Used from 1960 to 1971, then removed in 1992.	EPA 1999.
130-KW-2, 166-KW Oil Storage Tank	Underground reinforced concrete structure with a storage capacity of 6.2E+06 L (1.65E+06 gal). Used from 1955 to 1970. Approximately 7,600 L (2,000 gal) of oil remain as a heel in this reinforced concrete tank.	No decision document.
132-KE-1, 116-KE Reactor Exhaust Stack	Site is the 53.4-m (175-ft)-tall reinforced concrete exhaust stack. Discharged ventilation air from the 105-KE Reactor Building. Operated from 1955 to 1971. Original height was 91.5 m (300 ft); top 38 m (125 ft) decontaminated and shortened between 1980 and 1981.	No decision document.
132-KW-1, 116-KW Reactor Exhaust Stack	Site is the 53.4-m (175-ft)-tall reinforced concrete exhaust stack. Discharged ventilation air from the 105-KW Reactor Building. Operated from 1955 to 1971. Original height was 91.5 m (300 ft); top 38 m (125 ft) decontaminated and shortened between 1980 and 1981.	No decision document.
1607-K1, Septic System	Site consists of a septic tank, leaching system, and associated piping that services the 1701-K badge house, 1720-K Patrol Change Room and offices, and 1721-K Trailer.	No decision document.
1607-K2, Septic System	Site consists of a septic tank, leaching system, and associated piping that receives sanitary sewage from the 183-KE Water Treatment Plant.	No decision document.
1607-K3, Septic System	Site consists of a septic tank, leaching system, and associated piping that receives sanitary sewage from 183-KW Water Treatment Plant.	No decision document.
1607-K5, Septic System	Site consists of a septic tank, leaching system, and associated piping that receives sanitary sewage from 1706-KE Flow Laboratory, 1706-K Water Treatment Laboratory, 105-KE Reactor Building, and the 115-KE Gas Recirculation System.	No decision document.
1607-K6, Septic System	Site consists of a septic tank, leaching system, and associated piping that receives sanitary sewage from 105-KW Reactor Building, 115-KW recirculation building, and 165-KW powerhouse.	No decision document.
600-29, 100-K Construction Lay-down Area, 100-K-41	An abandoned dumping area containing several depressed areas and waste burning sites. Used as the construction laydown area for the construction of 105-KW. Operated from 1952 to 1954.	EPA 1999.
UPR-100-K-1, 100-KE Fuel Storage Basin Leak	Low-level mixed waste site discovered in 1974 during modification of the 105-KE fuel storage basin. Received fuel storage basin effluent that included debris from fuel cladding failures. Radioactive (primarily plutonium) substance leaked to soil beneath 105-KE fuel storage basin.	EPA 1999.

CVP = cleanup verification package
WSRF = Waste Site Reclassification Form

Table A-6. 100-IU-2 and 100-IU-6 Operable Unit Waste Site Information and Status. (4 Pages)

Site Name	Site Information	Site Status
600-3, Hanford Townsite Dumping Area and Paint Pit	Site consists of a shallow trench that appears to be an old borrow pit approximately 37 x 27 x 1.2 m (120 x 90 x 4 ft) and a dumping area spread over an area about 280 x 490 m (925 x 1,600 ft). Waste includes dried paint and paint cans, roofing paper, possible asbestos-containing material, steel, aluminum, burnt wood, etc.	EPA 1999.
600-5, Waste Oil Dump, Asphalt Heliport	Site consists of a circular asphalt or heavy oil area 4.6 m (15 ft) in diameter and an asphalt or heavy oil ditch 7.6 m (25 ft) long, 38 cm (15 in.) wide, and 2.5 cm (1 in.) deep. Also located at this site is a metal flag and steel pipe.	EPA 1999.
600-23, Dumping Area Within Gravel Pit #11	Site was an area of buried debris inside a large gravel pit.	EPA 2000a. Site has been remediated and interim closed. See CVP-2001-00020.
600-52, White Bluffs Surface Basin	Site was a depression in the ground that may have received discharges from the 600-106 Pickling Acid Crib.	EPA 1999. Site has been reclassified as no action. See WSRF 2003-028.
600-98, East White Bluffs City Landfills	Site consisted of two unlined pre-Hanford landfills.	EPA 1999. Site has been reclassified as no action. See WSRF 2004-098.
600-99, JA Jones #2	Site contained minor construction equipment used by the J.A. Jones Construction Company and included wood scraps, concrete, and some metallic waste.	EPA 1999. Site has been reclassified as no action. See WSRF 2003-037.
600-100, White Bluffs Landfill	Site is an unlined depression that received industrial, commercial, domestic, and farm waste.	EPA 1999.
600-107, Cribs at 213-J&K Storage Facility	Site consisted of two small cribs located in the 213-J and 213-K Storage Vault Facility.	EPA 1999. Site has been reclassified as no action. See WSRF 2003-033.
600-108, 213-K Vault	This waste site consists of the 213-K Vault only, which is one of two parallel, reinforced concrete, earth-covered storage facilities. Originally built to store containers of processed plutonium product; later used to store explosives and ammunition.	EPA 1999.
600-109, HTCL, Hanford Trailer Camp Landfill	Site is located within gravel pit and consists of scattered debris and typical domestic and construction waste that were used during construction of the Hanford Site facilities.	EPA 1999.
600-110, HTL, Hanford Townsite Landfill	Site consisted of an unlined excavated area used for pre-Hanford dumping of industrial and domestic waste. Site backfilled for construction of Hanford construction camp.	EPA 1999. Site has been reclassified as no action. See WSRF 2004-062.
600-111, P-11 Critical Mass Laboratory Crib	Site is the location of a demolished facility and crib that may have subsurface contamination. Facilities were called the P-11 Critical Mass Laboratory and included the 120 and 123 Buildings.	EPA 1999.
600-120, White Bluffs Spare Parts Burn Pit	Site was a burn pit that was used for industrial and commercial wastes. Site appears to have been backfilled with coal ash.	EPA 1999.
600-124, White Bluffs Burn Site and Paint Disposal Area	The site is an area with evidence of burning and paint disposal. Possible asbestos-containing material is scattered about.	EPA 1999.
600-125, White Bluffs Waste Disposal Trench 1	Site currently looks like a sandy depression with wood, ceramic, and metal debris on the surface.	EPA 1999.

Table A-6. 100-IU-2 and 100-IU-6 Operable Unit Waste Site Information and Status. (4 Pages)

Site Name	Site Information	Site Status
600-127, White Bluffs Fuel Storage Area	Site is two loading docks and a rectangular area surrounded by a low soil berm. Wood supports suggest fuel tanks storage at this site.	EPA 1999.
600-128, White Bluffs Oil and Oil Filter Dump Site	Site was a pre-Hanford, White Bluffs Community oil dump area that included canister-type oil filters.	EPA 1999. Site has been remediated and interim closed. See WSRF 2003-039.
600-129, White Bluffs Community Dump Site	Site was a pre-Hanford, White Bluffs Community dump site of miscellaneous debris and trash.	EPA 1999. Site has been remediated and interim closed. See WSRF 2004-136.
600-131, White Bluffs Special Fabrication Shops	Site included the remnants of the Special Fabrication Shop and Warehouse, boiler house, loading dock/well, and a water station.	EPA 1999. Site has been remediated and interim closed. See WSRF 2003-045.
600-132, Construction Contractor Shop Landfill	Site was a large, open borrow pit, with access ramps for trucks, ridges in the bottom where scraped, and piles of soil near the edges. Miscellaneous trash was scattered about the site.	EPA 1999. Site has been remediated and interim closed. See WSRF 2003-040.
600-139, White Bluffs Automotive Repair Shop	Site was an area thought to be associated with an automotive repair shop, due to type of surface debris: battery caps, engine gaskets, dumped waste oil, and fragments of tail lights.	EPA 1999. Site has been remediated and interim closed. See WSRF 2003-041.
600-146, Steel Structure on Northwest Side of Gable Mountain	The site includes a steel structure constructed of steel "I" beam and "L" beams. The interior of the structure contains stainless steel piping running throughout. Metal grating is located on three levels of the structure. The structure appears to be lying in a horizontal position. Debris observed lying around the structure includes stainless steel pipe, metal rings, metal boxes, empty cans, and wood.	
600-149, Small Arms Range	Site is a practice range for rifles, shotguns, machine guns, hand grenades, smoke bombs, and other small arms.	EPA 1999.
600-176, White Bluffs Paint Disposal Area	Site appears to be a dumping area for paint.	EPA 1999.
600-178, 213-J and 213-K Guard House Toilet Pit	The site is a toilet pit opening within a 4.3- x 4.9-m (14- x 16-ft) concrete pad that is the remains from the guard house. Apparently the opening is to a sanitary sewage pit located beneath the pad. No evidence of a sewage distribution system (septic tank) is apparent.	No decision document.
600-181, White Bluffs Oil Dump	Site was an oil dumping area with asphalt-like surface.	EPA 1999. Site has been remediated and interim closed. See WSRF 2003-048.
600-182, White Bluffs Asbestos Pipe Lagging and Excess Piping	The site is excess piping materials and an area of highly degraded piping insulation that appears to be made of asbestos or a similar material.	No decision document.

Table A-6. 100-IU-2 and 100-IU-6 Operable Unit Waste Site Information and Status. (4 Pages)

Site Name	Site Information	Site Status
600-186, Hanford Construction Camp Septic Tanks and Sewage	The waste site includes all the septic tanks as well as the sewage treatment plants at the Hanford Construction camp.	No decision document.
600-188, White Bluffs Waste Disposal Trench 2	The site is an open trench with industrial waste filling about one-third of it. There is evidence of chemical or oil dumping as well as empty 208-L (55 gal) drums.	EPA 1999.
600-190, White Bluffs Tar/Paint Disposal Area	Site was an area where tar and/or paints appeared to have been dumped.	EPA 1999. Site has been remediated and interim closed. See WSRF 2003-047.
600-191, White Bluffs Community Dump Site 2	Site was a pre-Hanford, White Bluffs Community dump site of miscellaneous debris and trash.	Site has been remediated and interim closed. See WSRF 2004-136.
600-201, White Bluffs Paint and Disposal Site	Site contained miscellaneous trash and debris including paint, glass, metal shavings, metal parts, and army-green canvas material.	EPA 1999. Site has been reclassified as no action. See WSRF 2003-038.
600-202, Four Burn and Burial Pits at Hanford Townsite	Site includes four burn and burial pits located closed together and arranged to form a triangle. The waste includes miscellaneous trash such as glass, china, bottles, kitchen materials, and a broken toilet bowl.	EPA 1999.
600-204, Hanford Townsite Burn and Burial Trench	Site was a long, narrow trench that was used for dumping and burning trash.	EPA 1999. Site has been remediated and interim closed. See WSRF 2003-043.
600-205, Hanford Townsite Landfill 2	Large area that appears to have been used as a dumping area for domestic waste for the Hanford Townsite community.	EPA 1999.
600-208, Hanford Construction Camp Boiler House Ponds	Site consists of 18 liquid disposal ponds that supported the boiler houses used for heating in the Construction Camp.	EPA 1999. Site has been reclassified as no action. See WSRF 2004-096.
600-213, Hanford Airport Underground Fuel Storage Tanks	The site is underground fuel storage tanks that were associated with the Hanford Airport. The airstrip runways are still visible. A windsock pole is visible just off the southeast corner of the airstrip intersection.	No decision document.
600-239, Debris in Pit 16	The site contains several large wooden beams, pallets, steel pipe, plates, and rubber tires.	Site has been reclassified as no action. See WSRF 2001-017.
600-280, Hardened Tar Site	The site is a 10- x 6-m area where tar was dumped.	No decision document.
628-1, White Bluffs Burn Pit	Site was a triangle-shaped area covered with sand and gravel and possibly used as a burn pit.	EPA 1999. Site has been remediated and interim closed. See WSRF 2003-046.

Table A-6. 100-IU-2 and 100-IU-6 Operable Unit Waste Site Information and Status. (4 Pages)

Site Name	Site Information	Site Status
JA Jones 1	Site was a trench used by the J.A. Jones Company.	EPA 2000a. Site has been remediated and interim closed. See CVP-2001-00019.
UPR-600-16, Fire and Contamination Spread	The area is currently a flat, featureless field that has been sown with rye grass. The P-11 Laboratory structure has been removed but contaminated soil may remain due to cleanup activities from a fire in 1951.	EPA 1999.

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WSRF = Waste Site Reclassification Form

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CVP-98-00001, *Cleanup Verification Package for the 100-D-22 Sludge Pit*, Bechtel Hanford, Inc., Richland, Washington.

CVP-98-00002, *Cleanup Verification Package for the 100-D-21 Sludge Pit*, Bechtel Hanford, Inc., Richland, Washington.

CVP-98-00003, *Cleanup Verification Package for the 100-D-20 Sludge Pit*, Bechtel Hanford, Inc., Richland, Washington.

CVP-98-00004, *Cleanup Verification Package for the 100-D-4 Sludge Pit*, Bechtel Hanford, Inc., Richland, Washington.

CVP-98-00005, *Cleanup Verification Package for the 1607-D2:1 Abandoned Tile Field*, Bechtel Hanford, Inc., Richland, Washington.

CVP-98-00006, *Cleanup Verification Package for the 116-C-1 Process Effluent Trench*, Bechtel Hanford, Inc., Richland, Washington.

CVP-98-00009, *Cleanup Verification Package for the 105-C Reactor Building Below-Grade Structures and Underlying Soils*, Bechtel Hanford, Inc., Richland, Washington.

CVP-99-00001, *Cleanup Verification Package for the 116-B-11 Retention Basin*, Bechtel Hanford, Inc., Richland, Washington.

CVP-99-00002, *Cleanup Verification Package for the 116-B-13 South Sludge Trench*, Bechtel Hanford, Inc., Richland, Washington.

CVP-99-00003, *Cleanup Verification Package for the 116-B-14 North Sludge Trench*, Bechtel Hanford, Inc., Richland, Washington.

CVP-99-00004, *Cleanup Verification Package for the 116-C-5 Retention Basin*, Bechtel Hanford, Inc., Richland, Washington.

CVP-99-00005, *Cleanup Verification Package for the 1607-D2:4 Septic Tank,* Bechtel Hanford, Inc., Richland, Washington.

CVP-99-00006, *Cleanup Verification Package for the 116-DR-9 Retention Basin*, Bechtel Hanford, Inc., Richland, Washington.

CVP-99-00007, *Cleanup Verification Package for the 116-D-7 Retention Basin*, Bechtel Hanford, Inc., Richland, Washington.

CVP-99-00008, *Cleanup Verification Package for the 116-B-12 Seal Pit Crib*, Bechtel Hanford, Inc., Richland, Washington.

CVP-99-00009, *Cleanup Verification Package for the 116-B-9 French Drain*, Bechtel Hanford, Inc., Richland, Washington.

CVP-99-00010, *Cleanup Verification Package for the 116-B-10 Dry Well/Quench Tank*, Bechtel Hanford, Inc., Richland, Washington.

CVP-99-00011, *Cleanup Verification Package for the 116-B-6A Crib and 116-B-16 Fuel Examination Tank*, Bechtel Hanford, Inc., Richland, Washington.

CVP-99-00012, *Cleanup Verification Package for the 116-B-1 Process Effluent Trench*, Bechtel Hanford, Inc., Richland, Washington.

CVP-99-00013, *Cleanup Verification Package for the 116-B-3 Pluto Crib*, Bechtel Hanford, Inc., Richland, Washington.

CVP-99-00014, *Cleanup Verification Package for the 116-B-4 French Drain*, Bechtel Hanford, Inc., Richland, Washington.

CVP-99-00015, *Cleanup Verification Package for the 116-B-2 Fuel Storage Basin Trench,* Bechtel Hanford, Inc., Richland, Washington.

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CVP-2000-00001, *Cleanup Verification Package for the 100-D-18 Sludge Trench*, Bechtel Hanford, Inc., Richland, Washington.

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APPENDIX B

REMEDIAL ACTION GOALS AND SUMMARY OF RESRAD METHODOLOGY

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REMEDIAL ACTION GOALS AND SUMMARY OF RESRAD METHODOLOGY

B.1 INTRODUCTION

Remedial action goals (RAGs) are the contaminant-specific numerical cleanup criteria developed to ensure that the remedial actions to be implemented will meet the remedial action objectives set forth in Section 2.1.1 of this document and in the *Interim Action Record of Decision for the 100-BC-1, 100-DR-1, and 100-HR-1 Operable Units, Hanford Site, Benton County, Washington* (Interim Action ROD) (EPA 1995), the *Amendment to the Interim Action Record of Decision for the 100-BC-1, 100-DR-1, and 100-HR-1 Operable Units* (ROD Amendment) (EPA 1997), the *Interim Action Record of Decision for the 100-BC-1, 100-BC-2, 100-DR-1, 100-DR-2, 100-FR-1, 100-FR-2, 100-HR-1, 100-HR-2, 100-KR-1, 100-KR-2, 100-IU-2, 100-IU-6, and 200-CW-3 Operable Units, Hanford Site, Benton County, Washington* (Remaining Sites ROD) (EPA 1999), and the *Record of Decision for the 100-BC-1, 100-BC-2, 100-DR-1, 100-DR-2, 100-FR-2, 100-HR-2, and 100-KR-2 Operable Units, Hanford Site (100 Area Burial Grounds), Benton County, Washington* (100 Area Burial Grounds ROD) (EPA 2000b). The RAGs are based on applicable or relevant and appropriate requirements (ARARs), to-be-considered (TBC) information, points of compliance, and the remedial action selected to support the land use identified in the RODs (EPA 1995, 1997, 1999, and 2000b).

The objective of this appendix is to develop and document RAGs for nonradionuclides and radionuclides at the 100 Areas that are protective of human health and the environment. Impacts to human health are addressed by evaluation of direct contact/exposure and groundwater/Columbia River pathways. A screening-level ecological risk evaluation is also done during the interim action phase. The conclusion of this evaluation will be documented in the relevant cleanup verification package or remaining sites verification package. These actions are interim until the final RODs for the 100 and 300 Areas are issued and placed in the Administrative Record. Ecological risk in the Hanford Site 100 Areas is being assessed through the River Corridor Baseline Risk Assessment (DOE-RL 2004). The overall process that was used to develop the RAGs is documented through a series of tables, as described in the following sections.

B.1.1 Hanford Site Cleanup Approach

Within the framework of CERCLA, a modified cleanup approach has been adopted for the Hanford Site in accordance with the *Hanford Past-Practice Strategy* (DOE-RL 1991). This strategy allows for the initiation of remedial actions based on a limited amount of pre-remediation site studies so that more resources can be allocated to actual cleanup, as discussed in the RODs (EPA 1995, 1997, 1999, and 2000b). Remedial action goals are developed for specific contaminants based on available waste site data and historical and analogous site information.

B.1.2 Contaminants of Potential Concern and Contribution to Risk

Based on the results of characterization activities and historical and analogous site information, a comprehensive list of contaminants of potential concern (COPCs) was identified for the 100 Area waste sites. Final contaminants of concern (COCs) for individual waste sites will be presented in site-specific cleanup verification documents.

Remedial action goals are developed for COPCs to attain acceptable levels of human health risk and protect groundwater and the Columbia River. The suitability of using individual RAGs as final cleanup values must be evaluated based on site-specific information considering the potential for interaction between contaminants and any cumulative effects. Because of uncertainty with the nature and extent of contamination, the RAGs are evaluated as if exposure comes from individual constituents. Consequently, RAGs are set at acceptable risk levels for exposure to individual constituents. The presence of multiple constituents may require downward adjustment of the cleanup levels at the time of cleanup verification to achieve the cumulative risk goals specified by the remedial action objectives.

B.2 NONRADIONUCLIDE REMEDIAL ACTION GOALS

Numeric RAGs, expressed in terms of concentration (mg/kg), were developed for each of the 100 Area nonradionuclide COPCs using the version of *Washington Administrative Code* (WAC) 173-340 (Ecology 1996) that was in effect at the time the September 1995 ROD (EPA 1995) was approved. Until different agreements are reached among the Tri-Parties (U.S. Environmental Protection Agency [EPA], Washington State Department of Ecology, and U.S. Department of Energy [DOE], Richland Operations Office), the Ecology 1996 WAC 173-340 Method B formulas will continue to be used to determine nonradionuclide direct exposure cleanup levels and the WAC 173-340 Method B "100 times rule" (Ecology 1996) will be used to determine soil cleanup levels protective of groundwater and the Columbia River. Development of RAGs for direct exposure, protection of groundwater, and protection of the Columbia River is summarized in the following subsections.

B.2.1 Direct Exposure Remedial Action Goals for Nonradionuclide Contaminants in Soil

Nonradionuclide direct exposure cleanup levels for soils were calculated using Method B formulas from the Ecology 1996 revision of WAC 173-340-740(3)(a)(iii)(A) and (B) for noncarcinogenic or carcinogenic substances, respectively. An exception to the use of WAC 173-340 is for lead, where the RAG is based on the *Guidance Manual for the Integrated Exposure Uptake Biokinetic Model for Lead in Children* (EPA 1994), and the use of WAC 173-340-750 to calculate direct exposure RAGs for contaminants where inhalation exposure is the controlling risk factor, such as for beryllium, cadmium, and hexavalent chromium.

For each nonradionuclide chemical constituent the carcinogenic and noncarcinogenic cleanup levels are cited (as available) in columns 4 and 5 of Table B-1. The lowest of these becomes the overall RAG for protection of human health via direct contact with contaminated soil, provided it

is greater than background and the required detection limit (RDL). If the lowest of the RAGs is lower than background or the RDL, the higher of background or the RDL becomes the cleanup level per WAC 173-340-700(4)(d) and WAC 173-340-700(6) (Ecology 1996). For purposes of this RDR/RAWP, the RDL is considered equivalent to the PQL as identified in WAC 173-340-700(6). The direct exposure cleanup levels tabulated in Table B-1 apply to the top 4.6 m (15 ft) of the soil column per WAC 173-340-740(6)(c) (Ecology 1996) and represent concentrations for individual COPCs that will be protective of human health from direct contact with contaminated waste for a residential land-use scenario. Institutional controls to prevent deep excavation or well drilling will be required if direct exposure RAGs are not obtained in the soil below 4.6 m (15 ft) in depth.

B.2.2 Groundwater Protection Remedial Action Goals for Nonradionuclide Contaminants in Soil

Nonradionuclide contaminant concentrations in soil equal to or less than 100 times the groundwater cleanup level are protective of groundwater per WAC 173-340-740(3)(a)(ii)(A) (Ecology 1996). Nonradionuclide groundwater cleanup levels based on maximum contaminant levels (MCLs) (40 *Code of Federal Regulations* [CFR] 141; 40 CFR 143) and Method B formulas for groundwater in WAC 173-340-720(3) (Ecology 1996), sections (a)(ii)(A) and (B) for noncarcinogenic or carcinogenic substances, respectively, are tabulated in Table B-2, columns 2, 3, and 4. The lowest of the groundwater cleanup levels or MCLs is used to calculate the soil cleanup level based on the "100 times" rule in the 5th column. The "100 times" rule values are then compared to background and the RDL. The lowest of the "100 times" rule value, background, or the RDL becomes the soil cleanup level protective of groundwater, per WAC 173-340-700(4)(d) and WAC 173-340-700(6) (Ecology 1996). Soil cleanup levels for individual COPCs based on the protection of groundwater and the Columbia River apply to the entire soil column per WAC 173-340-740(6)(b) (Ecology 1996).

B.2.3 Columbia River Protection Remedial Action Goals for Nonradionuclide Contaminants in Soil

To maintain consistency, the same methodology used to obtain contaminant concentrations in soil protective of groundwater is applied to obtain contaminant concentrations in soil protective of the Columbia River, with the additional application of a dilution-attenuation factor of 2 to represent dilution occurring between the groundwater and river interface. This is described in Table B-3 (i.e., the soil cleanup level to be protective of the river shall be 100 times the remedial action goal with application of a dilution attenuation factor [DAF] of 2). Nonradionuclide surface water cleanup levels based on AWQC (40 CFR 131), "Water Quality Standards for Surface Waters of the State of Washington" (WAC 173-201A), and Method B formulas for surface water cleanup levels in WAC 173-340-730(3) (Ecology 1996), sections (a)(iii)(A) and (B) for noncarcinogenic or carcinogenic substances, respectively, are tabulated in Table B-3, columns 2, 3, and 4. The lowest of the cleanup levels is used to calculate the soil cleanup level based on the "100 times DAF" rule. The "100 times DAF" rule values are then compared to background and the RDL. The lowest of the "100 times DAF" rule value, background, or the RDL becomes the soil cleanup RAG protective of groundwater, per WAC 173-340-700(4)(d) and WAC 173-340-700(6) (Ecology 1996). Soil cleanup levels for individual COPCs based on

the protection of groundwater and the Columbia River apply to the entire soil column per WAC 173-340-740(6)(b) (Ecology 1996).

B.2.4 Summary of Remedial Action Goals for Nonradionuclide Contaminants

Summaries of the cleanup levels for direct contact, protection of groundwater, and protection of the river are presented in Table B-4. For reference, the chemical abstract system (CAS) number and distribution coefficient (Kd value) for each contaminant are also included. The CAS number is used to identify contaminants when variations in chemical names or spelling occur. The Kd value is used in computer modeling described in Appendix C to determine if a higher soil concentration is protective of groundwater or the river at a site where the soil cleanup levels protective of groundwater or the river are exceeded, per WAC 173-340-740(3)(a)(ii)(A) (Ecology 1996).

B.2.5 Cleanup Verification Evaluation of Sites With Multiple Contaminants

During cleanup verification, it must be noted that if a waste site involves multiple contaminants and/or multiple pathways of exposure, the total excess lifetime cancer risk for a site shall not exceed one in one hundred thousand (1×10^{-5}), and the total hazard index for substances with similar noncarcinogenic toxic effects shall not exceed one (WAC 173-340-705[4]) (Ecology 1996). Should the presence of multiple contaminants occur, WAC 173-340-705 (Ecology 1996) provides that Method B cleanup levels for individual substances must be modified in accordance with the human health risk assessment procedures outlined in WAC 173-340-708 (Ecology 1996) so that total excess lifetime cancer risk is less than 10^{-5} and the total hazard index is less than one. This modification of cleanup levels, if necessary, would take place during the verification of site cleanup following remediation. Calculation of cumulative excess cancer risk for comparison to a total excess cancer risk of 10^{-5} for detected nonradionuclides whose RDL or practical quantitation limit (PQL) is higher than the calculated cleanup level shall use the calculated cleanup level when analyses with "J" qualifiers or no qualifiers are available.

B.3 RADIONUCLIDE CLEANUP LEVELS

Soil radionuclide cleanup levels for the 100 Area of the Hanford Site are based upon determinations of individual radionuclide activities that will be protective of direct exposure dose (15 mrem/yr above background, approximating the CERCLA risk range of 10^{-4} to 10^{-6}) and protective of groundwater and the Columbia River (a cumulative dose of 4 mrem/yr dose for photon and beta emitters, 20,000 pCi/L for tritium, 8 pCi/L for strontium-90, and 30 µg/L for total uranium). The RESidual RADioactivity (RESRAD) model was selected by the Tri-Parties as the dose assessment model for generating RAGs for radionuclide contaminants in soil and for verifying that concentrations remaining after remedial action achieve the 15 mrem/yr cleanup level. The RESRAD model was developed by Argonne National Laboratory (ANL 2001) to implement DOE guidelines for residual radioactive material in soil. The most current version of RESRAD will be used for conducting dose assessments.

B.3.1 Radionuclide Cleanup Levels For Direct Exposure

Single radionuclide soil concentrations corresponding to a 15 mrem/yr dose in a rural-residential scenario were calculated using RESRAD version 6.4 and the appropriate parameters from Table B-8. To perform the calculations, the parameters were entered into the RESRAD data menu, the radon gas exposure pathway was suppressed, a concentration in soil for each radionuclide was assigned (1,000 pCi/g), and appropriate times for calculations were selected. For the calculations, default times of 1, 3, 10, 30, 100, 300, and 1,000 years were used. The basic radiation dose limit of 15 mrem/yr was input to correspond to direct exposure in a rural-residential scenario. Values for some of the parameters in Table B-8 (e.g., thickness of the contaminated zone, thickness of the uncontaminated zone, and areal extent of the site) depend upon site-specific characteristics. For purposes of developing direct exposure cleanup levels to guide field excavation, generic values have been assumed such that the entire 4.6-m (15-ft)-thick shallow zone is assumed contaminated and the entire deep zone (assumed to be 12 m thick in the 100 Area generic site model) is assumed uncontaminated. No cover material is assumed to exist on top of the contaminated shallow zone.

After the RESRAD software was run, the summary report for radiological dose was accessed by viewing the RESRAD output document "summary.rep." The values provided in the RESRAD summary report under "Single Radionuclide Soil Guidelines," in the table headed "Summed Dose/Source Ratios and Single Radionuclide Soil Guidelines" copied into Table B-9 were examined. The concentration in the RESRAD output column headed by G(i, tmin) is the concentration (activity) of each radionuclide in soil corresponding to a 15 mrem/yr dose. These values were recorded in Table B-5, with an appropriate number of significant figures. The published and calculated radionuclide cleanup levels are compared against the Hanford Site soil background value and the RDL in Table B-5, for each radionuclide, to verify that the published or calculated soil concentrations corresponding to a 15 mrem/yr dose are not less than the background concentrations or the RDL. If a single radionuclide soil concentration corresponding to a 15 mrem/yr dose is less than background and/or the RDL the larger of the values becomes the cleanup level for remedial action per WAC 173-340-700(4)(d) and WAC 173-340-707(2) (Ecology 1996), respectively. The cleanup levels determined in this way are presented in thefifth column of Table B-5.

B.3.2 Radionuclide Cleanup Levels For Groundwater Protection

After remediation, residual radioactive and nonradioactive contaminants remaining in soil must be at such levels that concentrations of contaminants that could migrate through the soil column to groundwater do not exceed cleanup levels considered protective of groundwater. Protection of groundwater is intended to achieve remedial action goals (RAGs) derived from maximum contaminant levels (MCLs) promulgated under the federal *National Primary Drinking Water Regulations* (40 CFR 141).

The average annual activity of beta particle and photon radioactivity from man-made radionuclides in drinking water shall not produce an annual dose equivalent to the total body or any internal organ greater than 4 mrem/yr, per 40 CFR 141.66. However, separate MCLs exist

for strontium-90, tritium (H-3), radium-226 and radium-228. The MCLs for strontium-90 and tritium are 8 pCi/L and 20,000 pCi/L, respectively (40 CFR 141.66). The MCL for combined radium-226 and radium-228 is 5 pCi/L (40 CFR 141.66). The MCL for alpha-emitting radionuclides (excluding radon and uranium) is 15 pCi/L (40 CFR 141.66). However, the more stringent of 15 pCi/L MCL or 1/25th of the derived concentration guide from DOE Order 5400.5 is used as the limit for alpha-emitting radionuclides based on the Remaining Sites ROD (EPA 1999).

The MCLs for all other man-made radionuclides (excluding radon and uranium) that would cause a 4-mrem/yr dose are calculated on the basis of a 2-L/day drinking water intake, using the 168-hour data listed in NBS Handbook 69 (NBS 1963). Using this guidance, the MCLs for many radionuclides have been calculated as shown in the *Soil Screening Guidance for Radionuclides: User's Guide* (EPA 2000a). The MCL values obtained from EPA (2000a) are used as noted in Table B-5. As appropriate, MCL values in Table B-5 are also cited from DOE Order 5400.5 and from 40 CFR 141.

Because uranium is naturally occurring, standards for man-made radionuclides do not apply to the uranium isotopes. A limit of 30 ug/L has been promulgated as the MCL for total uranium in groundwater in 40 CFR 141.66. This corresponds to a uranium activity of 21.2 pCi/L at the Hanford Site background distribution of uranium isotopes uranium-234, uranium-235, and uranium-238 (BHI 2001).

To determine the most conservative radionuclide soil concentrations for 100 Area groundwater and river protection using RESRAD it is assumed that the entire thickness of the vadose zone is contaminated. The Columbia River protection remedial action goals for radionuclides are identical to the groundwater protection remedial action goals so the same soil cleanup levels will be protective of both groundwater and the river. To determine radionuclide activities in soil that are protective of groundwater, exposure pathways in the RESRAD input file for external gamma exposure, inhalation, soil ingestion and radon are suppressed. Pathways for ingestion of plants, meat, milk, aquatic foods, and drinking water are active. Appropriate input parameters including radionuclide distribution coefficient (K_d) values (Table B-7) are entered into the RESRAD data menu, a concentration in soil for each radionuclide is assigned (1,000 pCi/g), and default times of 1, 3, 10, 30, 100, 300, and 1,000 years are used for the initial calculation. The basic radiation dose limit of 4 mrem/yr is input for groundwater protection.

The RESRAD software is run and the concentration report and graphical output for radionuclides in drinking water are accessed to determine which radionuclides do or do not reach groundwater in 1,000 years. The concentration report is accessed by viewing the file "concent.rep" in the RESRAD output. The graphical output for concentration of radionuclides in drinking water is accessed in the RESRAD version 6.4 Graphics Display by selecting:

Type: Concentration
Radionuclide: Individual
Media (Pathways): Well Water

If the well water concentration predicted in the concentration report and the graphical output displays zero for the full 1,000 years the contaminant does not impact groundwater within 1,000 years. For the current evaluation (groundwater protection in the 100 Area assuming no uncontaminated zone) the graphical output shows that cobalt-60, cesium-137, nickel-63, potassium-40, strontium-90, technetium-99, tritium (H-3), and the uranium isotopes uranium-234, uranium-235, and uranium-238 are predicted to reach groundwater within 1,000 years. The peak (maximum) years of the groundwater concentrations for these radionuclides are obtained from the RESRAD summary report for radiological dose in the RESRAD output table headed "Summed Dose/Source Ratios and Single Radionuclide Soil Guidelines." The peak year of groundwater concentration for each radionuclide is in the column in Table B-10 headed by "tmin, years." For the current evaluation the peak years of groundwater concentrations of cobalt-60, cesium-137, iodine-129, neptunium-237, nickel-63, potassium-40, strontium-90, technetium-99, tritium (H-3), and the uranium isotopes uranium-234, uranium-235, and uranium-238 are shown in Table B-6.

The peak years of groundwater concentration were entered as calculation times in the RESRAD inputs and the RESRAD software was rerun. For the current evaluation individual runs were performed for each radionuclide to avoid interference of daughter products. After the RESRAD software was rerun, the concentration report ("concent.rep" in the RESRAD output) was accessed and the predicted well water concentrations were read at the peak years of groundwater concentration and recorded in Table B-6. The soil activity of each the radionuclide to meet groundwater RAGs was calculated using the well water concentration at the peak year of groundwater concentration. The soil activities to meet groundwater RAGs are calculated using the following relationship:

(Soil activity, pCi/g, to meet groundwater RAG) = (Input soil activity) x (RAG) / (Isotope well water concentration at peak year in the concentration report)

The soil activities calculated to meet groundwater RAGs in Table B-6 were entered into RESRAD and the software was rerun to determine that the predicted drinking water concentrations match the groundwater RAGs at the peak year of groundwater concentration for each radionuclide.

B.3.3 Summary of Determination of Radionuclide Cleanup Levels

Soil radionuclide cleanup levels are summarized in Table B-7. It should be noted that for most radionuclides the direct exposure cleanup level is more restrictive than the soil activity protective of groundwater. Only for nickel-63 does the soil activity protective of groundwater become the cleanup level. If the soil activity protective of groundwater is less than background or the practical quantitation limit the higher of these two values will be the cleanup level, per the Ecology 1996 revisions of WAC 173-340-700(4)(d) and WAC 173-340-707(2), respectively.

The single radionuclide soil concentrations corresponding to a 15 mrem/yr dose listed in column 5 of Table B-7 apply to the top 4.6 m (15 ft) below the surface and represent soil activities for individual radionuclides that would not pose an unacceptable dose to humans from direct exposure to contaminated waste/soil in the rural-residential land use scenario. These values would decrease based on the presence of cumulative effects if more than one radionuclide represented a significant share of the dose at the same waste site.

Radionuclides that are reported together (plutonium-239/240 and uranium-233/234) have cleanup levels based upon the predominant radionuclide, as described below:

- The calculated cleanup levels for plutonium-239 and plutonium-240 are so close together that analyses of contaminated soils will have higher associated errors than the differences in the cleanup levels. Therefore, the lower of the two values for plutonium-239 and 240 is used as the cleanup level for plutonium-239/240.

- Uranium-234 will be the predominant isotope of the pair uranium-233/234 in the 100 Areas. Uranium-233 is effectively ignored for most applications because it will only be present in areas where irradiated thorium was processed, or in areas (none at the Hanford Site) specific to "use" of uranium-233. Therefore, the value for uranium-234 is used as the cleanup level for the pair.

B.4 USING RESRAD FOR WASTE SITE RADIONUCLIDE CLEANUP VERIFICATION

The input parameters and assumptions used in RESRAD to generate the lookup values presented in this remedial design report/remedial action work plan are summarized in Table B-8. For the purpose of site cleanup verification, the RESRAD input values (e.g., the thickness of the contaminated zone, the thickness of the uncontaminated zone, and the size of the waste site) will be determined on a site-specific basis. RESRAD calculates all radionuclides in the decay chain (daughters) in calculating ingrowth and decay. It has not been determined what daughters were present at the time of waste emplacement, but they would be insignificant dose contributors; therefore, estimated daughters are not included as input.

Values for some parameters (e.g., thickness of the contaminated zone, thickness of the uncontaminated zone, areal extent of the site, and leachability) depend on specific site

characteristics. Waste sites near the river (such as outfalls) may require modified input parameters. For purposes of developing lookup values to guide field excavation, generic values have been assumed; however, to verify whether a specific site has met cleanup goals, input values will be determined on a site-specific basis.

The general process will be to first determine the nature and extent of residual contamination (concentrations and thickness of contaminated zone[s]). This information will then be input to the RESRAD model to evaluate migration potential of contaminants. The specific process to determine the thickness of the contaminated zone(s) and the associated contaminant profile will follow a hierarchy as shown in the following steps:

1. Assume worst case: Concentrations of residual contamination are assumed to be uniform from the bottom of the excavation to groundwater. If modeling using this assumption predicts that this is protective of groundwater and the river, no further evaluation will be performed.

2. Site-specific information: Use process knowledge, historic sampling data, remediation data, etc., to determine the profile of residual contamination in soil. If modeling using this site-specific information is sufficient to predict site conditions are protective of groundwater and the river, no further evaluation is required.

3. Analogous site information: Compare the waste site to other sites for which profiles have been determined to see if appropriate analogies can be made. The factors considered could include site stratigraphy, depth to groundwater, volume of liquid disposed, and type of contaminants. If available analogous site information is sufficient, no further evaluation is required.

4. Subsurface sampling: The safest, most cost-effective method (e.g., trenching, boreholes) will be used to obtain site-specific data. The data obtained from subsurface sampling are not intended to meet statistical criteria for representative sampling, but will provide a qualitative measure of the extent of contamination below the site. Location will be determined on a site-by-site basis by DOE using data collected during excavation.

It is anticipated that, through data collection in subsurface sampling events, information will be gained to determine if Option 4 is a viable option to verify the conceptual model to allow for site closeout. The Tri-Parties will evaluate the information to determine whether to continue this practice.

B.5 RESRAD VERSION HISTORY

The RESRAD version history is available from the RESRAD Internet Website at (http://web.ead.anl.gov/resrad/home2/reshstry.cfm). This history is supplemented with notes presented at *Hanford Federal Facility Agreement and Consent Order* (Tri-Party Agreement) (Ecology et al. 1998) unit managers' meetings.

B.6 REFERENCES

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Table B-1. Nonradionuclide Direct Exposure Cleanup Levels. (4 Pages)

Contaminant	Background (mg/kg)	RDL (mg/kg)	Direct Exposure Cleanup Levels (mg/kg) [a]		Direct Exposure Cleanup Level (mg/kg)
			Carcinogen	Noncar-cinogen	
Metals					
Antimony	5 [b]	0.6		32	32
Arsenic	20 [c]	10	0.667	24	20 [c]
Barium	132	2		16,000 [a]	16,000
Beryllium	1.51	0.5	10.4 [d]	160	10.4
Boron	NA	2		16,000	16,000
Cadmium	0.81 [b]	0.5	13.9 [d]	80	13.9
Chromium, Total	18.5	1		120,000 [a]	120,000
Chromium VI	NA	0.5	2.1 [d]	240	2.1
Cobalt	15.7	2		1,600	1,600
Copper	22.0	1		2,960	2,960
Lead	10.2	5		353 [e]	353
Lithium	33.5	2.5		1,600	1,600
Manganese	512	5		11,200	11,200
Mercury	0.33	0.2		24	24
Methyl Mercury	NA	NA		8	8
Molybdenum	NA	2		400	400
Nickel	19.1	4		1,600	1,600
Selenium	0.78 [b]	1		400	400
Silver	0.73	0.2		400	400
Vanadium	85.1	2.5		560	560
Zinc	67.8	1		24,000	24,000
Inorganics and TPH					
Cyanide	NA	0.5		1,600	1,600
Nitrate (as Nitrogen)	11.8	0.75		128,000	128,000
Nitrite (as Nitrogen)	NA	0.75		8,000	8,000
Sulfate	237	5		NA	NA
Sulfide	NA	5		NA	NA
TPH	NA	5		NA	NA
VOAs					
Acetone [f]	NA	0.02		72,000	72,000
Carbon Tetrachloride [f]	NA	0.005	7.69	56	7.69
Methylene Chloride [f]	NA	0.005	133	4,800	133
Toluene [f]	NA	0.005		6,400	6,400
Semivolatiles					
Acenapthene	NA	0.33		4,800	4,800
Acenapthylene [g]	NA	0.33		4,800	4,800
Anthracene	NA	0.33		24,000	24,000
Benzo(a)anthracene	NA	0.33	1.37		1.37
Benzo(a)pyrene	NA	0.33	0.137		0.33 [c]
Benzo(b)fluoranthene	NA	0.33	1.37		1.37

Table B-1. Nonradionuclide Direct Exposure Cleanup Levels. (4 Pages)

Contaminant	Background (mg/kg)	RDL (mg/kg)	Direct Exposure Cleanup Levels (mg/kg) [a]		Direct Exposure Cleanup Level (mg/kg)
			Carcinogen	Noncar-cinogen	
Benzo(k)fluoranthene	NA	0.33	13.7		13.7
Benzo(g,h,i)perylene [g]	NA	0.33		2,400	2,400
Bis(2-chloro-1-methylethyl) ether	NA	0.92	14.3		14.3
Bis(2-chloroethoxy)methane [g]	NA	0.33	0.909		0.909
Bis(2-chloroethyl) ether	NA	0.33	0.909		0.909
Bis(2-ethylhexyl)phthalate	NA	0.33	71.4	1,600	71.4
Bromophenylphenyl ether; 4-	NA	0.33		NA	NA
Butylbenzylphthalate	NA	0.33		16,000	16,000
Carbazole	NA	0.33	50		50
Chloro-3-methylphenol; 4- [g]	NA	0.33		4,000	4,000
Chloroanilene; 4-	NA	0.33		320	320
Chloronaphthalene; 2-	NA	0.33		6,400	6,400
Chlorophenol;2-	NA	0.33		400	400
Chlorophenylphenyl ether; 4-	NA	0.33		NA	NA
Chrysene	NA	0.33	137		137
Dibenzo(a,h)anthracene	NA	0.33	0.137		0.33 [c]
Dibenzofuran	NA	0.33		160	160
Dichlorobenzene; 1,2-	NA	0.33		7,200	7,200
Dichlorobenzene; 1,3-	NA	0.33		2,400	2,400
Dichlorobenzene; 1,4-	NA	0.33	41.7	1,600	41.7
Dichlorobenzidine; 3,3'-	NA	0.33	2.22		2.22
Dichlorophenol; 2,4-	NA	0.33		240	240
Diethylphthalate	NA	0.33		64,000	64,000
Dimethylphthalate	NA	0.33		80,000	80,000
Dimethylphenol; 2,4-	NA	0.33		1,600	1,600
Di-n-butylphthalate	NA	0.33		8,000	8,000
Di-n-octylphthalate	NA	0.33		1,600	1,600
Dinitro-2-methylphenol; 4,6-	NA	0.33		8.00	8.00
Dinitrophenol; 2,4-	NA	0.825		160	160
Dinitrotoluene; 2,4-	NA	0.33		160	160
Dinitrotoluene; 2,6-	NA	0.33		80.0	80.0
Ethylene glycol	NA	5		160,000	160,000
Fluoranthene	NA	0.33		3,200	3,200
Fluorene	NA	0.33		3,200	3,200
Hexachlorobenzene	NA	0.33	0.625	64	0.625
Hexachlorobutadiene	NA	0.33	12.8	16	12.8
Hexachlorocyclopentadiene	NA	0.33		480	480
Hexachloroethane	NA	0.33	71.4	80	71.4
Hydrazine	NA	0.33	0.333		0.333
Indeno(1,2,3-cd) pyrene	NA	0.33	1.37		1.37
Isophorone	NA	0.33	1,050	16,000	1,050
Methylnaphthalene; 2-	NA	0.33		320	320

Table B-1. Nonradionuclide Direct Exposure Cleanup Levels. (4 Pages)

Contaminant	Background (mg/kg)	RDL (mg/kg)	Direct Exposure Cleanup Levels (mg/kg) [a]		Direct Exposure Cleanup Level (mg/kg)
			Carcinogen	Noncar-cinogen	
Methylphenol; 2- (cresol;o-)	NA	0.33		4,000	4,000
Methylphenol; 4- (cresol;p-)	NA	0.33		400	400
Naphthalene	NA	0.33		1,600	1,600
Nitroaniline; 2-	NA	0.33		240	240
Nitroaniline; 3-	NA	0.33	47.6	24	24
Nitroaniline; 4-	NA	0.33	47.6	240	47.6
Nitrobenzene	NA	0.33		40.0	40.0
Nitrophenol; 2-	NA	0.66		NA	NA
Nitrophenol; 4-	NA	0.66		640	640
Nitroso-di-n-propylamine;N-	NA	0.33	0.143		0.33 [c]
Nitrosodiphenylamine;N-	NA	0.33	204		204
Pentachlorophenol	NA	0.33	8.33	2,400	8.33
Phenanthrene [g]	NA	0.33		24,000	24,000
Phenol	NA	0.33		24,000	24,000
Pyrene	NA	0.33		2,400	2,400
Tributyl Phosphate	NA	3.3	185	16,000	185
Trichlorobenzene; 1,2,4-	NA	0.33		800	800
Trichlorophenol; 2,4,5-	NA	0.33		8,000	8,000
Trichlorophenol; 2,4,6-	NA	0.33	90.9		90.9
Pesticides and PCBs					
Aldrin	NA	0.00165	0.0588	2.40	0.0588
BHC, alpha	NA	0.00165	0.159		0.159
BHC, beta	NA	0.00165	0.556		0.556
BHC, delta	NA	0.00165	NA		NA
BHC, gamma (Lindane)	NA	0.00165	0.769	24	0.769
Chlordane (alpha, gamma)	NA	0.0165	2.86	40	2.86
Dalapon	NA	0.1		2,400	2,400
Db; 2,4-	NA	0.1		640	640
DDD, 4,4'-	NA	0.0033	4.17		4.17
DDE, 4,4'-	NA	0.0033	2.94		2.94
DDT, 4,4'-	NA	0.0033	2.94	40	2.94
Dicambra	NA	0.1		2,400	2,400
Dichlorophenoxyacetic acid; 2,4-	NA	0.4		800	800
Dichloroprop [g]	NA	0.1		800	800
Dieldrin	NA	0.003	0.0625	4	0.0625
Dinoseb (DNBP)	NA	0.01		80	80
Endosulfan (I, II, sulfate)	NA	0.003		480	480
Endrin (and ketone, aldehyde)	NA	0.003		24	24
Heptachlor	NA	0.002	0.222	40	0.222
Heptachlor epoxide	NA	0.002	0.11	1.04	0.11
Methoxychlor	NA	0.02		400	400
Polychlorinated Biphenyls [h]	NA	0.017	0.5 [i]		0.5

Table B-1. Nonradionuclide Direct Exposure Cleanup Levels. (4 Pages)

Contaminant	Background (mg/kg)	RDL (mg/kg)	Direct Exposure Cleanup Levels (mg/kg) [a]		Direct Exposure Cleanup Level (mg/kg)
			Carcinogen	Noncar-cinogen	
PCB Aroclor-1016	NA	0.017	14.3	5.6	5.6
PCB Aroclor-1221	NA	0.017	0.5		0.5
PCB Aroclor-1232	NA	0.017	0.5		0.5
PCB Aroclor-1242	NA	0.017	0.5		0.5
PCB Aroclor-1248	NA	0.017	0.5		0.5
PCB Aroclor-1254	NA	0.017	0.5	1.6	0.5
PCB Aroclor-1260	NA	0.017	0.5		0.5
Silvex (tp;2,4,5-)	NA	0.02		640	640
Toxaphene	NA	0.2	0.909		0.909
Trichlorophenoxyacetic acid; 2,4,5-	NA	0.02		800	800

[a] Calculated using the appropriate formulas from Ecology 1996, WAC 173-340-740, with toxicity values updated through April 11, 2007, from the EPA Integrated Risk Information System (IRIS) at http://www.epa.gov/iris or from the Risk Assessment Information System (RAIS) database of the Oak Ridge National Laboratory (ORNL) on the Internet at http://risk.lsd.ornl.gov.

[b] Hanford Site-specific background not available. Value is from Ecology, 1994, *Natural Background Soil Metals Concentrations in Washington State,* Publication No. 94-115, Washington State Department of Ecology, Olympia, Washington.

[c] Where cleanup levels are less than background or RDLs, cleanup levels default to background or RDLs per Ecology (1996), WAC 173-340-700(4)(d) and WAC 173-340-707(2), respectively. The arsenic cleanup level of 20 mg/kg has been agreed to by the Tri-Party Agreement Project Managers as discussed in Section 2.1.2.1 of this document. The Hanford Site background for arsenic is 6.5 mg/kg.

[d] Carcinogenic cleanup level calculated based on the inhalation exposure pathway; WAC 173-340-750(3), 1996.

[e] Calculated using *Guidance Manual for the Integrated Exposure Uptake Biokinetic Model for Lead in Children*, EPA/540/R-93/081, Publication No. 9285.7, U.S. Environmental Protection Agency, Washington, D.C.

[f] Common laboratory contaminant unlikely to be found in soil. If detected in soil, all analyses of blanks, duplicates, and splits should be checked and the original soil sample reanalyzed.

[g] Toxicity data for this chemical are not available. Cleanup levels are based on surrogate chemicals:
Contaminant: acenapthylene; surrogate: acenapthene
Contaminant: benzo(g,h,i)perylene; surrogate: pyrene
Contaminant: bis(2-chloroethoxy)methane; surrogate: bis(2-chloroethyl)ether
Contaminant: chloro-3-methylphenol; 4-; surrogate: methylphenol; 3-
Contaminant: dichloroprop (pesticide); surrogate: Dichlorophenoxyacetic acid; 2,4-; (2,4-D)
Contaminant: phenathrene; surrogate: anthracene.

[h] The soil cleanup value for PCBs is based on the formula presented in WAC 173-340-740(3)(a)(iii)(B), Ecology 1996, and the cancer potency factor for ingestion of PCBs of 2.0 kg-day/mg (soils) from the EPA Integrated Risk Information System (IRIS) on the Internet at http://www.epa.gov/iris on January 3, 2006.

NA = not available
PCB = polychlorinated biphenyl
RDL = required detection limit
TPH = total petroleum hydrocarbon
VOA = volatile organic analysis

Table B-2. Nonradionuclide Soil Cleanup Levels Protective of Groundwater. (6 Pages)

Contaminant	Groundwater Cleanup Level (µg/L) [a]		Ground-water MCL [b] (µg/L)	Soil Cleanup Level based on "100 X Rule" [c] (mg/kg)	Background (mg/kg)	RDL (mg/kg)	Soil RAGs for Groundwater Protection (mg/kg)
	Carcinogen	Noncarcinogen					
Metals							
Antimony		6.40	6	0.6	5 [d]	0.6	5 [e]
Arsenic	0.0583	4.80	5	0.00583	6.5	10	20 [e]
Barium		3,200	2,000	200	132	2	200
Beryllium		32	4	0.4	1.51	0.5	1.51 [e]
Boron		3,200		320	NA	2	320
Cadmium		8.00	5	0.5	0.81 [d]	0.5	0.81 [e]
Chromium, Total		24,000	100	10	18.5	1	18.5 [e]
Chromium VI		48		4.8	NA	0.5	4.8
Cobalt		320		32	15.7	2	32
Copper		592	1,000	59.2	22.0	1	59.2
Lead			15	1.5	10.2	5	10.2 [e]
Lithium		320		32	33.5	2.5	33.5 [e]
Manganese		2,240	50	5	512	5	512 [e]
Mercury		4.80	2	0.2	0.33	0.2	0.33 [e]
Methyl Mercury		1.60		0.16	NA		0.16
Molybdenum		80		8	NA	2	8
Nickel		320	100	10	19.1	4	19.1 [e]
Selenium		80	50	5	0.78 [d]	1	5
Silver		80	100	8	0.73	0.2	8
Vanadium		112		11.2	85.1	2.5	85.1 [e]
Zinc		4,800	5,000	480	67.8	1	480
Inorganics and TPH							
Cyanide		320	200	20	NA	0.5	20
Nitrate (as Nitrogen		25,600	10,000	1,000	11.8	0.75	1,000
Nitrite (as Nitrogen		1,600	1,000	100	NA	0.75	100
Sulfate			250,000	25,000	237	5	25,000
Sulfide				NA	NA	5	NA
TPH				200	NA	5	200

Table B-2. Nonradionuclide Soil Cleanup Levels Protective of Groundwater. (6 Pages)

Contaminant	Groundwater Cleanup Level (µg/L) [a]		Ground-water MCL [b] (µg/L)	Soil Cleanup Level based on "100 X Rule" [c] (mg/kg)	Background (mg/kg)	RDL (mg/kg)	Soil RAGs for Groundwater Protection (mg/kg)
	Carcinogen	Noncarcinogen					
VOAs							
Acetone [g]		7,200		720	NA	0.02	720
Carbon Tetrachloride [g]	0.337	5.60	5	0.0337	NA	0.005	0.0337
Methylene Chloride [g]	5.83	480	5	0.5	NA	0.005	0.5
Toluene [g]		640	1,000	64	NA	0.005	64
Semivolatiles							
Acenapthene		960		96	NA	0.33	96
Acenapthylene [f]		960		96	NA	0.33	96
Anthracene		2,400		240	NA	0.33	240
Benzo(a)anthracene	0.120			0.012	NA	0.33	0.33 [e]
Benzo(a)pyrene	0.0120		0.2	0.0012	NA	0.33	0.33 [e]
Benzo(b)fluoranthene	0.120			0.012	NA	0.33	0.33 [e]
Benzo(k)fluoranthene	1.20			0.12	NA	0.33	0.33 [e]
Benzo(g,h,i)perylene [f]		480		48	NA	0.33	48
Bis(2-chloro-1-methylethyl) ether	1.25			0.125	NA	0.33	0.33 [e]
Bis(2-chloroethoxy)methane [f]	0.0398			0.004	NA	0.33	0.33 [e]
Bis(2-chloroethyl) ether	0.0398			0.004	NA	0.33	0.33 [e]
Bis(2-ethylhexyl)phthalate	6.25	320	6	0.6	NA	0.33	0.6
Bromophenylphenyl ether; 4-				NA	NA	0.33	NA
Butylbenzylphthalate		3,200		320	NA	0.33	320
Carbazole	4.38			0.438	NA	0.33	0.438
Chloro-3-methylphenol; 4- [f]		800		80	NA	0.33	80
Chloroanilene; 4-		64		6.4	NA	0.33	6.4
Chloronaphthalene; 2-		640		64	NA	0.33	64
Chlorophenol;2-		80		8.00	NA	0.33	8.00
Chlorophenylphenyl ether; 4-				NA	NA	0.33	NA

Table B-2. Nonradionuclide Soil Cleanup Levels Protective of Groundwater. (6 Pages)

Contaminant	Groundwater Cleanup Level (µg/L) [a]		Ground-water MCL [b] (µg/L)	Soil Cleanup Level based on "100 X Rule" [c] (mg/kg)	Background (mg/kg)	RDL (mg/kg)	Soil RAGs for Groundwater Protection (mg/kg)
	Carcinogen	Noncarcinogen					
Chrysene	12			1.2	NA	0.33	1.2
Dibenzo(a,h)anthracene	0.0120			0.0012	NA	0.33	0.33 [e]
Dibenzofuran		32.0		3.20	NA	0.33	3.20
Dichlorobenzene; 1,2-		720	600	60	NA	0.33	60.0
Dichlorobenzene; 1,3-		240		24.0	NA	0.33	24.0
Dichlorobenzene; 1,4-	1.82		75	0.182	NA	0.33	0.33 [e]
Dichlorobenzidine; 3,3-	0.194			0.0194	NA	0.33	0.33 [e]
Dichlorophenol; 2,4-		48		4.80	NA	0.33	4.80
Diethylphthalate		12,800		1,280	NA	0.33	1,280
Dimethylphthalate		16,000		1,600	NA	0.33	1,600
Dimethylphenol; 2,4-		320		32.0	NA	0.33	32.0
Di-n-butylphthalate		1,600		160	NA	0.33	160
Di-n-octylphthalate		320		32	NA	0.33	32
Dinitro-2-methylphenol; 4,6-		1.60		0.160	NA	0.33	0.33 [e]
Dinitrophenol; 2,4-		32		3.20	NA	0.825	3.20
Dinitrotoluene; 2,4-		32		3.20	NA	0.33	3.20
Dinitrotoluene; 2,6-		16		1.60	NA	0.33	1.60
Ethylene glycol		3,200		320	NA	5	320
Fluoranthene		640		64	NA	0.33	64
Fluorene		640		64	NA	0.33	64
Hexachlorobenzene	0.0547	12.8	1	0.00547	NA	0.33	0.33 [e]
Hexachlorobutadiene	0.561	1.60		0.0561	NA	0.33	0.33 [e]
Hexachlorocyclopentadiene		96	50	5	NA	0.33	5
Hexachloroethane	3.13	8		0.313	NA	0.33	0.313
Hydrazine	0.0146			0.00146	NA	0.33	0.33 [e]
Indeno(1,2,3-cd) pyrene	0.120			0.012	NA	0.33	0.33 [e]
Isophorone	92.1	3,200		9.21	NA	0.33	9.21
Methylnaphthalene; 2-		32		3.2	NA	0.33	3.2
Methylphenol; 2- (cresol;o-)		800		80	NA	0.33	80.0

Table B-2. Nonradionuclide Soil Cleanup Levels Protective of Groundwater. (6 Pages)

Contaminant	Groundwater Cleanup Level (µg/L) [a]		Ground-water MCL [b] (µg/L)	Soil Cleanup Level based on "100 X Rule" [c] (mg/kg)	Background (mg/kg)	RDL (mg/kg)	Soil RAGs for Groundwater Protection (mg/kg)
	Carcinogen	Noncarcinogen					
Methylphenol; 4- (cresol;p-)		80		8.00	NA	0.33	8.00
Naphthalene		160		16	NA	0.33	16.0
Nitroaniline; 2-		24		2.4	NA	0.33	2.4
Nitroaniline; 3-	2.08	2.40		0.208	NA	0.33	0.33 [e]
Nitroaniline; 4-	2.08	24.0		0.208	NA	0.33	0.33 [e]
Nitrobenzene		4.00		0.40	NA	0.33	0.40
Nitrophenol; 2-				NA	NA	0.66	NA
Nitrophenol; 4-		128		12.8	NA	0.66	12.8
Nitroso-di-n-propylamine;N-	0.0125			0.00125	NA	0.33	0.33 [e]
Nitrosodiphenylamine;N-	17.9			1.79	NA	0.33	1.79
Pentachlorophenol	0.729	480	1	0.0729	NA	0.33	0.33 [e]
Phenanthrene [f]		2,400		240	NA	0.33	240
Phenol		4,800		480	NA	0.33	480
Pyrene		480		48	NA	0.33	48
Tributyl Phosphate	16.2	3,200		1.62	NA	3.3	3.3 [e]
Trichlorobenzene; 1,2,4-		80	70	7.0	NA	0.33	7
Trichlorophenol; 2,4,5-		1,600		160	NA	0.33	160
Trichlorophenol; 2,4,6-	7.95			0.795	NA	0.33	0.795
Pesticides, Herbicides, and PCBs							
Aldrin	0.00515	0.480		0.000515	NA	0.00165	0.00165 [e]
BHC, alpha	0.0139			0.00139	NA	0.00165	0.00165 [e]
BHC, beta (Hexachlorocyclohexane)	0.0486			0.00486	NA	0.00165	0.00486
BHC, delta				NA	NA	0.00165	NA
BHC, gamma (Lindane)	0.0673	4.80	0.2	0.00673	NA	0.00165	0.00673
Chlordane (alpha, gamma)	0.25	8	2	0.025	NA	0.0165	0.025
Dalapon		480	200	20	NA	0.1	20
Db; 2,4-		128		12.8	NA	0.1	12.8
DDD, 4,4-	0.365			0.0365	NA	0.0033	0.0365
DDE, 4,4-	0.257			0.0257	NA	0.0033	0.0257

Table B-2. Nonradionuclide Soil Cleanup Levels Protective of Groundwater. (6 Pages)

Contaminant	Groundwater Cleanup Level (µg/L) [a]		Ground-water MCL [b] (µg/L)	Soil Cleanup Level based on "100 X Rule" [c] (mg/kg)	Background (mg/kg)	RDL (mg/kg)	Soil RAGs for Groundwater Protection (mg/kg)
	Carcinogen	Noncarcinogen					
DDT, 4,4-	0.257	8.00		0.0257	NA	0.0033	0.0257
Dicambra		480		48	NA	0.1	48
Dichlorophenoxyacetic acid; 2,4-		160	70	7	NA	0.4	7
Dichloroprop [f]		160	70	7	NA	0.1	7
Dieldrin	0.00547	0.80		0.000547	NA	0.003	0.003 [e]
Dinoseb (DNBP)		16	7	0.7	NA	0.01	0.7
Endosulfan (I, II, sulfate)		96		9.6	NA	0.003	9.6
Endrin (and ketone, aldehyde)		4.8	2	0.2	NA	0.003	0.2
Heptachlor	0.0194	8	0.4	0.00194	NA	0.002	0.002 [e]
Heptachlor epoxide	0.00962	0.208	0.2	0.000962	NA	0.002	0.002 [e]
Methoxychlor		80	40	4	NA	0.02	4
Polychlorinated Biphenyls [h]	0.0438		0.5	0.00438	NA	0.017	0.017 [c]
PCB Aroclor-1016	0.0438	1.12		0.00438	NA	0.017	0.017 [e]
PCB Aroclor-1221	0.0438			0.00438	NA	0.017	0.017 [e]
PCB Aroclor-1232	0.0438			0.00438	NA	0.017	0.017 [e]
PCB Aroclor-1242	0.0438			0.00438	NA	0.017	0.017 [e]
PCB Aroclor-1248	0.0438			0.00438	NA	0.017	0.017 [e]
PCB Aroclor-1254	0.0438	0.32		0.00438	NA	0.017	0.017 [e]
PCB Aroclor-1260	0.0438			0.00438	NA	0.017	0.017 [e]
Silvex (TP; 2,4,5-)		128	50	5	NA	0.02	5
Toxaphene	0.0795		3	0.00795	NA	0.2	0.2 [e]
Trichlorophenoxyacetic acid; 2,4,5-		160		16	NA	0.02	16

Table B-2. Nonradionuclide Soil Cleanup Levels Protective of Groundwater. (6 Pages)

Contaminant	Groundwater Cleanup Level (µg/L) [a]		Ground-water MCL [b] (µg/L)	Soil Cleanup Level based on "100 X Rule" [c] (mg/kg)	Background (mg/kg)	RDL (mg/kg)	Soil RAGs for Groundwater Protection (mg/kg)
	Carcinogen	Noncarcinogen					

[a] Calculated using the appropriate formulas from Ecology 1996, WAC 173-340-720, with toxicity values updated through April 11, 2007, from the EPA Integrated Risk Information System (IRIS) at http://www.epa.gov/iris or from the Risk Assessment Information System (RAIS) database of the Oak Ridge National Laboratory (ORNL) on the Internet at http://risk.lsd.ornl.gov.

[b] Maximum Contaminant Levels (MCL) (40 CFR 141) and Secondary Maximum Contaminant Levels (40 CFR 143).

[c] Per WAC 173-340-740(3)(a)(ii)(A), Ecology 1996, in effect at the time the 1995 ROD was approved, nonradioactive contaminant concentrations in soil equal to or less than 100 times the groundwater cleanup level are protective of groundwater. The following example calculation assumes unit density for soil:
Y µg/L x 100 x 1 L/1,000 mL x 1 mL/1g x 1,000 g/1 kg x 1 mg/1,000 µg = 0.Y mg/kg.

[d] Hanford Site-specific background not available. Value is from Ecology, 1994, *Natural Background Soil Metals Concentrations in Washington State,* Publication No. 94-115, Washington State Department of Ecology, Olympia, Washington.

[e] Where cleanup levels are less than background or RDLs, cleanup levels default to background or RDLs per Ecology 1996, WAC 173-340-700(4)(d) and WAC 173-340-707(2), respectively. The arsenic cleanup level of 20 mg/kg has been agreed to by the Tri-Party Agreement Project Managers as discussed in Section 2.1.2.1 of this document.

[f] Toxicity data for these chemicals are not available. Cleanup levels are based on surrogate chemicals.
Contaminant: acenapthylene; surrogate: acenapthene
Contaminant: benzo(g,h,i)perylene; surrogate: pyrene
Contaminant: bis(2-chloroethoxy)methane; surrogate: bis(2-chloroethyl)ether
Contaminant: chloro-3-methylphenol; 4-; surrogate: methylphenol; 3-
Contaminant: phenathrene; surrogate: anthracene
Contaminant: dichloroprop; surrogate: Dichlorophenoxyacetic acid; 2,4-; (2,4-D)

[g] Common laboratory contaminant unlikely to be found in soil. If detected in soil, all analyses of blanks, duplicates, and splits should be checked and the original soil sample reanalyzed.

[h] The soil cleanup value for PCBs is based on the formula presented in WAC 173-340-740(3)(a)(iii)(B), Ecology 1996, and the cancer potency factor for ingestion of PCBs of 2.0 kg-day/mg (high risk and persistence) from the EPA Integrated Risk Information System (IRIS) on the internet at http://www.epa.gov/iris on January 3, 2006.

NA = not available
PCB = polychlorinated biphenyl
RDL = required detection limit
ROD = record of decision
TPH = total petroleum hydrocarbon
VOA = volatile organic analysis

Table B-3. Nonradionuclide Soil Cleanup Levels Protective of the Columbia River. (6 Pages)

Contaminant	Surface Water Cleanup Level (µg/L)[a]		Surface Water AWQC[b] (µg/L)	Soil RAG based on "100 X DAF"[c] (mg/kg)	Background (mg/kg)	RDL (mg/kg)	Soil Cleanup Levels for River Protection (mg/kg)
	Carcinogen	Noncarcinogen					
Metals							
Antimony		1,040	14	2.8	5[d]	0.6	5[e]
Arsenic	0.0982	17.7	0.018	0.0036	6.5	10	20[e]
Barium		2,000 (MCL)		400	132	2	400
Beryllium		273	4	0.8	1.51	0.5	1.51[e]
Boron				NA	NA	2	NA
Cadmium		20.3	0.91	0.182	0.81[d]	0.5	0.81[e]
Chromium, Total		243,000	65	13	18.5	1	18.5[e]
Chromium VI		486	10	2	NA	0.5	2
Cobalt				NA	15.7	2	NA
Copper		2,660	7.8	1.56	22.0	1	22.0[e]
Lead			2.1	0.42	10.2	5	10.2[e]
Lithium				NA	33.5	2.5	NA
Manganese				NA	512	5	512
Mercury			0.012	0.0024	0.33	0.2	0.33[e]
Methyl Mercury				NA	NA	NA	NA
Molybdenum				NA	NA	2	NA
Nickel		1,100	137	27.4	19.1	4	27.4
Selenium		2,700	5	1	0.78[d]	1	1
Silver		25,900	2.6	0.52	0.73	0.2	0.73[e]
Vanadium				NA	85.1	2.5	NA
Zinc		16,500	91	18.2	67.8	1	67.8[e]
Inorganics and TPH							
Cyanide		51,900	5.2	1.04	NA	0.5	1.04
Nitrate (as Nitrogen)		10,000		2,000	11.8	0.75	2,000
Nitrite (as Nitrogen)		1,000		200	NA	0.75	200
Sulfate				NA	237	5	NA
Sulfide				NA	NA	5	NA
TPH				200	NA	5	200

Table B-3. Nonradionuclide Soil Cleanup Levels Protective of the Columbia River. (6 Pages)

Contaminant	Surface Water Cleanup Level (µg/L) [a]		Surface Water AWQC [b] (µg/L)	Soil RAG based on "100 X DAF" [c] (mg/kg)	Background (mg/kg)	RDL (mg/kg)	Soil Cleanup Levels for River Protection (mg/kg)
	Carcinogen	Noncarcinogen					
VOAs							
Acetone [f]				NA	NA	0.02	NA
Carbon Tetrachloride [f]	2.66	96.8	0.25	0.05	NA	0.005	0.05
Methylene Chloride [f]	960	173,000	4.70	0.94	NA	0.005	0.94
Toluene [f]		19,400	6,800	1,360	NA	0.005	1,360
Semivolatiles							
Acenapthene		643		129	NA	0.33	129
Acenapthylene [g]		643		129	NA	0.33	129
Anthracene		25,900	9,600	1,920	NA	0.33	1,920
Benzo(a)anthracene	0.296		0.0028	0.00056	NA	0.33	0.33 [e]
Benzo(a)pyrene	0.0296		0.0028	0.00056	NA	0.33	0.33 [e]
Benzo(b)fluoranthene	0.296		0.0028	0.00056	NA	0.33	0.33 [e]
Benzo(k)fluoranthene	2.96		0.0028	0.00056	NA	0.33	0.33 [e]
Benzo(g,h,i)perylene [g]		2,590	960	192	NA	0.33	192
Bis(2-chloro-1-methylethyl) ether			37.5	7.50	NA	0.92	7.50
Bis(2-chloroethoxy)methane [g]	0.854			0.017	NA	0.33	0.33 [e]
Bis(2-chloroethyl) ether	0.854			0.017	NA	0.33	0.33 [e]
Bis(2-ethylhexyl)phthalate	3.56	399	1.8	0.36	NA	0.33	0.36
Bromophenylphenyl ether; 4-				NA	NA	0.33	NA
Butylbenzylphthalate		1,250		250	NA	0.33	250
Carbazole				NA	NA	0.33	NA
Chloro-3-methylphenol; 4- [g]				NA	NA	0.33	NA
Chloroanilene; 4-				NA	NA	0.33	NA
Chloronaphthalene; 2-		1,030		206	NA	0.33	206
Chlorophenol;2-		96.7		19.34	NA	0.33	19.34
Chlorophenylphenyl ether; 4-				NA	NA	0.33	NA

Table B-3. Nonradionuclide Soil Cleanup Levels Protective of the Columbia River. (6 Pages)

Contaminant	Surface Water Cleanup Level (µg/L) [a]		Surface Water AWQC [b] (µg/L)	Soil RAG based on "100 X DAF" [c] (mg/kg)	Background (mg/kg)	RDL (mg/kg)	Soil Cleanup Levels for River Protection (mg/kg)
	Carcinogen	Noncarcinogen					
Chrysene	29.6		0.00280	0.00056	NA	0.33	0.33 [e]
Dibenzo(a,h)anthracene	0.0296		0.00280	0.00056	NA	0.33	0.33 [e]
Dibenzofuran				NA	NA	0.33	NA
Dichlorobenzene; 1,2-		4,200	2,700	540	NA	0.33	540
Dichlorobenzene; 1,3-		1,400	400	80	NA	0.33	80
Dichlorobenzene; 1,4-	4.86		400	0.972	NA	0.33	0.972
Dichlorobenzidine; 3,3-	0.0462		400	0.0080	NA	0.33	0.33 [e]
Dichlorophenol; 2,4-		191	93	18.6	NA	0.33	18.6
Diethylphthalate		28,400	23,000	4,600	NA	0.33	4,600
Dimethylphthalate		72,000	313,000	14,400	NA	0.33	14,400
Dimethylphenol; 2,4-		553		110.6	NA	0.33	110.6
Di-n-butylphthalate		2,910	2,700	540	NA	0.33	540
Di-n-octylphthalate				NA	NA	0.33	NA
Dinitro-2-methylphenol; 4,6-				NA	NA	0.33	NA
Dinitrophenol; 2,4-		3,460	70	14.0	NA	0.825	14
Dinitrotoluene; 2,4-		1,360	0.110	0.022	NA	0.33	0.33 [e]
Dinitrotoluene; 2,6-		682		136	NA	0.33	136
Ethylene glycol				NA	NA	5	NA
Fluoranthene		90.2		18.0	NA	0.33	18.0
Fluorene		3,460	1,300	260	NA	0.33	260
Hexachlorobenzene	0.000466	0.239	0.000750	0.0000932	NA	0.33	0.33 [e]
Hexachlorobutadiene	29.9	187	0.440	0.088	NA	0.33	0.33 [e]
Hexachlorocyclopentadiene		3,580	240	48	NA	0.33	48
Hexachloroethane	5.33	29.8	1.90	0.38	NA	0.33	0.38
Indeno(1,2,3-cd) pyrene	0.296		0.00280	0.00056	NA	0.33	0.33 [e]
Hydrazine				NA	NA	0.33	NA
Isophorone	1,560	118,000	8.40	1.68	NA	0.33	1.68
Methylnaphthalene; 2-				NA	NA	0.33	NA
Methylphenol; 2- (cresol;o-)				NA	NA	0.33	NA

Table B-3. Nonradionuclide Soil Cleanup Levels Protective of the Columbia River. (6 Pages)

Contaminant	Surface Water Cleanup Level (µg/L)[a]		Surface Water AWQC[b] (µg/L)	Soil RAG based on "100 X DAF"[c] (mg/kg)	Background (mg/kg)	RDL (mg/kg)	Soil Cleanup Levels for River Protection (mg/kg)
	Carcinogen	Noncarcinogen					
Methylphenol; 4- (cresol;p-)				NA	NA	0.33	NA
Naphthalene		4,940		988	NA	0.33	988
Nitroaniline; 2-				NA	NA	0.33	NA
Nitroaniline; 3-				NA	NA	0.33	NA
Nitroaniline; 4-				NA	NA	0.33	NA
Nitrobenzene		449	17	3.4	NA	0.33	3.40
Nitrophenol; 2-				NA	NA	0.66	NA
Nitrophenol; 4-		6,270		1,254	NA	0.66	1,254
Nitroso-di-n-propylamine;N-	0.819			0.164	NA	0.33	0.33[e]
Nitrosodiphenylamine;N-	9.73			1.946	NA	0.33	1.946
Pentachlorophenol	4.91	7,070	0.28	0.056	NA	0.33	0.33[e]
Phenanthrene[g]		25,900	9,600	1,920	NA	0.33	1,920
Phenol		1,110,000	21,000	4,200	NA	0.33	4,200
Pyrene		2,590	960	192	NA	0.33	192
Tributyl Phosphate					NA	3.3	NA
Trichlorobenzene; 1,2,4-		227		45.4	NA	0.33	45.4
Trichlorophenol; 2,4,5-				NA	NA	0.33	NA
Trichlorophenol; 2,4,6-	3.93		2.10	0.42	NA	0.33	0.42
Pesticides, Herbicides, and PCBs							
Aldrin	0.0000816	0.0167	0.00013	0.0000163	NA	0.00165	0.00165[e]
BHC, alpha	0.00791			0.00158	NA	0.00165	0.00165[e]
BHC, beta (Hexachlorocyclohexane)	0.0277			0.00554	NA	0.00165	0.00554
BHC, delta				NA	NA	0.00165	NA
BHC, gamma (Lindane)	0.0384	5.98	0.019	0.0038	NA	0.00165	0.0038
Chlordane (alpha, gamma)	0.00131	0.0919	0.00057	0.000114	NA	0.0165	0.0165[e]
Dalapon				NA	NA	0.1	NA
Db; 2,4-				NA	NA	0.1	NA
DDD, 4,4-	0.000504		0.00083	0.000101	NA	0.0033	0.005[e]
DDE, 4,4-	0.000356		0.00059	0.0000712	NA	0.0033	0.005[e]

Table B-3. Nonradionuclide Soil Cleanup Levels Protective of the Columbia River. (6 Pages)

Contaminant	Surface Water Cleanup Level (µg/L) [a]		Surface Water AWQC [b] (µg/L)	Soil RAG based on "100 X DAF" [c] (mg/kg)	Background (mg/kg)	RDL (mg/kg)	Soil Cleanup Levels for River Protection (mg/kg)
	Carcinogen	Noncarcinogen					
DDT, 4,4-	0.000356	0.0242	0.00059	0.0000712	NA	0.0033	0.005 [e]
Dicambra				NA	NA	0.1	NA
Dichlorophenoxyacetic acid; 2,4-				NA	NA	0.4	NA
Dichloroprop [g]				NA	NA	0.1	NA
Dieldrin	0.0000867	0.0278	0.00014	0.0000173	NA	0.003	0.003 [e]
Dinoseb (DNBP)				NA	NA	0.01	NA
Endosulfan (I, II, sulfate)		57.6	0.056	0.0112	NA	0.003	0.0112
Endrin (and ketone, aldehyde)		0.196	0.76	0.039	NA	0.003	0.039
Heptachlor	0.000129	0.116	0.000210	0.00000258	NA	0.002	0.002 [e]
Heptachlor epoxide	0.0000636	0.00301	0.0001	0.00000127	NA	0.002	0.002 [e]
Methoxychlor		8.36		1.67	NA	0.02	1.67
Polychlorinated Biphenyls [h]	0.000104		0.00017	0.000021	NA	0.017	0.017 [e]
PCB Aroclor-1016	0.00297	0.00582		0.00059	NA	0.017	0.017 [e]
PCB Aroclor-1221	0.000104			0.000021	NA	0.017	0.017 [e]
PCB Aroclor-1232	0.000104			0.000021	NA	0.017	0.017 [e]
PCB Aroclor-1242	0.000104			0.000021	NA	0.017	0.017 [e]
PCB Aroclor-1248	0.000104			0.000021	NA	0.017	0.017 [e]
PCB Aroclor-1254	0.000104	0.00166		0.000021	NA	0.017	0.017 [e]
PCB Aroclor-1260	0.000104			0.000021	NA	0.017	0.017 [e]
Silvex (TP; 2,4,5-)					NA	0.02	NA
Toxaphene	0.00045		0.0002	0.00004	NA	0.2	0.2
Trichlorophenoxyacetic acid; 2,4,5-					NA	0.02	NA

Table B-3. Nonradionuclide Soil Cleanup Levels Protective of the Columbia River. (6 Pages)

Contaminant	Surface Water Cleanup Level (µg/L) [a]		Surface Water AWQC [b] (µg/L)	Soil RAG based on "100 X DAF" [c] (mg/kg)	Background (mg/kg)	RDL (mg/kg)	Soil Cleanup Levels for River Protection (mg/kg)
	Carcinogen	Noncarcinogen					

[a] Calculated using the appropriate formulas from Ecology 1996, WAC 173-340-730, with toxicity values updated through April 11, 2007, from the EPA Integrated Risk Information System (IRIS) at http://www.epa.gov/iris or from the Risk Assessment Information System (RAIS) database of the Oak Ridge National Laboratory (ORNL) on the Internet at http://risk.lsd.ornl.gov.

[b] Ambient Water Quality Criteria (AWQC) or criterion continuous concentration from 40 CFR 131.36 and WAC 173-201A-040 calculated using water hardness of 85 ppm $CaCO_3$.

[c] To maintain consistency, the same methodology used to obtain contaminant concentrations in soil protective of groundwater was applied to obtain contaminant concentrations in soil protective of the Columbia River (i.e., 100 times the remedial action goal with application of a dilution-attenuation factor [DAF] of 2)..

[d] Hanford Site-specific background not available. Value is from Ecology, 1994, *Natural Background Soil Metals Concentrations in Washington State,* Publication No. 94-115, Washington State Department of Ecology, Olympia, Washington.

[e] Where cleanup levels are less than background or RDLs, cleanup levels default to background or RDLs per Ecology 1996, WAC 173-340-700(4)(d) and WAC 173-340-707(2), respectively. The arsenic cleanup level of 20 mg/kg has been agreed to by the Tri-Party Agreement Project Managers as discussed in Section 2.1.2.1 of this document.

[f] Common laboratory contaminant unlikely to be found in soil. If detected in soil, all analyses of blanks, duplicates, and splits should be checked and the original soil sample reanalyzed.

[g] Toxicity data for these chemicals are not available. Cleanup levels are based on surrogate chemicals.
Contaminant: acenapthylene; surrogate: acenapthene
Contaminant: benzo(g,h,i)perylene; surrogate: pyrene
Contaminant: bis(2-chloroethoxy)methane; surrogate: bis(2-chloroethyl)ether
Contaminant: chloro-3-methylphenol; 4-; surrogate: methylphenol; 3-
Contaminant: phenathrene; surrogate: anthracene
Contaminant: dichloroprop; surrogate: Dichlorophenoxyacetic acid; 2,4-; (2,4-D).

[h] The soil cleanup value for PCBs is based on the formula presented in WAC 173-340-740(3)(a)(iii)(B), Ecology 1996, and the cancer potency factor for ingestion of PCBs of 2.0 kg-day/mg (high risk and persistence) from the EPA Integrated Risk Information System (IRIS) on the internet at http://www.epa.gov/iris on January 3, 2006.

NA = not available
PCB = polychlorinated biphenyl
RDL = required detection limit
TPH = total petroleum hydrocarbon
VOA = volatile organic analysis

Table B-4. Nonradionuclide Soil Lookup Value Summary. (4 Pages)

Contaminant	Kd Value (mL/g)	Back-ground (mg/kg)	Soil Cleanup Levels (mg/kg) [a]		
			Direct Exposure	Protective of Groundwater	Protective of the River
Metals					
Antimony	45	5	32	5 [b]	5 [b]
Arsenic	3	20	20	20	20
Barium	25	132	16,000	200	400
Beryllium	790	1.51	10.4 [c]	1.51 [b]	1.51 [b]
Boron [d]	3	--	16,000	320	--
Cadmium	30	0.81 [e]	13.9 [c]	0.81 [b]	0.81 [b]
Chromium, Total	200	18.5	120,000	18.5 [b]	18.5 [b]
Chromium VI [d]	0	--	2.1 [c]	4.8	2
Cobalt	50	15.7	1,600	32	--
Copper	22	22.0	2,960	59.2	22.0 [b]
Lead	30	10.2	353	10.2 [b]	10.2 [b]
Lithium	50	33.5	1,600	33.5 [b]	--
Manganese	50	512	11,200	512 [b]	512 [b]
Mercury	30	0.33	24	0.33 [b]	0.33 [b]
Methyl Mercury	--	--	8	0.16	0.16
Molybdenum [d]	20	--	400	8	--
Nickel	65	19.1	1,600	19.1 [b]	27.4
Selenium	150	0.78 [e]	400	5	1
Silver	90	0.73	400	8	0.73 [b]
Strontium	25	--	48,000	960	--
Tin	130	--	48,000	960	--
Uranium (soluble salts)	2	3.21	240	3.21	3.21
Vanadium	1,000	85.1	560	85.1 [b]	--
Zinc	30	67.8	24,000	480	67.8 [b]
Inorganics and TPH					
Cyanide	0	--	1,600	20	1.04
Fluoride	0.0143	2.81	4,800	960	400
Nitrate (as Nitrogen)	0	11.8	128,000	1,000	2,000
Nitrite (as Nitrogen)	0	--	8,000	100	200
Sulfate	2	237	--	25,000	50,000
Sulfide	0	--	--	--	--
TPH	50	--	--	200	200
VOAs					
Acetone [f]	0.0006	--	72,000	720	--
Carbon Tetrachloride [f]	0.152	--	7.69	0.0337	0.05
Methylene Chloride [f]	0.01	--	133	0.5	0.94
Toluene [f]	0.14	--	6,400	64	1,360
Xylene [f]	0.233	--	16,000	160	--
Semivolatiles					
Acenapthene	4.9	--	4,800	96	129
Acenapthylene [h]	6.12	--	4,800	96	129

Table B-4. Nonradionuclide Soil Lookup Value Summary. (4 Pages)

Contaminant	Kd Value (mL/g)	Back-ground (mg/kg)	Soil Cleanup Levels (mg/kg)[a]		
			Direct Exposure	Protective of Groundwater	Protective of the River
Anthracene	23.5	--	24,000	240	1,920
Benzo(a)anthracene	360	--	1.37	0.015[g]	0.015[g]
Benzo(a)pyrene	5,500	--	0.137	0.015[g]	0.015[g]
Benzo(b)fluoranthene	880	--	1.37	0.015[g]	0.015[g]
Benzo(k)fluoranthene	2,020	--	13.7	0.015[g]	0.015[g]
Benzo(g,h,i)perylene[h]	2,680	--	2,400	48	192
Bis(2-chloro-1-methylethyl) ether	0.0392	--	14.3	0.33[g]	7.50
Bis(2-chloroethoxy)methane[h]	0.00277	--	0.909	0.33[g]	0.33[g]
Bis(2-chloroethyl) ether	0.0760	--	0.909	0.33[g]	0.33[g]
Bis(2-ethylhexyl)phthalate	110	--	71.4	0.6	0.36
Bromophenylphenyl ether; 4-	4.16	--	--	--	--
Butylbenzylphthalate	13.8	--	16,000	320	250
Carbazole	200	--	50	0.437	--
Chloro-3-methylphenol; 4-[h]	--	--	4,000	80	--
Chloroanilene; 4-	0.0725	--	320	6.4	--
Chloronaphthalene; 2-	2.98	--	6,400	64	206
Chlorophenol;2-	0.388	--	400	4.00	19.34
Chlorophenylphenyl ether; 4-	--	--	--	--	--
Chrysene	200	--	137	1.2	0.1[g]
Dibenzo(a,h)anthracene	1,790	--	0.137	0.03[g]	0.03[g]
Dibenzofuran	11.3	--	160	3.20	--
Dichlorobenzene; 1,2-	0.379	--	7,200	60.0	540
Dichlorobenzene; 1,3-	0.434	--	2,400	24.0	80
Dichlorobenzene; 1,4-	0.616	--	41.7	0.33[g]	0.972
Dichlorobenzidine; 3,3-	0.724	--	2.22	0.33[g]	0.33[g]
Dichlorophenol; 2,4-	0.147	--	240	4.80	18.6
Diethylphthalate	0.0820	--	64,000	1,280	4,600
Dimethylphthalate	0.0371	--	80,000	1,600	14,400
Dimethylphenol; 2,4-	0.209	--	1,600	32.0	110.6
Di-n-butylphthalate	1.57	--	8,000	160	540
Di-n-octylphthalate	83,200	--	1,600	32	--
Dinitro-2-methylphenol; 4,6-	0.6015	--	8.00	0.2[g]	--
Dinitrophenol; 2,4-	0.00001	--	160	3.20	14
Dinitrotoluene; 2,4-	0.0955	--	160	3.20	0.013[g]
Dinitrotoluene; 2,6-	0.0692	--	80.0	1.60	136
Ethylene glycol	0.001	--	160,000	3,200	--
Fluoranthene	49.1	--	3,200	64	18.0
Fluorene	7.71	--	3,200	64	260
Hexachlorobenzene	80	--	0.625	0.013[g]	0.013[g]
Hexachlorobutadiene	53.7	--	12.8	0.05[g]	0.05[g]

Table B-4. Nonradionuclide Soil Lookup Value Summary. (4 Pages)

Contaminant	Kd Value (mL/g)	Back-ground (mg/kg)	Soil Cleanup Levels (mg/kg) [a]		
			Direct Exposure	Protective of Groundwater	Protective of the River
Hexachlorocyclopentadiene	200	--	480	5	48
Hexachloroethane	1.78	--	71.4	0.313	0.38
Hydrazine	0.0143	--	0.333	0.33 [g]	--
Indeno(1,2,3-cd) pyrene	3,470	--	1.37	0.03 [g]	0.03 [g]
Isophorone	0.0468	--	1,050	9.21	1.68
Methylnaphthalene; 2-	2.98	--	320	3.2	--
Methylphenol; 2- (cresol;o-)	0.434	--	4,000	80.0	--
Methylphenol; 4- (cresol;p-)	0.434	--	400	8.00	--
Naphthalene	1.19	--	1,600	16.0	988
Nitroaniline; 2-	0.0527	--	240	2.4	--
Nitroaniline; 3-	0.0516	--	24	0.33 [g]	--
Nitroaniline; 4-	0.0516	--	47.6	0.33 [g]	--
Nitrobenzene	0.119	--	40.0	0.40	3.40
Nitrophenol; 2-	--	--	--	--	--
Nitrophenol; 4-	0.309	--	640	12.8	1,254
Nitroso-di-n-propylamine;N-	0.0240	--	0.33	0.33 [g]	0.33 [g]
Nitrosodiphenylamine;N-	1.29	--	204	1.79	1.946
Pentachlorophenol	0.592	--	8.33	0.2 [g]	0.2 [g]
Phenanthrene [h]	23.5	--	24,000	240	1,920
Phenol	0.0288	--	24,000	480	4,200
Pyrene	68	--	2,400	48	192
Tributyl Phosphate	1.89	--	185	3.3 [g]	--
Trichlorobenzene; 1,2,4-	1.66	--	800	7	45.4
Trichlorophenol; 2,4,5-	1.60	--	8,000	160	--
Trichlorophenol; 2,4,6-	0.381	--	90.9	0.795	0.42
Pesticides and PCBs					
Aldrin	48.7	--	0.0588	0.002 [g]	0.002 [g]
BHC, alpha	1.76	--	0.159	0.002 [g]	0.002 [g]
BHC, beta	2.14	--	0.556	0.00486	0.00554
BHC, delta	3.38	--	--	--	--
BHC, gamma (Lindane)	1.35	--	0.769	0.00673	0.0038
Chlordane (alpha, gamma)	51	--	2.86	0.025	0.02 [g]
Dalapon	0.00274	--	2,400	20	--
Db; 2,4-	0.1	--	640	12.8	--
DDD, 4,4'-	45.8	--	4.17	0.0365	0.0033 [g]
DDE, 4,4'-	86.4	--	2.94	0.0257	0.0033 [g]
DDT, 4,4'-	678	--	2.94	0.0257	0.0033 [g]
Dicambra	0.0288	--	2,400	48	--
Dichlorophenoxyacetic acid; 2,4-	0.0294	--	800	7	--
Dichloroprop [h]	0.0294	--	800	7	--

Table B-4. Nonradionuclide Soil Lookup Value Summary. (4 Pages)

Contaminant	Kd Value (mL/g)	Back-ground (mg/kg)	Soil Cleanup Levels (mg/kg) [a]		
			Direct Exposure	Protective of Groundwater	Protective of the River
Dieldrin	25.6	--	0.0625	0.0033 [g]	0.0033 [g]
Dinoseb (DNBP)	3.54	--	80	0.7	--
Endosulfan (I, II, sulfate)	2.04	--	480	9.6	0.0112
Endrin (and ketone, aldehyde)	10.8	--	24	0.2	0.039
Heptachlor	9.53	--	0.222	0.002 [g]	0.002 [g]
Heptachlor epoxide	83.2	--	0.11	0.002 [g]	0.002 [g]
Methoxychlor	80	--	400	4	1.67
Polychlorinated Biphenyls	530	--	0.5 [i]	0.017 [g]	0.017 [g]
PCB Aroclor-1016	107	--	0.5	0.017 [g]	0.017 [g]
PCB Aroclor-1221	10.3	--	0.5	0.017 [g]	0.017 [g]
PCB Aroclor-1232	10.3	--	0.5	0.017 [g]	0.017 [g]
PCB Aroclor-1242	44.8	--	0.5	0.017 [g]	0.017 [g]
PCB Aroclor-1248	43.9	--	0.5	0.017 [g]	0.017 [g]
PCB Aroclor-1254	75.6	--	0.5	0.017 [g]	0.017 [g]
PCB Aroclor-1260	530	--	0.5	0.017 [g]	0.017 [g]
Silvex (tp;2,4,5-)	0.08	--	640	5	--
Toxaphene	95.8	--	0.909	0.2 [g]	0.2 [g]
Trichlorophenoxyacetic acid;2,4,5-	0.049	--	800	16	--

[a] Nonradionuclide soil concentrations protective of groundwater and the river are based upon application of the "100 times" rule (Ecology 1996).

[b] Where cleanup levels are less than background, cleanup levels default to background per WAC 173-340-700[4][d] (Ecology 1996).

[c] Carcinogenic cleanup level calculated based on the inhalation exposure pathway (WAC 173-340-750[3]) (Ecology 1996) using an airborne particulate mass-loading rate of 0.0001 g/m^3 (WDOH 1997).

[d] No Hanford Site-specific or Washington State background value available.

[e] Hanford Site-specific background not available. Value is from Ecology (1994).

[f] Common laboratory contaminant unlikely to be found in soil. If detected in soil, all analyses of blanks, duplicates, and splits should be checked and the original soil sample reanalyzed.

[g] Where cleanup levels are less than RDLs, cleanup levels default to RDLs per WAC 173-340-707(2) (Ecology 1996). The cited RDLs are based on analytical method numbers that may not be available for rapid turnaround analyses. Prior notification and concurrence with the laboratory may be necessary to analyze to meet this RDL. Actual detection limits may differ from any RDL.

[h] Toxicity data for this chemical are not available. Cleanup levels are based on surrogate chemicals:
Contaminant: acenapthylene; surrogate: acenapthene
Contaminant: benzo(g,h,i)perylene; surrogate: pyrene
Contaminant: bis(2-chloroethoxy)methane; surrogate: bis(2-chloroethyl)ether
Contaminant: chloro-3-methylphenol; 4-; surrogate: methylphenol; 3-
Contaminant: dichloroprop (pesticide); surrogate: Dichlorophenoxyacetic acid; 2,4-; (2,4-D)
Contaminant: phenathrene; surrogate: anthracene

[i] The soil cleanup value for PCBs is based on the formula presented in WAC 173-340-740(3)(a)(iii)(B), Ecology 1996, and the cancer potency factor for ingestion of PCBs of 2.0 kg-day/mg (soils) from the EPA Integrated Risk Information System (IRIS) on the internet at < http://www.epa.gov/iris >.

Kd = Distribution coefficient discussed in Appendix E. When unavailable from DOE-RL 2008, Kd values are taken from the Ecology CLARC Database at < http://www.ecy.wa.gov > or from the Risk Assessment Information System database maintained by the Oak Ridge National Laboratory at < http://risk.lsd.ornl.gov >.

PCB = polychlorinated biphenyl
RDL = required detection limit
TPH = total petroleum hydrocarbon
VOA = volatile organic analysis

Table B-5. RESRAD Determination of Direct Exposure Soil Lookup Values for Radionuclides. (2 Pages)

Radionuclides	Soil Concentration Corresponding to 15 mrem/yr (pCi/g)[a]	Hanford Site Background Activity (pCi/g)[b]	Required Detection Limit (pCi/g)[c]	Value Selected for Direct Exposure Lookup Value (pCi/g)
Ag (silver)-108m	2.39	NA[d]	0.1	2.39
Americium-241	32.2	NA[d]	1	32.2
Carbon-14	15.2	NA[d]	2	15.2
Cesium-137	6.2	1.1	0.1	6.2
Cobalt-60	1.5	0.008	0.05	1.5
Curium-243	22.1	NA[d]	1	22.1
Europium-152	3.4	NA[d]	0.1	3.4
Europium-154	3.2	0.033	0.1	3.2
Europium-155	135	0.054	0.1	135
Iodine-129	0.228	NA[d]	2	2[f]
Neptunium-237	2.44	NA[d]	1[e]	2.44
Nickel-63	4,029	NA[d]	30[e]	4,029
Niobium-94	2.43	NA[d]	0.2	2.43
Plutonium-238	39.0	0.004	1	39.0
Plutonium-239/240	35.1	0.025	1	35.1
Potassium-40	8.15	16.6	0.5	16.6[g]
Radium-226	1.06	0.815	0.1	1.06
Radium-228	1.69	NA[d]	0.2	1.69
Strontium-90	4.5	0.18	1[e]	4.5
Technetium-99	3.6	NA[d]	15	15[f]
Thorium-228	2.7	NA[d]	1[e]	2.7
Thorium-230	3.2	NA[d]	1[e]	3.2
Thorium-232	1.0	1.3	1[e]	1.3[g]
Tritium (H-3)[h]	406	NA[d]	30[e]	406
Uranium-233/234	0.30	1.1	1[e]	1.1[g]
Uranium-235	0.32	0.11	0.5	0.5[f]
Uranium-238	0.32	1.1	1[e]	1.1[g]

Table B-5. RESRAD Determination of Direct Exposure Soil Lookup Values for Radionuclides. (2 Pages)

Radionuclides	Soil Concentration Corresponding to 15 mrem/yr (pCi/g)[a]	Hanford Site Background Activity (pCi/g)[b]	Required Detection Limit (pCi/g)[c]	Value Selected for Direct Exposure Lookup Value (pCi/g)

[a] The RESRAD methodology used to calculate the single radionuclide soil concentrations is presented in Appendix B. Values in the table are lookup values based on the generic site model. Site-specific RAGs will be calculated for site closeout verification using site-specific information.

[b] Background concentrations are the 90th percentile values of the log normal distribution of site-wide soil background data. However, when comparing maximum concentrations at a site to background it is appropriate to use the 95th percentile. When this is done it should be stated in a footnote. Source: Table 5-1 of *Hanford Site Background: Part 2, Soil Background for Radionuclides* (DOE-RL 1996).

[c] The RDLs are based on contract-required quantitation limits/contract-required detection limits for offsite laboratories.

[d] NA = Not available; contaminant not evaluated during the background study.

[e] This RDL is not available via rapid turnaround; it is only available via a protocol method requiring a longer turnaround time.

[f] Where cleanup levels are less than practical quantitation limits (PQLs) of the best available analytical methodology, cleanup levels default to the PQLs (WAC 173-340-745[6][c] [1996]). Laboratory contractual RDLs are equivalent to PQLs for these analytes. Periodic review will be performed to determine if alternate or improved methodology has been developed yielding lower analytical detection limits.

[g] Contractual RDLs are set at a nominal 1 pCi/g for these isotopes. Actual sample detection limits are expected to be below this value for routine soil analyses. It is expected that the presence of analytes greater than the lookup values will be detected and reported for most samples.

[h] Tritium samples will be taken 15.2 cm (6 in.) below the excavation surface. If tritium is detected, a path forward will be developed with the lead regulatory agency for appropriate cleanup verification sampling (per TPA-CN-177).

RDL = required detection limit
RESRAD = RESidual RADioactivity

Table B-6. RESRAD Determination of Soil Radionuclide Lookup Values Protective of 100 Area Groundwater (2 Pages)

Radionuclides	RESRAD Input Soil Activity, (pCi/g)	Peak Year of Groundwater Concentration (yr)	Rqdionuclide Drinking Water RAG (pCi/L)	Drinking Water Concentration at Peak Year (pCi/L)	Calculated Soil Activity Protective of Groundwater [a] (pCi/g)	Hanford Site Background Activity (pCi/g) [b]	Required Detection Limit (RDL) (pCi/g)	Lookup Value Protective of Groundwater (pCi/g)
Ag (silver)-108m	1,000	NA	None	NA	NA	NA	0.1	NA
Americium-241	1,000	NA	1.2	NA	NA	NA	1	NA
Carbon-14	1,000	NA	2,000	NA	NA	NA	2	NA
Cesium-137	1,000	43	60	165.3	364	1.1	0.1	364
Cobalt-60	1,000	7.6	100	29.1	3,440	0.008	0.05	3,440
Curium-243	1,000	NA	15	NA	NA	NA	1	NA
Europium-152	1,000	NA	200	NA	NA	NA	0.1	NA
Europium-154	1,000	NA	60	NA	NA	0.033	0.1	NA
Europium-155	1,000	NA	600	NA	NA	0.054	0.1	NA
Iodine-129	1,000	18.1	1	4.42E+05	0.0023	NA	2	2 [d]
Neptunium-237	1,000	242	15	3.33E+04	0.45	NA	1 [c]	1 [d]
Nickel-63	1,000	138	50	1,680	30	NA	30 [c]	30
Niobium-94	1,000	NA	6.1	NA	NA	NA	0.2	NA
Plutonium-238	1,000	NA	1.6	NA	NA	0.004	1	NA
Plutonium-239/240	1,000	NA	1.2	NA	NA	0.025	1	NA
Potassium-40	1,000	65	1.9	1.22E+05	0.016	16.6	0.5	16.6 [e]
Radium-226	1,000	NA	5	NA	NA	0.815	0.1	NA
Radium-228	1,000	NA	5	NA	NA	NA	0.2	NA
Strontium-90	1,000	42	8	766.1	10.4	0.18	1 [c]	10.4
Technetium-99	1,000	3.6	900	3.651E+06	0.25	NA	15	15 [d]

Table B-6. RESRAD Determination of Soil Radionuclide Lookup Values Protective of 100 Area Groundwater (2 Pages)

Radionuclides	RESRAD Input Soil Activity, (pCi/g)	Peak Year of Groundwater Concentration (yr)	Rqdionuclide Drinking Water RAG (pCi/L)	Drinking Water Concentration at Peak Year (pCi/L)	Calculated Soil Activity Protective of Groundwater [a] (pCi/g)	Hanford Site Background Activity (pCi/g) [b]	Required Detection Limit (RDL) (pCi/g)	Lookup Value Protective of Groundwater (pCi/g)
Thorium-228	1,000	NA	15	NA	NA	NA	1 [c]	NA
Thorium-230	1,000	NA	15	NA	NA	NA	1 [c]	NA
Thorium-232	1,000	NA	2	NA	NA	1.3	1 [c]	NA
Tritium (H-3)	1,000	3.7	20,000	2.98E+06	6.7	NA	10 [c]	10
Uranium-233/234	1,000	33	21.2	2.36E+05	0.090	1.1	1 [c]	1.1 [e]
Uranium-235	1,000	33	21.2	2.36E+05	0.090	0.11	0.5	0.5 [d]
Uranium-238	1,000	33	21.2	2.36E+05	0.090	1.1	1 [c]	1.1 [e]

[a] Calculated with RESRAD Version 6.4 using drinking water concentrations at peak year with 4.6 m cover and no uncontaminated deep zone (12 m contaminated zone and no uncontaminated unsaturated zone). Calculated using the formula: (Soil activity protective of groundwater) = (Input soil activity) x (MCL) / (Drinking water concentration at peak year).

[b] Background concentrations are 90th percentile values of the log normal distribution of Hanford Site soil background data from Table 5-1 of DOE-RL 1996.

[c] This RDL is not available via rapid turnaround; it is only available via a method requiring a longer turnaround time. Prior notification and concurrence with the laboratory is necessary to analyze to meet this RDL. Actual detection limits may differ from any RDL.

[d] The remedial action goal is below the RDL. The value presented is the RDL.

[e] The remedial action goal is below the Hanford-specific soil background concentration. The value presented is the Hanford-specific soil background concentration.

NA = Not Applicable or Not Available. For calculated soil activities or lookup values protective of groundwater RESRAD predicts these radionuclides will not reach groundwater within 1,000 years assuming that no uncontaminated vadose zone exists between contamination and groundwater.

RAG = Remedial action goal or drinking water maximum contaminant level (MCL) obtained from 40 CFR 141.66 or from EPA/540-R-00-007 (EPA 2000a) as calculated using National Bureau of Standards (NBS Handbook 69) (NBS 1963) maximum permissible concentrations.

Table B-7. Summary of 100 Area Radionuclide Lookup Values (2 Pages)

Radionuclides	Distribution Coefficient, Kd Value, (mL/g)	Background Activity (pCi/g) [a]	Required Detection Limit (pCi/g)	Direct Exposure Lookup Value (pCi/g)	Lookup Value Protective of Groundwater (pCi/g)	Lookup Value Protective of the Columbia River (pCi/g)
Ag (silver)-108m	90	NA	0.1 [b]	2.39	NA	NA
Americium-241	200	NA	1	32.2	NA	NA
Carbon-14	200 [c]	NA	2	15.2	NA	NA
Cesium-137	50	1.1	0.1	6.2	364	728 [d]
Cobalt-60	50	0.008	0.05	1.5	3,440	6,880 [d]
Curium-243	200	NA	1 [b, e]	22.1	NA	NA
Europium-152	200	NA	0.1	3.4	NA	NA
Europium-154	200	0.033	0.1	3.2	NA	NA
Europium-155	200	0.054	0.1	135	NA	NA
Iodine-129	1	NA	2	2 [f]	2 [f]	2 [f]
Neptunium-237	15	NA	1	2.44	1 [f]	1 [f]
Nickel-63	30	NA	30 [g]	4,029	30	60
Niobium-94	200	NA	0.2 [b]	2.43	NA	NA
Plutonium-238	200	0.004	1	39.0	NA	NA
Plutonium-239/240	200	0.025	1	35.1	NA	NA
Potassium-40 [h]	4	16.6	0.5 [b]	16.6 [i]	16.6 [i]	16.6 [i]
Radium-226	200	0.815	0.1	1.04	NA	NA
Radium-228	200	NA	0.2	1.69	NA	NA
Strontium-90	25	0.18	1 [g]	4.5	10.4	20.8
Technetium-99	0	NA	15	15 [f]	15 [f]	15 [f]
Thorium-228	200	NA	1 [g]	2.7	NA	NA
Thorium-230	200	NA	1 [g]	3.2	NA	NA
Thorium-232	200	1.3	1 [g]	1.0 [i]	NA	NA

Table B-7. Summary of 100 Area Radionuclide Lookup Values (2 Pages)

Radionuclides	Distribution Coefficient, Kd Value, (mL/g)	Background Activity (pCi/g) [a]	Required Detection Limit (pCi/g)	Direct Exposure Lookup Value (pCi/g)	Lookup Value Protective of Groundwater (pCi/g)	Lookup Value Protective of the Columbia River (pCi/g)
Tritium (H-3)	0	NA	10 [g]	406	10 [f]	13.4 [d]
Uranium-233/234	2	1.1	1 [g]	1.1 [i]	1.1 [i]	1.1 [i]
Uranium-235	2	0.11	0.5 [g]	0.5 [f]	0.5 [f]	0.5 [f]
Uranium-238	2	1.1	1 [g]	1.1 [i]	1.1 [i]	1.1 [i]

NA = Not Available. For lookup values protective of groundwater or the Columbia River RESRAD predicts these radionuclides will not reach groundwater within 1,000 years assuming that no uncontaminated vadose zone exists between contamination and groundwater. A site-specific evaluation must be performed to demonstrate groundwater/river protection using either: (1) The analogous site evaluation described in Appendix C to show that residual concentrations are not predicted to migrate to groundwater within 1,000 years based on the soil-partitioning coefficient (Kd value) of the constituent(s) and the thickness of the vadose zone underlying the remediation footprint; or (2) A RESRAD calculation brief showing that residual radionuclide concentrations are predicted to be protective of groundwater.

[a] Background concentrations are 90th percentile values of the log normal distribution of Hanford Site soil background data from Table 5-1 of DOE-RL 1996. However, when comparing maximum activities at a site to background it is appropriate to use the 95th percentile UCL values from the same table. If this is necessary it should be stated in a table footnote.

[b] No RDL has been established for this isotope. Value shown represents expected performance relative to defined RDLs for cesium-137 and cobalt 60.

[c] The Kd of 200 for C-14 will be applicable to the 100 Areas, except for the 100-K Area, where a site-specific value will be established prior to close out of waste sites.

[d] The lookup value for protection of the Columbia River is the radionuclide-specific soil activity protective of groundwater from Table B-6 multiplied by the dilution-attenuation factor (DAF) of 2. See discussion in Appendix C.

[e] Curium-243 is not resolvable from curium-244. The laboratory reports the total of curium-243 and curium-244.

[f] Where cleanup levels are less than practical quantitation limits (PQLs) of the best available analytical methodology, cleanup levels default to the PQLs (WAC 173-340-745[6][c]) (1996). Laboratory contractual RDLs are equivalent to PQLs for these analytes. Periodic review will be performed to determine if alternate or improved methodology has been developed yielding lower analytical detection limits.

[g] This RDL is not available via rapid turnaround; it is only available via a method requiring a longer turnaround time. Prior notification and concurrence with the laboratory is necessary to analyze to meet this RDL. Actual detection limits may differ from any RDL.

[h] Potassium-40 is a naturally occurring radionuclide and should not be reported as a COC or COPC.

[i] The remedial action goal is below the Hanford-specific soil background concentration. The value presented is the Hanford-specific soil background concentration.

Table B-8. Input Parameter Values Used in RESRAD to Calculate Remedial Action Goals for Direct Exposure and Groundwater/River Protection. (6 Pages)

RESRAD Category	Parameter	Units	User Input, Direct Exposure [a]	User Input, Groundwater/ River Protection [b]	Rationale	Reference
Exposure Pathways		NA	External Gamma, Inhalation, Plant Ingestion, Meat Ingestion, Milk Ingestion, Aquatic Foods, Drinking Water, Soil Ingestion	Plant Ingestion, Meat Ingestion, Milk Ingestion, Aquatic Foods, Drinking Water		
R011 - CZ	Area of CZ	m^2	10,000	10,000	Generic site model [c]	
	Thickness of CZ [d]	m	4.6	12	Direct exposure cleanup standards apply to the upper 4.6 m (15 ft) and GW/River protection standards apply to the bottom 12 m of the vadose zone in the generic site model.	**DOE-RL et al. 2008**
	Length Parallel to Aquifer Flow	m	100	100	Square root of contaminated site area	
	Radiation Dose Limit	mrem/yr	15	4	Direct exposure - proposed federal standard for soil; GW/River - standard promulgated under SDWA	40 CFR 196 40 CFR 141
	Elapsed Time of Waste Placement	yr	0	0	RESRAD default	
R012 –Principal Radionuclides Concentrations	All radionuclide contaminants of concern	pCi/g	95% UCL statistical values	95% UCL statistical values		
R013 - Cover and CZ Hydrological Data	Cover Depth	m	0	4.6	Generic site model; GW/River - Assume clean fill is used to applicable depth of remediation	
	Density of Cover Material	g/cm^3	Not used	1.6		
	Cover Erosion Rate	m/yr	Not used	0.001		
	Density of CZ	g/cm^3	1.6 - Soil 2.31 - Concrete	1.6 - Soil 2.31 - Concrete	Hanford 100 Area-specific data Concrete-specific density	DOE/RL-90-07 (DOE-RL 1992) *Perry's Chemical Engineers' Handbook*, (Perry 1973)
	CZ Erosion Rate	m/yr	0.001	0.001	RESRAD default	

Table B-8. Input Parameter Values Used in RESRAD to Calculate Remedial Action Goals for Direct Exposure and Groundwater/River Protection. (6 Pages)

RESRAD Category	Parameter	Units	User Input, Direct Exposure [a]	User Input, Groundwater/ River Protection [b]	Rationale	Reference
R013 - Cover and CZ Hydrological Data (cont.)	CZ Total Porosity		0.4	0.4	WDOH guidance	WDOH/320-015 (WDOH 1997)
	CZ Field Capacity		0.15	0.15	Same as SZ Field Capacity	
	CZ Hydraulic Conductivity	m/yr	250	250	Hanford 100 Area-specific data	DOE/RL-96-11 (DOE-RL 1997) DOE/RL-93-37 (DOE-RL 1994b)
	CZ b Parameter		4.05	4.05	WDOH guidance	WDOH/320-015 (WDOH 1997)
	Humidity in Air	g/cm^3	8	8	RESRAD default	
	Evapotranspiration Coefficient		0.81	0.81	**Conservative agreement among Tri-Parties**	**Based on DOE-RL et al. 2008**
	Wind Speed	M/s	3.4	3.4	Hanford Site average	PNNL-12087 (Burke et al. 1999)
	Precipitation	m/yr	0.173	0.173	Based on 17.3 cm (6.81 in.) average annual rainfall	PNNL-15160 (PNNL 2005)
	Irrigation Rate	m/yr	0.76	0.76	EPA, Region X guidance	Letter from EPA
	Irrigation Mode		Overhead	Overhead	RESRAD default	
	Runoff Coefficient		0.2	0.2	RESRAD default	
	Watershed Area for Nearby Stream or Pond	m^2	1,000,000	1,000,000	RESRAD default	
	Accuracy for Water/Soil Computations		0.001	0.001	RESRAD default	
R014 - SZ Hydrological Data	Density of SZ	g/cm^3	1.6	1.6	Hanford 100 Area-specific data	DOE/RL-90-07 (DOE-RL 1992)
	SZ Total Porosity		0.4	0.4	WDOH guidance	WDOH/320-015 (WDOH 1997)
	SZ Effective Porosity		0.25	0.25	Agreement among the Tri-Parties [e]	ANL 1993, Table 3.2
	SZ Field Capacity		0.15	0.15	Field Capacity = Total Porosity - Effective Porosity	ANL 1993, Equation 4.4
	SZ Hydraulic Conductivity	m/yr	5,530	5,530	Hanford 100 Area-specific data	DOE/RL-96-11 (DOE-RL 1997) DOE/RL-93-37 (DOE-RL 1994b)
	SZ Hydraulic Gradient		0.00125	0.00125	Based on GW velocity = 27.8 m/yr, porosity = 0.25, hydraulic conductivity = 5,530	DOE/RL-94-136 (DOE-RL 1994a)
	SZ b Parameter		4.05	4.05	WDOH guidance	WDOH/320-015 (WDOH 1997)

Table B-8. Input Parameter Values Used in RESRAD to Calculate Remedial Action Goals for Direct Exposure and Groundwater/River Protection. (6 Pages)

RESRAD Category	Parameter	Units	User Input, Direct Exposure [a]	User Input, Groundwater/ River Protection [b]	Rationale	Reference
	Water Table Drop Rate	m/yr	0.001	0.001	RESRAD default	
R014 - SZ Hydrological Data (cont.)	Well Pump Intake Depth	m below water table	4.6	4.6	Typical RCRA well screen length	
	Nondispersion or Mass-Balance		ND	ND	RESRAD default	
	Well Pumping Rate	m^3/yr	250	250	RESRAD default	
R015 - Uncontaminated and Unsaturated Strata Hydrological Data	Number of Unsaturated Strata		1	1	Generic site model; one contaminated zone, one uncontaminated zone	DOE/RL-96-17 (this document)
	Thickness [d]	m	12	0	Generic site model	DOE/RL-96-17 (this document), **DOE-RL et al. 2008**
	Soil Density	g/cm^3	1.6 - Soil 2.31 - Concrete	1.6 - Soil 2.31 - Concrete	Hanford 100 Area-specific data Concrete specific density	DOE/RL-90-07 (DOE-RL 1992) *Perry's Chemical Engineers' Handbook* (Perry 1973)
	Total Porosity		0.4	0.4	WDOH guidance	WDOH/320-015 (WDOH 1997)
	Effective Porosity		0.25	0.25	Agreement among the Tri-Parties [e]	ANL 1993, Table 3.2
	Field Capacity		0.15	0.15	Field Capacity = Total Porosity - Effective Porosity	ANL 1993, Equation 4.4
	Soil-specific b Parameter		4.05	4.05	WDOH guidance	WDOH/320-015 (WDOH 1997)
	Hydraulic Conductivity	m/yr	250	250	Hanford 100-Area specific data	DOE/RL-96-11 (DOE-RL 1997) DOE/RL-93-37 (DOE-RL 1994b)
R016 - Distribution Coefficients and Leach Rates	CZ K_d	mL/g	Contaminant-specific	Contaminant-specific	Appendices D and E	DOE/RL-96-17 (this document)
	Uncontaminated Zone K_d		Contaminant-specific	Contaminant-specific	Appendices D and E	DOE/RL-96-17 (this document)
	Saturated Zone K_d		Contaminant-specific	Contaminant-specific	Appendices D and E	DOE/RL-96-17 (this document)
	Leach Rate	yr	Contaminant-specific	Contaminant-specific	RESRAD manual	
	Saturated Solubility		0	0	RESRAD default	
R017 - Inhalation and External Gamma	Inhalation Rate	m^3/yr	7,300	Not used	WDOH guidance	WDOH/320-015 (WDOH 1997)
	Mass Loading for Inhalation	g/m^3	0.0001	Not used	WDOH guidance	WDOH/320-015 (WDOH 1997)
	Exposure Duration	yr	30	30	RESRAD default	

Table B-8. Input Parameter Values Used in RESRAD to Calculate Remedial Action Goals for Direct Exposure and Groundwater/River Protection. (6 Pages)

RESRAD Category	Parameter	Units	User Input, Direct Exposure [a]	User Input, Groundwater/ River Protection [b]	Rationale	Reference
R017 - Inhalation and External Gamma (cont.)	Indoor Dust Filtration Factor		0.4	Not used	RESRAD default	
	External Gamma Shielding Factor		0.8	Not used	WDOH guidance	WDOH/320-015 (WDOH 1997)
	Indoor Time Fraction		0.6	Not used	WDOH guidance	WDOH/320-015 (WDOH 1997)
	Outdoor Time Fraction		0.2	Not used	WDOH guidance	WDOH/320-015 (WDOH 1997)
	Shape Factor		Circular	Not used	RESRAD default	
R018 - Ingestion Pathway Data, Dietary Parameters	Fruits, Vegetables, and Grain Consumption	kg/yr	110	110	WDOH guidance	WDOH/320-015 (WDOH 1997)
	Leafy Vegetable Consumption	kg/yr	2.7	2.7	WDOH guidance	WDOH/320-015 (WDOH 1997)
	Milk Consumption	L/yr	100	100	WDOH guidance	WDOH/320-015 (WDOH 1997)
	Meat and Poultry Consumption	kg/yr	36	36	WDOH guidance	WDOH/320-015 (WDOH 1997)
	Fish Consumption	kg/yr	19.7 [f]	19.7 [f]	WDOH guidance	WDOH/320-015 (WDOH 1997)
	Other Seafood Consumption	kg/yr	0.9	0.9	RESRAD default	
	Soil Ingestion	g/yr	73 [f]	Not used	WDOH guidance	WDOH/320-015 (WDOH 1997)
	Drinking Water Intake	L/yr	730	730	WDOH guidance	WDOH/320-015 (WDOH 1997)
	Drinking Water Contamination Fraction		1	1	RESRAD default	
	Household Water Contamination Fraction		1	1	RESRAD default	
	Livestock Water Contamination Fraction		1	1	RESRAD default	
	Irrigation Water Contamination Fraction		1	1	RESRAD default	
	Aquatic Food Contamination Fraction		0.5	0.5	RESRAD default	
	Plant Food Contamination Fraction		-1	-1	RESRAD default	

Table B-8. Input Parameter Values Used in RESRAD to Calculate Remedial Action Goals for Direct Exposure and Groundwater/River Protection. (6 Pages)

RESRAD Category	Parameter	Units	User Input, Direct Exposure [a]	User Input, Groundwater/ River Protection [b]	Rationale	Reference
R018 - Ingestion Pathway Data, Dietary Parameters (cont.)	Meat Contamination Fraction		-1	-1	RESRAD default	
	Milk Contamination Fraction		-1	-1	RESRAD default	
R019 - Ingestion Pathway Data, Nondietary	Livestock Fodder Intake for Meat	kg/d	68	68	RESRAD default	
	Livestock Fodder Intake for Milk	kg/d	55	55	RESRAD default	
	Livestock Water Intake for Meat	L/d	50	50	RESRAD default	
	Livestock Water Intake for Milk	L/d	160	160	RESRAD default	
	Livestock Intake of Soil	kg/d	0.5	0.5	RESRAD default	
	Mass Loading for Foliar Deposition	g/m^3	0.0001	0.0001	RESRAD default	
	Depth of Soil Mixing Layer	m	0.15	0.15	RESRAD default	
	Depth of Roots	m	0.9	0.9	RESRAD default	
R020 – Groundwater Usage	Groundwater Fractional Usage - Drinking Water		1	1	RESRAD default	
	Groundwater Fractional Usage - Household Usage		1	1	RESRAD default	
	Groundwater Fractional Usage - Livestock Water		1	1	RESRAD default	
	Groundwater Usage - Irrigation		1	1	RESRAD default	
R021 - Radon	Radon parameters are not used; Radon is not a Hanford Site COPC.				WDOH guidance	WDOH/320-015 (WDOH 1997)

Table B-8. Input Parameter Values Used in RESRAD to Calculate Remedial Action Goals for Direct Exposure and Groundwater/River Protection. (6 Pages)

RESRAD Category	Parameter	Units	User Input, Direct Exposure [a]	User Input, Groundwater/ River Protection [b]	Rationale	Reference

Note: Site-specific input parameters, such as the thickness of the contaminated zone and the thickness of the uncontaminated zone, will be determined on a site-specific basis for cleanup verification calculations.

[a] Input parameters used to calculate single radionuclide soil concentrations corresponding to a 15 mrem/yr dose.

[b] Input parameters used to determine if contaminants in soil will reach groundwater within a 1,000-year time frame.

[c] Generic site model parameters will be changed to site-specific values for cleanup verification.

[d] These values are for preliminary use only. The thickness of the contaminated zone and the thickness of the uncontaminated zone will be determined on a site-specific basis for cleanup verification calculations.

[e] Use of an effective porosity of 0.25 as a generic 100 Area input parameter is based upon agreement among the Tri-Parties. An effective porosity of 0.25 corresponds to values for sand and gravel reported in ANL (1993), Table 3.2.

[f] *Environmental Restoration Contractor Meeting Minutes - 100 Area Remedial Action and Waste Disposal Unit Managers' Meeting*, May 18, 2000, ERC CCN 079768, Approved by U.S. Environmental Protection Agency, Washington State Department of Ecology, and U.S. Department of Energy, Richland Operations Office, Richland, Washington. The soil ingestion input parameter values are in accordance with WAC 173-340-740(3)(iii)(B), Ecology 1996.

ANL = Argonne National Laboratory
CZ = contaminated zone
EPA = U.S. Environmental Protection Agency
GW = groundwater
NA = not applicable
ND = not detected
RCRA = *Resource Conservation and Recovery Act of 1976*
SDWA = *Safe Drinking Water Act*
SZ = saturated zone
UCL = upper confidence limit
WDOH = Washington State Department of Health

Table B-9. RESRAD Output Showing Calculated Single Radionuclide Soil Concentrations Corresponding to a 15 mrem/yr Direct Exposure Dose Rate.

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RESRAD Version 6.4 File: C:\RESRAD_FAMILY\RESRAD\EVAPOTRANSPIRATION81.RAD
            Summed Dose/Source Ratios DSR(i,t) in (mrem/yr)/(pCi/g)
            and Single Radionuclide Soil Guidelines G(i,t) in pCi/g
         at tmin = time of minimum single radionuclide soil guideline
     and at tmax = time of maximum total dose =   184.1 ñ 0.4 years
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Nuclide (i)	Initial (pCi/g)	tmin (years)	DSR(i,tmin)	G(i,tmin) (pCi/g)	DSR(i,tmax)	G(i,tmax) (pCi/g)
Ac-227	1.000E+03	0.000E+00	4.456E+00	3.366E+00	1.027E-02	1.460E+03
Ag-108m	1.000E+03	0.000E+00	6.284E+00	2.387E+00	2.194E+00	6.836E+00
Am-241	1.000E+03	0.000E+00	4.663E-01	3.217E+01	3.400E-01	4.411E+01
Ba-133	1.000E+03	0.000E+00	1.236E+00	1.214E+01	7.853E-06	1.910E+06
C-14	1.000E+03	0.000E+00	9.871E-01	1.520E+01	0.000E+00	*4.455E+12
Cm-243	1.000E+03	0.000E+00	6.704E-01	2.238E+01	7.954E-03	1.886E+03
Co-60	1.000E+03	0.000E+00	9.905E+00	1.514E+00	2.789E-10	5.379E+10
Cs-134	1.000E+03	0.000E+00	5.438E+00	2.758E+00	6.659E-27	*1.295E+15
Cs-137	1.000E+03	0.000E+00	2.400E+00	6.250E+00	3.133E-02	4.787E+02
Eu-152	1.000E+03	0.000E+00	4.376E+00	3.428E+00	2.983E-04	5.029E+04
Eu-154	1.000E+03	0.000E+00	4.729E+00	3.172E+00	2.335E-06	6.425E+06
Eu-155	1.000E+03	0.000E+00	1.114E-01	1.346E+02	7.331E-13	2.046E+13
H-3	1.000E+03	11.71 ñ 0.02	3.690E-02	4.065E+02	0.000E+00	*9.597E+15
I-129	1.000E+03	97.9 ñ 0.2	1.254E+02	1.196E-01	2.125E+01	7.059E-01
K-40	1.000E+03	360.3 ñ 0.7	2.963E+00	5.063E+00	4.371E-01	3.432E+01
Mn-54	1.000E+03	0.000E+00	2.289E+00	6.554E+00	0.000E+00	*7.746E+15
Nb-94	1.000E+03	0.000E+00	6.174E+00	2.429E+00	6.006E+00	2.497E+00
Ni-63	1.000E+03	0.000E+00	3.723E-03	4.029E+03	8.552E-04	1.754E+04
Np-237	1.000E+03	0.000E+00	6.143E+00	2.442E+00	4.637E+00	3.235E+00
Pu-238	1.000E+03	0.000E+00	3.851E-01	3.895E+01	9.031E-02	1.661E+02
Pu-239	1.000E+03	0.000E+00	4.276E-01	3.508E+01	4.163E-01	3.603E+01
Pu-240	1.000E+03	0.000E+00	4.275E-01	3.509E+01	4.104E-01	3.655E+01
Pu-241	1.000E+03	55.7 ñ 0.1	1.409E-02	1.065E+03	1.172E-02	1.280E+03
Ra-226	1.000E+03	91.9 ñ 0.2	1.421E+01	1.055E+00	1.374E+01	1.092E+00
Ra-228	1.000E+03	1.755 ñ 0.004	8.858E+00	1.693E+00	3.700E-09	4.054E+09
Sb-125	1.000E+03	0.000E+00	1.272E+00	1.179E+01	0.000E+00	*1.033E+15
Se-79	1.000E+03	12.36 ñ 0.02	5.190E+01	2.890E-01	2.414E-12	*6.969E+10
Sr-90	1.000E+03	0.000E+00	3.287E+00	4.564E+00	3.467E-02	4.326E+02
Tc-99	1.000E+03	12.30 ñ 0.02	4.141E+00	3.623E+00	1.899E-13	*1.697E+10
Th-228	1.000E+03	0.000E+00	5.571E+00	2.692E+00	5.792E-29	*8.195E+14
Th-230	1.000E+03	1.000E+03	4.754E+00	3.155E+00	1.156E+00	1.297E+01
Th-232	1.000E+03	58.7 ñ 0.1	1.436E+01	1.045E+00	1.417E+01	1.059E+00
U-232	1.000E+03	183.9 ñ 0.4	3.932E+01	3.815E-01	3.932E+01	3.815E-01
U-233	1.000E+03	184.3 ñ 0.4	5.070E+01	2.959E-01	5.066E+01	2.961E-01
U-234	1.000E+03	184.3 ñ 0.4	4.962E+01	3.023E-01	4.960E+01	3.024E-01
U-235	1.000E+03	184.3 ñ 0.4	4.706E+01	3.187E-01	4.703E+01	3.189E-01
U-236	1.000E+03	184.3 ñ 0.4	4.720E+01	3.178E-01	4.717E+01	3.180E-01
U-238	1.000E+03	184.3 ñ 0.4	4.718E+01	3.180E-01	4.716E+01	3.181E-01

*At specific activity limit

Table B-10. RESRAD Output Showing Year of Maximum Predicted Groundwater Concentration for Each Radionuclide.

RESRAD Version 6.4 File: C:\RESRAD_FAMILY\RESRAD\EVAPOTRANSPIRATION81_NOVZ.RAD
Summed Dose/Source Ratios DSR(i,t) in (mrem/yr)/(pCi/g)
and Single Radionuclide Soil Guidelines G(i,t) in pCi/g
at tmin = time of minimum single radionuclide soil guideline
and at tmax = time of maximum total dose = 32.63 ñ 0.07 years

Nuclide (i)	Initial (pCi/g)	tmin (years)	DSR(i,tmin)	G(i,tmin) (pCi/g)	DSR(i,tmax)	G(i,tmax) (pCi/g)
Ac-227	1.000E+03	30.74 ñ 0.06	1.122E+01	1.336E+00	1.120E+01	1.339E+00
Ag-108m	1.000E+03	182.0 ñ 0.4	1.680E-03	8.929E+03	6.898E-04	2.174E+04
Am-241	1.000E+03	1.000E+03	1.496E-02	1.003E+03	9.252E-05	1.621E+05
Ba-133	1.000E+03	15.00 ñ 0.03	1.668E-04	8.993E+04	1.142E-04	1.313E+05
C-14	1.000E+03	0.000E+00	0.000E+00	*4.455E+12	0.000E+00	*4.455E+12
Cm-243	1.000E+03	1.000E+03	1.690E-08	8.878E+08	2.324E-10	6.454E+10
Co-60	1.000E+03	7.57 ñ 0.01	8.625E-04	1.739E+04	1.316E-04	1.140E+05
Cs-134	1.000E+03	2.571 ñ 0.005	1.361E-03	1.102E+04	6.166E-07	2.433E+07
Cs-137	1.000E+03	42.73 ñ 0.09	1.382E-02	1.085E+03	1.338E-02	1.121E+03
Eu-152	1.000E+03	0.000E+00	0.000E+00	*1.765E+14	0.000E+00	*1.765E+14
Eu-154	1.000E+03	0.000E+00	0.000E+00	*2.639E+14	0.000E+00	*2.639E+14
Eu-155	1.000E+03	0.000E+00	0.000E+00	*4.652E+14	0.000E+00	*4.652E+14
H-3	1.000E+03	3.734 ñ 0.007	1.846E-01	8.125E+01	4.853E-03	3.091E+03
I-129	1.000E+03	18.07 ñ 0.04	1.405E+02	1.067E-01	1.255E+02	1.195E-01
K-40	1.000E+03	64.9 ñ 0.1	3.125E+00	4.800E+00	1.695E+00	8.852E+00
Mn-54	1.000E+03	0.821 ñ 0.002	2.080E-05	7.211E+05	3.571E-15	4.201E+15
Nb-94	1.000E+03	0.000E+00	0.000E+00	*1.875E+11	0.000E+00	*1.875E+11
Ni-63	1.000E+03	137.7 ñ 0.3	1.374E-03	1.092E+04	7.113E-04	2.109E+04
Np-237	1.000E+03	242.0 ñ 0.5	1.227E+02	1.223E-01	1.774E+01	8.453E-01
Pu-238	1.000E+03	188.8 ñ 0.4	1.045E-02	1.435E+03	2.453E-03	6.114E+03
Pu-239	1.000E+03	1.000E+03	1.441E-05	1.041E+06	8.781E-07	1.708E+07
Pu-240	1.000E+03	927 ñ 2	3.673E-04	4.084E+04	2.651E-05	5.658E+05
Pu-241	1.000E+03	1.000E+03	4.963E-04	3.022E+04	1.144E-06	1.311E+07
Ra-226	1.000E+03	156.6 ñ 0.3	5.577E+00	2.690E+00	1.810E+00	8.286E+00
Ra-228	1.000E+03	0.000E+00	0.000E+00	*2.726E+14	0.000E+00	*2.726E+14
Sb-125	1.000E+03	2.661 ñ 0.005	4.490E+00	3.341E+00	3.753E-04	3.997E+04
Se-79	1.000E+03	3.543 ñ 0.007	6.380E+01	2.351E-01	8.728E+00	1.719E+00
Sr-90	1.000E+03	41.76 ñ 0.08	1.122E-01	1.337E+02	1.095E-01	1.370E+02
Tc-99	1.000E+03	3.571 ñ 0.007	5.053E+00	2.969E+00	6.858E-01	2.187E+01
Th-228	1.000E+03	0.000E+00	0.000E+00	*8.195E+14	0.000E+00	*8.195E+14
Th-230	1.000E+03	945 ñ 2	9.009E-01	1.665E+01	9.901E-03	1.515E+03
Th-232	1.000E+03	0.000E+00	0.000E+00	*1.097E+05	0.000E+00	*1.097E+05
U-232	1.000E+03	32.54 ñ 0.07	1.879E+02	7.985E-02	1.879E+02	7.985E-02
U-233	1.000E+03	32.72 ñ 0.07	5.660E+01	2.650E-01	5.656E+01	2.652E-01
U-234	1.000E+03	32.84 ñ 0.07	5.542E+01	2.707E-01	5.538E+01	2.709E-01
U-235	1.000E+03	32.72 ñ 0.07	5.243E+01	2.861E-01	5.239E+01	2.863E-01
U-236	1.000E+03	32.83 ñ 0.07	5.268E+01	2.847E-01	5.264E+01	2.849E-01
U-238	1.000E+03	32.84 ñ 0.07	5.263E+01	2.850E-01	5.259E+01	2.852E-01

*At specific activity limit

APPENDIX C

METHODOLOGY FOR DETERMINING IF CONTAMINANTS IN SOIL REACH GROUNDWATER, AND FOR DETERMINING CONTAMINANT-SPECIFIC CONCENTRATIONS IN SOIL THAT ACHIEVE PROTECTION OF GROUNDWATER AND THE COLUMBIA RIVER

APPENDIX C

METHODOLOGY FOR DETERMINING IF CONTAMINANTS IN SOIL REACH GROUNDWATER, AND FOR DETERMINING CONTAMINANT-SPECIFIC CONCENTRATIONS IN SOIL THAT ACHIEVE PROTECTION OF GROUNDWATER AND THE COLUMBIA RIVER

C.1 INTRODUCTION

Residual nonradioactive and radionuclide contaminants remaining in soil after remediation must be at levels such that concentrations of contaminants reaching groundwater and, eventually, the Columbia River, by migration through the soil column do not exceed remedial action goals (RAGs) considered protective of these resources. For nonradioactive contaminants, the 100 times rule is applied first to determine concentrations that can remain in place without impacting groundwater. If residual contaminant concentration exceeds concentrations calculated using the 100 times rule, the RESidual RADioactivity (RESRAD) model can be used on a site-specific basis to determine if residual concentrations are protective. For radionuclide contaminants, RESRAD is used first to determine which contaminants reach groundwater, then to calculate concentrations that can remain in place protective of groundwater and the river. Methodology for modeling to protect the Columbia River is the same as that for modeling protection of groundwater, with the concentration multiplied by a factor to account for dilution and attenuation as contaminants migrate through the groundwater to the river.

C.2 BACKGROUND

The RESRAD model incorporates a dynamic, one-dimensional, analytical model to evaluate contaminant migration from a source in the vadose zone to groundwater (ANL 2001). The RESRAD model provides the flexibility to incorporate site-specific information to develop a model of contamination that can contain three distinct layers: a cover layer above the remaining soil contamination, a contaminated layer, and an uncontaminated vadose layer between the contaminated layer and the groundwater. The contaminated and vadose layer can be divided into multiple zones dependent on the availability of site-specific information. Using heterogeneous information to create discrete zones greatly influences the determination of transport time of contaminant species.

The generic site model is illustrated in Figure C-1. Site geometry, location relative to the Columbia River, and depth to groundwater are generic 100 Area inputs; site-specific inputs will be used for closeout verification. It is assumed that there are two zones beneath the excavated waste site (1) a contaminated zone of uniform concentration, and (2) an uncontaminated zone. The contaminated zone is assumed to be half of the vadose zone below 4.6 m (15 ft).

C.3 CALCULATIONAL METHODOLOGY

To run the RESRAD model for protection of groundwater and the Columbia River, appropriate distribution coefficients for residual radioactive soil contaminants are selected from Appendix E; parameters for user input for groundwater protection are entered from Appendix B, Table B-8; and site-specific parameters are used, when appropriate. The RESRAD model is run with only the drinking water exposure pathway active (all other exposure pathways are suppressed). The graphical and numerical output for a 1,000-year time frame for the drinking water pathway are inspected (the RESRAD model can evaluate migration and decay of radionuclides for a 1,000-year time period). If the concentration of a soil contaminant in drinking water is zero at all times, the contaminant does not reach groundwater. If a soil contaminant at its residual concentration is shown not to reach groundwater, further remediation is not required.

C.3.1 Application of RESRAD to Nonradioactive Contaminants

C.3.1.1 Modeling of Nonradionuclide Fate and Transport Using RESRAD. The RESRAD model is only applied to nonradioactive contaminants if they fail to meet cleanup levels calculated using the 100 times rule. Although RESRAD was created to perform pathway analysis for exposures to radioactive materials, the calculations for environmental transport can be applied to any nonvolatile chemical. Nonradioactive contaminants are introduced into the model using, as surrogates, radioisotopes with long half-lives. The ideal surrogate would have a half-life greater than 100,000 years without daughter ingrowth (such as thorium-232). The 15 radionuclides that have been evaluated to be used as surrogates for nonradionuclides in RESRAD modeling are tabulated in Table C-1. Because the model can be evaluated over a 1,000-year period, the effects of radioactive decay on the final result would be less than 0.1%.

Table C-1. Long-Lived Surrogate Radionuclides for RESRAD Modeling.

No.	Long-lived Surrogate Radionuclide	Half-life (yr)	No.	Long-lived Surrogate Radionuclide	Half-life (yr)	No.	Long-lived Surrogate Radionuclide	Half-life (yr)
1	Al-26	7.16E+05	6	I-129	1.60E+07	11	Sm-147	1.06E+11
2	Cl-36	3.01E+05	7	K-40	1.28E+09	12	Th-232	1.41E+10
3	Cm-248	3.39E+05	8	Np-237	2.14E+06	13	U-235	7.04E+08
4	Cs-135	3.00E+06	9	Pu-242	3.76E+05	14	U-236	2.34E+06
5	Gd-152	1.08E+14	10	Pu-244	8.26E+08	15	U-238	4.47E+09

Once a surrogate radionuclide is selected for a nonradioactive contaminant, it is entered into the program and assigned the distribution coefficient (from Appendix E) of the nonradioactive contaminant it is simulating. There is no need to convert nonradionuclide mass-based concentrations to activity-based concentrations. Inputting nonradionuclide soil concentrations (mg/kg) as surrogate radionuclide concentrations (pCi/g) will result in RESRAD output of predicted groundwater concentrations in μg/L (RESRAD units are pCi/L). The RESRAD model is run as described above using site-specific parameters and the parameters from Appendix B for

the drinking water pathway. The RESRAD graphical and numerical outputs are evaluated. If the concentration of a soil contaminant in groundwater is predicted to be zero at all times, the contaminant is predicted not to reach groundwater. If a soil contaminant at its residual concentration is predicted not to reach groundwater further remediation is not required. However, if a contaminant is predicted to reach groundwater within 1,000 years its predicted concentration at the year of peak concentration may be evaluated to determine if it exceeds groundwater cleanup standards. If groundwater cleanup standards are not predicted to be exceeded further remediation is not required.

C.3.1.2 Analogous Site Contaminant Depth/Distribution Coefficient Model. An analogous site contaminant depth/K_d value model has been developed to predict if the concentrations of contaminants in soil that exceed cleanup levels for groundwater or river protection are protective of groundwater and the river at a site. The *100 Area Analogous Sites RESRAD Calculations* (BHI 2005) calculation brief predicts whether or not contaminants at analogous sites in 100 Area soils may migrate to groundwater within a 1,000 year time frame based on their K_d value and the vertical distance to groundwater. The analogous site contaminant depth/K_d value model assumes that uncontaminated soil exists in the vadose zone between the bottom of the waste site and groundwater. The assumption of an uncontaminated zone beneath the waste site is reasonable based on analogous site data that includes test pits and boreholes completed at several operable units in the 100 Area (BHI 1999a, 1999b, 2001a, 2001b, 2002; DOE-RL 1992, 1994a, 1994b, 1995). The test pit and/or borehole data show that contaminant concentrations that are below direct exposure cleanup levels decrease to background concentrations within less than 3 m (10 ft) below the elevation at which the contamination occurs.

To apply the analogous site contaminant depth/K_d value model, the groundwater elevation and sample elevation must be known. For example, at a 100-B/C Area waste site all contaminant concentrations are below direct exposure cleanup levels, but groundwater and/or river protection cleanup levels are exceeded for some contaminants. The surface elevation at the waste site is 135 m above mean sea level and the groundwater elevation is 118 m above mean sea level. All samples were taken from the upper 4.6 m (15 ft) of the soil column. Using these parameter values (and 3 m as the maximum contamination depth below the sample point), the uncontaminated vadose zone thickness is calculated to be 9.4 m. From Table C-2 or Figure C-2, the minimum K_d value at which contaminants are not predicted to migrate to groundwater within 1,000 years is determined to be 8 mL/g. Therefore, the residual concentrations of all contaminants that have K_d values greater than 8 mL/g are protective of groundwater and the river.

Table C-2. Minimum Contaminant K_d Values Protective of Groundwater for Various Unsaturated/Uncontaminated Zone Thicknesses.[a]

Uncontaminated Zone Thickness (m)	K_d Value (mL/g)	Uncontaminated Zone Thickness (m)	K_d Value (mL/g)	Uncontaminated Zone Thickness (m)	K_d Value (mL/g)
0	80	6	12	12	7
2	40	7	10	16	6
2	27	8	9	18	6
3	20	9	8	20	4
4	16	10	8	22	4
5	14	11	7	25	3

[a] From Table 2 of BHI 2005, *100 Area Analogous Sites RESRAD Evaluation*, Calculation Number 0100X-CA-V0050, Rev. 0, Bechtel Hanford Inc., Richland, Washington.

C.3.1.3 Evaluation of Residual Concrete Rubble. Direct exposure cleanup levels for nonradionuclides and radionuclides are the same for residual soils, concrete rubble, and other waste materials remaining behind at waste sites. However, because the K_d values of contaminants in soil and concrete rubble may be considerably different it is possible that contamination in concrete rubble can be shown to be protective of groundwater and the river when contaminants in soil are not (and vice versa). Table C-3 comparing K_d values in soil and concrete is provided for use in RESRAD modeling or determinations using the analogous sites contaminant depth/K_d value model.

Table C-3. Soil and Concrete K_d Values for 100 Area RESRAD Modeling. (3 Pages)

Contaminant	Soil K_d Value[a] (mL/g)	Concrete K_d Value (mL/g)
Radionuclides		
Ag (silver)-108m	90	1[b]
Americium-241	200	5,000[b]
Barium-133	25	25[c]
Carbon-14	200	1,000[d]
Cesium-137	50	2[b]
Cobalt-60	50	100[b]
Europium-152	200	1,000[b]
Europium-154	200	1,000[b]
Europium-155	200	1,000[b]
Nickel-63	30	100[b]
Plutonium-238	200	5,000[b]
Plutonium-239/240	200	5,000[b]
Potassium-40[e]	4	4[c]
Radium-226	200	50[b]
Radium-228	200	50[b]

Table C-3. Soil and Concrete K_d Values for 100 Area RESRAD Modeling. (3 Pages)

Contaminant	Soil K_d Value [a] (mL/g)	Concrete K_d Value (mL/g)
Strontium-90	25	1 [b]
Technetium-99	0	200 [f]
Thorium-228	200	5,000 [b]
Thorium-232	200	5,000 [b]
Tritium (H-3)	0	0 [b]
Uranium-233/234	2	2,000 [b]
Uranium-235	2	2,000 [b]
Uranium-238	2	2,000 [b]
Total Uranium	2	2,000 [b]
Metals		
Antimony	45	45 [c]
Arsenic	3	100 [b]
Barium	25	25 [c]
Cadmium	30	30 [c]
Chromium, Total	200	200 [c]
Chromium VI	0	870 [d]
Copper	22	100 [b]
Lead	30	500 [b]
Manganese	50	100 [b]
Mercury	30	30 [c]
Nickel	30	100 [b]
Selenium	5	0.1 [b]
Silver	90	1 [b]
Vanadium	1,000	100 [b]
Zinc	30	30 [c]
Inorganics and Total Petroleum Hydrocarbons		
Cyanide	0	0 [c]
Sulfate	0	0 [c]
Sulfide	0	0 [c]
TPH	NA	NA
Semivolatiles		
Anthracene	23.5	23.5 [c]
Benzo(a)anthracene	357	357 [c]
Benzo(b)fluoranthene	1,230	1,230 [c]
Benzo(k)fluoranthene	1,230	1,230 [c]
Benzo(a)pyrene	5,500	5,550 [c]
Benzo(g,h,i)perylene	1,230	1,230 [c]
Bis(2-ethylhexyl)phthalate	111	111 [c]
Indeno(1,2,3-cd)pyrene	3,470	3,470 [c]

Table C-3. Soil and Concrete K_d Values for 100 Area RESRAD Modeling. (3 Pages)

Contaminant	Soil K_d Value [a] (mL/g)	Concrete K_d Value (mL/g)
Pesticides and PCBs		
BHC, gamma (Lindane)	1.35	1.35 [c]
Chlordane (alpha, gamma)	51.3	51.3 [c]
Dieldrin	25.6	25.6 [c]
DDD, 4,4'-	45.8	45.8 [c]
DDE, 4,4'-	86.4	86.4 [c]
DDT, 4,4'-	678	678 [c]
Polychlorinated Biphenyls (PCBs; Aroclors)	530	530 [c]

[a] Radionuclides, metals, and PCBs soils K_d values are from Appendix E of this document. Semivolatiles and pesticides soils K_d values are from the Washington Dept. of Ecology CLARC Database on the internet at https://fortress.wa.gov/ecy/clarc/CLARCOverview.html.
[b] Most conservative value for non-degraded concrete from Bradbury, M. H. and F. A. Sarott, 1995, *Sorption Databases for the Cementitious Near-Field of a L/ILW Repository for Performance Assessment*, ISSN 1019-0643, Paul Scherrer Institute, Wurenlingen and Villegen, Germany.
[c] No concrete K_d value known; soil K_d value should be used and discussed.
[d] From DOE-RL (2001), Appendix F of *SAP for Interim Closure of the 105-D/105-H Reactor Below-Grade Structures and Underlying Soils*.
[e] Naturally occurring radionuclide. Should not be reported as a COC.
[f] From Crawford, B. A. 1998, *Tank 241-AX-104 Residual Solids Leach Test Results, TWR-3548*, Rev. 0, December 1998, Numatec Hanford Corporation, Richland, Washington.
NA = not available
PCB = polychlorinated biphenyls

C.3.2 Protection of the Columbia River

To achieve protection of the Columbia River, the calculation of RAGs for residual soil contamination must consider two additional contaminant transport steps beyond the migration of contaminants through the soil column and their subsequent leaching into groundwater. The additional contaminant transport steps are as follows:

1. The transportation, from beneath the waste site to near-river wells (the point of compliance), of contaminants that have leached to groundwater

2. The mixing of groundwater contaminant concentrations with river water within the substrate at the groundwater/river interface.

The model that addresses these two steps is the dilution attenuation factor (DAF) model, summarized in Appendix D. This model accounts for the time required for a contaminant to travel through the groundwater underlying a site to the river, radionuclide decay during that travel-time period, and a 1:1 dilution factor applied to contaminant concentrations measured in near-river wells (to account for the difference in concentration between the near-river well and the substrate at the groundwater/river interface). In evaluating contaminant transport time, the model uses a 1,000-year period (starting from site closeout) and considers the effect of

retardation as contaminants move from under the waste site to the river. As appropriate, dilution factors greater than 1:1 will be evaluated on a constituent-specific basis using Hanford Site data.

C.3.3 Application of Criteria for Protection of Groundwater and Surface Water

Residual contaminant concentrations remaining in soil after remediation must be at levels considered protective of groundwater and the Columbia River. The process for determining soil concentrations that are protective of groundwater and the river depends on whether the contaminant is a radionuclide or nonradioactive contaminant.

The *Model Toxics Control Act* (*Washington Administrative Code* [WAC] 173-340) states that concentrations of residual nonradioactive contaminants are considered protective of groundwater at levels equal to or less than 100 times the groundwater cleanup levels (i.e., the RAGs presented in Table B-4) established in accordance with WAC 173-340-720, unless it can be demonstrated that a higher soil concentration is protective of groundwater at the site (WAC 173-340-740[3][a][ii][A]). The 100 times rule is applied to nonradioactive contaminants as the first step in calculating residual soil concentrations that are protective of groundwater. If residual concentrations exceed cleanup levels calculated using the 100 times rule, site-specific modeling (e.g., RESRAD) will be performed.

The 100 times rule does not apply to residual radionuclide contaminants. For radionuclides, groundwater protection is demonstrated through technical evaluation using RESRAD.

The same methodology applied to residual soil contamination to ensure protection of groundwater is applied to ensure protection of the Columbia River. To be protective of the Columbia River, residual soil concentrations of nonradioactive contaminants must also be less than or equal to 100 times applicable state and federal standards (maximum contaminant levels and ambient water quality criteria) for surface water (WAC 173-201A and 40 *Code of Federal Regulations* 131, respectively). For residual nonradioactive contaminants, protection of the river is achieved by reducing concentrations remaining in soil after remediation to concentrations less than or equal to 100 times the RAG after the DAF has been applied. If residual concentrations exceed river protection cleanup levels calculated using the 100 times rule, site-specific modeling will be performed. For residual radionuclide contaminants shown by the RESRAD model to reach groundwater, protection of the river is achieved by reducing concentrations remaining in soil after remediation to concentrations less than or equal to the value calculated by RESRAD to achieve the RAG after the DAF has been applied.

C.4 REFERENCES

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WAC 173-340, "Model Toxics Control Act--Cleanup," *Washington Administrative Code*, 1996.

C.5 BIBLIOGRAPHY

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Figure C-1. Generic Site Model.

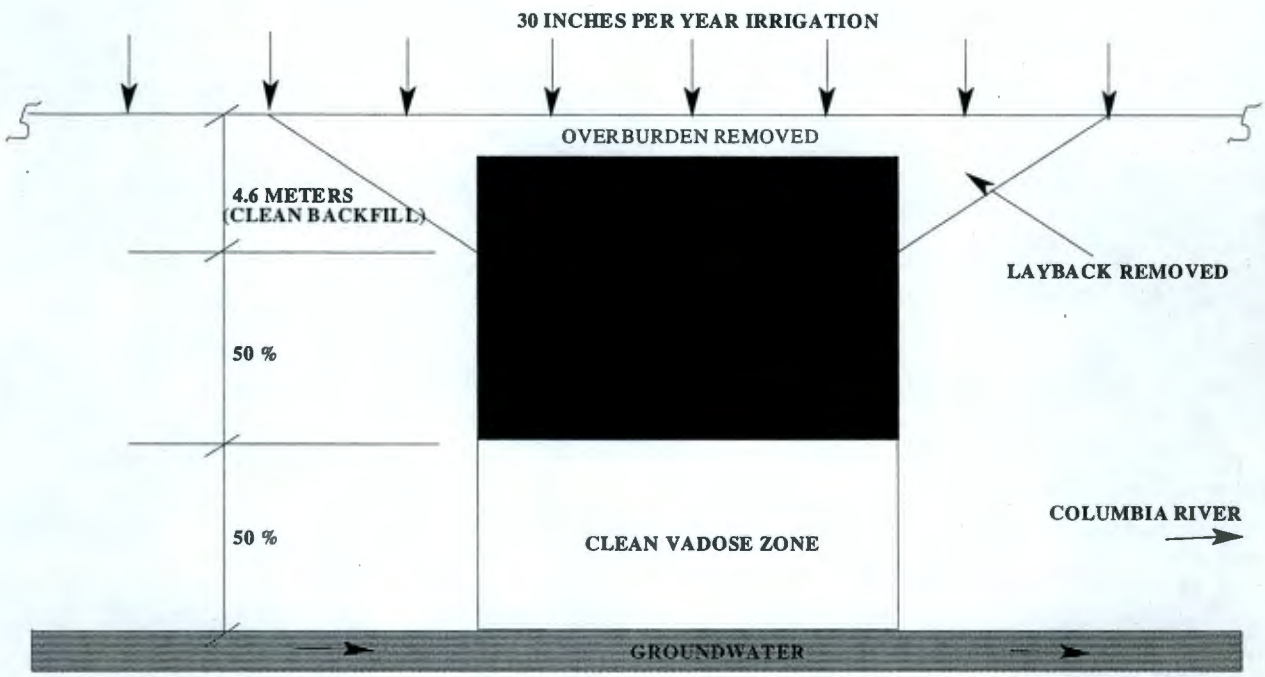
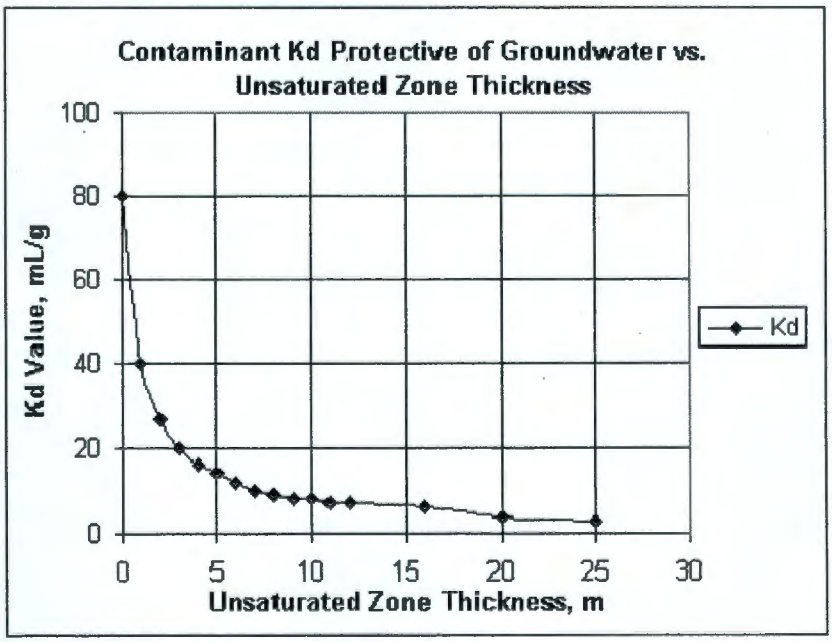


Figure C-2. Minimum Contaminant K_d Values Protective of Groundwater for Various Unsaturated/Uncontaminated Zone Thicknesses.



APPENDIX D

DESCRIPTION OF DILUTION ATTENUATION FACTORS

APPENDIX D

DESCRIPTION OF DILUTION ATTENUATION FACTORS

D.1 ESTIMATING GROUNDWATER/RIVER DILUTION ATTENUATION FACTORS

Soil cleanup to protect surface water in the Columbia River involves calculating dilution factors between groundwater and the river, and calculation of the attenuation of radionuclides as they migrate in groundwater to the river. These dilution attenuation factors (DAFs) are used in conjunction with the river protection remedial action goals (RAGs) to calculate RAGs (after the DAF has been applied) that are concentrations in groundwater underlying a site that are protective of the river.

D.2 CALCULATION METHOD

This section describes the methodology for calculating DAFs. An example is presented below on how to calculate DAFs and how to use DAFs to calculate RAGs based on the DAF.

The first step is to calculate the time required for a contaminant to reach the river from groundwater underlying a site. This time is calculated as follows:

$$T=\left(\frac{D}{V_w}\right)\times R_f$$

where:

T = time for contaminant to reach the river (yr)
D = distance from waste site to the river (m)
V_w = average pore velocity in groundwater (m/yr)
R_f = retardation factor in groundwater (unitless).

Distances between Remedial Design Group 1 waste sites and the river are presented in Table D-1. The distance selected to calculate DAFs for this remedial design report was 200 m (660 ft). The average pore velocity in groundwater is assumed to be 27.82 m/yr (91.25 ft/yr) (DOE-RL 1995).

Table D-1. Distances to the Columbia River.

Site	Distance to the River (m)
116-B-1	200
116-B-11	170
116-C-1	250
116-C-5	250
116-B-13	200
116-B-14	170

The relative retardation factor (R_f) values are estimated from soil/water distribution coefficients (K_d [mL/g]) with the following relationship (WHC 1990):

$$R_f = 1 + \left(\frac{P_b}{N_e} \times K_d \right)$$

where:

P_b = bulk density in soil (g/cm^3, noting that 1 cm^3 = 1 mL)
N_e = effective porosity at saturation of soil (WHC 1990).

The distribution coefficients are developed as described in Appendix E and are summarized in Table D-2. The bulk density in soil and effective porosity values are presented in Table D-3.

Table D-2. Distribution Coefficient (K_d) Values. (2 Pages)

Contaminant	Distribution Coefficient (K_d) Values (mL/g)
Ag-108m	90
Am-241	200
C-14	200
Cs-134	50
Cs-137	50
Co-60	50
Eu-152	200
Eu-154	200
Eu-155	200
H-3	0
K-40	4

Table D-2. Distribution Coefficient (K_d) Values. (2 Pages)

Contaminant	Distribution Coefficient (K_d) Values (mL/g)
Na-22	4
Ni-63	30
Pu-238	200
Pu-239/240	200
Ra-226	100
Sr-90	25
Tc-99	0
Th-228	200
Th-232	200
U-234	2
U-235	2
U-238	2
Antimony	1.4
Arsenic	3
Barium	25
Cadmium	30
Chromium (III)	200
Chromium (VI)	0
Lead	30
Manganese	50
Mercury	30
Zinc	30
Aroclor 1260	530
Benzo(a)pyrene	5,500
Chrysene	200
Pentachlorophenol	53

Table D-3. Parameters Used to Calculate Relative Retardation Factors (R_f).

Parameter	Value	Source
Bulk density	1.7 g/cm^2	DOE-RL 1995
Effective porosity at saturation	0.25	DOE-RL 1995

Over the time period T, radionuclide contaminants in groundwater will decay as shown below:

$$\frac{C_{gw}}{C_{gw-onsite}} = 0.5^{T/t_{1/2}}$$

where:

C_{gw} = concentration in groundwater at the groundwater/river interface (substrate) (pCi/L)
$C_{gw\text{-}onsite}$ = concentration in groundwater underlying the site (pCi/L)
$t_{1/2}$ = radionuclide half-life (yrs), presented in Table D-4.

Table D-4. Radionuclide Half-Lives.

Radionuclide	Radionuclide Half-Life (yr)
Am-241	432
C-14	5.73E+03
Cs-134	2.06
Cs-137	30.2
Co-60	5.27
Eu-152	13.6
Eu-154	8.8
Eu-155	4.96
H-3	12.3
K-40	1.28E+09
Na-22	2.6
Ni-63	100
Pu-238	87.8
Pu-239/Pu-240	2.439E+04
Ra-226	1,600
Sr-90	28.6
Tc-99	2.13E+05
Th-228	1.91
Th-232	1.41E+10
U-233/U-234	1.59E+05
U-235	7.04E+08
U-238	4.47E+09

Concentrations in groundwater underlying a site corresponding to concentrations in near-river wells (the compliance point for the groundwater/river interface) are estimated using a dilution factor that accounts for mixing of groundwater and surface water in the river substrate.
A comparison of near-river wells, seeps, and river water indicates that groundwater/river dilution factors can range from <2 to 10 (WHC 1993). A groundwater/river dilution factor of 1:1 was specified in the 100-HR-3 and 100-KR-4 Record of Decision (EPA 1996).

This approach is summarized as follows to develop the DAF:

$$C_{river} \times 2 = C_{gw}$$

$$C_{gw-onsite} = \frac{C_{river} \times 2}{0.5^{T/t_{1/2}}}$$

$$C_{gw-onsite} = \frac{C_{river} \times 2}{0.5^{(D/V_w \times R_f)/t_{1/2}}}$$

D.3 METHODOLOGY APPLIED

The initial step in calculating concentrations in soil protective of the Columbia River is selecting surface water concentrations protective of human health and the environment. For an individual contaminant, the most restrictive value from the following is applicable: Washington State surface water quality criteria (*Washington Administrative Code* [WAC] 173-201A-0450), federal ambient water quality criteria developed in accordance with the *Clean Water Act*, WAC 173-340 Method B values, and maximum contaminant levels or, if more restrictive, 1/25th of the derived concentration guide in surface water. The RAGs protective of the Columbia River are summarized in Table 2-4.

These concentrations are used to calculate the corresponding concentrations in groundwater underlying the site that are protective of the river. The following example is presented for plutonium-239:

$$\frac{1.2\ \text{pCi/L} \times 2}{0.5^{[((200\text{m}/27.82\text{m/yr}) \times 1361)/24390\text{yr}]}} = 3.17\ \text{pCi/L}$$

where:

$$R_f = 1361 = 1 + [(1.7\,g/cm^3/0.25) \times 200.]$$

This is the concentration in groundwater underlying a site (200 m [660 ft] from a near-river well) that corresponds to the RAG protective of the river for plutonium-239 (i.e., the RAG after the DAF has been applied). The RESRAD model is used to calculate a value in soil that meets this RAG after the DAF has been applied.

D.4 REFERENCES

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APPENDIX E

DISTRIBUTION COEFFICIENTS FOR CONTAMINANTS IN SOIL

APPENDIX E

DISTRIBUTION COEFFICIENTS FOR CONTAMINANTS IN SOIL

The distribution coefficient (K_d) is an empirical parameter that represents the tendency for a chemical substance to adsorb to soil. Typically, it is measured in the laboratory as the ratio of concentration in soil (C_s) to concentration in water (C_w), at equilibrium, as shown below:

$$K_d = \frac{C_s}{C_w}$$

The greater the extent of adsorption in soil, the greater the value of K_d.

Values for K_d can be used in models to quantify the amount of contaminant in soil that can leach to groundwater. K_d values measured for an individual substance can vary substantially based on differences in soil properties. For example, the range of K_d values for plutonium and zinc measured in different soils can span four orders of magnitude (Dragun 1988, Baes and Sharp 1983). The variables affecting K_d include the relative abundance of different cations and anions in soil, soil pH, reduction-oxidation potential, cation exchange capacity, and organic matter content (Dragun 1988, Barney 1978).

Ideally, the K_d value to model leaching potential in Hanford Site soils should be based on site-specific measurements. However, sole reliance on site-specific measurements generally is not feasible. An alternate approach to developing K_d values for modeling is to (1) identify the range of K_d values measured in or under conditions similar to those encountered in Hanford Site soils, and (2) select a value that provides a conservatively reasonable estimate of contaminant leaching to groundwater. These selected values can be used to develop remedial action goals in soil.

E.1 METHODOLOGY

Several studies have compiled K_d values for a variety of soil, sediment, and leachate conditions at the Hanford Site. These values generally span a range depending on soil and leachate (liquid waste stream) conditions. These conditions include varying combinations in soils and leachate of (1) high or low salt concentrations, (2) high or low organic matter concentrations, and (3) acid (low pH) or neutral/basic (moderate to high pH) conditions.

Selecting reasonable values for K_d involved evaluating the characteristics of Hanford Site soils and identifying the K_d value corresponding the closest to those characteristics. The hierarchy of data used to select K_d values was to use Hanford Site-specific data in preference to more general compilations of K_d values in the literature. The selected values were compared with the range of

general literature values. Finally, uncertainties in the data were discussed to support the selected K_d value.

E.2 HANFORD SITE SOIL CHARACTERISTICS

For purposes of selecting K_d values from the literature, most Hanford Site soils are characterized as low-salt, low-organic matter content with neutral to basic pH (Serne and Wood 1990). Hanford Site soils typically are sandy with very little organic carbon content (Ames and Serne 1991). Soil pH measured in 100 Area soils range from 6.5 to 7.66. Total organic carbon concentrations range from 600 to 1,640 parts per million (ppm) (DOE-RL 1994).

E.3 K_d DATA SOURCES

The principal sources of information on Hanford Site-specific K_d values consulted in this analysis were Ames and Serne (1991) and Serne and Wood (1990). These references provided information on most of the radionuclide and nonradioactive inorganic contaminants in soil in the 100 Areas. Ames and Serne (1991) provided ranges of K_d values for different waste stream characteristics (high/low dissolved solids, high/low organic content, and low/neutral to high pH); these parameters are more variable than soil characteristics at the Hanford Site. Ames and Serne also recommended conservative estimates of K_d values for use in modeling contaminant leaching (WHC 1990). Ames and Serne (1991) recommended K_d values for all of the contaminants of potential concern, except for carbon, arsenic, antimony, thorium, and radium. Serne and Wood (1990) summarized available information on K_d values, and identified changes in K_d values with changing conditions in soil. These references did not reveal information on K_d values for thorium and arsenic. Information on these two contaminants in soil was developed from the range of K_d values compiled by Baes and Sharp (1983). Baes and Sharp presented ranges of K_d values for 222 agricultural soils and clays between pH 4.5 and 9. The K_d values presented in these sources are summarized in Table E-1.

E.4 SELECTED K_d VALUES

The K_d values selected for modeling contaminant concentrations leaching to groundwater are summarized in Table E-1. Uncertainties in the data for selected contaminants are discussed below.

Antimony: Estimates of K_d for antimony at the Hanford Site range from 0 to 40 (Ames and Serne 1991). Studies of the soil chemistry and observed mobility of antimony-containing waste have resulted in K_d values ranging from <1 to >1,000 (Ames and Rai 1978). A value of 1.4 was selected as a K_d for antimony in Hanford Site soils.

Table E-1. Summary of Soil/Water Distribution Coefficients. (2 Pages)

Contaminants of Potential Concern	K_d in the FFS[a]	Revised K_d Value	Source for Revised K_d Value	Ames and Serne (1991)		Baes and Sharp (1983)	
				Recommended Value	Range	Geometric Mean	Observed Range
Silver-108m	90	90	ANL 1993	--	--	--	--
Americium-241	200	200	Ames and Serne 1991	200	100 to 500	810	1.0 to 47,230
Carbon-14	0.05	200[b]	BHI 2002a	NA	NA	5	0 to 10
Cesium-137	50	50	Ames and Serne 1991	50	50 to 3,000	1,110	10 to 52,000
Cobalt-60	50	50	Ames and Serne 1991	50	10 to 3,000	55	0.2 to 3,800
Europium-152	200	200	Ames and Serne 1991	200	100 to 500	--	--
Europium-154	200	200	Ames and Serne 1991	200	100 to 500	--	--
Europium-155	200	200	Ames and Serne 1991	200	100 to 500	--	--
Tritium (H-3)	0.05	0	Serne and Wood 1990	--	--	--	--
Nickel-63	30	30	Ames and Serne 1991	4	1 to 30	--	--
Plutonium-238	25	200	Serne and Wood 1990	25	100 to 2,000	1,800	11 to 300,000
Plutonium-239/240	25	200	Serne and Wood 1990	25	100 to 2,000	1,800	11 to 300,000
Strontium-90	25	25	Ames and Serne 1991	25	20 to 200	27	0.15 to 3,300
Technetium-99	0.05	0	Serne and Wood 1990	0	0	--	--
Thorium-232	0.05	200	Ames and Rai 1978	--	--	60,000	2,000 to 510,000
Uranium-233/234	2	2	Serne and Wood 1990	2	2 to 2,000	45	10.5 to 4,400
Uranium-235	2	2	Serne and Wood 1990	2	2 to 2,000	45	10.5 to 4,400
Uranium-238	2	2	Serne and Wood 1990	2	2 to 2,000	45	10.5 to 4,400
Antimony	0.05	45[c] 1.4	Ames and Rai 1978	0	0 to 40	--	--
Arsenic	0.05	3	Baes and Sharp 1983	--	--	303 (As III); 6.7 (As V)	1.0 to 8.3 (As III); 1.9 to 18 (As V)
Barium	25	25	Ames and Serne 1991	25	20 to 200	--	--
Cadmium	30	30	Ames and Serne 1991	30	100 to 200	6.7	1.26 to 26.8

Table E-1. Summary of Soil/Water Distribution Coefficients. (2 Pages)

Contaminants of Potential Concern	K_d in the FFS[a]	Revised K_d Value	Source for Revised K_d Value	Ames and Serne (1991)		Baes and Sharp (1983)	
				Recommended Value	Range	Geometric Mean	Observed Range
Chromium (hexavalent)	0.05	0	Ames and Serne 1991, Thornton 1995	0 (Cr VI)	0 (Cr VI)	37	1.2 to 1,800
Lead	30	30	Ames and Serne 1991	30	100 to 200	99	4.5 to 7,640
Manganese	50	50	Ames and Serne 1991	50	10 to 3,000	150	0.2 to 10,000
Mercury	30	30	Ames and Serne 1991	30	100 to 200	--	--
Zinc	30	30	Ames and Serne 1991	30	100 to 200	16	0.1 to 8,000
Aroclor 1260 (PCB)	530	530	EPA 1989	--	--	--	--
Benzo(a)pyrene	5,500	5,500	EPA 1989	--	--	--	--
Chrysene	200	200	EPA 1989	--	--	--	--
Pentachlorophenol	53	53	EPA 1989	--	--	--	--

[a] *100 Area Source Operable Unit Focused Feasibility Study* (DOE-RL 1995).
[b] The K_d of 200 for carbon-14 will be applicable to the 100 Areas, except for the 100-K Area where a site-specific value will be established prior to closeout of the waste sites.
[c] The Tri-Parties have not agreed upon a Kd for antimony. The value of 45 mL/g will be used for EPA lead sites and 1.4 mL/g will be used for Ecology lead sites.
FFS = focused feasibility study
NA = not applicable
PCB = polychlorinated biphenyl

Arsenic: Estimates of K_d have not been developed for arsenic at the Hanford Site. The range of values cited in the literature are 1 to 8.3 for As III (geometric mean of 3.3) and 1.9 to 18 for arsenic V (geometric mean of 6.7) (Baes and Sharp 1983). A value of 3 was selected as a K_d for arsenic in Hanford Site soils.

Carbon-14: An estimate of the K_d for carbon-14 has been developed for the 100 Areas of the Hanford Site. The leach testing of 100-F Area soils, documented in the *Cleanup Verification Package for the 100-F-19:1 and 100-F-19:3 Reactor Cooling Water Effluent Pipelines, 100-F-34 Biology Facility French Drain, and 116-F-12 French Drain*, Appendix D, "100-F Area Soil Hexavalent Chromium and Carbon-14 Leachability Study Summary Report" (BHI 2002a), indicates that carbon-14 was not detected in the leachate. Carbon-14 soil concentrations up to 48.7 pCi/g were used in the leach testing with no resulting carbon-14 detections in the water leachate. Values for K_d in 100-F Area soils are likely to be appropriate throughout the 100 Areas due to similarities in soil conditions (DOE 1999). Based on 100 Area leach study results, a K_d value of 200 was selected for carbon-14, except for the 100-K Area, where a site-specific value will be established prior to close out of waste sites.

Cesium: Ames and Serne (1991) recommended a K_d of 50 from values ranging from 50 to 3,000. Baes and Sharp (1983) cite a range from 10 to 52,000, with a geometric mean of 1,100.

According to Serne and Wood (1990), the available data indicate that a minimum value of 200 is reasonable for ambient conditions in soil at the Hanford Site (near neutral pH, low dissolved-solids concentrations, and low organic-matter content); the value of 200 was selected as a K_d for cesium based on data evaluated by Serne and Wood (1990).

Chromium: The mobility of chromium in soil will vary greatly with valence. Chromium VI is highly mobile in soil and has been estimated to have a K_d of zero (Ames and Serne 1991). However, chromium VI is readily reduced in soil to chromium III by the presence of ferrous ion and organic matter. A minor amount of chromium III can be oxidized to chromium VI through the presence of manganese oxides in soils and sediments (Thornton 1995). A suggested K_d value for chromium III is 200 mL/g.

Plutonium: Ames and Serne (1991) recommended a K_d of 25, with a range from 100 to 2,000. Baes and Sharp (1983) cite a range from 11 to 300,000, with a geometric mean of 1,800. Serne and Wood (1990) cite studies in which plutonium sorption in a pH range from 4 to 8.5 was high, with K_d >1,980. Based on the available data, Serne and Wood (1990) recommended a range of K_d values from ~100 to 1,000 for ambient soil conditions at the Hanford Site. Data reviewed by Serne and Wood (1990) appear to show similarities in the behavior of plutonium and americium in soil, while Ames and Serne (1991) recommend a K_d of 200 for americium. Based on this range of information, a K_d of 200 was selected for plutonium.

Radium: Estimates of K_d have not been developed for radium at the Hanford Site, and there were no data cited in Baes and Sharp (1983). ANL (1993) compiled data indicating K_d values at acidic pHs (2-6) ranging from 0 to 60, and K_d values at neutral/basic pHs (7-7.7) ranging from 100 to 2,400. Data summarized in Ames and Rai (1978) indicate K_d values at neutral/basic pHs ranging from 214 to 354. A conservative estimate of 100 was selected as a K_d for radium in Hanford Site soils.

Thorium: Estimates of K_d have not been developed for thorium at the Hanford Site. The range of literature values cited by Baes and Sharp (1983) is from 2,000 to 510,000. Values for K_d at a pH of 8.15 in medium sands (40-130) and very fine sands (310-470) (ANL 1993) are likely to be appropriate for soil conditions at the Hanford Site. The higher K_d values appear to be associated more with silty-clay soils (Ames and Rai 1978). Distribution coefficient values for thorium are lower with low soil pH. A conservative estimate of 200 was selected as a K_d for thorium in Hanford Site soils.

Uranium: Ames and Serne (1991) recommend a K_d of 2 for uranium based on an observed range from 2 to 2,000. Baes and Sharp (1983) cite a range from 10.5 to 4,400, with a geometric mean of 45. Serne and Wood (1990) suggest that uranium would sorb poorly to soil under neutral and basic conditions, and concluded that additional data were required to support a recommended K_d value. Uranium has been detected in groundwater at 100 Area sites, suggesting that it has some mobility in soil. While it is likely that K_d values are higher, a K_d of 2 was selected to model contaminant leaching.

E.5 LEACH TESTS TO DETERMINE DISTRIBUTION COEFFICIENTS

The regulatory agencies allow for the development and use of site-specific K_d values to evaluate protection of groundwater and the Columbia River from residual contaminants in soil and other media. Leach tests have been performed at the Hanford Site for hexavalent chromium at the 100-D, 100-H, and 100-F Areas. Leach tests for carbon-14 have also been performed at the 100-F Area. The results of the carbon-14 leach tests were used to select a K_d value of 200 mL/g as described in Section E.4, "carbon-14." Based on an agreement with the regulators, hexavalent chromium leach test results are used to compare residual soil concentrations to hexavalent chromium concentrations in leach test soils that did not produce leachate that exceeded the groundwater and river water quality criteria. If residual soil concentrations are below the hexavalent chromium concentrations that produced leachate exceeding water quality criteria, the site is determined to be protective of groundwater and the river. Results and application of the hexavalent chromium leach tests are presented in the "100-F Area Soil Hexavalent Chromium and Carbon-14 Leachability Study Summary Report" (BHI 2002a, Appendix D). In the 300 Area, leach tests were used to develop revised K_d values and cleanup levels for uranium to evaluate protection of groundwater and the Columbia River. This effort is described in *Protection of 300 Area Groundwater from Uranium-Contaminated Soils at Remediated Sites* (BHI 2002b).

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APPENDIX F

100 AREA SOURCE REMEDIATION SITES PUBLIC INVOLVEMENT PLAN

APPENDIX F

100 AREA SOURCE REMEDIATION SITES PUBLIC INVOLVEMENT PLAN

F.1 OVERVIEW

This plan outlines public involvement activities that were conducted for each interim action record of decision (ROD), and also activities that will be conducted during the 100 Area source remediation sites remedial design and remedial action. The interim action RODs signed by the Tri-Parties (the U.S. Environmental Protection Agency [EPA], the Washington State Department of Ecology [Ecology], and the U.S. Department of Energy, Richland Operations Office [RL]) defined remedial action as excavation, treatment as appropriate or required, and disposal of contaminated soils and debris from these sites.

F.2 100 AREA REMEDIAL ACTION PUBLIC INVOLVEMENT ACTIVITIES

The following outlines the specific public involvement activities that have been conducted for the 100 Area remedial actions. These events addressed the activities pertaining to ROD proceedings for the 100 Areas.

F.2.1 1995 Record of Decision

The proposed plan describing the cleanup action for the high-priority waste sites in 100 Areas was issued for public comment on June 26, 1995. The public comment period for this proposed plan was held June 26, 1995, through August 9, 1995. The ROD was signed in September 1995 (EPA 1995).

F.2.2 1997 Record of Decision Amendment

The proposed plan that would amend the 1995 ROD to increase the number of waste sites to be remediated in the 100 Areas was issued for public comment on December 16, 1996. The public comment period for this proposed plan was held December 16, 1996, through January 15, 1997. The ROD Amendment was signed in April 1997 (EPA 1997).

F.2.3 Remaining Sites Record of Decision

The proposed plan that addressed cleanup of remaining miscellaneous waste sites at the 100 Areas was issued for public comment on November 2, 1998. The public comment period for this proposed plan was held November 2, 1998, through December 1, 1998. The Remaining Sites ROD was signed in August 1999 (EPA 1999).

F.2.4 100 Area Burial Grounds Record of Decision

The proposed plan that discussed the alternatives analyzed for cleanup of 45 burial grounds in the 100 Areas and provided the recommended cleanup action was issued for public comment on May 22, 2000. The public comment period for this proposed plan was held May 22, 2000, through June 20, 2000. A public meeting was held on June 14, 2000 in Hood River, Oregon, to discuss the cleanup action and allow the public to provide their input. The 100 Area Burial Grounds ROD was signed in September 2000 (EPA 2000).

F.3 PUBLIC INVOLVEMENT PLANNING

This public involvement plan outlines the strategy to be used to provide information during the remedial design and remedial action processes. Throughout the public involvement process, decision making is the responsibility of the Tri-Parties.

F.3.1 Actions to be Taken During Remedial Design

- Update the Hanford Advisory Board's Environmental Restoration Committee on remedial design progress; the committee will provide this information to the full board (as needed or requested).
- Provide government-to-government consultation with the Native American Tribes during remedial design, and/or when pertinent information becomes available (as needed or requested). RL will concurrently transmit documents to the Native American Tribes, Ecology, and the EPA.
- Presentation to Natural Resource Trustee Council (as needed or requested).
- Information for the general public (Hanford Update articles).

F.3.2 Actions to be Taken During Remedial Action

Actions will be taken to provide information to interested stakeholders as pertinent information becomes available.

- Update the Hanford Advisory Board's Environmental Restoration Committee on remedial action progress; the committee will provide this information to the full board (as needed or requested).
- Provide government-to-government consultation with the Native American Tribes (as needed or requested).
- Presentation to Natural Resource Trustee Council (as needed or requested).

- Information for the general public (Hanford Update articles).
- Prepare a fact sheet to describe the 100 Area remedial action progress (as needed).

F.3.3 Actions to be Taken for an Explanation of Significant Difference to the Record of Decision

It may be determined that a "significant change" to the selected remedy is necessary if waste is left in place at large sites, thereby precluding unrestricted use. Significant changes are defined as changes that significantly modify the scope, performance, or cost of a component of the remedy as presented in the ROD. All significant changes shall be addressed in an ESD.

- Update the Hanford Advisory Board's Environmental Restoration Committee on the ESD; the committee will provide this information to the full board (as requested).
- Provide government-to-government consultation with the Native American Tribes on the ESD (as requested).
- Presentation to Natural Resource Trustees (as requested).
- Prepare a fact sheet to describe the ESD (send to mailing list).
- Information for the general public (Hanford Update articles).
- Notify the public regarding the decision to plug-in newly discovered waste sites through the periodic publication of explanations of significant difference (ESDs).

If the lead regulatory agency decides to invoke the "balancing factor" provisions of the ROD, a 30-day public comment period will be held.

F.4 REFERENCES

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APPENDIX G

GUIDANCE FOR CLEANUP VERIFICATION PACKAGES AND REMAINING SITES VERIFICATION PACKAGES

(This appendix was replaced in its entirety; therefore, no revision bars are shown.)

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ACRONYMS

CFR	*Code of Federal Regulations*
COC	contaminant of concern
COPC	contaminant of potential concern
CVP	cleanup verification package
DQA	data quality assessment
DQO	data quality objective
EPA	U.S. Environmental Protection Agency
ERDF	Environmental Restoration Disposal Facility
RAG	remedial action goal
RAO	remedial action objective
RDR/RAWP	remedial design report/remedial action work plan
RESRAD	RESidual RADioactivity (dose model)
ROD	record of decision
RSVP	remaining sites verification package
SAP	sampling and analysis plan
UCL	upper confidence limit
WAC	*Washington Administrative Code*

APPENDIX G

GUIDANCE FOR CLEANUP VERIFICATION PACKAGES AND REMAINING SITES VERIFICATION PACKAGES

G.I INTRODUCTION TO APPENDIX G

G.I-1.0 PREFACE

The purpose of this appendix is to provide guidance to assist both authors and readers of cleanup verification packages (CVPs) and remaining sites verification packages (RSVPs). Remediation of future waste sites in the 100 and 300 Areas are expected to contain fewer concerns about radionuclides and more concerns about nonradionuclides. To streamline the CVPs and make them easier to read and understand, these documents will henceforth use the format of the RSVPs. Authors will use this appendix as guidance for the cleanup verification and remaining sites verification processes and as guidance for preparing CVP and RSVP documents.

The CVPs have generally been written for larger waste sites with mainly radionuclide contaminants that are included in the 1995 record of decision (ROD) (EPA 1995), the 1997 ROD Amendment (EPA 1997a), and the Burial Grounds ROD (EPA 2000). The RSVPs were developed for mostly smaller waste sites included in the Remaining Sites ROD (EPA 1999) and in subsequent Explanations of Significant Difference (ESDs) that added candidate waste sites for remediation. The RSVPs generally do not have a radionuclide component.

G.I-2.0 SCOPE

The scope of this guidance is limited to the CVPs and RSVPs for 100 Area remedial actions covered by this remedial design report/remedial action work plan (RDR/RAWP). This is a guidance document, not a requirements document. Deviations from the guidance are acceptable; however, they should be documented in the CVP or RSVP along with corresponding rationale.

The following are three potential examples where it may be appropriate to deviate from this guidance:

- A small waste site is **sampled or** remediated **and sampled**; **analytical results indicate** all radionuclides and chemical constituents are below remedial action goals (RAGs). **The decision-makers agree** to attach the raw analytic data to the TPA-MP-14 waste site reclassification form with a location map and a brief description of the action(s) **performed**. No other effort may be needed for reclassification or cleanup verification of this waste site.

- Site-specific guidance from the decision makers specifically provides an alternate method for a portion of the CVP/RSVP or for an entire CVP/RSVP. This site-specific guidance should

be documented in specific meeting minutes, by correspondence, or specifically noted in the alternate CVP/RSVP approved by decision makers.

- Continuing process improvements may require deviation from this guidance in an effort to improve and streamline the CVPs and RSVPs. CVP and RSVP process changes will be incorporated into this appendix during future revisions of this document. Material process changes and decision-maker concurrence with material CVP and RSVP changes are documented either in meeting minutes or by correspondence.

The remainder of this guidance describes many of the steps and details of both a CVP and an RSVP. It is not designed to serve as a textbook, general statistics primer, or RESidual RADioactivity (RESRAD) manual. The guidance describes how many of the CVPs and RSVPs are prepared.

G.II CLEANUP VERIFICATION PACKAGES AND REMAINING SITES VERIFICATION PACKAGES

EXECUTIVE SUMMARY

The executive summary restates (at a high level) the contents of the CVP/RSVP. Included in this summary is a table documenting achievement of remedial action objectives (RAOs) for the given waste site. Table G-1 is an example of such a table. In addition, an example Waste Site Reclassification Form (WSRF) is also included. In a CVP, the WSRF follows the Executive Summary but the RSVP is an attachment to the WSRF.

Table G-1. Summary of Attainment of Remedial Action Objectives. (3 Pages)

Regulatory Requirement	Remedial Action Goals	Results	Remedial Action Objectives Attained?	Ref.
Direct Exposure – Radionuclides	Attain 15 mrem/yr dose rate above background over 1,000 years.	**Example Language:** *Maximum dose rate calculated by RESRAD is 4.59 mrem/yr.*	Yes	e
Direct Exposure – Nonradionuclides	Attain individual COC RAGs.	**Example Language:** *All individual COC concentrations are below the RAGs.*	*Yes*	*e,f*
Meet Nonradionuclide Risk Requirements	Attain a hazard quotient of <1 for all individual noncarcinogens.	**Example Language:** *The hazard quotients for individual nonradionuclide COCs in the shallow zone and overburden are less than 1.*	*Yes*	*g*

Table G-1. Summary of Attainment of Remedial Action Objectives. (3 Pages)

Regulatory Requirement	Remedial Action Goals	Results	Remedial Action Objectives Attained?	Ref.
	Attain a cumulative hazard quotient of <1 for noncarcinogens.	**Example Language:** *The cumulative hazard quotient is less than 1 for the shallow zone and overburden.*	*Yes*	*g*
	Attain an excess cancer risk of <1 x 10^{-6} for individual carcinogens.	**Example Language:** *Excess cancer risk values for individual nonradionuclide COCs are less than 1 x 10^{-6}.*	*NA*	*g*
	Attain a total excess cancer risk of <1 x 10^{-5} for carcinogens.	**Example Language:** *Total excess cancer risk is less than 1 x 10^{-5}.*	*NA*	*g*
Groundwater/ River Protection – Radionuclides	Attain single COC groundwater and river protection RAGs.	**Example Language:** *Cesium-137, cobalt-60, nickel-63, strontium-90, and tritium are calculated to reach groundwater in the 1,000 years of the RESRAD model run. However, none of these constituents is predicted to migrate to groundwater (and thus the Columbia River) at concentrations exceeding groundwater or river criteria within 1,000 years. Therefore, residual concentrations achieve the remedial action objectives for groundwater and river protection.*	*Yes*	*b*
	Attain National Primary Drinking Water Standards: 4 mrem/yr (beta/gamma) dose rate to target receptor/organs. [a]	**Example Language:** *The organ-specific dose rate is below the 4 mrem/yr dose rate limit.*		*h*
	Meet drinking water standards for alpha emitters: the more stringent of the 15 pCi/L MCL or 1/25th of the derived concentration guide per DOE Order 5400.5. [b]	**Example Language:** *There are no alpha-emitting COCs for this site.*	*NA*	*h*
	Meet total uranium standard of 21.2 pCi/L. [c]	**Example Language:** *Isotopic uranium concentrations are below background.*	*NA*	*e*

Table G-1. Summary of Attainment of Remedial Action Objectives. (3 Pages)

Regulatory Requirement	Remedial Action Goals	Results	Remedial Action Objectives Attained?	Ref.
Groundwater/ River Protection – Nonradionuclides	Attain individual nonradionuclide groundwater and river cleanup requirements.	**Example Language:** *Residual concentrations of lead exceeded soil RAGs for the protection of groundwater and/or the Columbia River. However, it is predicted that lead will not migrate to groundwater (and thus the Columbia River) at concentrations exceeding groundwater or river criteria within 1,000 years.*[d] *Therefore, residual concentrations achieve the remedial action objectives for groundwater and river protection.*	*Yes*	*e*
Other supporting Information	Sampling plan (Appendix B).			*i*

Example Footnotes:

[a] "National Primary Drinking Water Regulations" (40 *Code of Federal Regulations* 141).

[b] *Radiation Protection of the Public and the Environment* (DOE Order 5400.5).

[c] Based on the isotopic distribution of uranium in the Hanford Site background, the 30 µg/L MCL (40 CFR 141) corresponds to 21.2 pCi/L. Concentration-to-activity calculations are documented in *Calculation of Total Uranium Activity Corresponding to a Maximum Contaminant Level for Total Uranium of 30 Micrograms per Liter in Groundwater*, 0100X-CA-V0038 (BHI 2001).

[d] *100 Area Analogous Sites RESRAD Calculations*, 0100X-CA-V0050, Rev. 0, Bechtel Hanford, Inc., Richland, Washington (2005).

[e] *118-F-1 Burial Ground Cleanup Verification RESRAD Calculation Brief*, 0100F-CA-V0280, Rev. 0, Washington Closure Hanford, Richland, Washington (2007).

[f] *118-F-1 Burial Ground Cleanup Verification 95% UCL Calculations*, 0100F-CA-V0279, Rev. 1, Washington Closure Hanford, Richland, Washington (2007).

[g] *118-F-1 Burial Ground Hazard Quotient and Carcinogenic Risk Calculations*, 0100F-CA-V0283, Rev. 0, Washington Closure Hanford, Richland, Washington (2007).

[h] *118-F-1 Burial Ground Comparison to Drinking Water Standards (MCL) Calculation*, 0100F-CA-V0281, Rev. 0, Washington Closure Hanford, Richland, Washington (2007).

[i] *118-F-1 Burial Ground Shallow Zone, Process Trenches, and Overburden Sample Design*, 0100F-CA-V0282, Rev. 0, Washington Closure Hanford, Richland, Washington (2007).

COC = contaminant of concern
MCL = maximum contaminant level
NA = not applicable
RAG = remedial action goal
RESRAD = RESidual RADioactivity (dose model)

Example Attachment ES-1

Waste Site Reclassification Form

Date Submitted: 10/08/07 Originator: L. M. Dittmer Phone: 372-9227	**WASTE SITE RECLASSIFICATION FORM** Operable Unit(s): 100-FR-2 Waste Site Code: 118-F-1 Type of Reclassification Action: Closed Out ☐ Interim Closed Out ☒ No Action ☐ RCRA Postclosure ☐ Rejected ☐ Consolidated ☐	Control Number: 2007-019

This form documents agreement among parties listed authorizing classification of the subject unit as Closed Out, Interim Closed Out, No Action, RCRA Postclosure, Rejected, or Consolidated. This form also authorizes backfill of the waste management unit, if appropriate, for Closed Out and Interim Closed Out units. Final removal from the NPL of No Action and Closed Out waste management units will occur at a future date.

Description of current waste site condition:

Remedial action at this site has been performed in accordance with remedial action objectives and goals established by the U.S. Environmental Protection Agency and the Washington State Department of Ecology, in concurrence with the U.S. Department of Energy, Richland Operations Office. The selected remedial action involves (1) excavating the site to the extent required to meet specified soil cleanup levels, (2) disposing of contaminated excavation materials at the Environmental Restoration Disposal Facility at the 200 Area of the Hanford Site, and (3) backfilling the site with clean soil to adjacent grade elevations. The excavation and disposal activities have been completed.

Basis for reclassification:

In accordance with this evaluation, the verification sampling results support a reclassification of this site to Interim Closed Out. The current site conditions achieve the remedial action objectives and the corresponding remedial action goals established in the *Record of Decision for the 100-BC-1, 100-BC-2, 100-DR-1, 100-DR-2, 100-FR-2, 100-HR-2, and 100-KR-2 Operable Units, Hanford Site (100 Area Burial Grounds), Benton County, Washington,* U. S. Environmental Protection Agency, Region 10, Seattle, Washington. The results of verification sampling show that residual contaminant concentrations do not preclude any future uses (as bounded by the rural-residential scenario) and allow for unrestricted use of shallow zone soils (i.e., surface to 4.6 m [15 ft] deep). The results also demonstrate that residual contaminant concentrations are protective of groundwater and the Columbia River. The 118-F-1 excavation area has a maximum depth of approximately 5.5 m (18 ft), which includes a shallow zone and a deep zone. However, the entire excavation area is considered one decision unit, and is closed out using the more restrictive shallow zone cleanup criteria; therefore, institutional controls to prevent uncontrolled drilling or excavation into the deep zone are not required. The basis for reclassification is described in detail in the *Cleanup Verification Package for the 118-F-1 Burial Ground* (CVP 2007-00001), Washington Closure Hanford, Richland, Washington.

Waste Site Controls:
Engineered Controls: Yes ☐ No ☒ Institutional Controls: Yes ☐ No ☒ O&M requirements: Yes ☐ No ☒
If any of the Waste Site Controls are checked Yes specify control requirements including reference to the Record of Decision, TSD Closure Letter, or other relevant documents.

S. L. Charboneau DOE Federal Project Director (printed)	Signature	Date
N/A Ecology Project Manager (printed)	Signature	Date
R. A. Lobos EPA Project Manager (printed)	Signature	Date

G.II-1.0 STATEMENT OF PROTECTIVENESS

A paragraph states that the waste site attains remedial action objectives of the relevant ROD and discusses the pertinent future land use for the area. Whether or not institutional controls are necessary is explained.

G.II-2.0 SITE DESCRIPTION AND BACKGROUND

The site history, waste disposal history, site physical dimensions, and location are summarized in this section of the CVP/RSVP and a figure(s) showing the vicinity map and/or site plan are provided.

G.II-3.0 CONFIRMATORY SAMPLING ACTIVITIES

The purpose of this section is to summarize results of site confirmatory sampling activities performed for the site. The type of information to be provided would include dates of site visits, dates of sampling, whether RL or regulatory agencies participated, objectives of the site visit, and any findings or determinations (e.g., nature and extent of contamination, visible description of staining, waste form) of the site visit.

Geophysical Investigations

This section describes geophysical surveys performed at the site including figures showing nature and extent of contamination.

Contaminants of Potential Concern for Confirmatory Sampling

The purpose of this section is to summarize and discuss all COPCs and provide a description of how they were derived (e.g., based on process knowledge, as listed in this RDR/RAWP, the DQO, or ROD [EPA 2000], based on analogous site information, visible inspection of waste form.)

Confirmatory Sample Design

The purpose of this section is to summarize the site-specific work instruction or other documentation/processes leading to sampling (e.g., phased approach using Visual Sample Plan[1] software and focused sampling, statistical sampling). This section typically includes a figure showing locations of confirmatory samples and a confirmatory sample summary table similar to Table G-2.

[1] Visual Sample Plan is a site map-based user-interface program that may be downloaded at http://dqo.pnl.gov.

Table G-2. Confirmatory Sample Summary.

Sample Location	Sample Media	Sample Number	Coordinate Locations	Depth (m bgs)	Sample Analysis
Example Information					
Septic tank	*Septic tank contents*	*J01XN2*	*N 147917 E 580875*	*3*	*GEA, gross alpha, gross beta, ICP metals, PCB, pesticides, mercury, SVOA, VOA*
		J01XN6			*Hexavalent chromium*
Duplicate septic tank samples	*Septic tank contents*	*J01XN3*	*N 147917 E 580875*	*3*	*GEA, gross alpha, gross beta, ICP metals, PCB, pesticides, mercury, SVOA, VOA*
		J01XN7			*Hexavalent chromium*
Ash located east of septic tank	*Ash*	*J01XN1*	*N 147917 E 580882*	*0.5*	*ICP metals, PCB, pesticides, mercury, SVOA*
		J01XN5			*Hexavalent chromium*
Equipment blank	*Silica sand*	*J01XN4*	*NA*	*NA*	*ICP metals, mercury, SVOA, PCB, pesticides*

Example Footnotes:
Source: Remaining Sites Field Sampling, Logbook.
bgs = below ground surface
GEA = gamma energy analysis
ICP = inductively coupled plasma
NA = not applicable
PCB = polychlorinated biphenyl
SVOA = semivolatile organic analysis
VOA = volatile organic analysis

Confirmatory Sample Results

The purpose of this section is to describe the results of confirmatory sampling activities and compare sampling results to the RAGs. This section also documents the determination of whether remedial action is recommended for the given waste site. Results of confirmatory sampling are provided in an appendix to the RSVP.

G.II-4.0 REMEDIAL ACTION SUMMARY

A description of the excavation and disposal activities is given in this section. The pre- and post-remediation topographic contours are shown in figures. Necessary information includes the dates of waste site excavation, description (and photographs if applicable) of materials excavated, disposal location of waste material, general excavation dimensions and elevations, and amount of material disposed from the site.

Additionally, the CVP/RSVP will discuss significant materials that may have been left at the site (if any) and what significant materials were removed. A summary of field screening activities (if applicable) that guided remedial actions is also included.

G.II-5.0 VERIFICATION SAMPLING ACTIVITIES

Describe and discuss the information used to develop the sampling designs for cleanup verification sampling including reference to appropriate documents and dates of sampling. Discuss the figures showing pre-excavation and post-excavation boundaries and site contours.

Contaminants of Concern and Contaminants of Potential Concern

Waste site COCs and COPCs identified for cleanup verification through process knowledge, previous sampling, and/or agreement with decision makers are listed in this section. During site remediation additional COCs/COPCs may be identified by in-process sampling for the site and COPCs previously identified may also be excluded. Additional COCs or COPCs identified for the site will be to demonstrate RAG and RAO attainment. Likewise, if during remediation and/or verification sampling a SAP-identified COPC is not detected, the constituent will be excluded from the final site COC list. Excluded COPCs are not included in calculation of waste site risk or hazard quotient. The rationale for the final site COC/COPC list is discussed in this section.

Verification Sample Design

The purpose of this section is to describe the verification sampling design for the given waste site. Sample designs are typically developed using Visual Sample Plan, which is a tool to develop the statistical sampling design for a given waste site. This tool uses the remediation footprint of the site to develop a systematic grid for verification soil sample collection. This section describes the number of samples and locations for the given site and includes a table listing the sample numbers, the associated Hanford Environmental Information System sample number, and the Washington State Plane coordinates of each sample location. These sample locations are also typically presented in a figure showing the remediation footprint of the given waste site.

The division of the site excavation into decision units (e.g., shallow zone and deep zone) is a function of the applicable RAGs. The direct exposure, groundwater protection, and river protection RAGs are applicable to soils within 4.6 m (15 ft) of the ground surface. This soil zone is referred to as the shallow zone. The groundwater protection and river protection RAGs are applicable to soils greater than 4.6 m (15 ft) below the ground surface. This soil zone is referred to as the deep zone. If a site is relatively clean and will meet the direct exposure cleanup criteria throughout the site excavation, it is appropriate to handle the entire site as a shallow zone decision unit.

A brief explanation regarding the remedial excavation decision units and cleanup verification sampling is included in this section. Discussion regarding the rationale for using a single shallow zone decision unit or dividing the site into separate shallow and deep zone decision units is given. Sampling dates and the number of samples collected per decision unit are discussed in this section. If any focused sampling was conducted, a summary of this activity and rationale is also included.

G.II-6.0 VERIFICATION SAMPLING RESULTS

The verification samples collected are submitted to offsite laboratories for analysis using approved EPA analytical methods. The laboratory-reported data results from the sampling are used in the statistical calculations (as appropriate) and are included in appendices to the CVP/RSVP.

The primary statistical calculation to support cleanup verification is the 95% upper confidence limit (UCL) on the arithmetic mean of the data. The 95% UCL values for each COC and detected COPC are computed for each decision unit (e.g., for the shallow and deep zones and overburden, as appropriate). If no detection for a given COPC was reported in the data set, no statistical evaluation or calculations are performed for that COPC. For the statistical evaluation of duplicate sample pairs, the samples are averaged before being included in the data set.

The statistical values represent the COC concentrations for each decision unit (e.g., shallow zone or deep zone soils). Statistical values are established in the 95% UCL calculations for compliance with cleanup standards calculation brief, where the data are evaluated per *Washington Administrative Code* (WAC) 173-340 guidance. The calculation brief is included in an appendix to the CVP/RSVP.

- **Radionuclides:** The 95% UCL is calculated on the arithmetic mean for each radionuclide COC and detected COPC. The laboratory reported values, including negative values, are used in the UCL calculation. If a UCL is negative, the value is rounded to zero. In instances where the laboratory does not report a value below the minimum detectable activity, half of the minimum detectable activity value is used in the 95% UCL value for all radionuclide nonparametric formulae that is used to calculate the 95% UCL value for all radionuclide verification data sets.

- **Nonradionuclides:** For nonradionuclides, the distribution of large data sets (10 or more data points per component) is examined per the guidelines presented in *Statistical Guidance for Ecology Site Managers* (Ecology 1992) and in *Statistical Guidance for Ecology Site Managers, Supplement S-6* (Ecology 1993). Small data sets (less than 10 data points per component) are evaluated in accordance with Section 5.2.1.4 of the site managers' guidelines (Ecology 1992).

  For nonradionuclide data flagged with "U" (i.e., less than detection), a value equal to half the practical quantitation limit is used in the 95% UCL calculation for COCs and detected

COPCs. When a nonradionuclide COC or COPC is detected in fewer than 50% of the samples collected, and for focused sampling, the maximum detected value is used for comparison with the RAGs instead of calculating the 95% UCL value.

Comparisons of quantified COC and COPC results with the RAGs for the waste site are summarized in appropriate tables. Comparison to statistical contaminant concentrations and comparisons to focused sampling results are presented in separate tables. Contaminants that were not detected by laboratory analysis are excluded from these tables. Calculated cleanup levels are not presented in the *Cleanup Levels and Risk Calculations (CLARC) Database* (Ecology 2005) under WAC 173-340-740(3) for aluminum, calcium, iron, magnesium, potassium, silicon, and sodium; therefore, these constituents are not considered site COPCs and are also not included in these tables. Potassium-40, radium-226, radium-228, thorium-228, and thorium-232 may be detected in waste site samples, but are excluded from these tables because these isotopes are not related to the operational history of the Hanford Site. The laboratory-reported data results for all constituents are stored in the Environmental Restoration (ENRE) project-specific database prior to archival in the Hanford Environmental Information System (HEIS) and are included in document appendices.

An example table showing the statistical results as determined in the UCL, site lookup values for shallow zone, groundwater protection, and river protection and a comparison of the statistical value to the lookup values is shown in Table G-3.

Table G-3. Comparison of Maximum or Statistical Contaminant Concentrations to Action Levels.[a] (3 Pages)

COC/COPC	Statistical Result (pCi/g)	Generic Site Lookup Values (pCi/g)			Does the Statistical Result Exceed Lookup Values?	Does the Statistical Result Pass RESRAD Modeling?
		Shallow Zone Lookup Value[b]	Groundwater Protection Lookup Value	River Protection Lookup Value		
Example Results:						
Cesium-137	*0.036*	*6.2*	*1,465*	*1,465*	*No*	--
Strontium-90	*0.49*	*4.5*	*27.6*	*27.6*	*No*	--
COC/COPC	**Statistical Result (mg/kg)**	**Remedial Action Goals (mg/kg)**			**Does the Statistical Result Exceed RAGs?**	**Does the Statistical Result Pass RESRAD Modeling?**
		Direct Exposure	**Soil Cleanup Level for Groundwater Protection**	**Soil Cleanup Level for River Protection**		
Example Results:						
Arsenic	*3.5 (<BG)*	*20[c]*	*20[c]*	*20[c]*	*No*	--
Barium	*106 (<BG)*	*16,000*	*200*	*400*	*No*	--
Beryllium	*0.35 (<BG)*	*10.4[f]*	*1.51[e]*	*1.51[e]*	*No*	--
Boron[g]	*5.3*	*16,000[d]*	*320*	*--[h]*	*No*	--
Chromium (total)	*9.0 (<BG)*	*120,000*	*18.5[e]*	*18.5[e]*	*No*	--

Table G-3. Comparison of Maximum or Statistical Contaminant Concentrations to Action Levels.[a] (3 Pages)

COC/COPC	Statistical Result (mg/kg)	Remedial Action Goals (mg/kg)			Does the Statistical Result Exceed RAGs?	Does the Statistical Result Pass RESRAD Modeling?
		Direct Exposure	Soil Cleanup Level for Groundwater Protection	Soil Cleanup Level for River Protection		
Example Results (cont):						
Chromium (hexavalent)	*0.6*	*2.1[f]*	*4.8*	*2*	*No*	--
Copper	*13.0 (<BG)*	*2,960[d]*	*59.2*	*22[e]*	*No*	--
Lead	*10.4*	*353[j]*	*10.2[e]*	*10.2[e]*	*Yes*	*Yes[j]*
Manganese	*318 (<BG)*	*11,200[d]*	*512[e]*	*512[e]*	*No*	--
Mercury	*0.03 (<BG)*	*24[d]*	*0.33[e]*	*0.33[e]*	*No*	--
Nickel	*10.0 (<BG)*	*1,600[d]*	*19.1[e]*	*27.4*	*No*	--
Vanadium	*38.6 (<BG)*	*560[d]*	*85.1[e]*	*--[h]*	*No*	--
Zinc	*47.8 (<BG)*	*24,000[d]*	*480*	*67.8[e]*	*No*	--
Anthracene	*0.065*	*24,000*	*240*	*1,920*	*No*	--
Benzo(a)anthracene	*0.05*	*1.37[k]*	*0.015[l]*	*0.015[l]*	*Yes*	*Yes[j]*
Benzo(a)pyrene	*0.05*	*0.137[k]*	*0.015[l]*	*0.015[l]*	*Yes*	*Yes[j]*
Benzo(b)fluoranthene	*0.04*	*1.37[k]*	*0.015[l]*	*0.015[l]*	*Yes*	*Yes[j]*
Benzo(g,h,i)perylene[m]	*0.140*	*2,400*	*48*	*192*	*No*	--
Benzo(k)fluoranthene	*0.076*	*13.7[k]*	*0.015[l]*	*0.015[l]*	*Yes*	*Yes[j]*
Chrysene	*0.06*	*137[k]*	*1.2*	*0.10[l]*	*No*	--
Dibenzo(a,h) anthracene	*0.024*	*0.137[k]*	*0.030[l]*	*0.030[l]*	*No*	--
Fluoranthene	*0.15*	*3,200[d]*	*64*	*18*	*No*	--
Fluorene	*0.030*	*3,200[d]*	*64*	*260*	*No*	--
Indeno(1,2,3-cd) pyrene	*0.04*	*1.37[k]*	*0.030[l]*	*0.030[l]*	*Yes*	*Yes[j]*

Table G-3. Comparison of Maximum or Statistical Contaminant Concentrations to Action Levels.[a] (3 Pages)

COC/COPC	Statistical Result (mg/kg)	Remedial Action Goals (mg/kg)			Does the Statistical Result Exceed RAGs?	Does the Statistical Result Pass RESRAD Modeling?
		Direct Exposure	Soil Cleanup Level for Groundwater Protection	Soil Cleanup Level for River Protection		
Phenanthrene[m]	*0.09*	*24,000[d]*	*240*	*1,920*	*No*	--
Pyrene	*0.14*	*2,400[d]*	*48*	*192*	*No*	--

Example Footnotes:

[a] RAG and lookup values obtained from the *Remedial Design Report/Remedial Action Work Plan for the 100 Area* (DOE-RL 2008b), as available. When no values were available in DOE-RL (2008b), appropriate values were determined per WAC 173-340-720, 730, and 740 and the most recent available carcinogenicity/toxicity data, unless otherwise noted.
[b] Activity corresponding to a single-radionuclide 15 mrem/yr exposure as calculated using a generic RESRAD model (DOE-RL 2008a).
[c] The cleanup value of 20 mg/kg has been agreed to by Tri-Party project managers. The basis for 20 mg/kg is provided in DOE-RL (2008b).
[d] Noncarcinogenic cleanup level calculated from WAC 173-340-740(3), Method B, 1996.
[e] Where cleanup levels are less than background, cleanup levels default to background (WAC 173-340-700[4][d]) (1996).
[f] Carcinogenic cleanup level calculated based on the inhalation exposure pathway (WAC 173-340-750[3]) (1996).
[g] No Hanford Site-specific or Washington State background value available.
[h] No cleanup level is available from the Ecology Cleanup Levels and Risk Calculations tables, and no toxicity values are available to calculate cleanup levels (Ecology 2005).
[i] A WAC 173-340-740(3) (1996) value for lead is not available. This value is based on the Guidance Manual for the Integrated Exposure Uptake Biokinetic Model for Lead in Children (EPA 1994).
[j] Based on the *100 Area Analogous Sites RESRAD Calculations* (BHI 2005), neither lead nor PAHs are expected to migrate more than 3 m (10 ft) vertically in 1,000 years. The vadose zone underlying the remediation footprint is approximately 13 m (43 ft) thick.
[k] Carcinogenic cleanup level calculated per WAC 173-340-740(3), Method B, 1996.
[l] Where cleanup levels are less than the RDL, cleanup levels default to the RDL (WAC 173-340-707[2], 1996 and DOE-RL 2008b).
[m] Toxicity data for this chemical are not available. RAGs for benzo(g,h,i)perylene and phenanthrene are based on the surrogate chemicals pyrene and anthracene, respectively.

-- = not applicable
BG = background
COC = contaminant of concern
COPC = contaminant of potential concern
RAG = remedial action goal
RESRAD = RESidual RADioactivity (dose assessment model)
RDL = required detection limit
WAC = *Washington Administrative Code*

G.II-7.0 VERIFICATION SAMPLE DATA EVALUATION

This section describes the evaluation of the sampling data in terms of comparison to the RAGs, as listed in the tables reporting the sample results, the radionuclide dose and risk requirements, the nonradionuclide risk requirements, and the WAC 173-340-740(7)(e) three-part test.

Ideally, evaluation of the results listed in the tables reporting the sample results indicates that all COPCs were quantified below RAGs and lookup values. In this case, residual concentrations of site COPCs are protective in relation to the requirements for direct exposure, groundwater protection, and river protection.

Comparison of Sample Data to the RAGs

Typically, with the exception of a few contaminants, evaluation of the results from verification sampling at the waste site will indicate that all COCs and COPCs were quantified below RAGs

and lookup values. Exceedance of cleanup levels for direct exposure seldom occurs but could trigger additional cleanup, a site-specific risk analysis, or other evaluation based upon the likelihood of a threat to human health. Residual concentrations of a few contaminants will often exceed soil RAGs for groundwater and river protection. When soil RAGs for groundwater and river protection are exceeded the distribution coefficient (K_d) for the contaminant is evaluated against the determinations in the *100 Area Analogous Sites RESRAD Calculations* (BHI 2005) to predict if the contaminant would be expected to migrate vertically to groundwater in 1,000 years. The thickness of the vadose zone beneath the excavation must be determined. The contaminant depth/K_d value model assumes that uncontaminated soil exists in the vadose zone between the bottom of the waste site and groundwater. The assumption of an uncontaminated zone beneath the waste site is reasonable based on analogous site data that includes test pits and boreholes completed in the operable units in the 100 Area. The test pit and/or borehole data show that contaminant concentrations that are below direct exposure cleanup levels decrease to background concentrations within less than 3 m (10 ft) below the elevation at which the contamination occurs.

Comparison of Sample Data to the Eco-Screening Levels. Sampling results will be compared against Ecological Screening Levels from a table providing the criteria described in Section 2.1.2.6, Ecological Risk Evaluation. The discussion in this section should be essentially the same discussion as the paragraph discussing the eco-screening results in the Executive Summary.

Evaluation of Remedial Action Goal Attainment

This section discusses how the verification sampling data are used in demonstrating RAG attainment.

Radionuclides

The individual radionuclide cleanup verification statistical values may be entered into the RESRAD computer code, (current version 6.4 [ANL 2007]), to predict the dose rate and the impact on groundwater and the river from residual radionuclide concentrations. Separate RESRAD runs are performed for separate units of a waste site area (e.g., the excavation footprint, overburden/BCL decision unit, and waste sorting trenches).

The results of the RESRAD dose rate predictions for the all-pathways scenarios for the units of the waste site area are typically shown in Figures of dose rate versus time (years). These dose rates represent the dose contributions from soils at relevant time periods. The 2018 date is included to correspond to the 30-year site cleanup schedule of the *Hanford Federal Facility Agreement and Consent Order* (Ecology et al. 1989). All dose rate predictions must be less than the 15 mrem/yr RAG to meet the RAGs. The RESRAD computations are shown in detail in calculation briefs presented in an Appendix to the CVP/RSVP.

Alternatively, for waste sites with few radionuclide COCs at concentrations well below the individual radionuclide lookup values, Table G-4 provides a typical comparison of the shallow

zone (including overburden) radionuclide cleanup verification statistically quantified values to direct exposure single radionuclide 15 mrem/yr dose-equivalence values using a sum of fractions evaluation. The columns on the left side of Table G-4 are the COCs and the 95% UCL values, corrected for background, as appropriate. The fourth column presents the single radionuclide 15 mrem/yr dose equivalence activity, and the last two columns present the statistical values divided by the dose equivalence activity.

Table G-4. Attainment of Radionuclide Direct Exposure RAG.

COCs	95% UCL Statistical Values (pCi/g)		Activity Equivalent to 15 mrem/yr Dose[a] (pCi/g)	Fraction	
	Shallow Zone	Overburden		Shallow Zone	Overburden
Example Results:					
Cesium-137	*0.044 (ND)*	*0 (<BG) (ND)*	*6.2*	*0.007*	*0*
Cobalt-60	*0.047 (ND)*	*0.049 (ND)*	*1.4*	*0.034*	*0.035*
Europium-152	*0.100 (ND)*	*0.15 (ND)*	*3.3*	*0.030*	*0.045*
Europium-154	*0.14 (ND)*	*0.14 (ND)*	*3*	*0.047*	*0.047*
Europium-155	*0.12 (ND)*	*0.08 (ND)*	*125*	*0.001*	*0.001*
			Sum of Fractions	*0.119*	*0.128*
			Equivalent Dose (mrem/yr)	*<1.8*	*<2*

Example Footnotes:

[a] Single radionuclide 15 mrem/yr dose-equivalence values and derivation methodology are presented in the *Remedial Design Report/Remedial Action Work Plan for the 100 Area* (DOE-RL 2008b).

BG = background
COC = contaminant of concern
ND = not detected (in all samples in the data set)
UCL = upper confidence limit

Radionuclide Risk Information

If RESRAD modeling is performed for radionuclide dose evaluation, the radionuclide risk information provided by the RESRAD run must be presented. The radionuclide RAG for direct exposure is derived from the Interim Action ROD (EPA 2000) and is expressed in terms of an allowable radiation dose above background (i.e., 15 mrem/yr). The RAG evaluation involved using the RESRAD model to estimate total annual radiation doses for 1,000 years for comparison to the RAG. Radiation presents a carcinogenic risk, and the RESRAD model also calculates the excess lifetime cancer risk associated with the estimated radiation doses. The "National Oil and Hazardous Substances Pollution Contingency Plan" (40 CFR 300) presents a target range for residual risk of 10^{-4} to 10^{-6}. A figure(s) may be provided to illustrate excess lifetime cancer risk as estimated using the RESRAD model. Because of radioactive decay, the risk decreases over time.

Nonradionuclides

The comparison table(s), using Table G-3 as an example, provide a comparison of the nonradionuclide cleanup verification statistical values to the direct exposure RAGs.

Attainment of Noncarcinogenic Risk Standards

For noncarcinogenic COCs, WAC 173-340-740(5)(a) and (b) specifies the evaluation of the hazard quotient, which is given as daily intake divided by a reference dose (DOE-RL 1995). For cleanup actions under the RODs (EPA 1995, 1997a, 2000a, 2000b), a comparable conservative approach is used to demonstrate attainment of the noncarcinogenic risk requirements.

The direct exposure nonradionuclide RAGs for soil are based on the WAC 173-340-740(3) Method B limits. These cleanup limits were set to be compliant with a hazard quotient of 1.0; therefore, the ratio of the cleanup verification statistical values to the cleanup limits (lookup value obtained from Table 2-1 of this RDR/RAWP) provides a conservative approach to addressing the hazard quotient.

The fraction of cleanup level (Fc) is calculated as follows:

$$Fc = S/V$$

where:

Fc = fraction of cleanup level (dimensionless)
S = statistical value of the COCs (in mg/kg)
V = lookup value (WAC 173-340-740(3) Method B derived, direct exposure RAG in mg/kg).

If the Fc is less than 1 for an individual COC, then the hazard quotient has been addressed. For multiple COCs, a sum of the individual COC Fc values was used to address the hazard index or cumulative hazard quotient. The Fc values for all noncarcinogenic COCs were summed. If that sum was less than 1, then the hazard index or cumulative hazard quotient has been addressed.

Attainment of Carcinogenic Risk Standards

For individual carcinogenic nonradionuclide COCs, the WAC 173-340-750(3) Method B cleanup limits are based on an incremental cancer risk of 1×10^{-6}. For cumulative carcinogenic COCs, the cumulative excess cancer risk must be less than 1×10^{-5}. If a linear relationship is assumed between environmental concentration and risk, the ratio (Fc) of the statistical value from the verification samples divided by the WAC 173-340-750(3) Method B limit, multiplied by 10^{-6}, is an estimate of the risk associated with the statistical value.

For multiple carcinogenic COCs, the risks of the individual COCs (described above) are summed. If no risk associated with a single COC exceeds 1×10^{-6}, and if the sum of the

individual COC risk does not exceed 1 x 10^{-5}, then the WAC 173-340-750(5)(a) and (b) Method B risk requirement has been addressed for this remedial action.

For the shallow zone, the individual COC and cumulative risk value are checked against the individual and cumulative WAC 173-340-750(5)(a) and (b) risk limits. This type of calculation is performed and documented in the 95% UCL calculation brief, which is included in an appendix to the CVP/RSVP.

Groundwater Remedial Action Goals Attained

The groundwater RAGs are applicable to all decision units (e.g., shallow zone, deep zone, and overburden).

Radionuclides

The estimated groundwater concentrations for all the radionuclide COCs contributed by the soils in the shallow zone (and deep zone, if present) are determined by RESRAD modeling, which is documented in a calculation brief. If the groundwater concentrations predicted by RESRAD indicate that COCs impact groundwater, then a separate calculation is needed to determine compliance with groundwater dose standards. Comparison of peak radionuclide concentrations to the groundwater RAGs is presented in a table similar to Table G-5.

Table G-5. Estimated Peak Radionuclide Groundwater Concentrations (Shallow Zone, Deep Zone, BCL Overburden, and Staging Pile Impacts) Compared to RAGs.

Radionuclide	Peak Concentration (pCi/L)	RAG (pCi/L)	RAGS Attained? (Yes/No)
Example Language:			
Tritium	*18,500*	*20,000*	*Yes*

Example Footnotes:
BCL = below cleanup level
RAG = remedial action goal

Nonradionuclides

The comparison table(s), using Table G-3 as an example, provides a comparison of the nonradionuclide cleanup verification statistical values to the groundwater and river protection RAGs. When the residual concentrations of a COC exceed the RAGs, a site-specific evaluation must be performed to predict if the COC will reach groundwater within 1,000 years. The *100 Area Analogous Sites RESRAD Calculations* (BHI 2005) and contaminant-specific soil partitioning coefficient (K_d) values are used to indicate if the COC will not migrate from the bottom of the excavation footprint through the unsaturated vadose zone to groundwater within 1,000 years.

The thickness of the vadose zone underlying the site must be determined to be greater than the distance the COC is predicted to migrate in 1,000 years and, as such, the contaminant will not reach groundwater (and, therefore, the Columbia River) in 1,000 years.

WAC 173-340 Three-Part Test For Nonradionuclides

This section documents application of the WAC 173-340-740(7)(e) three-part test for nonradionuclides using the most restrictive RAGs applicable for each zone. (The most restrictive RAG is defined as the lowest of the direct exposure, groundwater protection, and river protection RAGs. The direct exposure, groundwater protection, and river protection RAGs are applicable to the shallow zone and overburden. Groundwater and river protection RAGs are applicable to the deep zone.) The WAC 173-340-740(7)(e) three-part test consists of the following criteria: (1) the cleanup verification statistical value must be less than the cleanup level, (2) no single detection can exceed two times the cleanup criteria, and (3) the percentage of samples exceeding the cleanup criteria must be less than 10%. The duplicate sample is treated as a separate sample for the three-part test. The split sample is only used for DQA purposes and is not included in the three-part test.

The application of this test is usually included in the 95% UCL calculation and is included in an appendix to the CVP/RSVP. An explanation of which COCs/COPCs pass and which fail this test is listed. Of those that fail, an explanation of how RESRAD modeling is used to ensure the COCs/COPCs satisfy the three-part test criteria is listed. A table (see Table G-6 as an example) may be provided to demonstrate that the criteria of the three-part test have been met.

G.II-8.0 DATA QUALITY ASSESSMENT PROCESS

The DQA has been integrated into the CVP/RSVP and is presented here as a subsection. The DQA is very briefly summarized in the body of the CVP/RSVP, with the detailed DQA (as represented with the following sections) placed in an appendix to the CVP/RSVP. The DQA process involves the scientific and statistical evaluation of data to determine if the data are of the right type, quality, and quantity to support the intended use (EPA 2000). The DQA process completes the data life cycle (i.e., planning, implementation, and assessment) that was initiated by the data quality objective (DQO) process.

The DQA process is not intended to be a definitive analysis of a project or problem, but instead provides an initial assessment of the reasonableness of the data that have been generated (EPA 2000).

The DQA focuses on the laboratory data, statistical error tolerances, and the overall DQO, specifically by addressing the question, "Are the data of the right type, quality, and quantity to support their intended use?" The intended use of the data is to make the appropriate decision regarding whether the site meets the RAOs as defined by the RAGs. The site closeout or cleanup decision rules are the RAGs. Completion of a CVP/RSVP following this guidance inherently is the functional equivalent of performing a DQA for a waste site.

Table G-6. Summary of the WAC 173-340 Three-Part Test [a].

COC/COPC	Most Restrictive Applicable RAG	Statistical Cleanup Verification Value (mg/kg)[b]	Maximum Detected Cleanup Verification Value (mg/kg)[c]	Total Number of Samples[d]	Percentage of Cleanup Verification Data Set Exceeding RAG[e]	Cleanup Criteria Attained?
Example Data **Waste Sorting Trenches**						
Lead	10.2[g]	18	32	5	20%	Yes[f]
Example Data **Overburden/BCL Piles**						
Lead	10.2[g]	12	22.8	16	37.5%	Yes[f]

Example Footnotes

[a] Only the COCs/COPCs that failed the WAC 173-340 Three-Part Test are presented.
[b] Criterion is statistical value cannot exceed most restrictive applicable RAG.
[c] Criterion is no single detection can exceed two times the most restrictive applicable RAG.
[d] Total number of samples in the decision unit may include field duplicate samples, which are included in the evaluation as separate samples.
[e] Criterion is percentage of data set exceeding the most restrictive applicable RAG cannot exceed 10%.
[f] Based on the *100 Area Analogous Sites RESRAD Calculations* (BHI 2005) and contaminant-specific soil-portioning coefficient (K_d) value, contaminant will not migrate vertically more than 3 m (10 ft) in 1,000 years. As the vadose zone underlying the site is greater than 3 m (10 ft) thick, the contaminant will not reach groundwater (and thus the Columbia River) in 1,000 years.
[g] Where cleanup levels are less than background, cleanup levels default to background (WAC 173-340-700[4][d]) (1996).

BCL = below contaminant level
COC = contaminant of concern
COPC = contaminant of potential concern
RAG = remedial action goal
RESRAD = RESidual RADioactivity (dose model)
WAC = *Washington Administrative Code*

The DQA is not performed on field screening data, as field screening data are not used in decisions regarding the rejection of null hypothesis. Thus, field decisions will be made based on the field screening data with the understanding that the decision to remediate a site shown to be contaminated based on field readings may not be within error tolerances. This is a risk management decision and is deemed as an acceptable risk by project decision makers.

After sampling is completed, confirmatory and verification sample data packages are validated to Level C per ENV-1, *Environmental Monitoring & Management,* Procedure 2.12, "Data Package Validation." Level C validation procedures are specified in *Data Validation Procedure for Chemical Analysis* (BHI 2000b) and *Data Validation Procedure for Radiochemical Analysis* (BHI 2000c).

Under the Level C validation procedure, the following items are reviewed, as appropriate, for each analytical method:

- Sample holding times
- Method blanks

- Matrix spike recovery
- Surrogate recovery
- Matrix spike/matrix spike duplicate results
- Sample replicates
- Associated batch laboratory control sample results
- Data package completeness.

For RSVPs and related documents (e.g., leachability study reports, data summary reports), all laboratory-applied "J" flags on radionuclide results will be deleted. A footnote will be included in the radionuclide data summary tables indicating that, because of laboratory reporting conventions, these results may have a nonrelevant "J" qualifier in the Hanford Environmental Information System database and/or in the analytical report.

Where the "J" qualifier is applied through the validation process, the qualifier will not be deleted and the traditional "estimated" footnote will be presented. The footnote will also direct the reader to the DQA section of the document. The DQA section provides additional discussion regarding the reasons why the "J" qualifier was applied during validation and also discusses the usability of the data.

Data flagged as below detection limits (i.e., "U") indicate that the analyte was analyzed for but not detected, and the concentration shown is the practical quantitation limit. Data flagged as rejected (i.e., "R") indicate that the data are not useable due to a quality assurance/quality control deficiency. All other validated results are considered accurate within the standard errors associated with the methods.

The adequacy of laboratory quality assurance/quality control is evaluated as a subset of the PARCC parameters (i.e., precision, accuracy, representativeness, completeness, and comparability) in the *100 Area Remedial Action Sampling and Analysis Plan* (100 Area SAP) (DOE-RL 2008a). The laboratory data are validated by a contractor, which reports whether the laboratory met the required target detection limits, precision (+/-30%), accuracy (+/-30%), and completeness (>90%). The proportion of analytical results in which the detection limits exceed the 100 Area SAP (DOE-RL 2008a) target detection limits are noted in the data evaluation section of the DQA.

Reported analytical detection levels are compared to the specified detection limits in the 100 Area SAP (DOE-RL 2008a). The data validation notes any analyses in which the detection limit or minimal detectable activity was above the 100 Area SAP-specified detection limits. The detection limits are based on optimal conditions. Interferences and different matrices may significantly affect the values shown. Exceeding the specified detection limits does not necessarily invalidate the data for decision-making purposes; however, the exceedances need to be evaluated on a case-by-case basis within the DQA.

A statement is made regarding acceptability of the matrix spike/matrix spike duplicate samples percent recoveries and relative percent differences. Acceptable limits are in the 100 Area SAP (DOE-RL 2008a).

G.II-9.0 SUMMARY FOR WASTE SITE RECLASSIFICAITON

The purpose of this section is to provide a statement that the given waste site has been evaluated and remediated in accordance with the RODs, and that the results of the verification sampling support a reclassification of the given waste site to "interim closed out."

It is stated that the waste site has been remediated in accordance with the applicable ROD (EPA 1995, 1997, 1999, 2000, etc.) and the current version of the RDR/RAWP (DOE-RL 2010). The amount of material for disposal at the ERDF is noted. Statistical sampling to verify the completeness of remediation, and analytical results for the waste site shown to meet the cleanup objectives for direct exposure, groundwater protection, and river protection are very briefly discussed. Accordingly, an interim closure reclassification is supported for the waste site. The waste site excavation area has a maximum depth is discussed as to how it relates to existence of a shallow zone and a deep zone and the possible need for institutional controls to prevent future intrusion into deep zone contamination. However, the entire excavation area may be considered one decision unit, and closed out using the more restrictive shallow zone cleanup criteria; therefore, institutional controls to prevent uncontrolled drilling or excavation into the deep zone may not be required.

When confirmatory sampling results indicate that residual concentrations of contaminants at the site meet the remedial action objectives for direct exposure, groundwater protection, and river protection remediation is not necessary and it can be stated that a reclassification of the site to "No Action" is supported. Site contamination does not extent into deep zone soils if it is not found in the shallow zone. Hence, confirmatory sampling activities are normally not required for deep zone soils. Therefore, institutional controls to prevent uncontrolled drilling or excavation into the deep zone are not required.

G.II-10.0 REFERENCES

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G.III SUPPLEMENTARY INFORMATION

The following sections are preserved as supplementary and background information for the CVP and RSVP processes because they have been previously approved by the Tri-Party decision-makers and may be difficult to obtain in other venues.

G.III-1.0 SUMMARY OF REMEDIAL ACTION OBJECTIVES AND GOALS

Remedial Action Objectives

The RAOs are broad guidelines intended to define and guide the remediation work. The RAOs are presented in the appropriate ROD. A brief summary of the RAOs is presented below. For more detailed information on the RAOs, see Section 2.0 of this RDR/RAWP and the RODs (EPA 1995, 1997a, 1999, 2000).

1. Protection from direct exposure. Protect human and ecological receptors from exposure to contaminants in soils, structures, and debris by dermal exposure, inhalation, or ingestion of radionuclides, inorganics, or organics.

2. Groundwater and river protection. Control the sources of groundwater contamination to minimize the impacts to groundwater resources, protect the Columbia River from further adverse impacts, and reduce the degree of groundwater cleanup that may be required under future actions.

3. Unlimited future land use. To the extent practicable, return soil concentrations to levels that allow for unlimited future use and exposure. Where it is not practicable to remediate to levels that will allow for unrestricted use in all areas, institutional controls and long-term monitoring will be required.

Remedial Action Goals

The RAGs are the specific numeric goals applied to evaluate the attainment of the RAOs. In accordance with the RODs and RDR/RAWP, the RAGs have been developed to support a rural-residential exposure scenario. In the rural-residential scenario, an individual is assumed to live in a residence on top of the waste site and to spend 20% of his/her time outdoors, 60% of his/her time indoors at that residence, and 20% of the time off site. While indoors the resident is assumed to receive 80% of the gamma radiation dose received by a person outdoors and 40% of the contaminated dust that will be available outdoors. It is further assumed that he/she consumes crops raised in a backyard garden, meat and milk from locally-raised livestock, and meat from local game animals and fish. Residual (i.e., post-cleanup) contaminant concentrations in the shallow zone (i.e., less than 4.6 m [15 ft]) soils are assumed for the soils in which crops are raised and on which animals providing meat and milk are raised. Water that is used by the resident for drinking, showering, and watering livestock is assumed to be taken from groundwater derived from surface water that has infiltrated through the deep zone (i.e., greater

than 4.6 m [15 ft]) soils beneath the site. In addition to the pathways already described, the resident is also assumed to be exposed to any direct gamma radiation associated with residual shallow zone soils. The scenario assumes no contact with an exposure to soils in the deep zone (i.e., below 4.6 m [15 ft]).

A more detailed description of the rural-residential scenario and how it is applied is provided in Section 3.0 of this RDR/RAWP.

Direct Exposure RAGs

Under the rural-resident scenario, direct exposure RAGs are applicable to soils that are less than 4.6 m (15 ft) below ground surface (shallow zone soils including overburden). Direct exposure RAGs for individual contaminants are listed in appropriate tables in the text of the RDR/RAWP and in calculation briefs for contaminants not included in the RDR/RAWP (BHI 2004). The general requirements for direct exposure RAGs at radioactive and nonradioactive waste sites are summarized below.

- **Radionuclide COCs:** Dose above background of less than 15 mrem/yr (this RAG must be met for 1,000 years).
- **Nonradionuclide COCs:**
  - Individual and cumulative hazard quotients of less than 1.0 for noncarcinogenic contaminants
  - Excess cancer risks of less than 1×10^{-6} for individual carcinogenic contaminants
  - Cumulative excess cancer risk of less than 1×10^{-5}
  - Cleanup verification sample results pass the *Model Toxics Control Act Cleanup Regulations* (*Washington Administrative Code* [WAC] 173-340-740[7][e]) three-part test.

Groundwater and River Protection RAGs

Groundwater and river protection RAGs are applicable to all vadose zone soils (shallow and deep zone soils). The groundwater and river protection RAGs are listed in appropriate tables in the text of the RDR/RAWP and in calculation briefs for contaminants not included in the RDR/RAWP (BHI 2004). The general requirements for groundwater and river protection RAGs at radioactive and nonradioactive waste sites are summarized below.

- **Beta- and gamma-emitting radionuclide COCs:** Meet "National Primary Drinking Water Regulations" (40 *Code of Federal Regulations* [CFR] 141.5) dose standards (4 mrem/yr total body or organ dose) for a period of 1,000 years starting from site cleanup.

- **Alpha-emitting radionuclide COCs:** Meet "National Primary Drinking Water Regulations" (40 CFR 141.5) (15 pCi/L excluding radon and uranium). The drinking water maximum contaminant level (MCL) for uranium is 30 μg/L, which corresponds to a total uranium activity of 21.2 pCi/L (BHI 2001).

- **Nonradionuclide COCs:** Meet the individual RAGs based on WAC 173-340-740(3)(a)(ii)(A) (January 1996), the "100 times dilution attenuation factor (DAF) times surface water quality" rule, Hanford Site or Washington State background, the laboratory analytical practical quantitation limit (PQL) with cleanup verification sample results passing the WAC 173-340-740(7)(e) three-part test, or demonstrate by site-specific modeling or other methods (e.g., leachability testing) that residual COC levels do not pose an unacceptable threat to groundwater or surface water for 1,000 years (i.e., residual soil levels do not have the potential to exceed groundwater or river water RAGs).

G.III-2.0 REMEDIAL ACTION FIELD ACTIVITIES WHERE RADIONUCLIDES ARE PRIMARY COCS

Field Screening and In-Process Sampling

Field screening and in-process sampling are conducted during the site remedial action as specified in the 100 Area SAP (DOE-RL 2008a). Both techniques are used to guide the excavation to quickly assess for the presence and level of contamination, and to assess when remediation is complete. Field screening is applicable to those sites (typically the large liquid effluent sites) where radionuclides are primary COCs and generally includes using a radiological data mapping system survey and hand-held sodium iodide (NaI) detectors. In-process sampling generally consists of gamma energy analyses and nonradionuclide analyses. A description of each general technique is discussed below.

- **Radiological Data Mapping System Survey.** When the excavation reaches the subcontract design limits, a radiological data mapping system survey (i.e., the man-carried radiological data system [MRDS], laser-assisted ranging and data system, or similar technology) is deployed to determine if further excavation is warranted. In the case of the MRDS technology, NaI gamma-energy detector equipment is mounted to a portable cart (or backpack) that is pulled (or carried) around the site by an operator. The operator stops at regular intervals and allows the equipment to count the radioactivity at that location. Global positioning system (GPS) coordinate information is transmitted with the radioactivity readings to computers in a nearby van. Operators in the van process the data, and maps of radioactivity at the site are plotted. If hot spots are detected during the survey, further excavation may be planned. The surveys are performed over a minimum of 50% of the site in accordance with field screening procedures. The data collection and mapping efforts are documented in the project files.

- **Sodium Iodide Detector.** If hot spots are identified during site excavation field screening, analysts attempt to confirm the presence of the hot spot with a hand-held NaI detector. If the

hot spot is found, a sample is collected and analyzed using gamma energy analyses. If the hot spot is not confirmed, the radiological mapping survey results at that particular location are reevaluated.

- **Laboratory Analysis.** In-process samples are collected for quick-turnaround laboratory analyses of radionuclides and nonradionuclides at onsite and offsite laboratories. They are used to guide excavation (particularly at sites where nonradionuclides are the primary COCs) and to distinguish between potentially clean materials and contaminated materials for disposal at ERDF. Data from these samples are used to corroborate data obtained from field screening and to assist in waste characterization. The field screening and in-process sampling and analysis efforts are documented in field logbooks and in the project files.

Variance Sampling and Analysis

Variance analysis (as described in the 100 Area SAP, Section A.6 [DOE-RL 2008]) determines the site-specific number of verification samples. The analysis is based on the minimum detectable difference approach presented in U.S. Environmental Protection Agency (EPA) guidance (EPA 1993). In this approach, contaminant variability is quantified and used to determine the number of samples required per EPA guidance to represent the site for clean site verification.

If required, variance analysis may be performed after field screening to indicate that RAGs are met. If variance samples are collected, they are collected from random sampling locations and submitted for analysis in accordance with the 100 Area SAP and the *100 Area Burial Grounds Remedial Action Sampling and Analysis Plan* (100 Area Burial Grounds SAP) (DOE-RL 2008a and 2001, respectively). The data are used for a preliminary assessment of whether the direct radionuclide exposure RAGs and variance requirements have been met. The data may indicate a low degree of variability and contaminant levels below the lookup values or RAGs.

The variance sampling section of the CVP/RSVP briefly describes the variance sampling, including sampling dates, number of variance samples, and type of analyses. The results of the variance analysis generally indicate that the number of verification samples to be taken is less than the default number of four; therefore, four final verification samples are usually collected from each shallow zone decision subunit. Variance analysis results and calculations are included in an appendix to the CVP/RSVP.

When a site is ready (based on field screening) for variance/cleanup verification sampling, the sample designs are developed for each decision unit (e.g., shallow zone, deep zone, overburden) in accordance with the 100 Area SAP (DOE-RL 2008a), and the 100 Area Burial Grounds SAP (DOE-RL 2001). The layout and orientation of the sampling designs are based on the size and shape of the decision unit.

The sampling designs are used to verify site status after remedial action excavation. If statistical sampling is used, random samples are collected to assess variability in contaminant levels (variance assessment). Each decision unit is separated into several sampling areas. Within each

of these sampling areas, a 16-node grid is established and random sampling locations are chosen. Based on the variance sample results, samples are then taken from the random points in each sampling area and are composited for analysis. These cleanup verification samples are used to verify that the site meets the RAGs. If focused sampling is used, the worst-case values are compared to the RAGs directly to verify cleanup. The sample design is documented in a calculation brief and is included in an appendix to the CVP/RSVP.

Cleanup Verification Sampling and Analysis

Final cleanup verification samples are generally collected following variance sampling, analysis, and data evaluation; however, depending on schedule needs, it is also acceptable to collect the variance and verification samples simultaneously. The 100 Area Burial Grounds SAP (DOE-RL 2001) does not require variance sampling. Each verification sample is a composite formed by combining samples collected at four randomly-selected nodes within each sampling area. The sample design methodology and sample location figures are presented in the calculation briefs for variance analysis and sample design in an appendix to the CVP/RSVP.

G.III-3.0 CLEANUP VERIFICATION DATA EVALUATION

This section presents the process that the cleanup verification data undergoes for data quality assessment (DQA) prior to RAG attainment assessment. The DQA process involves the scientific and statistical evaluation of data to determine if the data are of the right type, quality, and quantity to support the intended use (EPA 1996). The DQA process completes the data life cycle (i.e., planning, implementation, and assessment) that was initiated by the data quality objective (DQO) process. The DQA review was performed in accordance with ENV-1, *Environmental Monitoring & Management*. The DQA process is not intended to be a definitive analysis of a project or problem, but instead provides an initial assessment of the reasonableness of the data that have been generated (EPA 1996).

The DQA focuses on the laboratory data, statistical error tolerances, and the overall DQO, specifically by addressing the question, "Are the data of the right type, quality, and quantity to support their intended use?" The intended use of the data is to make the appropriate decision regarding whether the site meets the RAOs as defined by the RAGs. The site closeout or cleanup decision rules are the RAGs. Completion of a CVP or RSVP following this guidance inherently is the functional equivalent of performing a DQA for a waste site.

The DQA is not performed on field screening data, as field screening data are not used in decisions regarding the rejection of null hypothesis. Thus, field decisions will be made based on the field screening data with the understanding that the decision to remediate a site shown to be contaminated based on field readings may not be within error tolerances. This is a risk management decision and is deemed as an acceptable risk by project decision makers.

Error Tolerances

- Type I – false-positive error (site does not meet RAGs when data indicate that it does): A 5% false-positive rate is consistent with the need to calculate a 95% upper confidence limit (UCL) of the mean and was selected for the statistical calculations (DOE-RL 2008a).

- Type II – false-negative error (site meets RAGs when data indicates that it does not): The sample design methodology is designed based on a false-negative error rate of 20%.

Data Validation

After sampling is completed, confirmatory and verification sample data packages are validated to Level C per ENV-1, *Environmental Monitoring & Management,* Procedure 2.12, "Data Package Validation." Level C validation procedures are specified in *Data Validation Procedure for Chemical Analysis* (BHI 2000b) and *Data Validation Procedure for Radiochemical Analysis* (BHI 2000c). Under the Level C validation procedure, the following items are reviewed, as appropriate, for each analytical method:

- Sample holding times
- Method blanks
- Matrix spike (MS) recovery
- Surrogate recovery
- MS/matrix spike duplicate (MSD) results
- Sample replicates
- Associated batch laboratory control sample results
- Data package completeness.

For CVPs, RSVPs, and related documents (e.g., leachability study reports, data summary reports), all laboratory-applied "J" flags on radionuclide results will be deleted. A footnote will be included in the radionuclide data summary tables indicating that, because of laboratory reporting conventions, these results may have a nonrelevant "J" qualifier in the Hanford Environmental Information System database and/or on the analytical report.

Where the "J" qualifier is applied through the validation process, the qualifier will not be deleted and the traditional "estimated" footnote will be presented. The footnote will also direct the reader to the DQA section of the document. The DQA section provides additional discussion regarding the reasons why the "J" qualifier was applied during validation, and also discusses the usability of the data.

Data flagged as below detection limits (i.e., "U") indicate that the analyte was analyzed for but not detected, and the concentration shown is the PQL. Data flagged as rejected (i.e., "R") indicate that the data are not useable due to a quality assurance/quality control deficiency. All other validated results are considered accurate within the standard errors associated with the methods.

The adequacy of laboratory quality assurance/quality control is evaluated as a subset of the PARCC parameters (i.e., precision, accuracy, representativeness, completeness, and comparability) in the 100 Area SAP (DOE-RL 2008a). The laboratory data are validated by a contractor, which reports whether the laboratory met the required target detection limits, precision (+/-30%), accuracy (+/-30%), and completeness (>90%). The proportion of analytical results in which the detection limits exceed the 100 Area SAP target detection limits are noted in the data evaluation section of the DQA.

Reported analytical detection levels are compared to the specified detection limits in the 100 Area SAP (DOE-RL 2008a). The data validation notes any analyses in which the detection limit or minimal detectable activity was above the 100 Area SAP-specified detection limits. The detection limits are based on optimal conditions. Interferences and different matrices may significantly affect the values shown. Exceeding the specified detection limits does not necessarily invalidate the data for decision-making purposes; however, the exceedances need to be evaluated on a case-by-case basis within the DQA.

A statement is made regarding acceptability of the MS/MSD samples percent recoveries and relative percent differences (RPDs). Acceptable limits are in the 100 Area SAP.

Supplementary Data Validation

If formal data validation did not include evaluation of all cleanup verification samples taken from a site, investigators review the study objectives in the 100 Area SAP to determine the context for evaluating the data. This evaluation encompasses all verification samples. The context for evaluating the data includes a comparison of analytical results to the PARCC parameters as specified in the 100 Area SAP. This section of the CVP or RSVP summarizes the results of that comparison and presents an evaluation of the affected data.

Reported analytical detection levels are compared to the specified detection limits in the "Analytical Performance Requirements" table of the 100 Area SAP (DOE-RL 2008a). The proportion of validated data with reported analytical detection levels above the specified detection limits are noted. Data qualification is not required if the reported analytical detection levels are sufficiently less than the RAGs and the associated data are of sufficient quality for decision-making purposes.

Analytical accuracy and precision are evaluated by examining and comparing the percent recovery and RPD between the main and duplicate samples. Only the COCs detected at five times the detection limit (or greater) are used for data analysis with regards to accuracy and precision. If all percent recoveries for laboratory control samples and inorganic MS and MSD were within acceptable limits, then the samples compare favorably.

- **Field Blank Samples.** Field blank samples are collected to detect any contamination from sampling equipment, cross-contamination from previously collected samples, or contamination from conditions during sampling. The blank sample results and anomalies are discussed in this section of the CVP or RSVP.

- **Field Duplicate Samples.** Duplicate samples are collected to provide a relative measure of the degree of local heterogeneity in the sampling medium, unlike laboratory duplicates that are used to evaluate precision in the analytical process. The field duplicates are evaluated by computing the RPD of the duplicate samples for each COC. Only analytes with values above five times the detection limits for both the master and duplicate samples are compared. The RPD of the results is described in this section of the CVP or RSVP, and those that fall outside the +/-30% range are discussed.

- **Field Split Samples.** Split samples are collected and analyzed by different laboratories to provide a relative measure of the degree of variability in the sampling, sample handling, and analytical techniques used by commercial laboratories. The field master and split samples are evaluated by computing the RPD of the split samples for each COC. Only analytes with values above five times the detection limits for both the master and split samples are compared. The RPD of results is described in this section of the CVP or RSVP, and those that fall outside the +/-30% range are discussed and a decision made as to the usability of the data.

  If split samples are collected by regulatory agencies, the results are discussed in this section. Regulatory split sample data are compared to verification samples using the RPD as described in Section II.5.4 of the 100 Area SAP (DOE-RL 2008).

G.III-4.0 CLEANUP VERIFICATION RAG EVALUATION PROCESS

This section discusses the calculations and modeling necessary for assessing and demonstrating RAG attainment.

Contaminants of Concern 95% Upper Confidence Limit

The primary statistical calculation to support cleanup verification is the 95% UCL on the arithmetic mean of the data. The 95% UCL values for each COC and detected COPC are computed for each decision unit (e.g., for the shallow zone, deep zone, and overburden soils, as appropriate in consideration of the non-detected portion of the data set). If a COPC is not detected the constituent is excluded from the 95% UCL calculation. For the statistical evaluation of duplicate sample pairs, the samples are averaged before being included in the data set. The statistical values represent the COC concentrations for each decision unit (e.g., shallow zone, deep zone, and overburden soils). The 95% UCL calculation brief is included in an appendix to the CVP/RSVP. The statistical value for each COC is compared to the cleanup criteria in the CVP/RSVP as part of the evaluation of attainment of the RAGs.

- **Radionuclides:** The 95% UCL is calculated on the arithmetic mean for each radionuclide COC and detected COPC. The laboratory reported values, including negative values, are used in the UCL calculation. If a UCL is negative, the value is rounded to zero. In instances where the laboratory does not report a value below the minimum detectable activity, half of

the minimum detectable activity value is used in calculating the 95% UCL value. The 95% UCL value for radionuclides is calculated assuming a nonparametric distribution without further evaluation of distributional form.

- **Nonradionuclides:** For nonradionuclides, the distribution of large data sets (10 or more data points per component) is examined per the guidelines presented in *Statistical Guidance for Ecology Site Managers* (Ecology 1992) and in *Statistical Guidance for Ecology Site Managers, Supplement S-6* (Ecology 1993). Small data sets (less than 10 data points per component) are evaluated assuming a nonparametric distribution.

  For nonradionuclide data flagged with "U" (i.e., less than detection), a value equal to half the PQL is used in the 95% UCL calculation for COCs and detected COPCs. Also, if greater than 50% of the verification sample results for nonradionuclide COCs and detected COPCs are below detection, then the statistical value is set equal to the maximum detected concentration from the sample data set.

- **Accounting for Background:** Radionuclide background is accounted for only in overburden soil by subtracting the background concentration from the statistical value. This accounts for anthropogenic and naturally occurring radionuclide background in surface soils. Only uranium background concentrations are accounted for in shallow and deep zone soils by subtracting uranium isotope concentrations from the statistical values. The radionuclide statistical values, after subtracting for background as appropriate, are used in the RESRAD modeling and risk calculations for evaluation of RAOs and RAG attainment. Nonradionuclide background concentrations are not accounted for except that nonradionuclide concentrations below background are not compared to cleanup levels and are not included in carcinogenic and noncarcinogenic risk calculations.

RESRAD Modeling

The individual radionuclide cleanup verification statistical values are entered into the RESRAD computer code (ANL 2005) based on the site model to estimate the dose, and to estimate the impact on groundwater and the river from residual COC concentrations. The RESRAD model is primarily intended for radionuclide contaminants but may also be used for nonradionuclides as discussed in Section C.3.1 of this RDR/RAWP to evaluate the potential for nonradionuclide COCs to reach groundwater. Overviews of the model runs are provided below. The RESRAD analysis is documented in a calculation brief included in an appendix to the CVP/RSVP. A summary of the RESRAD input parameters is provided in Appendix B of this RDR/RAWP.

- **Shallow Zone Direct Exposure Dose and Risk Evaluation.** The cleanup verification values and site-specific parameters are entered into RESRAD for analysis of (1) total radionuclide dose (effective dose mrem/yr) and (2) estimated risk attributable to radionuclides.

- **Protection of Groundwater Evaluation.** The cleanup verification values (radionuclide and nonradionuclide [if necessary] COCs) and site-specific parameters are entered into RESRAD

for analysis of the individual radionuclide COC groundwater concentrations from residual COC concentrations in soil.

- **Drinking Water/Groundwater Dose Assessment.** RESRAD estimates the site impact to groundwater. These RESRAD estimated radionuclide groundwater concentrations are used for calculating individual organ doses received from drinking water. A detailed approach for calculating the individual dose rates is given below.

Attainment of Radionuclide Direct Exposure Standards

The current version of the RESRAD computer code (ANL 2005) is used to demonstrate that the direct exposure radionuclide dose limit of 15 mrem/yr above background is not exceeded. For the shallow zone and overburden decision units, all contaminant pathways contribute to the direct exposure dose estimate. For the deep zone decision unit, only the water-dependent pathways contribute to the direct exposure dose estimate.

The statistical value (95% UCL) is used for input to the RESRAD model. The direct radiation exposure dose to the resident living in his/her basement is conservatively estimated by substituting (for analysis purposes) a case where the resident is standing on level ground with the soil containing concentrations representative of residual (i.e., post-cleanup) shallow zone soils. (This is conservative because it ignores the potential shielding effects of concrete basement walls and any clean backfill between residual soils and the basement walls.) The results of the RESRAD direct exposure dose estimate may be presented in a figure. This dose represents the summed dose contributions from soils at the relevant time frames. This computation is summarized in a calculation brief. The actual doses at the waste site will be considerably less than these calculations because the site will be backfilled with clean fill soil.

Attainment of Nonradionuclide Direct Exposure Standards

The shallow zone statistical value for the COC is compared to the cleanup criteria to evaluate the attainment of direct exposure RAGs. Comparison of nonradionuclide direct exposure RAGs to the shallow zone statistical values is summarized in a table.

Attainment of Nonradionuclide Noncarcinogenic Risk Standards

For noncarcinogenic COCs, WAC 173-340-740(5)(a) and (b) specifies the evaluation of the hazard quotient, which is given as daily intake divided by a reference dose (DOE-RL 1995). For cleanup actions under the Interim Action ROD (EPA 1995), a comparable conservative approach is used to demonstrate attainment of the noncarcinogenic risk requirements.

The direct exposure nonradionuclide RAGs for soil are based on the WAC 173-340-740(3) Method B limits. These cleanup limits were set to be compliant with a hazard quotient of 1.0; therefore, the ratio of the cleanup verification statistical values to the cleanup limits (lookup value obtained from Table 2-1 of this RDR/RAWP) provides a conservative approach to addressing the hazard quotient.

The fraction of cleanup level (Fc) is calculated using the formula Fc = S/V, where:

Fc = fraction of cleanup level (dimensionless)
S = statistical value of the COCs (in mg/kg)
V = lookup value (WAC 173-340-740(3) Method B derived, direct exposure RAG in mg/kg).

If the Fc is less than 1 for an individual COC, then the hazard quotient has been addressed.

For multiple COCs, a sum of the individual COC Fc values was used to address the hazard index or cumulative hazard quotient. The Fc values for all noncarcinogenic COCs were summed. If that sum was less than 1, then the hazard index or cumulative hazard quotient has been addressed.

Attainment of Nonradionuclide Carcinogenic Risk Standards

For individual carcinogenic nonradionuclide COCs, the WAC 173-340-750(3) Method B cleanup limits are based on an incremental cancer risk of 1×10^{-6}. For cumulative carcinogenic COCs, the cumulative excess cancer risk must be less than 1×10^{-5}. If a linear relationship is assumed between environmental concentration and risk, the ratio (Fc) of the statistical value from the verification samples divided by the WAC 173-340-750(3) Method B limit, multiplied by 10^{-6}, is an estimate of the risk associated with the statistical value.

For multiple carcinogenic COCs, the risks of the individual COCs (described above) are summed. If no risk associated with a single COC exceeds 1×10^{-6}, and if the sum of the individual COC risk does not exceed 1×10^{-5}, then the WAC 173-340-750(5)(a) and (b) Method B risk requirement has been addressed for this remedial action.

For the shallow zone, the individual COC and cumulative risk value are checked against the individual and cumulative WAC 173-340-750(5)(a) and (b) risk limits. This type of calculation is performed and documented in the 95% UCL calculation brief, which is included in an appendix to the CVP/RSVP.

Attainment of Groundwater Remedial Action Goals

The groundwater RAGs are applicable to all decision units (e.g., shallow zone, deep zone, and overburden). A contaminant depth/soil-partitioning coefficient (K_d) value model has been developed to predict if the concentrations of contaminants in soil that exceed cleanup levels for groundwater or river protection are protective of groundwater and the river at a site. The *100 Area Analogous Sites RESRAD Calculations* calculation brief (BHI 2005) predicts whether or not contaminants in 100 and 300 Area soils are expected to migrate to groundwater within a 1,000 year time frame based on their K_d value and the vertical distance to groundwater. The contaminant depth/K_d value model assumes that uncontaminated soil exists in the vadose zone between the bottom of the waste site and groundwater. The assumption of an uncontaminated

zone beneath the waste site is reasonable based on analogous site data that includes test pits and boreholes completed in the operable units in the 100 and 300 Areas. The test pit and/or borehole data show that contaminant concentrations that are below direct exposure cleanup levels decrease to background concentrations within less than 3 m (10 ft) below the elevation at which the contamination occurs.

- **Radionuclides.** The estimated groundwater concentrations for all the radionuclide COCs contributed by the soils in the shallow zone (and deep zone, if present) are determined by RESRAD modeling, which is documented in the RESRAD calculation brief. If the groundwater concentrations predicted by RESRAD indicate that COCs impact groundwater, then a separate calculation brief for comparison to drinking water standards is needed to determine compliance with groundwater dose standards.

  Depending on the ROD, the "National Primary Drinking Water Regulations" (40 CFR 141.66) establish a gross-alpha particle standard of 15 pCi/L for alpha-emitting radionuclides (excluding radon and uranium), or DOE Order 5400.5 establishes derived concentration guidelines (DCGs) for alpha emitters. For the DCG-based limits, 1/25th of the DCG is used.

  The 40 CFR 141.66 regulations establish a 4 mrem/yr dose standard for beta- and gamma-emitting radionuclides in drinking water. They also specify the method of calculating dose: the individual organ-dose calculational method given in National Bureau of Standards (NBS) Handbook 69 (NBS 1963).

  To determine if any organ receives a dose of more than 4 mrem/yr, the dose to each organ is calculated from the COC radionuclide mixture.

  The "National Primary Drinking Water Regulations" establish an MCL for total uranium of 30 µg/L.

  There is a critical organ for each radionuclide (i.e., the organ that receives the highest dose from ingestion of that radionuclide). The critical organs for each radionuclide are determined from the maximum permissible concentration (MPCs) listed in Table 1 of NBS Handbook 69 (NBS 1963), and are denoted in bold in Table G-2. The factor C_4 (i.e., the concentration that will produce a dose of 4 mrem/yr to that organ) is calculated for each organ and radionuclide and compared to the applicable MPC. The equation for the calculation of C_4 for radionuclide "A" and organ "x" is as follows:

  $$C_4^A (x) = 4.4 \times 10^6 \text{ (MPC/ORL)}.$$

  The term "ORL" is the occupational radiation limit (in rems) for the organ given in the *National Primary Drinking Water Regulations* (EPA 1976). The ORLs for the individual organs are listed below:

- Total body - 5
- Gonads - 5
- Thyroid - 30
- Bone - 29.1
- Other organs - 15.

The C_4 factors for the COCs are summarized in Table G-7.

Table G-7. Factors for Calculating Radionuclide-Specific Organ Doses Using Methodology Mandated by the Safe Drinking Water Act for Comparison to the 4 mrem/yr Standard for Beta and Gamma Emitters. (2 Pages)

Radionuclide	Organ	4 mrem/yr Equivalent Concentration (C_4 in pCi/L)[a]
Cobalt-60	**GI(LLI)**	100
	Total Body	900
	Liver	3,000
Cesium-137	Bone	80
	GI(LLI)	2,000
	Total Body	200
	Liver	60
Europium-152	Bone	30,000
	GI(LLI)	200
	Total Body	2E+05
	Liver	1E+05
Europium-154	Bone	5,000
	GI(LLI)	60
	Total Body	7E+04
	Liver	6E+04
Europium-155	Bone	1E+05
	GI(LLI)	600
	Total Body	9E+05
	Liver	6E+05
Strontium-90	**Bone**	8
	GI(LLI)	100
	Total Body	8
Nickel-63	**Bone**	50
	GI(LLI)	3,000
	Total Body	2,000
	Liver	600

Table G-7. Factors for Calculating Radionuclide-Specific Organ Doses Using Methodology Mandated by the Safe Drinking Water Act for Comparison to the 4 mrem/yr Standard for Beta and Gamma Emitters. (2 Pages)

Radionuclide	Organ	4 mrem/yr Equivalent Concentration (C_4 in pCi/L)[a]
Carbon-14	Total Body	9,000
	Bone	2,000

NOTE: Critical organs are shown in bold.

[a] Calculated by methodology given in *National Interim Primary Drinking Water Regulations*, Appendix IV, "Dosimetric Calculations for Man-Made Radioactivity" (EPA 1997b).

GI(LLI) = gastrointestinal tract-lower large intestine

The cumulative dose for each organ at time "t" needs to be calculated separately and the sum of fractions equation (EPA 1976) calculated, as shown below. If a radionuclide does not have an MPC for the organ of interest, the C_4 factor for total body dose is used in the calculation. The calculations performed are documented in the comparison to drinking water standards calculation brief. The organs for which doses need to be computed are total body, bone, gastrointestinal tract-lower large intestine, and liver. The individual organ doses are compared to 4 mrem/yr. Using this methodology, the doses are not summed for different organs for the comparison to 4 mrem/yr.

$$\text{Dose}_{\text{organ x}}(t) = [\text{ConcA}(t)/C_4^A(x) + \text{ConcB}(t)/C_4^B(x) + \ldots] \times (4 \text{ mrem/yr})$$

If the dose for organ "x" is less than 4 mrem/yr, then the standard is met.

If the groundwater concentrations predicted by RESRAD indicate that COCs impact groundwater, a table is provided in the CVP/RSVP that shows the total peak concentration for each detected radionuclide COC and provides the individual RAGs for comparison, as shown in Table G-8. A figure may be provided in the CVP/RSVP that shows the calculated dose to organs from groundwater.

Table G-8. Estimated Peak Radionuclide Groundwater Concentrations (Summed over Shallow and Three Deep Zone Levels) Compared to RAGs. (2 Pages)

Radionuclide	Peak Concentration (pCi/L)	Approximate Time of Peak Concentration (years)	RAG (pCi/L)
Americium-241	0	0	15
Carbon-14	0	0	2,000
Cobalt-60	0	0	100
Cesium-137	0	0	60
Europium-152	0	0	200

Table G-8. Estimated Peak Radionuclide Groundwater Concentrations (Summed over Shallow and Three Deep Zone Levels) Compared to RAGs. (2 Pages)

Radionuclide	Peak Concentration (pCi/L)	Approximate Time of Peak Concentration (years)	RAG (pCi/L)
Europium-154	0	0	60
Europium-155	0	0	600
Nickel-63	0	0	50
Plutonium-238	0	0	15
Plutonium-239/240	0	0	15
Strontium-90	0	0	8

- **Nonradionuclides**. If the statistical value of a COC is below the soil background value, the COC is not considered further in the groundwater protection evaluation, and the groundwater protection RAG is considered to be attained.

  To determine the RAG for a contaminant in soil that is protective of groundwater, WAC 173-340-740(3)(a)(ii)(A) (January 1996) is applied (as a first test) to the groundwater action level for each COC. Application of WAC 173-340-740(3)(a)(ii)(A) (January 1996), involves a conversion of groundwater action levels (µg/L) to equivalent soil action levels (mg/kg). This calculation is based on a kg/L density conversion factor assumption. For example, a RAG of 1 µg/L has a corresponding soil equivalent RAG of 0.1 mg/kg (e.g., 1 µg/L = 0.001 mg/L, 0.001 mg/L ÷ 1 kg/L = 0.001 mg/kg, 100 x 0.001 mg/kg = 0.1 mg/kg). After conversion of the groundwater action level to a soil equivalent value, the COC statistical values can be compared directly to the RAG soil equivalent value. Per WAC 173-340-740(3)a, the COC statistical values that are less than the RAG soil equivalent value are considered protective of the groundwater.

  If the statistical value of a COC is determined to be equal to or lower than the analytical method PQL, which is the lowest detectable value, but the PQL is greater than the cleanup RAG, the RAG is considered to have been attained in accordance with WAC 173-340-707. For example, the groundwater action level for polychlorinated biphenyls (PCBs) is 0.01 µg/L (or 0.00001 mg/L), which after applying WAC 173-340-740(3)(a)(ii)(A) (January 1996) provides a soil RAG of 0.001 mg/kg. Direct comparison of the statistical value to this soil RAG is inappropriate because the PQL at which PCBs are detectable is greater than 0.001 mg/kg. Therefore, in this case, the PQL for PCB analysis and the corresponding statistical value are considered protective of the groundwater. In cases where the COC analytical PQL is below the RAG, the statistical value is directly compared to the soil equivalent RAG.

Attainment of Columbia River Remedial Action Goals

- **Radionuclides**. The individual radionuclide Columbia River RAG is equivalent to the groundwater RAG[2]; therefore, if the individual radionuclide groundwater RAG is attained, the individual Columbia River RAG is also attained.

- **Nonradionuclides**. If the statistical value of a COC is below the background value, it is not considered further in Columbia River protection cleanup verification evaluation, and the Columbia River RAG has been attained.

  To determine soil RAGs for other nonradionuclide contaminants that are protective of surface water, the "100 times surface water quality times DAF" rule is applied (as a first test) to the surface water protection action level for each COC. Application of the "100 times surface water quality times DAF" rule involves a conversion of surface water protection action levels (μg/L) to equivalent soil action levels (mg/kg). This calculation is based on a 1-kg/L density conversion factor assumption. A DAF based on a dilution of 2:1 has been established in Appendix D of this RDR/RAWP for nonradionuclides. The "100 times surface water quality times DAF" rule is then applied to provide a soil equivalent RAG that is protective of the Columbia River. The statistical value is then directly compared to the soil equivalent RAG for surface water protection. If the statistical value is lower, the Columbia River RAGs are attained.

  If the statistical value of a COC is determined to be equal to the analytical method PQL, but the PQL is greater than the cleanup RAG, the RAG is considered to have been attained in accordance with WAC 173-340-707. For example, the ambient water quality criterion for PCBs is 0.014 μg/L (or 0.000014 mg/L), which after applying a DAF and WAC 173-340-740(3)(a)(ii)(A) (January 1996), provides a soil RAG of 0.0028 mg/kg. In this case, a direct comparison of the statistical value to the RAG of 0.0028 mg/kg is not made because the PQL for PCB analysis (i.e., statistical value) is considered protective of the Columbia River.

  If the Columbia River RAG is not attained by these methods, then the statistical values are modeled using RESRAD (as described in Appendix B) to determine if nonradionuclides reach the groundwater within 1,000 years after remediation. If these nonradionuclides do not reach the groundwater, then they do not reach the Columbia River; thus, Columbia River RAGs are attained.

  If RESRAD modeling indicates that contaminants do reach the groundwater within 1,000 years, the travel time in the groundwater underlying the site to the Columbia River is estimated as described in Appendix C. If contaminants do not reach the Columbia River within 1,000 years in concentrations exceeding the RAGs, then Columbia River RAOs are attained.

[2] Because there are no ambient water quality criteria for radionuclides, the groundwater action levels apply to river protection.

WAC 173-340-740(7)(e) Three-Part Test for Nonradionuclides

This section documents application of the WAC 173-340-740(7)(e) three-part test for nonradionuclides using the most restrictive RAGs applicable for each zone. (The most restrictive RAG is defined as the lowest of the direct exposure, groundwater protection, and river protection RAGs. The direct exposure, groundwater protection, and river protection RAGs are applicable to the shallow zone and overburden. Groundwater and river protection RAGs are applicable to the deep zone.) The WAC 173-340-740(7)(e) three-part test consists of the following criteria: (1) the cleanup verification statistical value must be less than the cleanup level, (2) no single detection can exceed two times the cleanup criteria, and (3) the percentage of samples exceeding the cleanup criteria must be less than 10%. The duplicate sample is treated as a separate sample for the three-part test. The split sample is only used for DQA purposes and is not included in the three-part test.

A table is used to summarize the results of the WAC 173-340-740(7)(e) three-part test for the overburden, shallow zone, and deep zone sample data sets. For each nonradionuclide COC, the table lists the most restrictive applicable RAG, the maximum detected value, the total number of samples collected, and the number of samples exceeding the most restrictive RAG. The final column of the table describes the result of applying the three criteria using the values listed in the preceding columns.

G.III-5.0 RADIONUCLIDE RISK INFORMATION

The radionuclide RAG for direct exposure is derived from the Interim Action ROD (EPA 1995), and is expressed in terms of an allowable radiation dose above background (i.e., 15 mrem/yr). The RAG evaluation involved using the RESRAD model to estimate total annual radiation doses for 1,000 years for comparison to the RAG. Radiation presents a carcinogenic risk, and the RESRAD model also calculates the excess lifetime cancer risk associated with the estimated radiation doses. The "National Oil and Hazardous Substances Pollution Contingency Plan" (40 CFR 300) presents a target range for residual risk of 10^{-4} to 10^{-6}. A figure can be used to illustrate excess lifetime cancer risk as estimated using the RESRAD model. Because of radioactive decay, the risk decreases over time.

G.III-6.0 REFERENCES

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APPENDIX H

REVEGETATION PLAN FOR THE 100 AREA

APPENDIX H

REVEGETATION PLAN FOR THE 100 AREA

H.1 INTRODUCTION

This revegetation plan is for the 100 Area waste sites covered in this remedial design report/remedial action work plan, which will be remediated as part of the *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* Remedial Action Project. Each remediated site and the associated support facilities (e.g., roads, spoils piles) that are disturbed during remediation will be revegetated under this plan.

This plan is generic; site-specific conditions will be evaluated and adjustments made when necessary. For example, at those sites where confirmatory sampling shows that remediation is not necessary, revegetation will depend on the current vegetative cover. Some of the sites will require no additional work, and others can be reseeded as they are. Consultations with Native American Tribes and the Natural Resource Trustee Council will also be made, as appropriate, for additional input.

This revegetation plan is built on the information provided in the *Revegetation Manual for the Environmental Restoration Contractor* (BHI 1997), the *Hanford Site Biological Resources Management Plan* (DOE-RL 2001a), the preliminary results of the *2001 Environmental Restoration Contractor Revegetation Monitoring Report* (BHI 2001), and from other revegetation that has occurred across the Hanford Site.

H.2 MITIGATION ACTION PLAN

A mitigation action plan has been prepared for the 100 Areas and 600 Area of the Hanford Site (DOE-RL 2001b). The majority of the sites identified in the mitigation action plan and this revegetation plan are waste sites to be remediated and areas impacted by remediation activities. Some sites, especially those in the 100-IU-2 and 100-IU-6 Operable Units, have naturally revegetated to a native shrub-steppe community providing high-quality vegetative cover. These sites will be identified in field surveys prior to initiation of remediation. If confirmatory sampling or remedial actions have the potential for disturbing species of concern, or removing high-quality habitat, supplemental mitigation (in addition to actions listed in the mitigation action plan) may be required. An ecological survey will be completed for all sites, and the need for additional mitigation will be identified in the survey report.

H.3 SITE DESCRIPTIONS

The current vegetation status for most of the waste sites to be remediated and the nearby areas for support facilities during remediation can be estimated from *Vegetation Communities Associated with the 100-Area and 200-Area Facilities on the Hanford Site* (Stegen 1994), which developed vegetation community maps for all of the 100 Areas. The vegetative status of each of

the 100 Areas varies, but the range is from totally nonvegetated within the 100-K Area perimeter fence to a mixture of nonvegetated and vegetated with low-quality communities, such as cheatgrass/Russian thistle (*Bromus tectorum/Salsola kali*) and rabbitbrush/cheatgrass (*Chrysothamnus nauseosus/Bromus tectorum*) at the 100-F Area. The nonvegetated sites have been kept free of plants through the use of herbicides. Before the 100 Area reactor facilities were constructed, much of the land along the river was in agricultural production. Before farming, the area is assumed to have been in a mixture of shrub-steppe and grasslands, dominated by sagebrush (*Artemisia tridentata*) and Sandberg's bluegrass (*Poa sandbergii*). Some of the wildlife that use the 100 Areas include mule deer, coyote, geese, and rodents such as Great Basin pocket mice and deer mice.

H.4 PURPOSE OF REVEGETATION

The goal of restoration is to revegetate the waste sites and support areas to communities dominated by native plant species. Shrubs such as sagebrush, hopsage, or bitterbrush will be planted to provide habitat and structure for nesting birds. Native grasses and forbs that are adapted to the site conditions will be planted to provide an understory. Because of the large amount of land that will be revegetated, the methods used will reflect what is feasible on a large-scale effort.

H.5 TOPSOIL

Fine-grained topsoil, such as sandy loam, is of low availability on the Hanford Site. In the few places where it exists, such as McGee Ranch and the Fitzner-Eberhardt Arid Lands Ecology Reserve, removal may cause unacceptable ecological effects at the borrow sites. Thus, backfill from nearby borrow pits will be used. The backfill is usually from the Hanford formation, which is gravels, sands, and silts with many intermixed cobbles. The number of larger cobbles and boulders increases with increasing distance up the river, with more at the 100-B/C Area and less at the 100-F Area.

For some sites, such as those at the 100-IU-2 and 100-IU-6 Operable Units (near the old Hanford and White Bluffs townsites), the material to be used as backfill may be a much sandier soil than in the Hanford formation borrow pits. The plant species seeded will be selected based on the soils to be revegetated and seed availability.

The backfill material from the borrow pits was originally deposited by the river, and a slow, natural revegetation of this backfill can be seen at the borrow sites that have been abandoned. Native species, including sagebrush and Sandberg's bluegrass, have become established and appear to out-compete nonnative species. The density of the vegetative cover at the abandoned borrow pits, however, is less than at other sites such as the old fields, which are usually dominated by cheatgrass and tumblemustard (*Sisymbrium altissimum*). The soils at the abandoned fields consist of much finer grained materials, with greater moisture-holding capacity and nutrient properties than the borrow sites. These fine-grained soils tend to favor cheatgrass, which often excludes establishment of shrubs.

Other sources of backfill that may be considered for use in the future include uncontaminated concrete rubble from nearby demolished buildings. If secondary material is used, it will be placed at least 2 to 3 m (6 to 10 ft) below final grade to allow sufficient soil for plant rooting.

H.6 SITE PREPARATION

For those sites that are currently vegetated, the top 15 to 46 cm (6 to 18 in.) of clean overburden will be saved and used as the topsoil for the excavation. If needed, this material may be spread into a thinner layer (about 5 to 10 cm [2 to 4 in.]) and used as topsoil for several adjacent sites.

The final surface contour will be graded to match the surrounding terrain by creating gentle slopes instead of flat surfaces. Any large boulders remaining should be buried deep in the excavation or randomly grouped on the surface to create additional wildlife habitat. For those sites not requiring backfill to match the surrounding grade, depressions may remain. The depressions should have sides no steeper than 3:1 or 4:1, and irregular grade to more closely match the surrounding native terrain.

H.7 SPECIES TO BE PLANTED

Native species of a Hanford genotype will be used for a majority of revegetation efforts. Sandberg's bluegrass and needle-and-thread grass (*Stipa comata*) have been collected on the Hanford Site and grown as an agricultural crop to provide a large quantity of seeds for revegetation. Seeds of other native plants, such as sagebrush, yarrow (*Achillea millefolium*), Carey's balsamroot (*Balsamorhiza careyana*), pine bluegrass (*Poa scabrella*), and snow buckwheat (*Eriogonum niveum*) may also be collected on the Hanford Site, and may be added to the planting mixture as available and as appropriate to each site. Additional seeds of other species may be provided by the Tribes and Trustees and combined with the species described above.

Guidance on seeding rates is provided in the revegetation manual (BHI 1997). The methods used for seeding will vary depending on soil type and conditions. For example, drill-seeding works best on soils with minimal amounts of rock while broadcast or hydro-seeding may be preferable on rocky soils. Seeds that are uncleaned or of an unsuitable shape or size may be broadcast over the site before the other seeds are planted. The action of the planting and mulching equipment will help set the broadcast seeds. Areas that have been used for support facilities and haul roads may have excessively compacted ground, making the area unsuitable for planting. If necessary, the soils in these areas will be loosened by ripping the soil with heavy equipment. If a seed drill is not appropriate at these areas, broadcast seeding (with subsequent harrowing or disking) may be used to plant seeds. Seeding each year will occur between November and mid-January.

Shrub tublings will be planted between November and January in the backfilled areas at a density ranging between 500 to 1,000 plants/ha (200 to 400 plants/acre), depending on the site.

H.8 FERTILIZER AND STRAW MULCH

While the usefulness of fertilizers is sometimes in question when seeding native species, the backfill material excavated from borrow pits is often deficient of nutrients. The cobble composition of excavated backfill material does not promote the establishment of cheatgrass as does finer grained topsoil. Therefore, the addition of some fertilizers may help the native planted species get established. To help clarify the role of fertilizer on native plant establishment, different types of fertilizer and rates may be applied to parts of revegetation sites. The success of each fertilized area will be monitored and compared after the first and second years for plant establishment and cost effectiveness. The fertilizer will be applied at the same time as the seeds, and the type and rate will be on a site-specific basis.

Straw mulch will be spread on the surface at a rate of 4.5 metric tons/ha (2 tons/acre) and crimped into the seedbed.

H.9 IRRIGATION

When irrigation is feasible, it will generally occur only at the time of initial seeding. No additional irrigation is planned at this time. The presence of cobble and larger gravels used as backfill on the sites act as a mulch, helping to conserve moisture. The effects of supplemental irrigation on restoration success were tested on the 116-C-1 restoration site during 1999 and 2000. Half of the site received 5 cm (2 in.) of supplemental water in the spring of each year while the other half only received the natural precipitation. Vegetation analysis of the two plots showed that species diversity was slightly higher on the nonirrigated side and that the total canopy cover (amount of ground covered by vegetation) was identical on both sites (BHI 2000). This relationship remains the same in the 2001 vegetation analysis (BHI 2001). The results at this test site indicate that supplemental irrigation in the spring did little to improve the rate of recovery. Vegetation analyses from other similar revegetation sites indicate that it is more beneficial to add supplemental water during the planting process than to increase germination.

H.10 MONITORING AND SUCCESS CRITERIA

The revegetated areas will be monitored for 5 years following planting. Monitoring each site and support area is not practical; therefore, monitoring will only be done on representative sites. The number of representative sites will vary, depending on the number and distribution of the sites revegetated each year.

Monitoring will be done using methods from *Steppe Vegetation of Washington* (Daubenmire 1970) to estimate percent canopy cover and frequency of occurrence for each species. A list of all species observed on the sites, including those not captured in the sampling plot frames, will be recorded. If the canopy cover of seeded plants is less than 1% in the spring of the second year, reseeding may occur the following fall if the cause of the reduced success can be identified and rectified. After 5 years, the criteria for success will be a total canopy cover of greater than

25% for native plants. If this is not achieved, the cause should be identified and rectified with additional plantings, fertilization, irrigation, or soil amendments, as applicable.

The vegetative cover and composition at each site following a revegetation effort will be site specific. There are several factors including seedbed, moisture regime, and topographic features that influence a native plant community establishment and success. Caution should be exercised when comparing success between different locations.

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