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DOE/RL-2011-111
Revision 0

Proposed Plan for Remediation of the 100-DR-1, 100-DR-2, 100-HR-1, 100-HR-2, and 100-HR-3 Operable Units

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

Contractor for the U.S. Department of Energy
under Contract DE-AC06-08RL14788

ch2m

P.O. Box 1600
Richland, Washington 99352

Approved for Public Release;
Further Dissemination Unlimited

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APPROVED
By Julia Raymer at 2:39 pm, Jul 20, 2016

Release Approval Date

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DOE/RL-2011-111, Rev. 0

U.S. Department of Energy, Richland Operations Office
U.S. Environmental Protection Agency
Washington State Department of Ecology

Public Comment Period July 26 through August 25, 2016

How You Can Participate:

Read this Proposed Plan and review documents in the Administrative Record at. http://pdw.hanford.gov/arpir/.

Comment on this Proposed Plan by mail or e-mail on or before August 25, 2016.

Kris Holmes, U.S. Department of Energy, Richland Operations Office
P.O. Box 550, A7-75
Richland, WA 99352
E-mail: 100DHAreaPP@rl.gov

See page 48 for more information about public involvement and contact information.

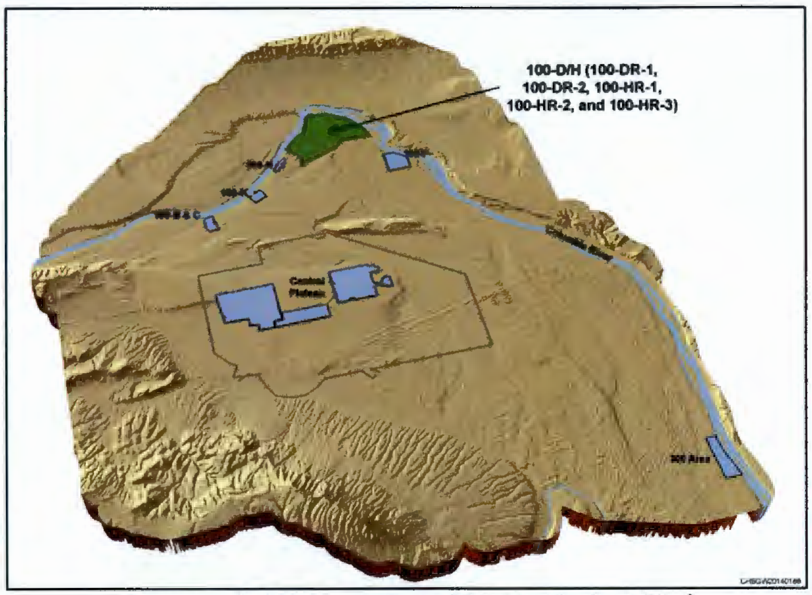


Figure 1. 100-D/H Location within the Hanford Site[1]

Inside this Plan

Introduction

The U.S. Department of Energy (DOE), Washington State Department of Ecology (Ecology), and U.S. Environmental Protection Agency (EPA) invite the Tribal Nations and public to comment on this ***Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) Proposed Plan***[2] for cleanup of contaminated soil in the 100-DR-1, 100-DR-2, 100-HR-1, and 100-HR-2 Source ***Operable Units (OUs)*** and contaminated ***groundwater*** in the 100-HR-3 Groundwater OU in the 100 Area of the Hanford Site located near Richland, Washington. These five OUs are referred to collectively as 100-D/H (Figure 1). DOE has completed its investigation of ***waste sites,*** some of which have already been addressed in previous cleanup actions, and the groundwater through the ***remedial investigation (RI)/feasibility study (FS)*** process.

[1] "D" stands for D Reactor area; "H" stands for H Reactor area. The five operable units are collectively referred to as 100-D/H.

[2] Important technical and administrative terms are used throughout this Proposed Plan. When these terms are first used, they appear in ***bold italics***. Explanations of these terms are provided in the "Glossary" at the end of this Proposed Plan.

The RI/FS concluded that some waste sites and some contaminants in the groundwater require ***remedial action*** due to unacceptable risk to human health and the environment (HHE). This Proposed Plan addresses the contamination in 295 waste sites[3] in the four source OUs, as well as contaminated groundwater in the 100-HR-3 OU.

DOE is issuing this Proposed Plan to summarize and seek Tribal Nations and public input on the cleanup alternatives considered and on the ***preferred alternative*** proposed for implementation. This Proposed Plan presents a summary of the evaluation of several remedial alternatives and identifies the preferred alternative. The alternatives were developed to address remediation of the 100-DR-1, 100-DR-2, 100-HR-1, and 100-HR-2 Source OUs and the 100-HR-3 Groundwater OU. Remediation alternatives that were evaluated include the following:

- Alternative 1 – ***No Action***
- Alternative 2 – ***Removal, Treatment, and Disposal (RTD)***, ***Monitored Natural Attenuation (MNA)*** with ***Institutional Controls (ICs)***, Pipeline Capping with ICs, and No Action for Waste Sites; and ***Pump and Treat***, Additional Groundwater Wells, Biological Treatment, and MNA with ICs for Groundwater
- Alternative 3 – RTD, MNA with ICs, Pipeline Capping with ICs, and No Action for Waste Sites; and Increased Capacity Pump and Treat, Additional Groundwater Wells, and MNA with ICs for Groundwater
- Alternative 4 – RTD, MNA with ICs, and No Action for Waste Sites; and Pump and Treat, Additional Groundwater Wells, and MNA with ICs for Groundwater

It is important to note that since 2012 when the RI/FS was finalized, many waste sites have been remediated, and groundwater has continued to be treated to remove Cr(VI) under interim remedial actions. The alternatives and associated costs reflect the OU status in 2012. These actions are further discussed in the "Previous Cleanup Actions and Decisions" section of this Proposed Plan.

Tribal Nations and public input on this Proposed Plan will help DOE and EPA, with input from Ecology, select a remedy for cleanup of contamination in the 100-DR-1, 100-DR-2, 100-HR-1, 100-HR-2, and 100-HR-3 OUs. Following consideration of Tribal Nations and public input on this Proposed Plan, a ***Record of Decision (ROD)*** will be prepared jointly by EPA and Ecology. In accordance with CERCLA, the ROD will be issued by DOE and EPA, identifying the final alternative selected for implementation. The concurrence of Ecology will be sought.

Tribal Nations and Public Involvement

Input from the Tribal Nations and the public on this Proposed Plan and the supporting analysis and information in the ***Administrative Record*** will be considered during final remedy selection. Comments will be accepted during the comment period (see sidebar on left side of page 1). For additional information regarding how to participate, see the "Community Participation" section of this Proposed Plan.

This Proposed Plan summarizes information that can be found in greater detail in the supporting documents included in the Administrative Record for the proposed remedial action at the 100-DR-1, 100-DR-2, 100-HR-1, 100-HR-2, and 100-HR-3 OUs. These supporting documents, including the *Remedial Investigation/Feasibility Study for the 100-DR-1, 100-DR-2, 100-HR-1, 100-HR-2, and 100-HR-3 Operable Units* (DOE/RL-2010-95; hereafter referred to as the 100-D/H RI/FS report), were used to evaluate alternatives and develop the preferred alternative and can be viewed online at http://pdw.hanford.gov/arpir/ and accessed electronically at the various

[3] Note that the alternative descriptions include actions for 297 waste sites since waste sites 116-DR-9 and 100-D-25 are counted twice because they have shallow and deep components and are addressed separately.

information repositories identified in the "Community Participation" section of this Proposed Plan. The 100-DH index is available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0075856H.

After all input submitted during the comment period has been reviewed and considered, a ROD will be issued that identifies the remedy selected. This input could result in the selection of a final remedial action that differs from the preferred alternative. A summary of significant comments received and responses will be published in the ***responsiveness summary*** issued with the ROD.

Agencies' Roles

DOE is the lead agency and is responsible for conducting the selected remedy. DOE is issuing this Proposed Plan as part of the public participation requirements under Section 117(a), "Public Participation," "Proposed Plan," of the ***Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA)*** (commonly known as "Superfund"); and the "***National Oil and Hazardous Substances Pollution Contingency Plan***" (commonly known as the National Contingency Plan, or NCP) (40 CFR 300.430[f][2], "Remedial Investigation/Feasibility Study and Selection of Remedy"). CERCLA establishes the broad federal authority for conducting cleanup at Superfund sites, and the NCP (40 CFR 300) includes the procedures and expectations for cleanup.

Ecology is the lead regulatory agency for 100-D/H, and EPA is the non-lead regulatory agency per the *Hanford Federal Facility Agreement and Consent Order* (***Tri-Party Agreement***) (Ecology et al., 1989a).

Preferred Alternative

Based on the results of the detailed and comparative evaluation of alternatives, the preferred remedial alternative is Alternative 3: RTD (104 waste sites), MNA with ICs (5 shallow and 34 deep waste sites), Pipeline Capping with ICs (1 waste site), and No Action (153 waste sites); and Increased Capacity Pump and Treat and MNA with ICs for Groundwater in the 100-HR-3 OU. RTD is used to excavate contaminated soil from waste sites. MNA with ICs is used for waste sites until radioactive contamination decays to protective levels. Pump and Treat and MNA with ICs are used to contain, treat, and prevent exposure to contaminated groundwater.

The preferred alternative meets the statutory requirements under CERCLA and the NCP (40 CFR 300) to select remedies that are protective of HHE, comply with ***applicable or relevant and appropriate requirements (ARARs)***, are cost effective, and use permanent solutions and alternative treatment technologies or resource recovery technologies to the maximum extent practicable. Alternative 3 is the preferred alternative because it provides the best balance of tradeoffs with regard to the criteria specified in Section 300.430 of the NCP. The alternative also satisfies the statutory preference for remedies that employ, as a principal element, treatment that permanently and significantly reduces the toxicity, mobility, or volume (TMV) of hazardous substances, pollutants, and contaminants. In addition to the preferred alternative, other alternatives that were evaluated are described in the "Summary of Remedial Alternatives" section of this Proposed Plan. Each alternative includes a combination of actions, all of which are explained briefly in this Proposed Plan and more fully in the 100-D/H RI/FS report (DOE/RL-2010-95).

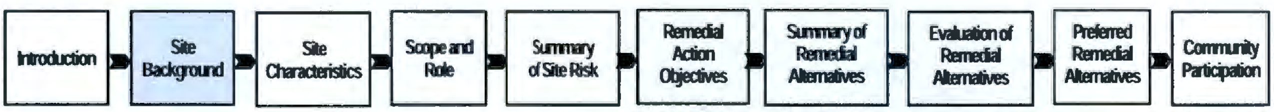
Proposed Plan Organization

The subsequent sections of this Proposed Plan provide the following discussions:

- **Site Background:** Provides facts about site contamination, investigations, interim remedial actions, and previous public participation.
- **Site Characteristics:** Includes descriptions of land and groundwater use, physical features impacting remedy selection, and the nature and extent of contamination of waste sites and the groundwater.

- **Scope and Role:** Discusses how the waste site and groundwater remedial actions fit into the overall Hanford Site cleanup strategy; provides descriptions of prior and planned cleanup actions.
- **Summary of Site Risks:** Identifies ***contaminants of concern (COCs)***, results of the ***baseline risk assessment***, and land and groundwater use assumptions.
- ***Remedial Action Objectives (RAOs)***: Describes what the proposed site cleanup is expected to accomplish.
- **Summary of Remedial Alternatives:** Identifies options for attaining the identified RAOs.
- **Evaluation of Remedial Alternatives:** Provides comparison of the options using CERCLA criteria.
- **Preferred Remedial Alternatives:** Provides an explanation of rationale for selecting the preferred alternatives and affirmation that they are expected to fulfill statutory and regulatory requirements.
- **Community Participation:** Provides information on how the Tribal Nations and the public can provide input to the remedy selection process.

The following graphic is included before each new section to indicate where the new section fits within this Proposed Plan:



Site Background

The Hanford Site is a 1,517 km^2 (586 mi^2), federally owned property located within the semiarid, shrub-steppe Pasco Basin of the Columbia Plateau in south central Washington State. In 2000, a Presidential Proclamation (65 FR 114, "Establishment of the Hanford Reach National Monument"), under authority of the *American Antiquities Act of 1906*, set aside about half of the Hanford Site for preservation as the Hanford Reach National Monument (HRNM), including lands in the River Corridor within about 0.4 km (0.25 mi) of the Columbia River (Figure 2). Historical nuclear material production and processing at the Hanford Site released contamination to the environment, resulting in areas of contaminated soil and groundwater that pose a risk to HHE. To facilitate cleanup, the Hanford Site has been divided into three areas: River Corridor, Central Plateau Outer Area, and Central Plateau Inner Area.

The area of the Hanford Site that borders the Columbia River is referred to as the River Corridor (Figure 2). The River Corridor, which spans approximately 570 km^2 (220 mi^2), has been divided into six geographic areas. These six areas were selected to define manageable portions of the River Corridor that align with historical operations (e.g., uranium fuel rod preparation or reactor operations). For River Corridor cleanup decisions, the 100-D/H Area includes the 100-DR-1, 100-DR-2, 100-HR-1, 100-HR-2, and 100-HR-3 OUs. The 100-HR-3 OU is comprised of groundwater contaminated from the 100-DR-1, 100-DR-2, 100-HR-1, and 100-HR-2 OUs.

The 100-D/H Area (Figure 2) encompasses approximately 20 km^2 (7.8 mi^2). The 100-D/H Area includes three deactivated nuclear reactors and support facilities that operated to produce plutonium from 1944 to 1967. Figure 3 shows the 105-D and 105-DR Reactors within the 100-D Area, and Figure 4 shows the 105-H Reactor within the 100-H Area. The area between the 100-D and 100-H Areas is undeveloped and is referred to as the Horn. The reactors were built to irradiate uranium fuel rods from which plutonium and other special nuclear materials were extracted. The reactors and processes associated with operations generated large quantities of liquid and solid wastes. Large volumes of river water were used as cooling water during reactor operations. The river water was treated to remove particulates and with sodium dichromate to reduce corrosion. Leaks of sodium dichromate concentrate, considered a ***principal threat waste***, from pipelines and spills resulted in high concentrations of hexavalent chromium (Cr(VI)) contamination of soil and in groundwater. Contaminated waste generated from reactor operations contained ***radionuclides***, hazardous chemicals, or both.

Investigations

DOE has completed six field investigations within 100-D/H. These include four ***limited field investigations (LFIs)***, one *Resource Conservation and Recovery Act of 1976* (RCRA) facility investigation/corrective measures study, and one comprehensive RI/FS (100-D/H RI/FS report [DOE/RL-2010-95]).

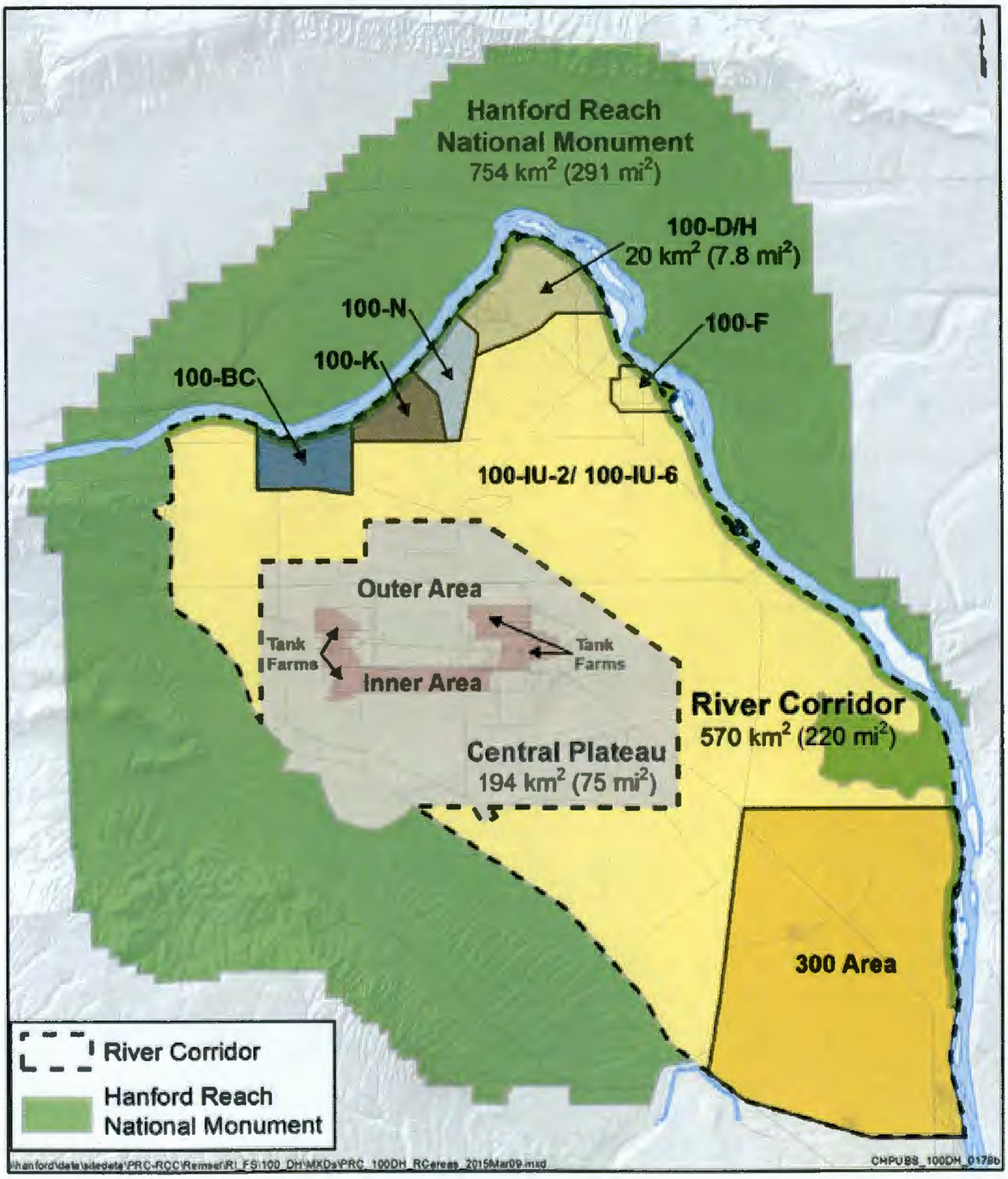


Figure 2. Hanford Site Area Designations

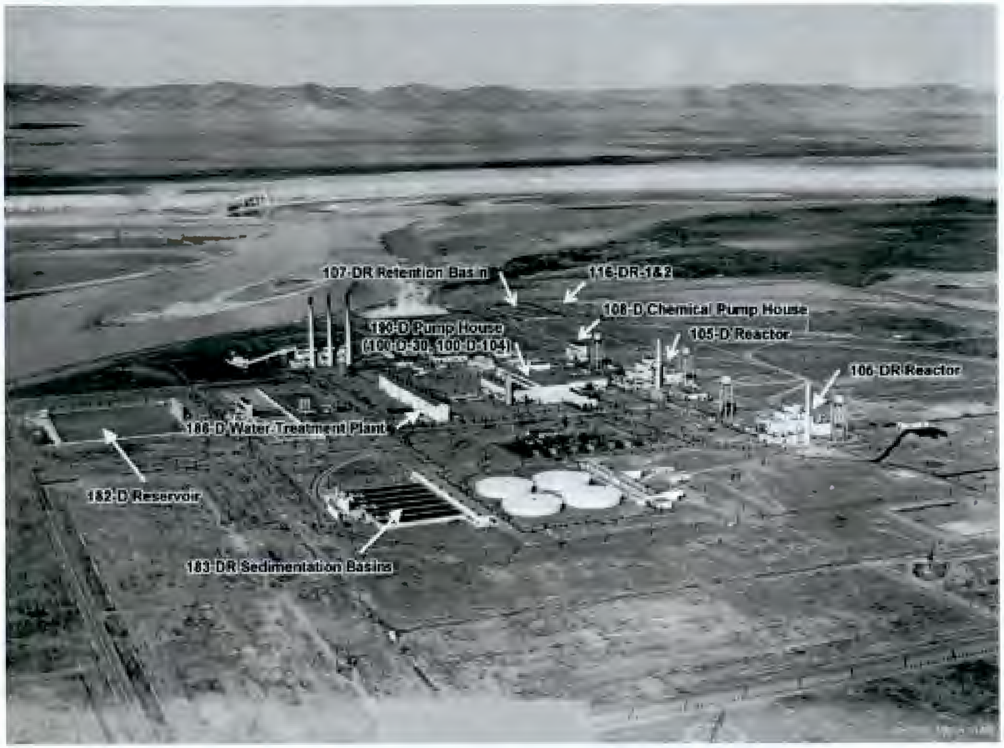


Figure 3. 105-D and 105-DR Reactors in the 100-D Area

Figure 4. 105-H Reactor in the 100-H Area

The results of the LFIs and RCRA investigation are presented in the following documents:

- *Limited Field Investigation Report for the 100-DR-1 Operable Unit* (DOE/RL-93-29)
- *Limited Field Investigation Report for the 100-HR-1 Operable Unit* (DOE/RL-93-51)
- *Limited Field Investigation Report for the 100-HR-2 Operable Unit* (DOE/RL-94-53)
- *Limited Field Investigation Report for the 100-HR-3 Operable Unit* (DOE/RL-93-43)
- Appendix D of *RCRA Facility Investigation/Corrective Measures Study Work Plan for the 100-DR-2 Operable Unit, Hanford Site, Richland, Washington* (DOE/RL-93-46)

The LFIs provided an initial characterization of the nature and extent of contamination, identified contaminant concentrations in waste sites that were above human health direct contact risk levels, and determined that Cr(VI) in groundwater was above ***drinking water standards (DWSs)*** and was entering the Columbia River at concentrations considered toxic to aquatic organisms. Based on these findings and the associated qualitative risk assessments, ***interim actions*** were implemented at 100-D/H to remediate contaminated soil and to treat Cr(VI)-contaminated groundwater.

In 2008, DOE prepared the *Integrated 100 Area Remedial Investigation/Feasibility Study Work Plan Addendum 1: 100-DR-1, 100-DR-2, 100-HR-1, 100-HR-2, and 100-HR-3 Operable Units* (DOE/RL-2008-46-ADD1), which summarized the current knowledge of contamination and identified the additional data needs to support final remedial decisions. The data needs were met by completing the RI/FS fieldwork in 2011. The results are documented in the 100-D/H RI/FS report (DOE/RL-2010-95).

Previous Cleanup Actions and Decisions

The 100-D/H Area included 128 facilities, such as storage buildings, offices, retention basins, maintenance shops, process plants, an electric substation, storage tanks, pump stations, and outfall structures. These facilities were removed under separate decisions not addressed in this Proposed Plan.

Waste site remedial action began in 1995 under the *Interim Remedial Action Record of Decision for the 100-BC-1, 100-DR-1, and 100-HR-1 Operable Units, Hanford Site, Benton County, Washington* (EPA/ROD/R10-95/126). These interim actions consisted primarily of RTD, followed by backfill and revegetation. Specifically, contaminated material was excavated and transported to the ***Environmental Restoration Disposal Facility (ERDF)***, located in the Hanford Site 200 Areas. The contaminated materials were treated as necessary to meet applicable land disposal restrictions (LDRs) and disposed at ERDF. Subsequent interim action RODs, interim action ROD amendments, and ***explanation of significant differences (ESD)*** identified additional waste sites or changes to interim remedial actions. The waste site decisions include the following:

- **1995 –** *Interim Remedial Action Record of Decision for the 100-BC-1, 100-DR-1, and 100-HR-1 Operable Units, Hanford Site, Benton County, Washington* (EPA/ROD/R10-95/126)
- **1997 –** *Amendment to the Interim Remedial Action Record of Decision for the 100-BC-1, 100-DR-1, and 100-HR-1 Operable Units, Hanford Site, Benton County, Washington* (EPA/AMD/R10-97/044) (adds additional waste sites for remediation and changes components of the selected interim remedial action)
- **1999 –** *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 (100 Area Remaining Sites)* (EPA/ROD/R10-99/039)

- **2000 –** *Interim Remedial Action 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* (EPA/ROD/R10-00/121)
- **2004 –** *Explanation of Significant Differences for the 100 Area Remaining Sites Interim Remedial Action Record of Decision* (EPA et al., 2004)
- **2009 –** *Explanation of Significant Differences for the 100 Area Remaining Sites Interim Remedial Action Record of Decision: Hanford Site, Benton County, Washington* (EPA et al., 2009a)

Between 1995 and November 2012, interim RTD remediation was completed for 180 waste sites in the 100-DR-1, 100-DR-2, 100-HR-1, and 100-HR-2 OUs. From November 2012 until a final ROD is issued, many waste sites will have been remediated under the interim remedial action ROD. Interim action will continue under current approved remedial design/remedial action work plans until the work plan for the final ROD is approved. Waste sites remediated after November 2012 will be evaluated again post-ROD to ensure they meet the requirements of the final ROD. A preliminary evaluation of these waste sites is presented later in this Proposed Plan.

In addition to the CERCLA interim remedial actions, three RCRA treatment, storage, and disposal units within 100-D/H have undergone closure (that is, closure requirements have been implemented so the remaining soil has met clean closure standards in accordance with WAC 173-303-610[2][b][ii]). These closures were conducted under the following:

- **1991 –** *183-H Solar Evaporation Basins Closure Postclosure Plan* (DOE/RL-88-04, Release 3) (waste solidification and removal)
- **1997 –** *183-H Solar Evaporation Basins Postclosure Plan* (DOE/RL-97-48) (last of the 183-H Solar Evaporation Basins demolished; unit and soil have been clean closed but groundwater is in post-closure care)
- **1999 –** *100-D Ponds Closure Plan* (DOE/RL-92-71) (clean closure)
- **2004 –** *105-DR Large Sodium Fire Facility Closure Plan* (DOE/RL-90-25) (clean closed)

Groundwater remedial actions have been conducted under the following:

- **1996 –** *Record of Decision for the 100-HR-3 and 100-KR-4 Operable Units Interim Remedial Actions, Hanford Site, Benton County, Washington* (EPA/ROD/R10-96/134)
- **1999 –** *Interim Remedial Action Record of Decision Amendment for the 100-HR-3 Operable Unit, Hanford Site, Benton County, Washington* (EPA/AMD/R10-00/122)
- **2003 –** *Explanation of Significant Difference for the 100-HR-3 Operable Unit, Hanford Site, Benton County, Washington* (EPA/ESD/R10-03/606)
- **2009 –** *Explanation of Significant Differences for the 100-HR-3 and 100-KR-4 Operable Units Interim Action Record of Decision: Hanford Site, Benton County, Washington* (EPA et al., 2009b)
- **2010 –** "Non-Significant Change for the 100-HR-3 and 100-KR-4 Operable Units Interim Action Record of Decision, Hanford Site, Washington, July 2010, Memo to File Regarding: Supplemental Actions for the In-Situ Reduction/Oxidation Manipulation Barrier Performance for the 100-HR-3 Groundwater Operable Unit Interim Remedy" (11-AMCP-0002)

Groundwater remediation by extraction and treatment was initiated in 1997 under the interim action ROD (EPA/ROD/R10-96/134) with startup of the first pump and treat system, HR-3. The objective of the interim remediation was to remove Cr(VI) contamination from groundwater and address immediate threats to the Columbia River. An in situ redox manipulation barrier was installed as a new technology for treating Cr(VI)-contaminated groundwater in the 100-D Area under the 1999 interim action ROD amendment (EPA/AMD/R10-00/122) and the 2003 ESD (EPA/ESD/R10-03/606). A second pump and treat system, DR-5, began operating in 2004. Under the 2009 ESD (EPA et al., 2009b), these two initial pump and treat systems (DR-5 and HR-3) were expanded to include additional plume treatment capacity. As part of this expansion, two new ion-exchange treatment facilities were constructed, and most of the wells under the HR-3 and DR-5 systems were transitioned to the new systems, HX and DX. The original treatment facilities for HR-3 and DR-5 stopped operating after this transition was complete. In 2009, it was determined that breakthrough of Cr(VI) was occurring, thus the barrier was not achieving the required level of performance. DOE, EPA, and Ecology (also known as the ***Tri-Parties***) agreed that the DX pump and treat system would provide adequate protection of the river and barrier maintenance could be discontinued (11-AMCP-0002). Table 1 identifies the pump and treat operating systems and their history through 2012. Since 2012, the DX and HX pump and treat systems have continued to operate within the 100-HR-3 OU under the interim action ROD. The treatment capacities have been increased; numerous wells (injection, extraction and monitoring) have been constructed; over 10,600 million L (2,800 million gal) of groundwater have been treated; and over 1,170 kg (2,580 lb) of Cr(VI) have been removed from the groundwater.

Table 1. 100-HR-3 OU Pump and Treat Operating History

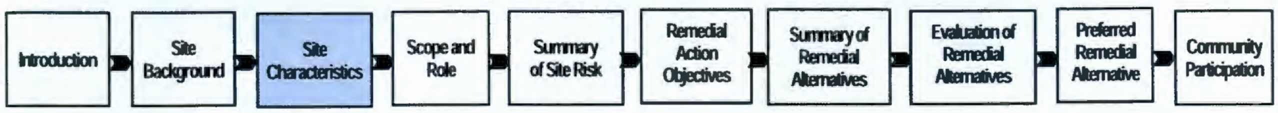
Pump and Treat System	Operating Period	Volume Pumped through December 2012, million L (million gal)	Hexavalent Chromium Removed through December 2012, kg (lb)
HR-3	June 1997 until shutdown in May 2011	4,171 (1,102)	405 (892)
DR-5	July 2004 until shutdown in March 2011	386 (102)	337(742)
DX	December 2010 through 2012	1,635 (432)	931 (2,052)
HX	September 2011 through 2012	1,332 (352)	43 (95)

Previous Public Participation

The Tri-Parties have conducted formal and informal public involvement during the previous interim remedial action decision processes for cleanup in the 100-DR-1, 100-DR-2, 100-HR-1, 100-HR-2, and 100-HR-3 OUs, as well as for deactivation and decommissioning of buildings in 100-D/H conducted pursuant to CERCLA removal authority. Public comment was sought and considered before selecting and amending all 100-D/H interim remedial actions. The historical input and advice from all parties, including the Tribal Nations, the state of Oregon, and the Hanford Advisory Board (a federally chartered advisory board comprised of representatives of diverse stakeholders concerned with Hanford Site cleanup), relative to the 100-DR-1, 100-DR-2, 100-HR-1, 100-HR-2, and 100-HR-3 OUs, were reviewed in the development of this Proposed Plan.

Previous Tribal Nations Participation

The Hanford Site is located on land ceded to the United States under separate treaties with the Confederated Tribes and Bands of the Yakama Nation and the Confederated Tribes of the Umatilla Indian Reservation. The Nez Perce Tribe also secured rights at what is now the Hanford Site in a separate treaty. DOE consults with these Tribal Nations. In addition, DOE consults with the Wanapum Band of Indians, who were historical residents on Hanford lands. DOE and EPA invited the Tribal Nations to formal consultation on the proposed River Corridor cleanup actions, including this cleanup action for 100-D/H. DOE has worked with Tribal Nations staff during the RI/FS process.



Site Characteristics

This section presents information on 100-D/H surface features, current land and groundwater uses, the nature and extent of waste site soil contamination, and groundwater contaminant plumes.

Site Features, and Land and Groundwater Use

The principal structures include the three reactors, parts of the export water system infrastructure, roads, and multiple support buildings (Figure 5). Most of these historical structures are to be removed under an existing removal action memorandum. These structures are not part of the 100-DR-1, 100-DR-2, 100-HR-1, 100-HR-2, or 100-HR-3 OUs and, therefore, are not addressed by this Proposed Plan. The 105-D, 105-DR, and 105-H Reactor buildings are in ***interim safe storage***, and there is no current plan to remove them under the existing removal action memorandum. The contaminated power poles (waste site 100-H-58) provide electrical power to the HX pump and treat facility and will be remediated after 100-HR-3 groundwater remediation is complete.

The 100-D/H Area is being used for waste management, environmental monitoring, waste site remediation, and conservation and restoration activities. The segment of the Columbia River adjacent to 100-D/H, which is part of the HRNM, is used for a variety of recreational activities. The land use in the HRNM includes preservation and conservation.

The raw water supply for the 100 and 200 Areas is provided from the Columbia River through a series of pump houses, reservoirs, and pipelines. This water distribution system is known as the water export system. A part of this system, including the 182-D reservoir, is located in 100-D/H.

Many communities downstream of the Hanford Site draw water from the Columbia River for all or part of their domestic water supply. The city of Richland water intake is the closest to the Hanford Site. The city of Richland filters and treats water from the river and routinely monitors it prior to its distribution to ensure that the water meets federal drinking water standards (maximum contaminant levels), as required by the *Safe Drinking Water Act*.

Physical Features Impacting Remedy Selection

The 100-D/H topography is gently sloping, with elevations ranging from approximately 154 m (505 ft) along the western boundary of the 100-D Area to 115 m (377 ft) south of the 100-H Area along the river shoreline. The average elevation in 100-D/H is 135 m (443 ft). The topography on the east side of the 100-D Area slopes downward, so the ground surface across the Horn is several meters lower in elevation. The gently sloping topography and soil types are easily excavated. Other topographic changes occur along the shoreline where the riverbank slopes steeply downward, toward the Columbia River.

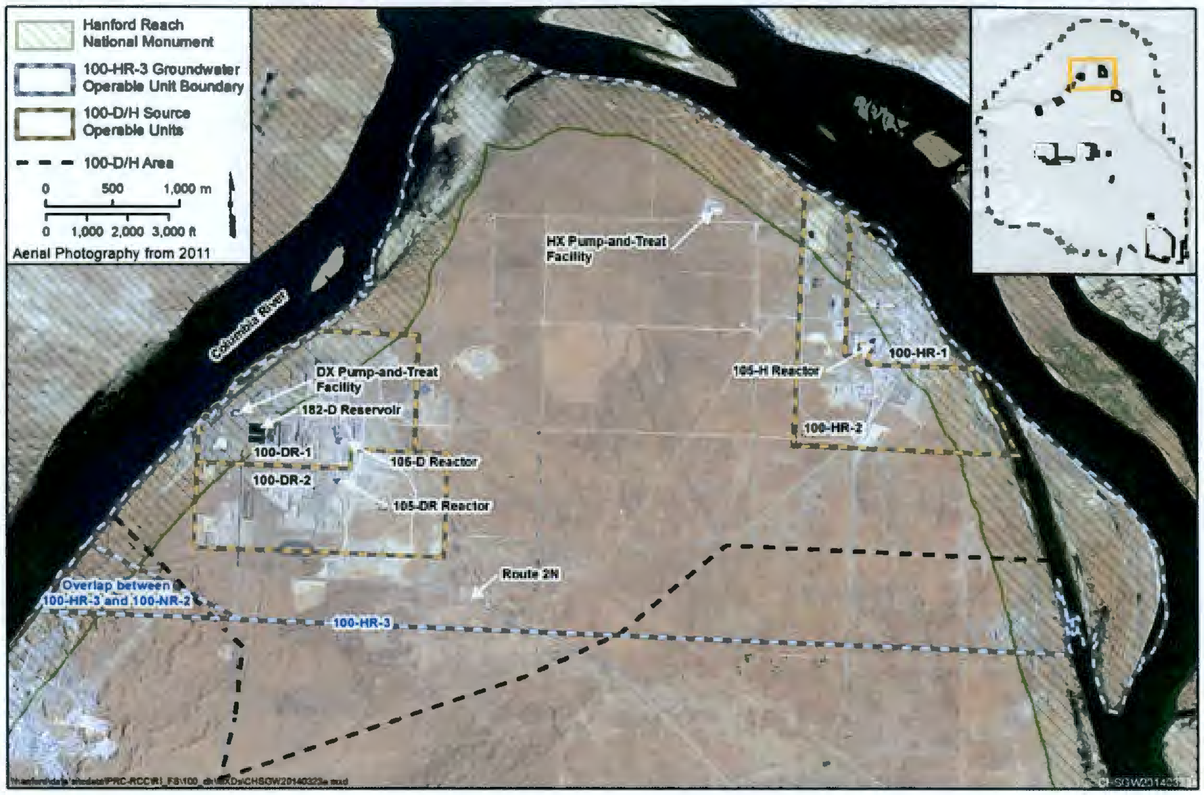
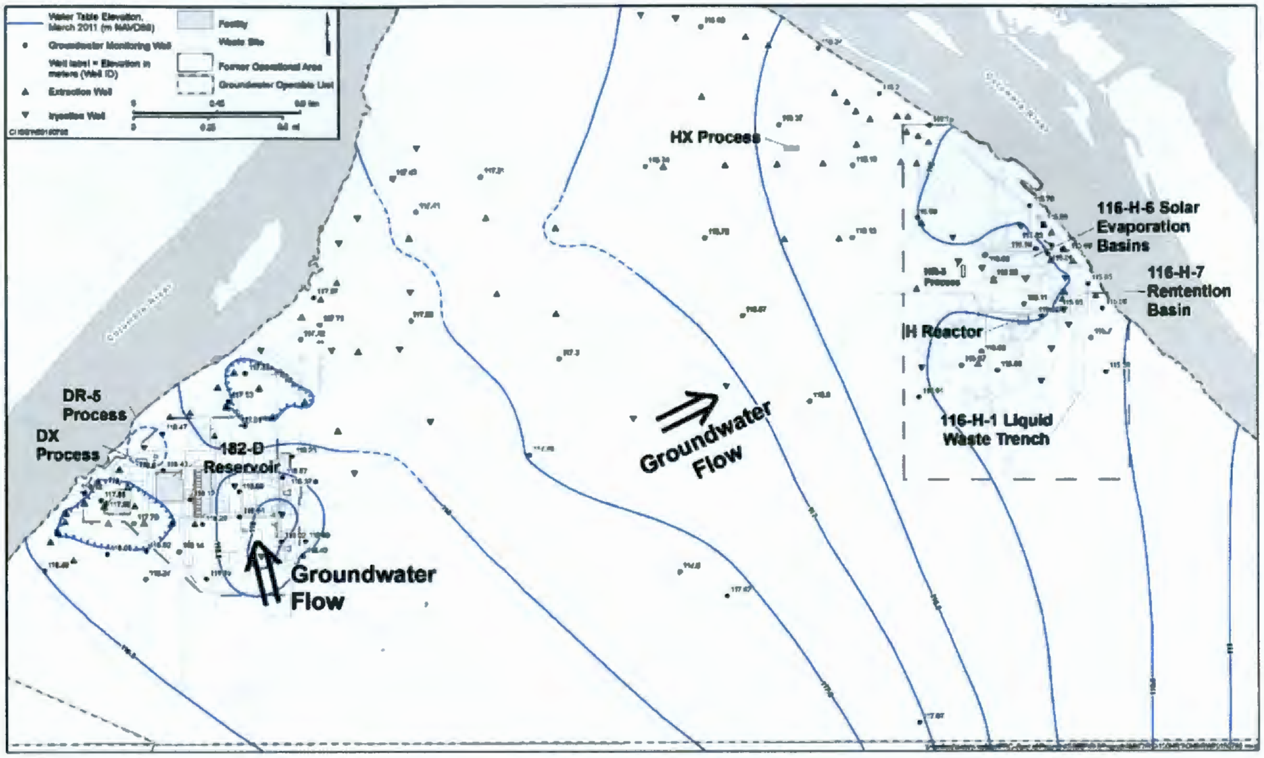


Figure 5. 100-D/H Area and Site Features

The thickness of the ***vadose zone*** in 100-D/H ranges from approximately 27 m (90 ft) in the 100-D Area to 5 m (15 ft) near the Columbia River in the 100-H Area. The shallow unconfined aquifer is found within sands and gravels beneath most of the 100-D Area and in sands and gravels at the 100-H Area. In the intervening area of the Horn, the shallow unconfined aquifer is variably within sands and gravels and gravel-dominated material. Fine-grained materials define the base of the unconfined aquifer. This material, part of the Ringold Formation upper mud unit (RUM), forms an ***aquitard*** that restricts groundwater flow. In 100-D/H, these fine-grained materials are not continuous at all locations. A confined to semiconfined aquifer is located in sandy water-bearing units in the RUM. The upper confined to semiconfined water-bearing unit varies from approximately 0.5 to 7 m (1.6 to 23 ft) thick.

An important factor influencing remedy selection is the interaction of contaminated groundwater with the Columbia River. Groundwater and the Columbia River are hydraulically connected at 100-D/H, and the river level influences groundwater flow, especially near the river. Groundwater generally flows north in the 100-D Area, west to east beneath the Horn, and northeast in the 100-H Area, discharging to the Columbia River. Figure 6 presents the water table in March 2011, depicting typical groundwater flow direction.

Groundwater flow is not always directed toward the river, as the ***hydraulic gradients*** change direction in response to river stage. This interaction with the river not only affects groundwater flow patterns but also contaminant transport rates, groundwater geochemistry, contaminant concentrations, and ***attenuation rates***.



Source: NAVD88, *North American Vertical Datum of 1988.*

Figure 6. 100-D/H Water Table Map (March 2011)

Groundwater in the unconfined aquifer discharges to the Columbia River via upwelling through the riverbed and riverbank seeps. Because the river stage regularly fluctuates up and down, flow beneath the shoreline is back and forth over a limited distance, with river water intruding into the unconfined aquifer and mixing with groundwater during high river stage. When the river stage drops to a low elevation, riverbank seeps appear. High river stage is generally from May through August, and low river stage is generally from September through January, with transitional levels in other months. River-stage fluctuation affects the extraction of contaminated groundwater along the river. The rate of groundwater discharge from the Hanford Site unconfined and confined aquifers is very low compared to the flow of the river.

The sands and gravels at 100-D/H provide a permeable media, which allows for efficient extraction of contaminated groundwater for treatment. This permeable media also allows efficient return of treated groundwater to the aquifer through wells or infiltration through the vadose zone.

Waste Site Contamination

Liquid wastes were disposed in basins, cribs, trenches, and ponds. The liquid waste discharged to the 100-DR-1, 100-DR-2, 100-HR-1, and 100-HR-2 OU waste sites contained metals, anions, radionuclides, and organic chemicals. The largest volume of waste from reactor operations was cooling water discharges containing Cr(VI) and radionuclides. Waste sites are shown in Figures 7 through 10. Mobile contaminants such as nitrate and Cr(VI) have migrated through the vadose zone to the groundwater. Key contaminants driving waste site cleanup include Cr(VI), strontium-90, and cesium-137. Solid wastes from reactor operations were disposed in burial grounds at depths up to 8 m (25 ft) below ground surface (bgs).

Figures 7 and 8 present the locations of waste sites in the 100-D/H OUs that have been remediated as of November 2012 under interim action RODs. Figures 9 and 10 show the locations of waste sites that had not been remediated under interim action RODs as of November 2012. The disposition of all waste sites is discussed in the "Summary of Remedial Alternatives" section of this Proposed Plan, which includes Table 3 that lists the waste site numbers for all of the waste sites shown in Figures 7 through 12. Vadose zone waste sites that were the source of Cr(VI) groundwater contamination are included in Table 3.

Groundwater Contamination

Groundwater contaminants include total chromium, Cr(VI), strontium-90, and nitrate. Figure 13 presents the groundwater COC plumes identified by concentrations greater than a DWS or state surface water quality standard. Cr(VI) contamination in groundwater is associated with reactor cooling water discharges to the cooling water retention basins and trenches, and unplanned releases of concentrated solutions in product transfer areas. Sodium dichromate handling and cooling water discharge locations, which were the sources of Cr(VI), are identified in the 100-D/H RI/FS report (DOE/RL-2010-95). The groundwater Cr(VI) plumes are the southern and northern plumes in the 100-D Area, and the Horn and 100-H Area plumes in the eastern portion of 100-D/H (DOE/RL-2011-118, *Hanford Site Groundwater Monitoring for 2011*). The total chromium, strontium-90, and nitrate contaminant plumes are generally collocated within the boundaries of the Cr(VI) plumes or are within the boundaries of current pump and treat system containment. The plume discussions in the 100-D/H RI/FS report identify the sources, concentrations, and plume characteristics.

Cr(VI). Cr(VI) in the 100-HR-3 OU exceeds the 10 µg/L Washington State surface water quality standard over an area of approximately 7.73 km^2 (2.98 mi^2) (DOE/RL-2011-118). DOE used the state surface water quality standard of 10 µg/L as a screening level to assess the potential for Cr(VI) to reach the river at concentrations greater than the state surface water quality standard. Concentrations were also compared to the ***Model Toxics Control Act (MTCA)*** (*Washington Administrative Code* [WAC] 173-340, "Model Toxics Control Act—Cleanup") Method B groundwater cleanup level of 48 µg/L. Concentrations of Cr(VI) ranged from 2 to 69,700 µg/L for the data used in the RI/FS evaluation. With startup of the DX pump and treat system, which was installed to expand treatment of the Cr(VI) plume in the 100-D Area, the highest concentrations have declined and in 2014 were less than 4,000 µg/L. Because the plume exceeds the 10 µg/L state surface water quality standard, the pump and treat systems intercept and treat contaminated groundwater prior to it reaching the river. Cr(VI) has also been observed in the confined to semiconfined aquifer at the 100-H Area and is also intercepted there prior to reaching the river at concentrations above standards identified above by the HX pump and treat system.

Total Chromium. Total chromium is collocated with Cr(VI), and treatment of Cr(VI) groundwater contamination will result in attainment of cleanup levels for total chromium. Both the MTCA (WAC 173-340) Method B groundwater cleanup level of 48 µg/L and the state surface water quality standard (10 µg/L) for Cr(VI) are less than the respective DWS (100 µg/L) and ***ambient water quality criteria*** (65 µg/L) for total chromium.

Nitrate. Nitrate contamination of groundwater in the 100-HR-3 OU is greater than the 45 mg/L (NO_3)[4] DWS primarily in the 100-D Area and a small area in 100-H, encompassing an area of approximately 0.34 km^2 (0.13 mi^2). The primary source of nitrate in 100-D/H is nitric acid used during reactor operations as a decontamination solution. Concentrations of nitrate ranged from 1.81 to 107 mg/L in data evaluated for the RI/FS.

[4] The EPA maximum contaminant level under the *Safe Drinking Water Act* for nitrate is 10 mg/L or 10 ppm. The 10 mg/L standard expressed as nitrogen (N) is equivalent to 45 mg/L expressed as nitrate.

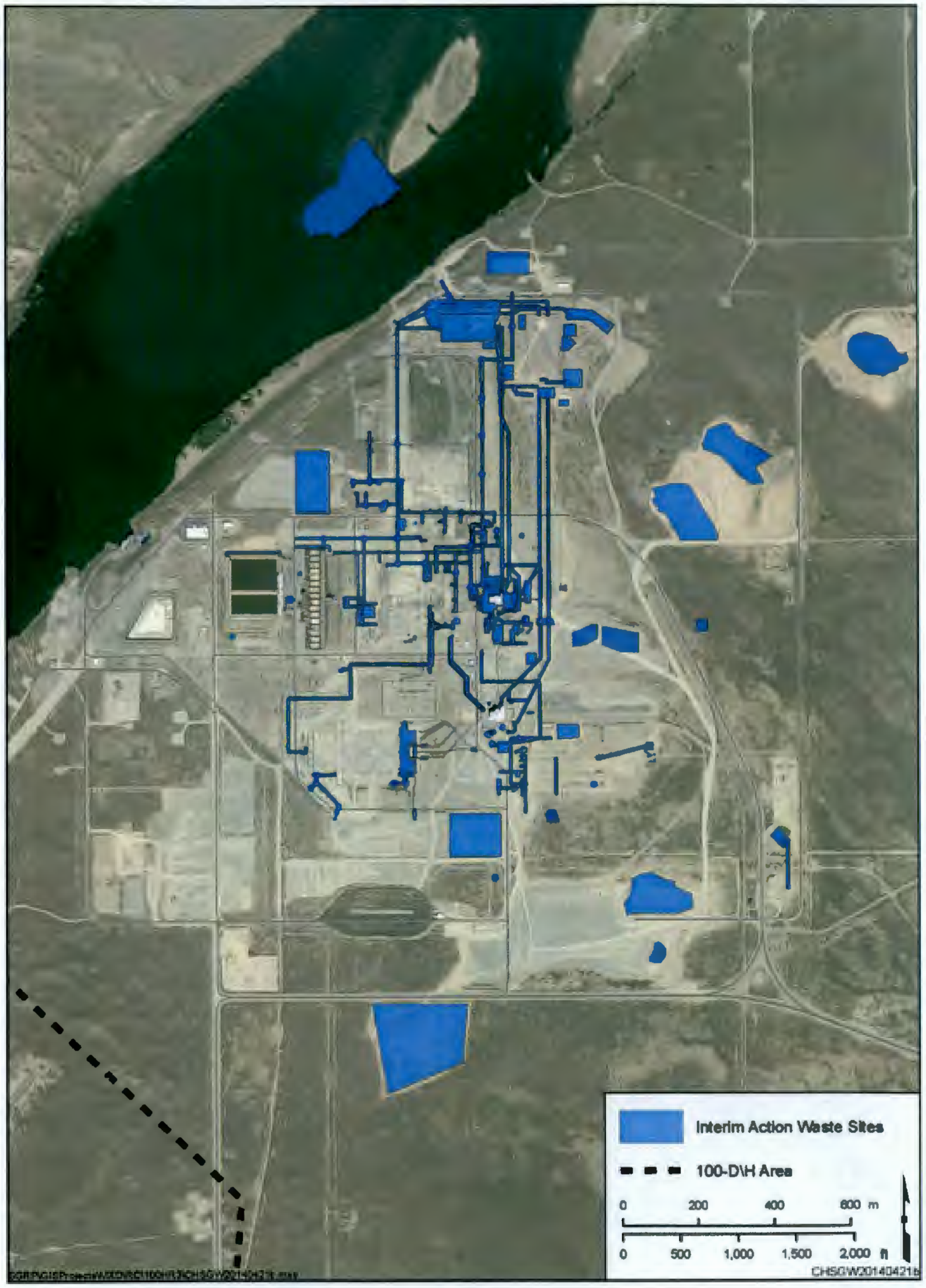


Figure 7. Waste Sites Remediated as of November 2012 under Interim Action RODs in the 100-DR-1 and 100-DR-2 OUs (Proposed for No Action, Table 3)

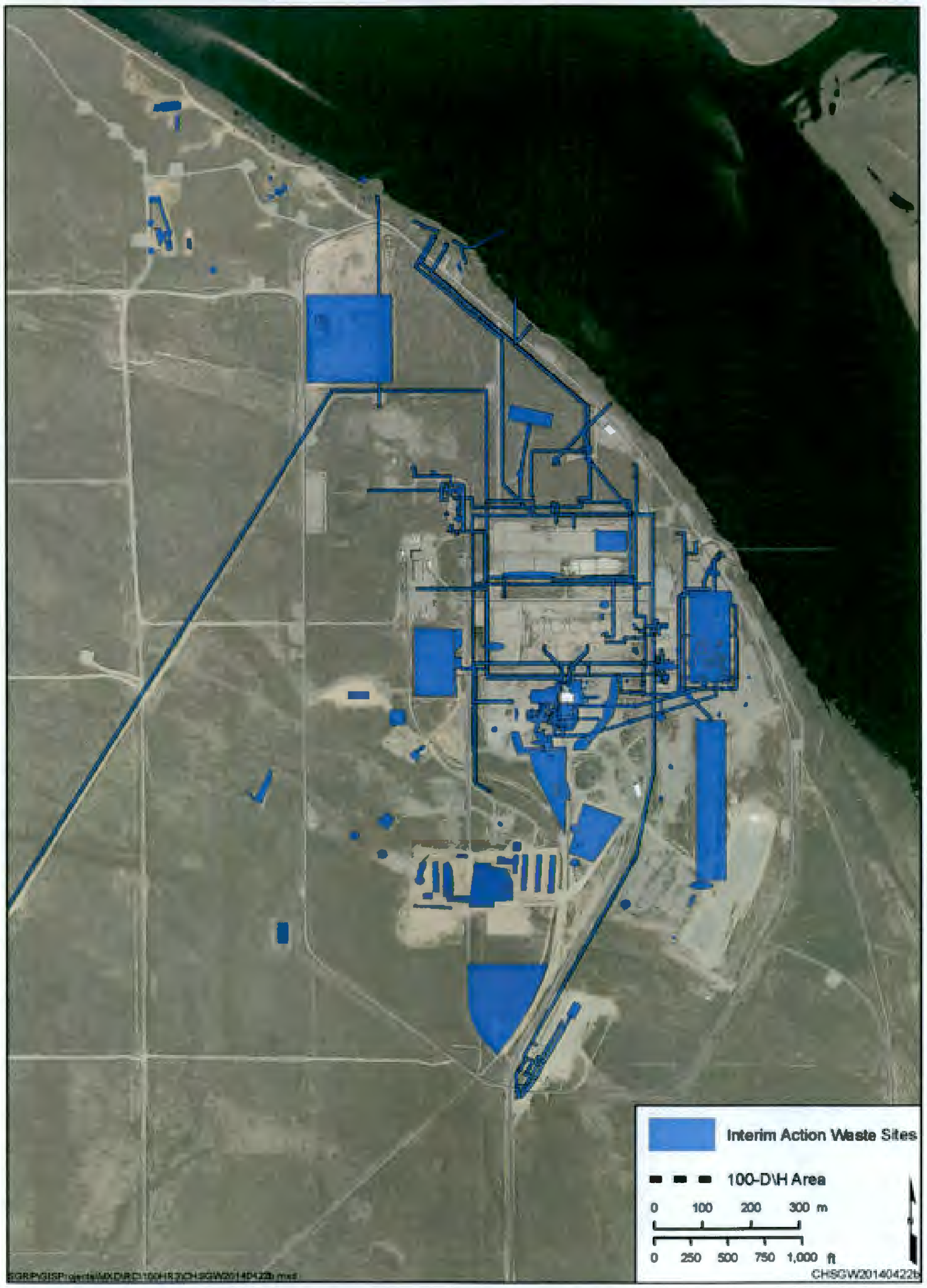


Figure 8. Waste Sites Remediated as of November 2012 under Interim Action RODs in the 100-HR-1 and 100-HR-2 OUs (Proposed for No Action, Table 3)

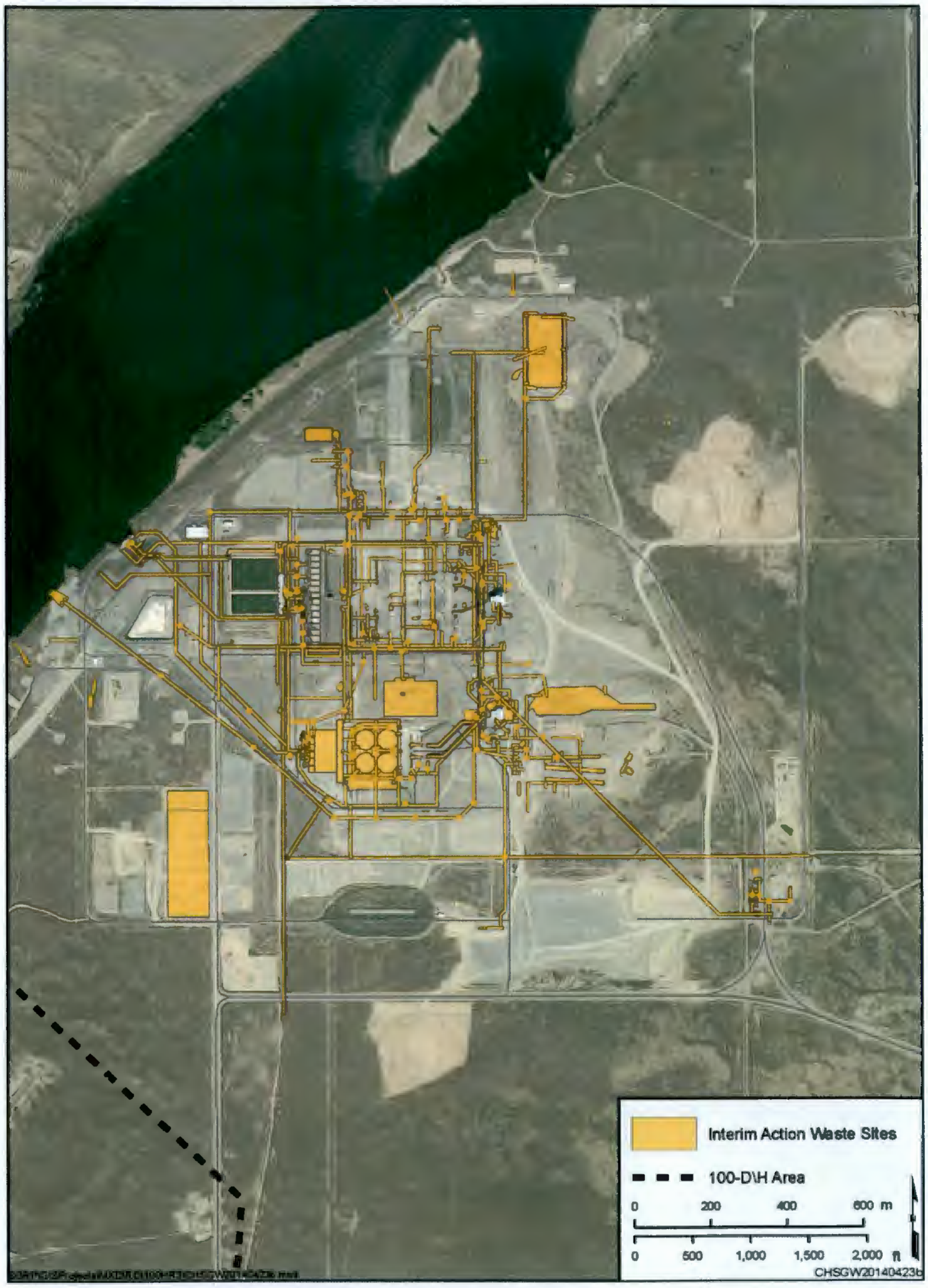


Figure 9. Waste Sites Not Remediated as of November 2012 under Interim Action RODs in the 100-DR-1 and 100-DR-2 OUs (Proposed for RTD, Table 3)

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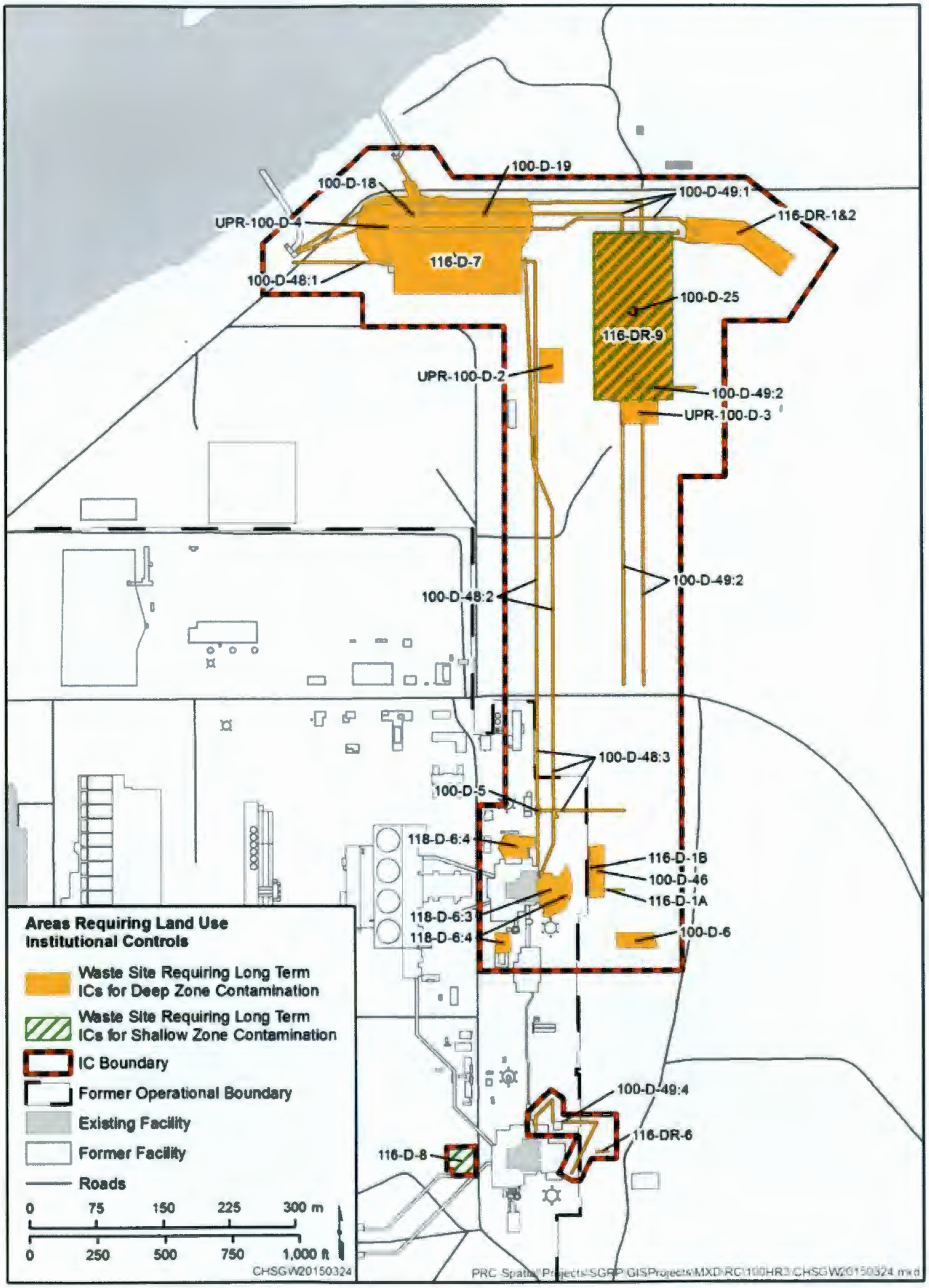
2 Figure 10. Waste Sites Not Remediated as of November 2012 under Interim Action RODs
3 in the 100-HR-1 and 100-HR-2 OUs (Proposed for RTD, Table 3)



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2 Figure 11. 100-D Area Waste Sites for MNA with ICs Under the Preferred Alternative (Table 6)

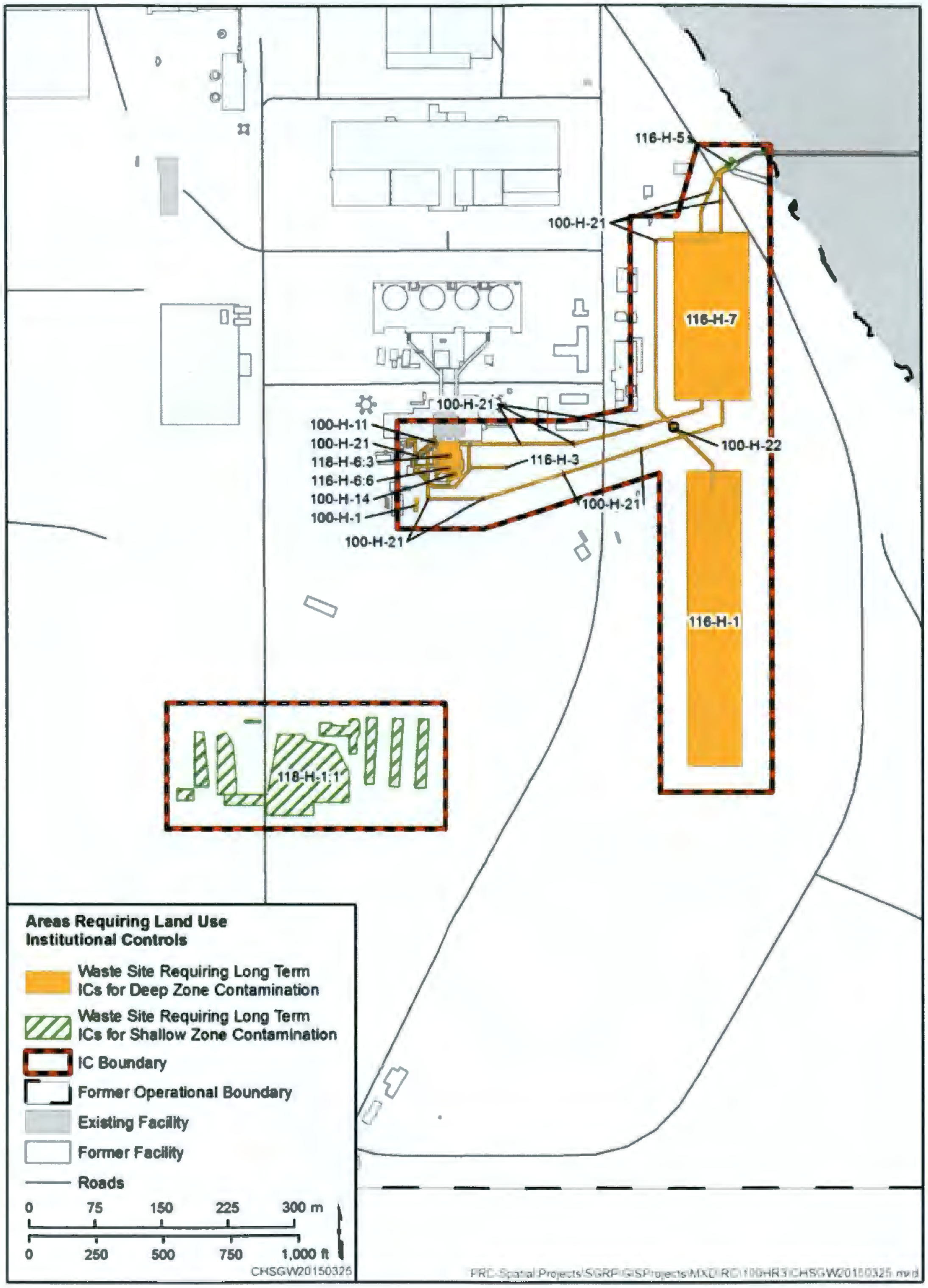


Figure 12. 100-H Area Waste Sites for MNA with ICs Under the Preferred Alternative (Table 6)

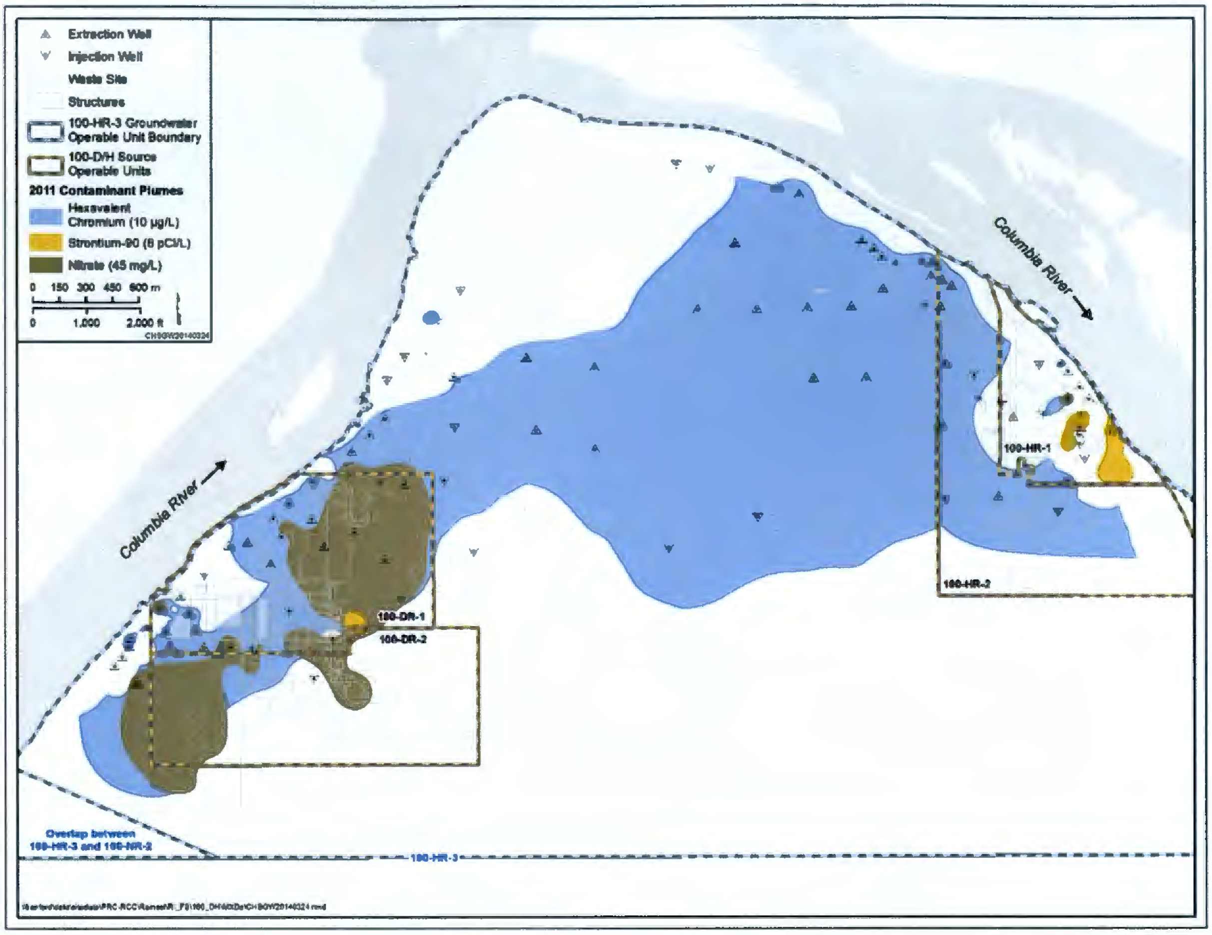


Figure 13. 100-HR-3 Groundwater Plume Map, 2011

Strontium-90. Leaks from the cooling water retention basins, as well as the intentional discharges of contaminated cooling water to the disposal trenches, account for most of the observed strontium-90 contamination in groundwater. Concentrations of strontium-90 in groundwater above the 8 pCi/L DWS are present in an area of 0.12 km^2 (0.05 mi^2). Concentrations of strontium-90 range from 1.1 to 110 pCi/L in data evaluated for the RI/FS. The observed concentrations were less than the lowest risk-based concentration for aquatic or riparian animals for strontium-90, which is 278 pCi/L for riparian animals. The risk-based numbers for fish and aquatic invertebrates are much higher.

Principal Threat Wastes

Principal threat wastes are those source materials at concentrations considered highly toxic or highly mobile that generally cannot be reliably contained or would present a significant risk to public health or the environment should exposure occur. Contaminated groundwater is generally not considered to be source material.

Principal threat wastes associated with 100-D/H such as fuel fragments, concentrated liquid sodium dichromate, and highly Cr(VI) contaminated soil and debris have been removed through earlier cleanup actions. No waste sites remain in the source OUs with contaminant concentrations that would constitute principal threat waste.

Introduction ▶ Site Background ▶ Site Characteristics ▶ Scope and Role ▶ Summary of Site Risk ▶ Remedial Action Objectives ▶ Summary of Remedial Alternatives ▶ Evaluation of Remedial Alternatives ▶ Preferred Remedial Alternative ▶ Community Participation

Scope and Role

This Proposed Plan addresses releases in the following OUs:

- 100-DR-1 Source OU
- 100-DR-2 Source OU
- 100-HR-1 Source OU
- 100-HR-2 Source OU
- 100-HR-3 Groundwater OU

The roles of the 100-DR-1, 100-DR-2, 100-HR-1, 100-HR-2, and 100-HR-3 OUs in the scope of the Hanford Site cleanup strategy are presented in the following section.

Hanford Site Overall Cleanup Strategy

This Proposed Plan is part of a cleanup strategy to complete remediation of the Hanford Site. The River Corridor and the Central Plateau (Figure 2) are the two main geographic areas for cleanup work on the Hanford Site. The 100-DR-1, 100-DR-2, 100-HR-1, 100-HR-2, and 100-HR-3 OUs are located in the 100-D/H Area, which is part of the River Corridor that includes the former reactor operations and fuel fabrication areas adjacent to the Columbia River. The Central Plateau includes the former fuel-processing facilities and numerous waste disposal facilities. The objective of the cleanup strategy is to ensure that cleanup actions address all threats to HHE in accordance with regulatory requirements.

The intent of the Hanford Site cleanup strategy is to shrink the site's waste management footprint to the Central Plateau for long-term waste management. The strategy includes remediation of waste sites and restoration of groundwater that (1) is protective of HHE, including the Columbia River; (2) restores groundwater to beneficial use wherever practicable; and (3) supports reasonably anticipated future uses.

Introduction ▶ Site Background ▶ Site Characteristics ▶ Scope and Role ▶ Summary of Site Risk ▶ Remedial Action Objectives ▶ Summary of Remedial Alternatives ▶ Evaluation of Remedial Alternatives ▶ Preferred Remedial Alternative ▶ Community Participation

Summary of Site Risk

A baseline risk assessment, as required under the NCP (40 CFR 300) to characterize current and potential threats to HHE and to provide information that can be used in the development and evaluation of remedial alternatives, is presented in the 100-D/H RI/FS report (DOE/RL-2010-95). Prior to the 100-D/H RI/FS, the River Corridor baseline risk assessment (DOE/RL-2007-21, *River Corridor Baseline Risk Assessment, Volume I: Ecological Risk Assessment* and *River Corridor Baseline Risk Assessment*; *Volume II, Human Health Risk Assessment* [hereafter referred to as the RCBRA]) and the Columbia River Component (DOE/RL-2010-117, *Columbia River Component Risk Assessment, Volume I: Screening-Level Ecological Risk Assessment* and *Columbia River Component Risk Assessment*; *Volume II: Baseline Human Health Risk Assessment* [hereafter referred to as the CRC]) were conducted to characterize current and potential future risks to HHE that may be posed by contamination in the River Corridor, including the OUs addressed in this Proposed Plan. The results of the RCBRA and the CRC are summarized in the 100-D/H RI/FS report.

The risk assessment for specific waste sites in the RI/FS relied on a comprehensive review of all available data for each waste site, including field data, radiological surveys, process history, analogous site information, personal interviews, engineering drawings and as-builts, and any other information identified during the development of the RI/FS. Post-interim remediation data, including closeout verification documentation, were included in the risk assessment if the data were available as of November 2012. The 100-D/H RI/FS report (DOE/RL-2010-95) determined that either:

- These waste sites had no remaining contaminants at concentrations greater than established standards that define acceptable levels of exposure, which are also the proposed final cleanup levels (Tables 7 and 8 at the end of this Proposed Plan); therefore, no further remedial action is necessary.

or

- It can be concluded that there are risks above established standards that define acceptable levels of exposure (Tables 7 and 8 at the end of this Proposed Plan), thus providing a basis for action.

Between December 2012 and December 2015, interim remediation was completed at 101 additional waste sites in the 100-D/H source OUs. These waste sites have been evaluated and determined they will satisfy final proposed cleanup levels (Tables 7 and 8) for all but three sites. The results of the waste site data evaluation (CHPRC-02895 *Evaluation of Remaining Site Verification Packages Approved after Transmittal of the Rev. 0 Remedial Investigation/Feasibility Study for the 100-DR-1, 100-DR-2, 100-HR-1, 100-HR-2, and 100-HR-3 Operable Units, DOE/RL-2010-95*) indicate that contaminant concentrations meet the final proposed cleanup levels except at shallow zone waste sites 118-D-2:1 and 100-H-54, and deep zone waste site 118-D3:1. Radionuclides will decay to levels protective of human health in less than 10 years at these three sites. These waste sites will be subject to MNA with ICs as discussed for shallow and deep waste sites under "Common Elements" in this Proposed Plan.

Under the preferred alternative (Alternative 3) and Alternatives 2 and 4 described below, all remediated waste sites with an RTD remedy identified in Table 3 will be evaluated post-ROD to determine if these waste sites meet the final cleanup levels. This evaluation will be the same as the evaluation that was conducted and reported in the 100-D/H RI/FS report (DOE/RL-2010-95) for human health direct contact (Table 7) and for groundwater and surface water protection (Table 8). Waste sites with contamination exceeding final cleanup levels for direct contact (Table 7) will require additional action to complete the RTD remedy.

Land and Groundwater Use Assumptions

Land use in the River Corridor is controlled by DOE, with the U.S. Fish and Wildlife Service (USFWS) managing the HRNM. DOE and the USFWS manage this federally owned land to protect natural and cultural resources while cleanup activities are being conducted. Such management is consistent with the *Final Hanford Comprehensive Land-Use Plan Environmental Impact Statement* (DOE/EIS-0222-F) and the *Supplement Analysis, Hanford Comprehensive Land-Use Plan Environmental Impact Statement* (DOE/EIS-0222-SA-01) for the Hanford Site. This joint management also reflects the requirements of the USFWS management plan (USFWS, 2008, *Hanford Reach National Monument: Final Comprehensive Conservation Plan and Environmental Impact Statement; Adams, Benton, Grant and Franklin Counties, Washington*) for the HRNM. Both DOE and the USFWS expect that this joint management of the Hanford Site will continue for many years into the future and that the property will remain under federal ownership. In June 2000, the HRNM was established within the boundaries of the Hanford Site (Figure 2). The Presidential Proclamation (65 FR 114) mandates preservation of the natural and cultural resources within the HRNM and specifically included the possibility of adding lands to the HRNM as they are remediated.

DOE's reasonably anticipated future use of the 100-DR-1, 100-DR-2, 100-HR-1, and 100-HR-2 OUs is conservation and preservation. EPA and Ecology believe that other uses, including residential use, are reasonably anticipated future land uses for these areas. In the preferred alternative, residential-based cleanup levels are proposed. The residential cleanup levels also allow for conservation and preservation uses and minimize the need for ICs and long-term monitoring.

The NCP establishes an expectation to "...return useable ground waters to their beneficial uses wherever practicable, within a time frame that is reasonable given the particular circumstances of the site..." (40 CFR 300.430[a][1][iii][F]). The Tri-Parties' goal for Hanford Site groundwater is to attain the regulatory goals by returning groundwater to its beneficial use as a potential future drinking water source.

Groundwater from the 100-HR-3 OU is currently contaminated above DWSs, and the interim action ROD (EPA/ROD/R10-96/134) includes ICs to protect human health. The DOE *Sitewide Institutional Controls Plan for Hanford CERCLA Response Actions and RCRA Corrective Actions* (DOE/RL-2001-41) prohibits withdrawal for uses other than monitoring through use restrictions currently in place. Groundwater in the risk evaluation was evaluated assuming potential future use for drinking water and other domestic activities. Contaminant concentrations were also compared to ambient water quality criteria and state surface water quality standards because groundwater discharges to the Columbia River via riverbank seeps and upwelling through the river bottom.

Current and Future Exposure Scenarios

Exposure to contamination in 100-D/H is currently controlled by DOE's site controls to prevent unacceptable exposure to humans. Risk to site workers is managed through health and safety programs.

For purposes of assessing future potential risk, various human exposure scenarios were evaluated in the RCBRA (DOE/RL-2007-21, Volume II), the CRC (DOE/RL-2010-117, Volume II), and the baseline human health risk assessment in the 100-D/H RI/FS report (Section 6.2.3 of DOE/RL-2010-95). These exposure scenarios were evaluated to reflect a range of land uses, including the residential scenario.

Residential Scenario. The residential scenario for exposure to chemicals used Washington State MTCA (WAC 173-340) cleanup levels for unrestricted use to evaluate risk. Each of the risk assessment exposure scenarios is described in the following text.

For assessing cancer risks and noncancer hazards from exposure to chemicals in the top 4.6 m (15 ft) of soil, MTCA (WAC 173-340-740, "Unrestricted Land Use Soil Cleanup Standards") Method B levels were used. MTCA Method B considers direct contact exposure of a child through incidental soil ingestion. It also considers the inhalation pathway based on exposure to adults and children from inhalation of vapors and dust in ambient air. Calculations of these MTCA cleanup standards (identified as the soil ***preliminary remediation goals [PRGs]***) are described in the 100-D/H RI/FS report (Section 8.1.4 of DOE/RL-2010-95).

For assessing cancer risks from radionuclides in soil, the residential scenario assumes that exposure to soil within the top 4.6 m (15 ft) occurs over a 30-year period. The scenario assumes that a residence is established on the waste site and the resident receives exposure from direct contact with the soil from the remediated waste site and through the food chain. This includes potential exposure through external radiation, incidental soil ingestion, and inhalation of ambient dust particulates. The food chain pathway includes exposure from consumption of fruits and vegetables grown in a backyard garden, as well as consumption of meat (beef and poultry) and milk from livestock raised in a pasture. Uptake of contamination into crops and livestock is assumed to occur from contamination present in soil. Contaminants in soil are transported through the soil column, into the underlying groundwater, and to a hypothetical downgradient well located at the waste site boundary that is used for drinking water consumption, irrigation of crops, and watering livestock, and for consumption of fish raised in a pond of water from the downgradient well. An additional evaluation was performed for groundwater use assuming that the only exposure was through use of groundwater as a drinking water source.

Groundwater. Groundwater contamination risk within the 100-HR-3 OU was evaluated using three different methods. First, concentrations of chemicals and radionuclides that were measured over the last 7 years were compared to federal and state DWSs and to MTCA (WAC 173-340), surface water quality standards, and MTCA Method B groundwater cleanup levels. Groundwater ***contaminants of potential concern (COPCs)*** were identified for evaluation of remedial alternatives when concentrations were greater than any of the standard values. Another comparative evaluation was then completed for groundwater ***exposure point concentrations*** developed using measurements that were collected per the RI/FS work plan (DOE/RL-2008-46-ADD1). Groundwater COPCs are described in the 100-D/H RI/FS report (Section 8.1.1 of DOE/RL-2010-95).

Finally, an additional evaluation calculated human health ***excess lifetime cancer risks (ELCRs)*** and hazards using the EPA residential drinking water exposure scenario (Section 6.3.7 of DOE/RL-2010-95, Tap Water Scenario). This scenario assumes that the groundwater is used as a tap water source for a 30-year period. Potential routes of exposure include ingestion, dermal contact, and inhalation of volatiles during household activities. Exposure point concentrations were used to calculate ELCRs and noncancer hazards. COPCs were identified when the ELCRs and noncancer hazards were greater than the acceptable risk thresholds identified in MTCA (WAC 173-340) and the NCP (40 CFR 300), or when a significant contribution to adverse human health effects was identified. In Title 40, *Code of Federal Regulations*, Part 300, "National Oil and Hazardous Substances Pollution Contingency Plan," the EPA considers a cumulative ELCR below 10^{-6} acceptable risk. Risks between 10^{-4} to 10^{-6} are generally referred to as an "acceptable risk range." Risks above 10^{-4} are considered unacceptable. However, for nonradionuclide contaminants, MTCA human health risk assessment procedures (WAC 173-340-708[5], "Human Health Risk Assessment Procedures") state that cancer risks resulting from multiple hazardous substances should not exceed 1×10^{-5} for unrestricted land use (MTCA Method B). Additionally, equations 720-1 and 720-2 in WAC 173-340-720, "Groundwater Cleanup Standards" (standard Method B groundwater cleanup levels), establish a hazard quotient of 1 for individual noncarcinogens and an acceptable cancer risk level of 1×10^{-6} for individual carcinogens, respectively.

For noncancer hazards for both the EPA and the MTCA human health risk assessment procedures (WAC 173-340-708[5]), the acceptable target ***hazard index*** is 1. A hazard index above 1 is considered unacceptable risk. The hazard index may exceed 1 even if all of the individual hazard quotients are less than 1. In this case, the chemicals may be segregated by similar mechanisms of toxicity and toxicological effects. Separate hazard index values may then be derived based on mechanism and effect.

Contaminant Fate and Transport Modeling

Fate and transport modeling was performed to simulate and predict the movement of contaminants in soil and groundwater. This modeling is described in the 100-D/H RI/FS report (Chapter 5 and Appendix F of DOE/RL-2010-95). Contaminant transport in soil was modeled to determine residual concentrations protective of groundwater and surface water. The results of the modeling were used in the evaluation of human health and ecological risk. In addition, contaminant transport in groundwater was modeled to predict time frames to achieve cleanup for the purpose of comparing the alternatives.

Human Health Soil Risk

Waste sites that have not been remediated were evaluated based on process history, sample data (when available), and analogous experience from sites already interim remediated. These waste sites were determined to pose an unacceptable risk to HHE from direct exposure and some are potential sources for groundwater contamination, thus providing the basis for remedial action.

The interim remediated waste sites in the 100-D/H source OUs with closeout verification data as of November 2012 from the shallow vadose zone (from 0 to 4.6 m [0 to 15 ft] bgs) were evaluated in the risk assessment presented in the 100-D/H RI/FS report (Chapter 6 of DOE/RL-2010-95). Six of these waste sites had risks above residential-based risk thresholds for radionuclides in the shallow zone. The radionuclide contamination in five of these waste sites will decay to below the risk threshold (1×10^{-4}) by 2038. One site (118-DR-2:2) exceeds the risk-based screening level for technetium-99, which has a half-life of 212,000 years and does not decay within a reasonable time frame. Table 2 lists soil COCs for 100-D/H.

Table 2. 100-D/H COCs

Soil Radionuclides	Soil Nonradionuclides		Groundwater Radionuclides	Groundwater Nonradionuclides
Carbon-14	Antimony	Aroclor 1016	Strontium-90	Total chromium
Cesium-137	Arsenic	Aroclor 1221		Hexavalent chromium
Cobalt-60	Barium	Aroclor 1232		Nitrate
Europium-152	Cadmium	Aroclor 1242		
Europium-154	Total chromium	Aroclor 1248		
Nickel-63	Hexavalent chromium	Aroclor 1254		
Strontium-90	Copper	Aroclor 1260		
Technetium-99	Lead	Benzo(a)pyrene		
	Mercury	Benzo(b)fluoranthene		
	Nickel	Benzo(k)fluoranthene		
	Silver	Chrysene		
	Zinc	Dibenz(a,h)anthracene		
		Indeno(1,2,3 cd)pyrene		
		Pyrene		

Thirty-two waste sites in the 100-DR-1, 100-DR-2, and 100-HR-1 OUs contain residual radionuclide contamination at depths deeper than 4.6 m (15 ft) bgs and present a potential risk from inadvertent exposure through deep excavation activities. A risk assessment using a residential exposure scenario for radionuclides was used to identify where unacceptable exposure could occur if the contamination was brought to the surface. These waste sites report an ELCR greater than 1×10^{-4} for the deep vadose zone contamination. Radionuclides associated with historical waste disposal contribute a majority of the ELCR and include cesium-137, cobalt-60, europium-152, europium-154, nickel-63, and strontium-90. These waste sites require action to prevent exposure through deep excavation activities to levels that pose unacceptable risk.

Groundwater Risks

Groundwater was evaluated as a potential drinking water source by comparing the exposure point concentrations for each contaminant against the federal and state DWSs and the Washington State groundwater cleanup levels. The groundwater risk assessment the 100-D/H RI/FS report (Chapter 6 of DOE/RL-2010-95) included an evaluation of data collected from 52 monitoring wells completed within the 100-HR-3 OU. The 100-HR-3 OU contains contamination in the groundwater that originated from the 100-DR-1, 100-DR-2, 100-HR-1, and 100-HR-2 OUs. For the purpose of the risk assessment, the 100-HR-3 OU was divided into three groundwater areas (referred to in the RI/FS as groundwater exposure areas): the 100-D exposure area (centered on the D and DR Reactors), 100-H exposure area (centered on the H Reactor), and the Horn exposure area (the area between the 100-D and 100-H Areas). The groundwater within the 100-HR-3 OU contains total chromium at concentrations greater than the federal DWS of 100 μg/L, nitrate at concentrations greater than the federal DWS of 10,000 μg/L,[5] and strontium-90 at concentrations above the federal DWS of 8 pCi/L.

Contaminant concentrations in the groundwater were also compared to surface water standards for protection of aquatic organisms because of groundwater discharges to the Columbia River. This comparison included the use of state surface water quality standards for fresh water and federal ambient water quality criteria. The groundwater within the 100-HR-3 OU contains Cr(VI) concentrations greater than the state surface water quality standard of 10 μg/L (WAC 173-201A, "Water Quality Standards for Surface Waters of the State of Washington").

Based on the results of the groundwater risk evaluation, concentrations of nitrate, total chromium, and strontium-90 are present at levels that exceed DWSs and are identified as COCs. Cr(VI) is present at levels that exceed the state surface water quality standard (WAC 173-201A) and 48 μg/L human health risk-based concentration (WAC 173-340-720, "Groundwater Cleanup Standards") in groundwater in the upland areas and is also identified as a COC.

Waste sites where interim remedial actions were performed prior to November 2012 were also evaluated as potential sources for groundwater and surface water contamination, as identified in the 100-D/H RI/FS report (DOE/RL-2010-95). Evaluation of these waste sites did not show residual contaminant concentrations that pose an unacceptable risk to groundwater or the Columbia River. Any remaining risk to groundwater from waste sites remediated after November 2012 will be addressed by the RTD remedy.

Ecological Risks at Upland Areas

The RCBRA (DOE/RL-2007-21, Volume I) and the 100-D/H RI/FS report (Chapter 7 of DOE/RL-2010-95) evaluated verification sampling data (collected following interim remediation at 100-D/H waste sites with upland habitat) for potential ecological risks. The ecological risk evaluations identified that interim remedial actions that have achieved interim action ROD cleanup levels to protect human health will also protect ecological receptors, particularly when the size of remedial actions is considered relative to ecological receptor home ranges. Once human health cleanup levels are achieved, residual contamination would not be sufficient to adversely impact populations and communities of ecological receptors. The 100-D/H RI/FS used information from the RCBRA and other sources to evaluate the risk to populations and communities of ecological receptors, and it was concluded that there was no ecological risk at remediated waste sites within the 100-DR-1, 100-DR-2, 100-HR-1, or 100-HR-2 OUs.

Ecological Risks at Riparian and Near-Shore Areas

The RCBRA (DOE/RL-2007-21, Volume I) and the CRC (DOE/RL-2010-117, Volume I) evaluated potential ecological risks present in the riparian, near-shore, and river areas in 100-D/H. The 100-D/H RI/FS report (Section 7.5 of DOE/RL-2010-95) used information from these risk assessments and from other sources to evaluate the risk to populations and communities of ecological receptors. The 100-D/H RI/FS evaluated contaminants present in these environments and pathways where Hanford Site operations may have released contaminants to the riparian, near-shore, and river environments. The evaluation included releases or potential releases of radionuclides, metals, and nitrate into the Columbia River from groundwater. The conceptual model depicting the relationships between sources and riparian or near-shore media (soil, sediment, pore water, and surface water) is presented in Chapters 4 and 7 and Appendix L of the 100-D/H RI/FS report. Total chromium and Cr(VI) in groundwater within the riverbed gravels are considered ***contaminants of ecological concern*** to

[5] The EPA maximum contaminant level under the *Safe Drinking Water Act* for nitrate is 10 mg/L or 10 ppm. The 10 mg/L standard expressed as nitrogen (N) is equivalent to 45 mg/L expressed as nitrate.

the 100-D/H near-shore area. No contaminants of ecological concern were identified in the riparian soils above risk thresholds.

Threatened or Endangered Species

The Hanford Reach contains three species listed as threatened or endangered under the federal *Endangered Species Act of 1973*. These include the upper Columbia River spring-run Chinook salmon and steelhead, and the bull trout. The spring-run Chinook salmon do not spawn in the Hanford Reach but use it as a migration corridor. Steelhead spawning has been observed in the Hanford Reach. The bull trout is not considered a resident species and is rarely observed in the Hanford Reach. The 100-HR-3 OU contains four groundwater COCs: Cr(VI), total chromium, nitrate, and strontium-90. The Columbia River rapidly dilutes groundwater contaminants to low concentrations, so the primary concern for ecological risk to aquatic biota is from exposure to pore water. As discussed in the 100-D/H RI/FS report (Chapter 7 and Appendix L of DOE/RL-2010-95), contaminated groundwater from the 100-HR-3 OU will have no effect on these fish species. This conclusion of no effect is because current and predicted concentrations of COCs in groundwater do not exceed toxicity thresholds for steelhead near known spawning areas. Groundwater upwelling occurs during the low-flow seasons that do not overlap with the time frame when early life stages of steelhead are present in river gravels within their established spawning areas (redds).

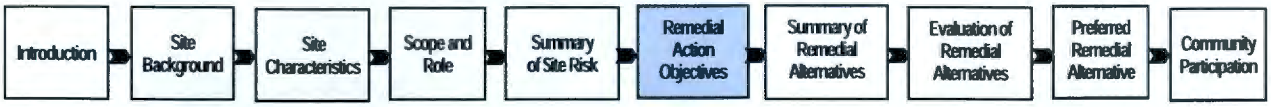
Contaminants of Concern

COCs are radionuclides and chemicals that pose an unacceptable threat to HHE and, therefore, need to be addressed by a remedial action. The soil COCs are evaluated in the 100-D/H RI/FS report (Chapters 5, 6, and 7 of DOE/RL-2010-95). The soil and groundwater COCs are contaminants that exceed an acceptable risk level or a federal or state standard, and these are listed in Table 2. Tables 7, 8, and 9 (at the end of this Proposed Plan) provide the proposed COC cleanup levels. The groundwater COCs for the 100-HR-3 OU are based on an evaluation of groundwater data, which were evaluated in Section 6.3 of the 100-D/H RI/FS report. The groundwater risk evaluation identified four COCs: strontium-90, nitrate, total chromium, and Cr(VI).

Conclusions

The extensive remedial actions implemented under interim action RODs have been successful in achieving risk-based cleanup goals for waste sites, as evaluated in the 100-D/H RI/FS report (DOE/RL-2010-95). Waste sites have been identified where action would be needed to address contamination at depth. Waste sites that have not yet undergone remediation pose an unacceptable risk if no actions are taken. Waste sites that have undergone remediation but have not yet been confirmed to have met cleanup levels protective of HHE may also pose unacceptable risks to HHE. Based on the results of the groundwater risk evaluation, nitrate, strontium-90, total chromium, and Cr(VI) are present in groundwater at levels that pose an unacceptable risk if no actions are taken.

It is the Tri-Parties' judgment that the preferred alternative identified in this Proposed Plan, or one of the other active measures considered in this Proposed Plan, is necessary to protect public health or welfare or the environment from actual or threatened releases of hazardous substances, pollutants, and contaminants into the environment that may present an imminent and substantial endangerment to public health or welfare.



Remedial Action Objectives

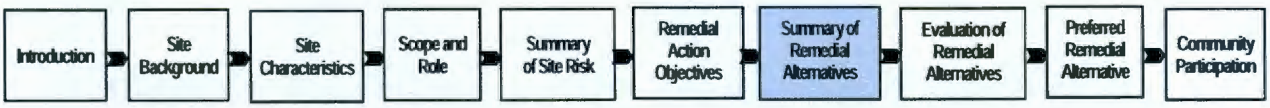
The RAOs describe what a proposed remedial action is expected to accomplish. RAOs generally include information on the media, COCs, potential exposure pathways, and remediation goals. The RAOs for the 100-DR-1, 100-DR-2, 100-HR-1, and 100-HR-2 OUs are RAOs #3 through #6. The RAOs for the 100-HR-3 OU are RAOs #1, #2, and #7. The RAOs are as follows:

- **RAO #1:** Prevent unacceptable risk to human health from ingestion of and incidental exposure to groundwater containing contaminant concentrations above federal and state standards and risk-based thresholds.
- **RAO #2:** Prevent unacceptable risk to human health and ecological receptors from groundwater discharges to surface water containing contaminant concentrations above federal and state standards and risk-based thresholds.
- **RAO #3:** Prevent unacceptable risk from contaminants migrating and/or leaching through soil that will result in groundwater concentrations that exceed standards and risk-based thresholds for protection of surface water and groundwater.
- **RAO #4:** Prevent unacceptable risk to human health and ecological receptors from exposure to the upper 4.6 m (15 ft) of soil, structures, and debris contaminated with nonradiological constituents at concentrations above the unrestricted land-use standards for human health (provided in MTCA Method B [WAC 173-340]) or soil contaminant levels protective of ecological receptors.
- **RAO #5:** Prevent unacceptable risk to human health and ecological receptors from exposure to the upper 4.6 m (15 ft) of soil, structures, and debris contaminated with radiological constituents. For human health and ecological receptors:
  - Prevent exposure to radiological constituents at concentrations at or above a dose rate limit that causes an ELCR threshold of 1×10^{-6} to 1×10^{-4} above background for the residential exposure scenario.
  - Protect ecological receptors based on a dose rate limit of 0.1 rad/day for terrestrial wildlife populations.
- **RAO #6:** Manage direct exposure to contaminated soils deeper than 4.6 m (15 ft) to prevent an unacceptable risk to HHE.
- **RAO #7:** Restore groundwater in 100-HR-3 to proposed cleanup levels, which include DWSs, within a time frame that is reasonable given the particular circumstances of the site.

Preliminary Remediation Goals

PRGs were developed based upon the RAOs and are acceptable protective exposure levels for specific contaminants based on the media (soil or groundwater) and exposure scenario (residential activities). During the FS process, PRGs were used to assess the effectiveness of the remedial alternatives in meeting RAOs and in identifying final cleanup levels. The PRGs are presented in Tables 7, 8, and 9 (provided at the end of this Proposed Plan) and are the cleanup levels to be achieved by all the alternatives, except the No Action alternative. PRGs were calculated for single contaminants.

Soil PRGs for direct contact human receptors are based on the residential scenario and were developed using standard approaches, consistent with state and federal guidance. Direct contact PRGs for nonradionuclides are based upon risk calculations provided in Washington State MTCA procedures (WAC 173-340) using either health hazard thresholds or 1 in 1,000,000 ELCR. Direct contact PRGs for radionuclides were calculated based upon acceptable radionuclide dose (15 mrem/yr) and on ELCR (1 in 10,000 risk). For each radionuclide, the lower of the dose or risk-based calculation is the PRG. The soil PRGs for groundwater and surface water protection are based upon modeling as described in the 100-D/H RI/FS report (Chapter 5 of DOE/RL-2010-95). The model input values included irrigation, in addition to annual precipitation, for transport calculations to identify PRGs that achieve drinking water protection and meet ambient water quality criteria and state surface water quality standards. The PRGs are provided in Table 8-3 in the 100-D/H RI/FS report and Table 8 of this Proposed Plan.



Summary of Remedial Alternatives

Remedial alternatives were developed and are provided in the 100-D/H RI/FS report (Chapter 9 of DOE/RL-2010-95), and the alternatives are based on the results of a technology screening. The alternatives include a range of technology groupings, as detailed in Chapter 8 and Appendix I of the 100-D/H RI/FS report. The technologies were developed to address the 100-DR-1, 100-DR-2, 100-HR-1, 100-HR-2, and 100-HR-3 OUs. Alternative 3 is the preferred alternative. The alternatives evaluated are as follows:

- **Alternative 1:** No Action.
- **Alternative 2:** RTD (104 waste sites), MNA with ICs (5 shallow and 34 deep waste sites), Pipeline Capping with ICs (1 waste site), and No Action (153 waste sites); Pump and Treat, Additional Groundwater Wells, Biological Treatment, and MNA with ICs for groundwater.
- **Alternative 3:** RTD (104 waste sites), MNA with ICs (5 shallow and 34 deep waste sites), Pipeline Capping with ICs (1 waste site), and No Action (153 waste sites); Increased Capacity Pump and Treat, Additional Groundwater Wells, and MNA with ICs for groundwater.
- **Alternative 4:** RTD (108 waste sites), MNA with ICs (2 shallow and 34 deep waste sites), and No Action (153 waste sites); Pump and Treat, Additional Groundwater Wells, and MNA with ICs for groundwater.

Description of Alternatives

This section provides descriptions of the four alternatives, including summaries of common elements that are similar for all of the alternatives. Table 3 identifies the waste site technologies and approaches under Alternatives 2, 3, and 4. The description of common elements is followed with summaries of distinguishing features for Alternatives 2, 3, and 4. These distinguishing features are used in the evaluation of alternatives to conduct a comparative analysis focusing on the relative performance of each alternative.

Table 3. Waste Site Alternatives

Technology/Approach	Alternatives 2 and 3	Alternative 4
No action	**(153 waste sites)**	**(153 waste sites)**
	100-DR-1 OU (77 waste sites): 100-D-1, 100-D-2, 100-D-10, 100-D-20, 100-D-21, 100-D-22, 100-D-24, 100-D-29, 100-D-3, 100-D-31:1, 100-D-31:10, 100-D-31:2, 100-D-31:3, 100-D-31:4, 100-D-31:5, 100-D-31:6, 100-D-31:7, 100-D-31:8, 100-D-31:9, 100-D-32, 100-D-4, 100-D-42, 100-D-45, 100-D-48:4, 100-D-49:3, 100-D-50:10, 100-D-50:3, 100-D-50:5, 100-D-56:1, 100-D-56:2, 100-D-59, 100-D-60, 100-D-61, 100-D-63,[a] 100-D-67, 100-D-7, 100-D-70, 100-D-74, 100-D-75:3, 100-D-80:1, 100-D-82, 100-D-83:4, 100-D-84:1, 100-D-85:1, 100-D-86:2, 100-D-87, 100-D-88, 100-D-9, 100-D-90, 100-D-108, 100-D-109,116-D-10, 116-D-2, 116-D-3, 116-D-4, 116-D-5, 116-D-6, 116-D-9, 116-DR-5, 118-D-6:2, 120-D-2, 126-D-2, 128-D-2, 130-D-1, 132-D-1, 132-D-2, 132-D-3, 132-D-4, 1607-D2:1, 1607-D2:2, 1607-D2:3, 1607-D2:4, 1607-D4, 1607-D5, 628-3, UPR-100-D-1, UPR-100-D-5	**100-DR-1 OU (77 waste sites):** 100-D-1, 100-D-2, 100-D-10, 100-D-20, 100-D-21, 100-D-22, 100-D-24, 100-D-29, 100-D-3, 100-D-31:1, 100-D-31:10, 100-D-31:2, 100-D-31:3, 100-D-31:4, 100-D-31:5, 100-D-31:6, 100-D-31:7, 100-D-31:8, 100-D-31:9, 100-D-32, 100-D-4, 100-D-42, 100-D-45, 100-D-48:4, 100-D-49:3, 100-D-50:10, 100-D-50:3, 100-D-50:5, 100-D-56:1, 100-D-56:2, 100-D-59, 100-D-60, 100-D-61, 100-D-63,[a] 100-D-67, 100-D-7, 100-D-70, 100-D-74, 100-D-75:3, 100-D-80:1, 100-D-82, 100-D-83:4, 100-D-84:1, 100-D-85:1, 100-D-86:2, 100-D-87, 100-D-88, 100-D-9, 100-D-90, 100-D-108, 100-D-109,116-D-10, 116-D-2, 116-D-3, 116-D-4, 116-D-5, 116-D-6, 116-D-9, 116-DR-5, 118-D-6:2, 120-D-2, 126-D-2, 128-D-2, 130-D-1, 132-D-1, 132-D-2, 132-D-3, 132-D-4, 1607-D2:1, 1607-D2:2, 1607-D2:3, 1607-D2:4, 1607-D4, 1607-D5, 628-3, UPR-100-D-1, UPR-100-D-5
	100-DR-2 OU (25 waste sites): 100-D-12, 100-D-13, 100-D-15, 100-D-23, 100-D-28:1, 100-D-43, 100-D-47, 100-D-53, 100-D-54, 100-D-64, 100-D-68, 100-D-94, 116-DR-10, 116-DR-4, 116-DR-7, 116-DR-8, 118-D-1, 118-D-4, 118-D-5, 118-DR-1, 128-D-1, 132-DR-1, 132-DR-2, 1607-D1, 600-30	**100-DR-2 OU (25 waste sites):** 100-D-12, 100-D-13, 100-D-15, 100-D-23, 100-D-28:1, 100-D-43, 100-D-47, 100-D-53, 100-D-54, 100-D-64, 100-D-68, 100-D-94, 116-DR-10, 116-DR-4, 116-DR-7, 116-DR-8, 118-D-1, 118-D-4, 118-D-5, 118-DR-1, 128-D-1, 132-DR-1, 132-DR-2, 1607-D1, 600-30
	100-HR-1 OU (37 waste sites): 100-H-10, 100-H-13, 100-H-17, 100-H-24, 100-H-28:1, 100-H-28:6, 100-H-28:8, 100-H-3, 100-H-30, 100-H-31, 100-H-33, 100-H-34, 100-H-35[a], 100-H-36, 100-H-38, 100-H-4, 100-H-40, 100-H-41, 100-H-45, 100-H-49:2, 100-H-50, 100-H-51:4, 100-H-51:5, 100-H-53, 100-H-7, 100-H-8, 100-H-9, 116-H-2, 116-H-4, 116-H-9, 118-H-6:2, 118-H-6:4, 118-H-6:5, 132-H-1, 1607-H2, 1607-H3, 1607-H4	**100-HR-1 OU (37 waste sites):** 100-H-10, 100-H-13, 100-H-17, 100-H-24, 100-H-28:1, 100-H-28:6, 100-H-28:8, 100-H-3, 100-H-30, 100-H-31, 100-H-33, 100-H-34, 100-H-35[a], 100-H-36, 100-H-38, 100-H-4, 100-H-40, 100-H-41, 100-H-45, 100-H-49:2, 100-H-50, 100-H-51:4, 100-H-51:5, 100-H-53, 100-H-7, 100-H-8, 100-H-9, 116-H-2, 116-H-4, 116-H-9, 118-H-6:2, 118-H-6:4, 118-H-6:5, 132-H-1, 1607-H2, 1607-H3, 1607-H4

Table 3. Waste Site Alternatives

Technology/Approach	Alternatives 2 and 3	Alternative 4
	100-HR-2 OU (14 waste sites): 100-H-2, 100-H-37, 118-H-1:2, 118-H-2, 118-H-3, 118-H-4, 118-H-5, 128-H-1, 128-H-2, 128-H-3, 132-H-2, 1607-H1, 600-151, 600-152	**100-HR-2 OU (14 waste sites):** 100-H-2, 100-H-37, 118-H-1:2, 118-H-2, 118-H-3, 118-H-4, 118-H-5, 128-H-1, 128-H-2, 128-H-3, 132-H-2, 1607-H1, 600-151, 600-152
Removal, treatment, and disposal to cleanup levels[b]	**(104 waste sites)**	**(108 waste sites)**
	100-DR-1 OU (43 waste sites): **100-D-101**, **100-D-102**, **100-D-103**, **100-D-104**, **100-D-105**, **100-D-107**, **100-D-30**, **100-D-31:11**, **100-D-31:12**, **100-D-50:1**, **100-D-50:4**, **100-D-50:6**, **100-D-50:7**, **100-D-50:8**, **100-D-50:9**, 100-D-52, **100-D-65**, **100-D-66**, **100-D-69**, **100-D-71**, **100-D-72**, **100-D-73**, **100-D-75:1**, **100-D-75:2**, **100-D-76**, **100-D-8**, **100-D-80:2**, **100-D-81**, **100-D-83:1**, **100-D-83:2**, **100-D-83:3**, **100-D-83:5**, **100-D-84:2**, **100-D-85:2**, **100-D-86:1**, **100-D-86:3**, **100-D-96:1**, **100-D-96:2**, **100-D-97**, **100-D-98:2**, **100-D-98:3**, **100-D-99**, **1607-D2:5**	**100-DR-1 OU (46 waste sites):** **100-D-101**, **100-D-102**, **100-D-103**, **100-D-104**, **100-D-105**, **100-D-107**, **100-D-30**, **100-D-31:11**, **100-D-31:12**, **100-D-50:1**, **100-D-50:4**, **100-D-50:6**, **100-D-50:7**, **100-D-50:8**, **100-D-50:9**, 100-D-52, , **100-D-65**, **100-D-66**, **100-D-69**, **100-D-71**, **100-D-72**, **100-D-73**, **100-D-75:1**, **100-D-75:2**, **100-D-76**, **100-D-8**, **100-D-80:2**, **100-D-81**, **100-D-83:1**, **100-D-83:2**, **100-D-83:3**, **100-D-83:5**, **100-D-84:2**, **100-D-85:2**, **100-D-86:1**, **100-D-86:3**, **100-D-96:1**, **100-D-96:2**, **100-D-97**, , **100-D-98:2**, **100-D-98:3**, **100-D-99**, **1607-D2:5,** 100-D-50:2, 116-DR-9/100-D-25
	100-DR-2 OU (13 waste sites): **100-D-100**, **100-D-106**, **100-D-14**, **100-D-62**, **100-D-77**, **100-D-78**, **116-DR-3**, **118-D-2:1**, **118-D-2:2**, **118-D-3:1**, **118-D-3:2**, 118-DR-2:2, **126-DR-1**	**100-DR-2 OU (14 waste sites):** **100-D-100**, **100-D-106**, **100-D-14**, **100-D-62**, **100-D-77**, **100-D-78**, **116-DR-3**, **118-D-2:1**, **118-D-2:2**, **118-D-3:1**, **118-D-3:2**, 118-DR-2:2, **126-DR-1,** 116-D-8
	100-HR-1 OU (24 waste sites): **100-H-28:2**, **100-H-28:3**, **100-H-28:4**, **100-H-28:5**, **100-H-28:7**, **100-H-42**, **100-H-43**, **100-H-44**, **100-H-46**, **100-H-48**, **100-H-49:1**, 100-H-5, **100-H-51:1**, **100-H-51:2**, **100-H-51:3**, **100-H-51:6**, **100-H-52**, **100-H-54**, **100-H-56**, **100-H-57**, **100-H-59:1**, **100-H-59:2**, **126-H-2**, **132-H-3**	**100-HR-1 OU (24 waste sites):** **100-H-28:2**, **100-H-28:3**, **100-H-28:4**, **100-H-28:5**, **100-H-28:7**, **100-H-42**, **100-H-43**, **100-H-44**, **100-H-46**, **100-H-48**, **100-H-49:1**, 100-H-5, **100-H-51:1**, **100-H-51:2**, **100-H-51:3**, **100-H-51:6**, **100-H-52**, **100-H-54**, **100-H-56**, **100-H-57**, **100-H-59:1**, **100-H-59:2**, **126-H-2**, **132-H-3**
	100-HR-2 OU (24 waste sites): 100-H-58, **600-380**, **600-381**, **600-382:1**, **600-382:2**, **600-382:3**, **600-382:4**, **600-382:5**, **600-383:1**, **600-383:10**, **600-383:2**, **600-383:3**, **600-383:4**, **600-383:5**, **600-383:6**, **600-383:7**, **600-383:8**, **600-383:9**, **600-384:1**, **600-384:2**, **600-384:3**, **600-384:4**, **600-384:5**, 600-385	**100-HR-2 OU (24 waste sites):** 100-H-58, **600-380**, **600-381**, **600-382:1**, **600-382:2**, **600-382:3**, **600-382:4**, **600-382:5**, **600-383:1**, **600-383:10**, **600-383:2**, **600-383:3**, **600-383:4**, **600-383:5**, **600-383:6**, **600-383:7**, **600-383:8**, **600-383:9**, **600-384:1**, **600-384:2**, **600-384:3**, **600-384:4**, **600-384:5**, 600-385

Table 3. Waste Site Alternatives

Technology/Approach	Alternatives 2 and 3	Alternative 4
Pipeline end-capping, ICs for entry and excavation restrictions (This site is a maternal bat colony.)	**100-DR-1 OU (1 waste site):** 100-D-50:2	**100-DR-1 OU (0 waste sites)**
MNA and ICs (deep zone) Excavation restrictions Waste sites with radiological contamination exceeding human health direct contact cleanup levels at a depth deeper than 4.6 m (15 ft) bgs	**(34 waste sites)**	**(34 waste sites)**
	100-DR-1 OU (21 waste sites): 100-D-5 (2028)[c] 100-D-6 (2028) 100-D-18 (2066) 100-D-19 (2042) 100-D-48:1(2093) 100-D-48:2 (2034) 100-D-48:3 (2028) 100-D-49:1 (2093) 100-D-49:2 (2117) 100-D-49:4 (2027) 116-D-1A (2203) 116-D-1B (2203) 116-D-7 (2125) 116-DR-1 & 2 (2148) 118-D-6:3 (2120) 118-D-6:4 (2143) UPR-100-D-2 (2034) UPR-100-D-3 (2034) UPR-100-D-4 (2093) 116-DR-9/100-D-25 (2064)[d]	**100-DR-1 OU (21 waste sites):** 100-D-5 (2028)[c] 100-D-6 (2028) 100-D-18 (2066) 100-D-19 (2042) 100-D-48:1(2093) 100-D-48:2 (2034) 100-D-48:3 (2028) 100-D-49:1 (2093) 100-D-49:2 (2117) 100-D-49:4 (2027) 116-D-1A (2203) 116-D-1B (2203) 116-D-7 (2125) 116-DR-1 & 2 (2148) 118-D-6:3 (2120) 118-D-6:4 (2143) UPR-100-D-2 (2034) UPR-100-D-3 (2034) UPR-100-D-4 (2093) 116-DR-9/100-D-25 (2064)[d]
	100-DR-2 OU (2 waste sites): 100-D-46 (2203) 116-DR-6 (2048)	**100-DR-2 OU (2 waste sites):** 100-D-46 (2203) 116-DR-6 (2048)
	100-HR-1 OU (11 waste sites): 100-H-1 (2019) 100-H-11 (2108) 100-H-12 (2108) 100-H-14 (2108) 100-H-21 (2019) 100-H-22 (2019) 116-H-1 (2110) 116-H-3 (2056) 116-H-7 (2098) 118-H-6:3 (2108) 118-H-6:6 (2108)	**100-HR-1 OU (11 waste sites):** 100-H-1 (2019) 100-H-11 (2108) 100-H-12 (2108) 100-H-14 (2108) 100-H-21 (2019) 100-H-22 (2019) 116-H-1 (2110) 116-H-3 (2056) 116-H-7 (2098) 118-H-6:3 (2108) 118-H-6:6 (2108)

Table 3. Waste Site Alternatives

Technology/Approach	Alternatives 2 and 3	Alternative 4
MNA and ICs (shallow zone) Residential use and excavation restrictions Waste sites with radiological contamination exceeding human health direct contact cleanup levels at a depth less than 4.6 m (15 ft) bgs	**(5 waste sites)**	**(2 waste sites)**
	100-DR-1 OU (2 waste sites): 116-DR-9/100-D-25 (2038)[d]	**100-DR-1 OU (0 waste sites)**
	100-DR-2 OU (1 waste site): 116-D-8 (2035)	**100-DR-2 OU (0 waste sites)**
	100-HR-1 OU (1 waste site): 116-H-5 (2016)	**100-HR-1 OU (1 waste site):** 116-H-5 (2016)
	100-HR-2 OU (1 waste site): 118-H-1:1 (2016)	**100-HR-2 OU (1 waste site):** 118-H-1:1 (2016)

a. The *Remedial Investigation/Feasibility Study for the 100-DR-1, 100-DR-2, 100-HR-1, 100-HR-2, and 100-HR-3 Operable Units* (DOE/RL-2010-95) evaluated these two sites prior to cleanup verification and recommended RTD for remedial action. These two waste sites were evaluated in April 2013 (100-D-63) and November 2013 (100-H-35) as part of the cleanup verification process. Results from verification sample analysis through the cleanup verification process indicated that no additional action is necessary for these sites.

b. Interim remediation by RTD has been conducted at waste sites shown in **bold** type between December 2012 and the date of the Record of Decision. Contaminant concentrations at these waste sites were compared to proposed final cleanup levels (Tables 7 and 8 at the end of this Proposed Plan). The results of this evaluation (CHPRC-02895, *Evaluation of Remaining Site Verification Packages Approved after Transmittal of the Rev. 0 Remedial Investigation/Feasibility Study for the 100-DR-1, 100-DR-2, 100-HR-1, 100-HR-2, and 100-HR-3 Operable Units, DOE/RL-2010-95*) indicate that contaminant concentrations meet proposed final cleanup levels for 98 of 101 waste sites. All of the interim remediated waste sites with an RTD remedy identified in this table will be evaluated for potential risks through a complete evaluation consistent with the RI/FS for human health direct contact and for groundwater and surface water protection. RTD will be conducted at these sites unless the evaluation determines that additional RTD is unnecessary because contaminant concentrations are less than final cleanup levels, except for shallow zone waste sites 118-D-2:1 and 100-H-54, and deep zone waste site 118-D3:1, which will be subject to MNA and ICs and will decay to levels protective of human health in less than 10 years.

c. Numbers in parentheses are the year that radioactive decay of elements decreases to concentrations less than cleanup levels.

d. These two waste sites (116-DR-9/100-D-25) are in the same location and have shallow and deep zone components, so the sites are addressed together in both the shallow zone and deep zone IC categories. Note that the shallow zone decay date differs from the deep zone date (2038 versus 2064) due to the different radionuclide concentrations in the shallow zone compared to the deep zone.

bgs	=	below ground surface	OU	=	operable unit
IC	=	institutional control	RI/FS	=	remedial investigation/feasibility study
MNA	=	monitored natural attenuation	RTD	=	removal, treatment, and disposal

Alternative 1 – No Action

Consideration of a No Action alternative is a requirement of the NCP (40 CFR 300.430[e][6]) and is included to provide a baseline for comparison against the other alternatives. Under the No Action alternative, no active remedial action is taken to address potential threats to HHE posed by the COCs present in soil and groundwater. All existing actions cease. Remaining waste site contamination above risk-based levels would not be addressed. Without further remedial action, fate and transport model predictions for groundwater indicate that Cr(VI) contamination does not attenuate to concentrations less than the MTCA groundwater cleanup standards (WAC 173-340-720) or the Washington State surface water quality standards (WAC 173-201A) for the modeling period of 75 years. Nitrate contamination attenuates to a concentration less than the DWS within 60 years. Strontium-90 contamination attenuates to a concentration less than the DWS within 63 years.

Common Elements

Common elements associated with Alternatives 2, 3, and 4 include the following.

No Action at 153 Waste Sites. The waste site-specific risk assessment in the RI/FS included a comprehensive review of all available data for each waste site, including field data, radiological surveys, process history, analogous site information, personal interviews, engineering drawings and as-builts, and any other information identified during the development of the RI/FS. Post-interim remediation data, including closeout verification documentation, were included in the risk assessment if the data were available as of November 2012. The 100-D/H RI/FS report (DOE/RL-2010-95) determined that these waste sites had no remaining contaminants at concentrations greater than established standards that define acceptable levels of exposure in soil and those protective of groundwater (Tables 7 and 8 at the end of this Proposed Plan), which are the proposed final cleanup levels. The RI/FS concluded that there is no basis for action at these waste sites.

RTD at 104 Waste Sites. Contaminated soil and debris above cleanup levels are excavated using shallow and deep excavation technology to the upper 4.6 m (15 ft) and as needed to protect groundwater, transported to ERDF, and treated as necessary prior to disposal. For sites with multiple residual contaminants, risks from individual contaminants will be added and evaluated to ensure that the waste site meets total risk limits of 10^{-4} for radionuclides, 10^{-5} for chemicals, or a hazard index of 1, as described in the "Summary of Site Risk" sections of this Proposed Plan. The estimated volume of contaminated material for removal is 133,000 m^3 (174,000 yd^3). The remediated waste sites are backfilled with clean borrow material and recontoured, followed by planting and establishing native vegetation. Additional components of RTD are presented in the 100-D/H RI/FS report (Section 9.2.2.2 of DOE/RL-2010-95). RTD of waste sites is anticipated to be completed within 5 years, with the exception of waste site 100-H-58. The contaminated power poles (waste site 100-H-58) provide electrical power to the HX pump and treat facility and will be remediated after 100-HR-3 groundwater remediation is complete.

Groundwater Pump and Treat. Groundwater contaminated with Cr(VI) is extracted from the aquifer using wells and is transferred to a facility for treatment. The treated water is then either returned to the aquifer through wells or an infiltration gallery or is discharged to surface water. Treatment is specific to Cr(VI) removal and uses an ion-exchange resin. The system capacities and designs are based on contaminant distributions and can be modified during treatment to optimize contaminant capture and removal. The number of wells and treatment system capacity varies for Alternatives 2, 3, and 4, as presented below in the descriptions of the alternatives. A remedial design/remedial action work plan that implements the selected alternative will identify the number of wells, treatment facilities, and treatment capacity to be used. During Cr(VI) pump and treat operations, strontium-90 and nitrate-contaminated groundwater may also be co-extracted with Cr(VI) contaminated groundwater. The effluent from the pump and treat systems is monitored to ensure that Cr(VI), nitrate and strontium-90 injection concentrations remain below DWSs and water quality standards. Alternatives 2, 3, and 4 add wells and use the existing pump and treat systems. The interim remedial action pump and treat systems included approximately 90 wells and two treatment facilities at the end of 2014. The groundwater pump and treat systems developed for Alternatives 2, 3, and 4 in the RI/FS assumed fixed locations and static pumping rates to achieve cleanup standards for Cr(VI) within a defined period, as presented in the 100-D/H RI/FS report (Chapter 5 of DOE/RL-2010-95). Pump and treat system optimization activities in the proposed alternatives incorporate new wells and variable pumping rates to target Cr(VI) removal and hydraulic plume capture to reduce contaminant discharge to the Columbia River. The estimated times until groundwater achieves cleanup requirements following implementation are presented below in the discussion for each alternative.

Groundwater Monitoring. Groundwater contaminant plumes are monitored to measure performance of the pump and treat systems, contaminant attenuation rates, and protectiveness of the remedy. Monitoring results are evaluated to identify if system modifications are needed to improve remedy effectiveness and to identify when the remedy achieves cleanup levels. Monitoring continues until groundwater achieves cleanup requirements.

MNA. MNA relies on natural attenuation processes, which include a variety of physical, chemical, or biological processes that, under favorable conditions, act without human intervention to reduce the mass, TMV, or concentration of contaminants in soil or groundwater. These in situ processes include biodegradation; dispersion; dilution; sorption; volatilization; radioactive decay; and chemical or biological stabilization, transformation, or destruction of contaminants. A description of MNA is presented in the 100-D/H RI/FS report (Section 9.2.2.3 of DOE/RL-2010-95).

Alternatives 2, 3, and 4 include MNA for radionuclides in the waste sites. Waste site natural attenuation occurs through radioactive decay, with the time required to achieve cleanup levels dependent on radionuclide half-lives. The waste sites to be addressed using MNA and ICs, and the year when radioactive decay achieves cleanup levels protective of unlimited use/unrestricted exposure (UU/UE) at each waste site are listed in Table 3.

Alternatives 2, 3, and 4 include MNA for nitrate and strontium-90 in groundwater. Natural attenuation processes, including diffusion and dispersion of nitrate and radioactive decay of strontium-90, will be monitored to confirm natural attenuation. Nitrate and strontium-90 will be co-extracted with the Cr(VI) and will be below cleanup standards upon reinjection. The different operating configurations for the pump and treat systems under Alternatives 2, 3, and 4 also cause variations for the nitrate and strontium-90 cleanup times. The estimated cleanup times are presented below in the discussion for each alternative.

ICs. ICs are nonengineered instruments, such as administrative and/or legal controls to limit uses of land, facilities, and environmental media to prevent unacceptable human health and environmental exposure to contaminants above levels deemed protective. ICs generally include nonengineered restrictions on activities and access to land, groundwater, surface water, waste sites, waste disposal areas, and other areas or media that may contain hazardous substances. Common types of ICs include procedural restrictions for access, warning notices, permits, easements, deed notifications, leases and contracts, and land-use controls, such as controlling excavation in areas where contamination remains at a depth deeper than 4.6 m (15 ft) bgs that exceeds residential direct contact cleanup levels.

Alternatives 2, 3, and 4 require ICs during the period before completion of the remedial action and following remedial action implementation where cleanup levels protective of UU/UE will not be achieved. Exposure to contamination deeper than 4.6 m (15 ft) bgs is not anticipated. Where contamination at depth exceeds the residential use cleanup levels, ICs are required to ensure that future activities do not bring this contamination to the surface or otherwise result in exposure to contaminant concentrations that exceed cleanup levels. Figures 11 and 12 show the 34 deep waste sites (with sampling results as of November 2012) that indicate radiological contamination at depths greater than 4.6 m (15 ft) bgs exceeding the residential use cleanup levels, which would be addressed using MNA and would be subject to ICs under Alternatives 2, 3, and 4. In addition, any waste sites remediated after November 2012, with radiological contamination at depths greater than 4.6 m (15 ft) bgs that exceed the residential use cleanup levels, would be addressed using MNA and would be subject to ICs. Drilling and excavation would be restricted within the IC boundaries shown in Figures 11 and 12 for deep waste sites. ICs will be maintained until cleanup levels are achieved, the concentrations of hazardous substances are at levels to allow for UU/UE, and EPA authorizes the removal of restrictions. Table 3 projects the year when radioactive decay will achieve cleanup levels and ICs can be removed. Alternatives 2, 3, and 4 also include MNA with ICs for the 116-H-5 and 118-H-1:1 shallow zone waste sites. The radiological decay for these two sites is expected to achieve concentrations that are less than human health direct contact cleanup levels in 2016.

For the waste sites remediated as of November 2012 that are subject to MNA with ICs under Alternatives 2, 3, and 4 based on radionuclide contamination, a rough-order-of-magnitude (ROM) cost was calculated for excavation and disposal of contaminated material as an alternative to implementing MNA and ICs. The ROM cost for RTD was $410 million, and RTD of the MNA and IC waste sites was not evaluated further.

ICs for consumptive use of groundwater will remain in place under Alternatives 2, 3, and 4 until the groundwater meets DWSs. DOE will control well drilling through excavation permits and restrict groundwater use in accordance with an approved plan until the groundwater achieves levels protective of UU/UE. Groundwater use is restricted through ICs to limited research purposes and for monitoring and treatment, as approved by EPA or Ecology.

Alternative 2

Estimated capital cost (non-discounted): *$88 million*

Estimated O&M cost (non-discounted): *$343 million*

Estimated total (non-discounted): *$432 million*

Estimated present value (discounted): *$333 million*

Estimated time to achieve waste site cleanup: *25 years*

Estimated time to achieve groundwater cleanup levels: *25 years for Cr(VI) and total chromium, 13 years for nitrate, and 56 years for strontium-90*

Alternative 2 includes the common elements described above and the following distinguishing features.

Alternative 2 (Figure 14) uses MNA with ICs for three waste sites (100-D-25, 116-D-8, and 116-DR-9) with shallow radionuclide contamination (depth less than 4.6 m [15 ft] bgs). Entry restrictions would be implemented at the waste sites with ICs for shallow zone contamination (Figure 12). ICs will be maintained until cleanup levels are achieved, the concentrations of hazardous substances are at levels to allow for UU/UE, and EPA authorizes the removal of restrictions. One pipeline waste site (100-D-50:2) is end-capped with an IC for entry/excavation. The time frames for maintaining ICs until the waste sites with radiological contamination achieve cleanup levels are included in Table 3. The estimated time frame (25 years) for waste site cleanup is based on MNA of the shallow zone radionuclides at waste sites 100-D-25, 116-D-8, and 116-DR-9.

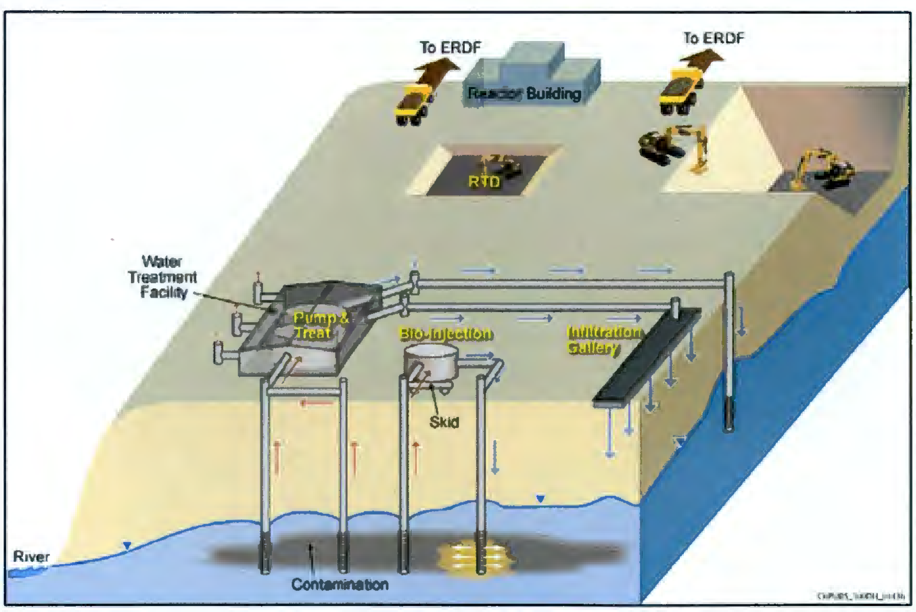


Figure 14. Alternative 2

For Cr(VI) groundwater contamination, Alternative 2 involves installing approximately 30 new wells for ***bioremediation*** technology (biological injection). The biological injection introduces a carbon source (e.g., cheese whey or sodium lactate) that provides a medium for biological growth. The biological growth produces a chemically reducing environment that promotes conversion of Cr(VI) to less toxic and less mobile trivalent chromium. The biological injection system includes a mixing facility and closed-loop ***injection wells*** and ***extraction wells***. This alternative, which uses the existing pump and treat system in combination with biological treatment, is designed to reduce the concentrations of Cr(IV) and total chromium to meet cleanup levels approximately 25 years after implementation. Cleanup of total chromium will be achieved through treatment of Cr(VI). The MNA processes are expected to achieve cleanup standards for nitrate in 13 years and strontium-90 in 56 years.

Alternative 3 – Preferred Alternative

Alternative 3 includes the common elements described above and the following distinguishing features.

Estimated capital cost (non-discounted): *$187 million*

Estimated O&M cost (non-discounted): *$234 million*

Estimated total (non-discounted): *$421 million*

Estimated present value (discounted): *$374 million*

Estimated time to achieve waste site cleanup: *25 years*

Estimated time to achieve groundwater cleanup levels: *12 years for Cr(VI) and total chromium, 6 years for nitrate, and 44 years for strontium-90*

Alternative 3 (Figure 15) uses MNA with ICs for three waste sites (100-D-25, 116-D-8, and 116-DR-9) with shallow radionuclide contamination (depth less than 4.6 m [15 ft] bgs). Entry restrictions would be implemented at the waste sites with ICs for shallow zone contamination (Figure 12). ICs will be maintained until cleanup levels are achieved, the concentrations of hazardous substances are at levels to allow for UU/UE, and EPA authorizes the removal of restrictions. One pipeline waste site (100-D-50:2) is end-capped with an IC for entry/excavation. The time frames for maintaining ICs until the waste sites with radiological contamination achieve cleanup levels are included in Table 6. The estimated time frame (25 years) for waste site cleanup is based on MNA of the shallow zone radionuclides at waste sites 100-D-25, 116-D-8, and 116-DR-9.

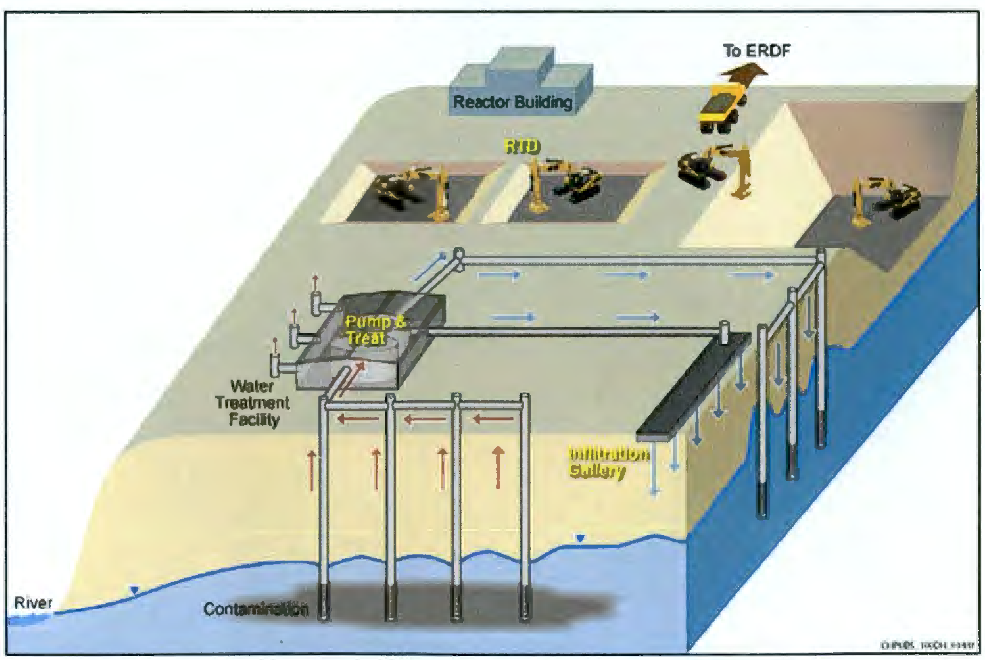


Figure 15. Alternative 3 – Preferred Alternative

For Cr(VI) groundwater contamination, Alternative 3 uses a pump and treat system designed to reduce concentrations of Cr(VI) and total chromium to meet cleanup levels 12 years after implementation. This alternative increases the treatment capacity of the current pump and treat system and adds approximately 80 new wells. Cleanup of total chromium will be achieved through treatment of Cr(VI). The MNA processes are expected to achieve cleanup standards for nitrate in 6 years and strontium-90 in 44 years.

Alternative 4

Estimated capital cost (non-discounted): *$106 million*

Estimated O&M cost (non-discounted): *$510 million*

Estimated total (non-discounted): *$616 million*

Estimated present value (discounted): *$430 million*

Estimated time to achieve waste site cleanup: *5 years*

Estimated time to achieve groundwater cleanup levels: *39 years for Cr(VI) and total chromium, 13 years for nitrate, and 56 years for strontium-90*

Alternative 4 includes the common elements described above and the following distinguishing features.

Alternative 4 (Figure 16) uses RTD for waste sites to remove contaminants that are above applicable cleanup levels, including the pipeline that would be capped under Alternatives 2 and 3 and three shallow zone radionuclide sites (100-D-25, 116-D-8, and 116-DR-9). The estimated volume of removed material is 184,000 m^3 (241,000 yd^3), which is an additional 51,000 m^3 (67,000 yd^3) greater than Alternatives 2 and 3. The estimated time frame (5 years) for waste site cleanup is based on waste site RTD.

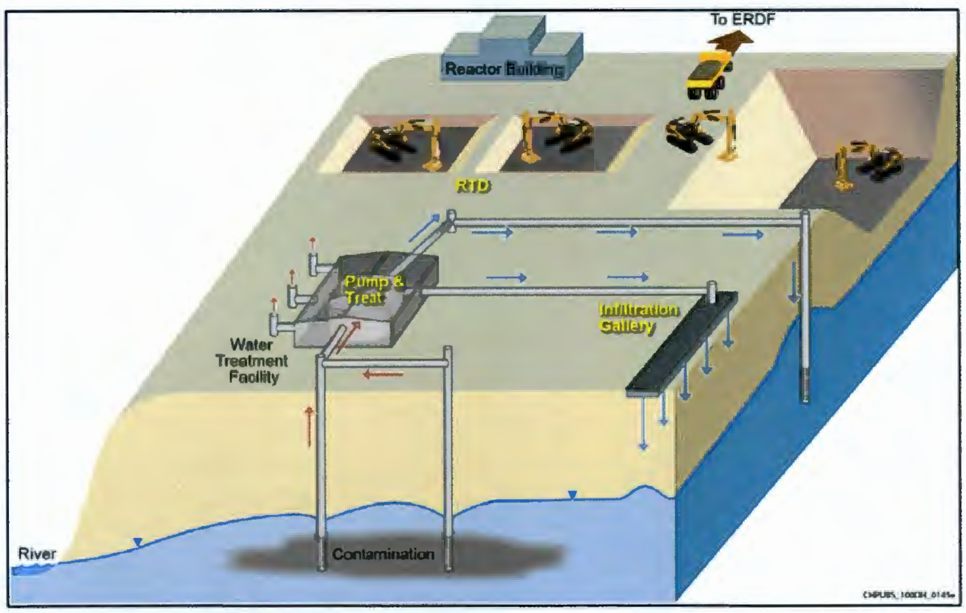
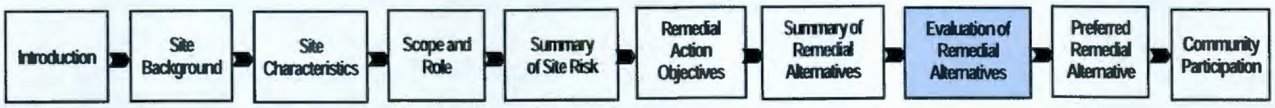


Figure 16. Alternative 4

For Cr(VI) groundwater contamination, Alternative 4 uses a pump and treat system designed to operate to reduce concentrations of Cr(VI) to meet cleanup levels 39 years after implementation. This will be accomplished by modifying the current pump and treat system and adding approximately 30 new wells. Cleanup of total chromium will be achieved through Cr(VI) treatment. The MNA processes are expected to achieve cleanup standards for nitrate in 13 years and strontium-90 in 56 years.



Evaluation of Remedial Alternatives

As part of the FS, DOE evaluated each remedial alternative against the threshold and balancing criteria in the NCP (40 CFR 300.430[e][9]). Following this evaluation, the Tri-Parties performed a comparative analysis to assess the overall performance of each alternative relative to the others. Figure 17 presents the nine CERCLA evaluation criteria. The nine criteria are categorized into three groups: threshold criteria, balancing criteria, and modifying criteria.

A remedial alternative must satisfy the two threshold criteria to be considered a viable alternative: overall protection of HHE, and compliance with ARARs. The five balancing criteria allow for a comparison of major tradeoffs among the alternatives. The modifying criteria, Washington State acceptance and community acceptance, cannot be fully considered until after Tribal Nations and public comments are received on this Proposed Plan. After completion of the formal public comment period, the Tri-Parties will consider the comments received before DOE and EPA issue a ROD. The modifying criteria are important considerations in the final evaluation of the remedial alternatives.

The following sections describe the comparative evaluation of alternatives that was used to identify the preferred alternative presented in this Proposed Plan. A comparative analysis of alternatives is provided in the 100-D/H RI/FS report (Chapter 10 of DOE/RL-2010-95). The alternatives presented in this Proposed Plan have been updated since completion of the RI/FS based on updated information and completion of additional remediation. The comparative evaluation is summarized in Table 4.

Threshold Criteria

Overall Protection of HHE. Alternative 1 (No Action) proposes no remediation of waste sites or contaminated groundwater and no ICs. This alternative is not protective of HHE.

For the waste sites in the 100-DR-1, 100-DR-2, 100-HR-1, and 100-HR-2 OUs and contaminated groundwater in the 100-HR-3 OU, Alternatives 2, 3, and 4 are protective of HHE, will achieve cleanup levels within a reasonable time frame, and meet this threshold criterion. Under Alternatives 2, 3, and 4, ICs will be used to prevent exposures above cleanup levels until those levels are met.

Compliance with ARARs. The ARAR identification process is based on CERCLA, the NCP (40 CFR 300), and guidance. The lead and non-lead agencies must identify requirements applicable or relevant and appropriate to the release or remedial action at a CERCLA site (NCP [40 CFR 300.400(g), "General"]). Alternative 1 (No Action) does not require action and, therefore, ARARs are not implicated. Alternatives 2, 3, and 4 will comply with ARARs. A complete list of identified ARARs is provided in the 100-D/H RI/FS report (Chapter 8 of DOE/RL-2010-95). The key ARARs are those used to establish the cleanup levels as listed in Tables 7, 8, and 9.

Balancing Criteria

Because Alternatives 2, 3, and 4 have a number of common elements, a principal focus of this summary of the balancing criteria assessment is on the differences between the alternatives.

Figure 17. CERCLA Evaluation Criteria

Table 4. Evaluation of Remedial Alternatives

Alternatives	Threshold Criteria		Balancing Criteria				
	Overall Protection of Human Health and the Environment	Compliance with ARARs	Long-Term Effectiveness and Permanence	Reduction in Toxicity, Mobility, or Volume through Treatment	Short-Term Effectiveness	Implementability	Cost (Present Value in $ Millions)*
1 – No Action	No	N/A	N/A	N/A	N/A	N/A	N/A
2 – RTD, MNA with ICs, Pipeline Capping with ICs, and No Action for Waste Sites; and Pump and Treat, Additional Groundwater Wells, Biological Treatment, and MNA with ICs for Groundwater	Yes	Yes	★★☆	★★★	★★☆	★☆☆	Waste sites $66 Groundwater $267 **Total: $333**
3 – RTD, MNA with ICs, Pipeline Capping with ICs, and No Action for Waste Sites; and Increased Capacity Pump and Treat, Additional Groundwater Wells, and MNA with ICs for Groundwater	Yes	Yes	★★☆	★★★	★★★	★★☆	Waste sites $66 Groundwater $308 **Total: $374**
4 – RTD, MNA with ICs, and No Action for Waste Sites; and Pump and Treat, Additional Groundwater Wells, and MNA with ICs for Groundwater	Yes	Yes	★★☆	★★★	★☆☆	★★☆	Waste sites $75 Groundwater $355 **Total: $430**

Note: The comparative evaluation metrics are defined as follows:

★★★ = Expected to perform very well against the criteria with fewer disadvantages or uncertainties.

★★☆ = Expected to perform moderately well with some disadvantages or uncertainties.

★☆☆ = Expected to perform less well with more disadvantages or uncertainty when compared to the other alternatives.

* Detailed cost estimates are presented in Appendix J of *Remedial Investigation/Feasibility Study for the 100-DR-1, 100-DR-2, 100-HR-1, 100-HR-2, and 100-HR-3 Operable Units* (DOE/RL-2010-95). Cost estimates reflect an expected accuracy of +50% to -30%.

ARAR = applicable or relevant and appropriate requirement
IC = institutional control
MNA = monitored natural attenuation
N/A = not applicable
RTD = removal, treatment, and disposal

Long-Term Effectiveness and Permanence. The long-term effectiveness and permanence criterion evaluates the risk remaining at the site after response objectives have been met. The evaluation considers the magnitude of the residual risk, and the adequacy and reliability of controls that may be required to manage treatment residuals or untreated waste.

For the waste sites, Alternatives 2, 3, and 4 each provide very good long-term effectiveness and permanence under RTD because COC-contaminated soil and debris exceeding cleanup levels are removed and transported to the ERDF. One pipeline is capped under Alternatives 2 and 3 and will require long-term controls to be protective, although the reliability of the ICs to be used is high and the residual risk is low. Capping of the pipeline ends is proposed because the pipeline is located in an underground tunnel that is an established maternal bat colony, and RTD would adversely affect the habitat. Three sites use MNA and ICs rather than RTD for remedial action under Alternatives 2 and 3 and will require controls to be protective until cleanup levels are met. Alternatives 2, 3, and 4 use MNA and ICs for 34 deep waste sites with radiological contamination at depths greater than 4.6 m (15 ft) bgs until cleanup levels are met. All three of the alternatives provide good long-term effectiveness and permanence for waste sites (other than the pipeline that will be capped) because the contaminated soil and debris exceeding cleanup levels are either removed to ERDF or are naturally attenuated through radioactive decay. Alternatives 2 and 3 may be rated slightly lower, as the pipeline capping at one waste site will need an IC to maintain protectiveness. The estimated time frames to achieve waste site cleanup are 25 years for Alternatives 2 and 3, and 5 years for Alternative 4.

The alternatives for groundwater treatment are comparable and provide good long-term effectiveness and permanence. The alternatives use a combination of both active treatment and MNA that permanently reduces COC concentrations over different time frames. Table 5 presents the estimated remedial action time frames for groundwater cleanup. At the end of the remedial time frame, the COC concentrations under each of the alternatives will be reduced to levels that are protective of HHE.

Reduction of TMV through Treatment. With RTD, treatment would be conducted to satisfy applicable RCRA LDRs and ERDF treatment requirements. Treatment would not be conducted where those requirements do not apply to the waste. Treatment to satisfy LDRs would result in a reduction of TMV. As a result, RTD provides reduction of TMV through treatment of waste subject to LDRs. Alternatives 2, 3, and 4 are comparable in the reduction of TMV through treatment, as RTD is the primary technology implemented for waste sites for all three alternatives.

Alternatives 2, 3, and 4 treat the same mass of groundwater contaminants. Alternatives 3 and 4 use pump and treat, while Alternative 2 uses pump and treat and biological treatment. Alternatives 2, 3, and 4 were all rated very good for this criterion.

Short-Term Effectiveness. This criterion assesses the time to achieve RAOs and any adverse effects that the remedy may pose to the community, workers, and the environment during the construction and implementation phases of remedial actions.

Alternative 4 achieves the shallow waste site RAOs faster than Alternatives 2 or 3 (5 years as opposed to 25 years) because it uses RTD for the three shallow zone waste sites with radionuclide contamination as opposed to using MNA with ICs. The volume of RTD materials is greater for Alternative 4 than Alternatives 2 and 3, which is anticipated to have potentially higher adverse effects during construction and implementation. However, the short-term adverse effects to workers are mitigated through health and safety programs, and risks to the community are low because of the remote location of the waste sites. Alternatives 2, 3, and 4 use MNA and ICs for 34 deep waste sites with radiological contamination at depths greater than 4.6 m (15 ft) bgs until cleanup levels are met.

Table 5. Comparison of Remedial Action Time Frame Estimates for 100-HR-3 Groundwater Operable Unit

COC	PRG	Alternative 1 – No Action	Alternative 2 – RTD, MNA with ICs, Pipeline Capping with ICs, and No Action for Waste Sites; and Pump and Treat, Additional Groundwater Wells, Biological Treatment, and MNA with ICs for Groundwater	Alternative 3 – RTD, MNA with ICs, Pipeline Capping with ICs, and No Action for Waste Sites; and Increased Capacity Pump and Treat, Additional Groundwater Wells, and MNA with ICs for Groundwater	Alternative 4 – RTD, MNA with ICs, and No Action for Waste Sites; and Pump and Treat, Additional Groundwater Wells, and MNA with ICs for Groundwater
Cr(VI)	10 µg/L*	Not achieved	25 years	12 years	39 years
Cr(VI)	48 µg/L*	Not achieved	11 years	6 years	11 years
Nitrate	45,000 µg/L	60 years	13 years	6 years	13 years
Strontium-90	8 pCi/L	63 years	56 years	44 years	56 years

Notes:

The remedial action time frame estimates are based on modeling as presented in *Remedial Investigation/Feasibility Study for the 100-DR-1, 100-DR-2, 100-HR-1, 100-HR-2, and 100-HR-3 Operable Units* (DOE/RL-2010-95). Total chromium in groundwater is primarily present as Cr(VI), so the remediation time frames are reflective of Cr(VI). Treatment of Cr(VI) groundwater contamination will result in attaining cleanup levels for total chromium in less time than Cr(VI), since the total chromium cleanup levels are greater than the Cr(VI) cleanup levels.

"Not achieved" indicates that COC concentrations in groundwater exceeded the PRG at the end of the 75-year modeling period.

*PRGs for Cr(VI) are 10 µg/L where groundwater discharges to surface water and 48 µg/L in the upland groundwater.

COC = contaminant of concern
Cr(VI) = hexavalent chromium
IC = institutional control
MNA = monitored natural attenuation
PRG = preliminary remediation goal (cleanup levels for groundwater)
RTD = removal, treatment, and disposal

For groundwater, Alternative 3 provides a higher level of short-term effectiveness when compared to Alternatives 2 and 4. Modeling estimates indicate that groundwater cleanup levels will be achieved sooner for all COCs under Alternative 3 compared to Alternatives 2 and 4 (Table 5) because of the increased pump and treat capacity relative to the other alternatives. The short-term adverse effects to workers during well installation and system operations are mitigated through health and safety programs, and risks to the community are low because of the remote location. The increased number of wells for Alternative 3 in comparison to Alternatives 2 and 4 represents an increased environmental effect. For all three of these alternatives, environmental risk and risks to workers are controlled and minimized using engineering measures and personal protective equipment.

Based on the shortest period to achieve groundwater RAOs and the ability to mitigate worker, public, and environmental effects during construction and implementation, Alternative 3 was the highest rated for this criterion. Alternative 2 was rated better than Alternative 4 based on a shorter time to achieve groundwater Cr(VI) cleanup.

Table 6. Waste Sites Included in the Preferred Alternative

Technology/Approach	Waste Sites
No Action	**100-DR-1 OU (77 waste sites):** 100-D-1, 100-D-2, 100-D-10, 100-D-20, 100-D-21, 100-D-22, 100-D-24, 100-D-29, 100-D-3, 100-D-31:1, 100-D-31:10, 100-D-31:2, 100-D-31:3, 100-D-31:4, 100-D-31:5, 100-D-31:6, 100-D-31:7, 100-D-31:8, 100-D-31:9, 100-D-32, 100-D-4, 100-D-42, 100-D-45, 100-D-48:4, 100-D-49:3, 100-D-50:10, 100-D-50:3, 100-D-50:5, 100-D-56:1, 100-D-56:2, 100-D-59, 100-D-60, 100-D-61, 100-D-63,[a] 100-D-67, 100-D-7, 100-D-70, 100-D-74, 100-D-75:3, 100-D-80:1, 100-D-82, 100-D-83:4, 100-D-84:1, 100-D-85:1, 100-D-86:2, 100-D-87, 100-D-88, 100-D-9, 100-D-90, 100-D-108, 100-D-109, 116-D-10, 116-D-2, 116-D-3, 116-D-4, 116-D-5, 116-D-6, 116-D-9, 116-DR-5, 118-D-6:2, 120-D-2, 126-D-2, 128-D-2, 130-D-1, 132-D-1, 132-D-2, 132-D-3, 132-D-4, 1607-D2:1, 1607-D2:2, 1607-D2:3, 1607-D2:4, 1607-D4, 1607-D5, 628-3, UPR-100-D-1, UPR-100-D-5
	100-DR-2 OU (25 waste sites): 100-D-12, 100-D-13, 100-D-15, 100-D-23, 100-D-28:1, 100-D-43, 100-D-47, 100-D-53, 100-D-54, 100-D-64, 100-D-68, 100-D-94, 116-DR-10, 116-DR-4, 116-DR-7, 116-DR-8, 118-D-1, 118-D-4, 118-D-5, 118-DR-1, 128-D-1, 132-DR-1, 132-DR-2, 1607-D1, 600-30
	100-HR-1 OU (37 waste sites): 100-H-10, 100-H-13, 100-H-17, 100-H-24, 100-H-28:1, 100-H-28:6, 100-H-28:8, 100-H-3, 100-H-30, 100-H-31, 100-H-33, 100-H-34, 100-H-35,[a] 100-H-36, 100-H-38, 100-H-4, 100-H-40, 100-H-41, 100-H-45, 100-H-49:2, 100-H-50, 100-H-51:4, 100-H-51:5, 100-H-53, 100-H-7, 100-H-8, 100-H-9, 116-H-2, 116-H-4, 116-H-9, 118-H-6:2, 118-H-6:4, 118-H-6:5, 132-H-1, 1607-H2, 1607-H3, 1607-H4
	100-HR-2 OU (14 waste sites): 100-H-2, 100-H-37, 118-H-1:2, 118-H-2, 118-H-3, 118-H-4, 118-H-5, 128-H-1, 128-H-2, 128-H-3, 132-H-2, 1607-H1, 600-151, 600-152
Removal, treatment, and disposal to cleanup levels[b]	**100-DR-1 OU (43 waste sites):** **100-D-101, 100-D-102, 100-D-103, 100-D-104, 100-D-105, 100-D-107, 100-D-30, 100-D-31:11, 100-D-31:12, 100-D-50:1, 100-D-50:4, 100-D-50:6, 100-D-50:7, 100-D-50:8, 100-D-50:9**, 100-D-52, **100-D-65, 100-D-66, 100-D-69, 100-D-71, 100-D-72, 100-D-73, 100-D-75:1, 100-D-75:2, 100-D-76, 100-D-8, 100-D-80:2, 100-D-81, 100-D-83:1, 100-D-83:2, 100-D-83:3, 100-D-83:5, 100-D-84:2, 100-D-85:2, 100-D-86:1, 100-D-86:3, 100-D-96:1, 100-D-96:2, 100-D-97, 100-D-98:2, 100-D-98:3,**[c] **100-D-99, 1607-D2:5**
	100-DR-2 OU (13 waste sites): **100-D-100, 100-D-106, 100-D-14, 100-D-62, 100-D-77, 100-D-78, 116-DR-3, 118-D-2:1, 118-D-2:2, 118-D-3:1, 118-D-3:2**, 118-DR-2:2, **126-DR-1**
	100-HR-1 OU (24 waste sites): **100-H-28:2, 100-H-28:3, 100-H-28:4, 100-H-28:5, 100-H-28:7, 100-H-42, 100-H-43, 100-H-44, 100-H-46, 100-H-48, 100-H-49:1**, 100-H-5, **100-H-51:1, 100-H-51:2, 100-H-51:3, 100-H-51:6, 100-H-52, 100-H-54, 100-H-56, 100-H-57, 100-H-59:1, 100-H-59:2, 126-H-2, 132-H-3**
	100-HR-2 OU (24 waste sites): 100-H-58, **600-380, 600-381, 600-382:1, 600-382:2, 600-382:3, 600-382:4, 600-382:5, 600-383:1, 600-383:10, 600-383:2, 600-383:3, 600-383:4, 600-383:5, 600-383:6, 600-383:7, 600-383:8, 600-383:9, 600-384:1, 600-384:2, 600-384:3, 600-384:4, 600-384:5**, 600-385

Table 6. Waste Sites Included in the Preferred Alternative

<table>
<tr><th>Technology/Approach</th><th colspan="2">Waste Sites</th></tr>
<tr><td>Pipeline end-capping, ICs for entry and excavation restrictions
(This site is a maternal bat colony.)</td><td colspan="2">100-DR-1 OU (1 waste site):
100-D-50:2</td></tr>
<tr><td rowspan="2">MNA and ICs (deep zone)
Excavation restrictions
Waste sites with radiological contamination exceeding human health direct contact cleanup levels at a depth deeper than 4.6 m (15 ft) bgs</td><td rowspan="2">100-DR-1 OU (21 waste sites):
100-D-5 (2028)[c]
100-D-6 (2028)
100-D-18 (2066)
100-D-19 (2042)
100-D-48:1(2093)
100-D-48:2 (2034)
100-D-48:3 (2028)
100-D-49:1 (2093)
100-D-49:2 (2117)
100-D-49:4 (2027)
116-D-1A (2203)
116-D-1B (2203)
116-D-7 (2125)
116-DR-1 & 2 (2148)
118-D-6:3 (2120)
118-D-6:4 (2143)
UPR-100-D-2 (2034)
UPR-100-D-3 (2034)
UPR-100-D-4 (2093)
116-DR-9/100-D-25 (2064)[d]</td><td>100-DR-2 OU (2 waste sites):
100-D-46 (2203)
116-DR-6 (2048)</td></tr>
<tr><td>100-HR-1 OU (11 waste sites):
100-H-1 (2019)
100-H-11 (2108)
100-H-12 (2108)
100-H-14 (2108)
100-H-21 (2019)
100-H-22 (2019)
116-H-1 (2110)
116-H-3 (2056)
116-H-7 (2098)
118-H-6:3 (2108)
118-H-6:6 (2108)</td></tr>
<tr><td rowspan="2">MNA and ICs (shallow zone)
Residential use and excavation restrictions
Waste sites with radiological contamination exceeding human health direct contact cleanup levels at a depth less than 4.6 m (15 ft) bgs</td><td>100-DR-1 OU (2 waste sites):
116-DR-9/100-D-25 (2038)[d]</td><td>100-DR-2 OU (1 waste site):
116-D-8 (2035)</td></tr>
<tr><td>100-HR-1 OU (1 waste site):
116-H-5 (2016)</td><td>100-HR-2 OU (1 waste site):
118-H-1:1 (2016)</td></tr>
</table>

a. The *Remedial Investigation/Feasibility Study for the 100-DR-1, 100-DR-2, 100-HR-1, 100-HR-2, and 100-HR-3 Operable Units* (DOE/RL-2010-95) evaluated these two sites prior to cleanup verification and recommended RTD for remedial action. These two waste sites were evaluated in April 2013 (100-D-63) and November 2013 (100-H-35) as part of the cleanup verification process. Results from verification sample analysis through the cleanup verification process indicated that no additional action is necessary for these sites.

b. Interim remediation by RTD has been conducted at waste sites shown in **bold** type between December 2012 and the date of the Record of Decision. Contaminant concentrations at these waste sites were compared to proposed final cleanup levels (Tables 7 and 8 at the end of this Proposed Plan). The results of this evaluation (CHPRC-02895, *Evaluation of Remaining Site Verification Packages Approved after Transmittal of the Rev. 0 Remedial Investigation/Feasibility Study for the 100-DR-1, 100-DR-2,*

Table 6. Waste Sites Included in the Preferred Alternative

Technology/Approach	Waste Sites

100-HR-1, 100-HR-2, and 100-HR-3 Operable Units, DOE/RL-2010-95) indicate that contaminant concentrations meet proposed final cleanup levels for 98 of 101 waste sites. All of the interim remediated waste sites with an RTD remedy identified in this table will be evaluated for potential risks through a complete evaluation consistent with the RI/FS for human health direct contact and for groundwater and surface water protection. RTD will be conducted at these sites unless the evaluation determines that additional RTD is unnecessary because contaminant concentrations are less than final cleanup levels, except for shallow zone waste sites 118-D-2:1 and 100-H-54, and deep zone waste site 118-D3:1, which will be subject to MNA and ICs and will decay to levels protective of human health in less than 10 years.

c. The numbers in parentheses are the year that radioactive decay of elements decreases to concentrations less than cleanup levels.

d. These two waste sites (116-DR-9/100-D-25) are in the same location and have shallow and deep zone components, so they are addressed together in both the shallow zone and deep zone IC categories. Note that the shallow zone decay date differs from the deep zone date (2038 versus 2064) because of different radionuclide concentrations in the shallow zone compared to the deep zone.

bgs	=	below ground surface	OU	=	operable unit
IC	=	institutional control	RI/FS	=	remedial investigation/feasibility study
MNA	=	monitored natural attenuation	RTD	=	removal, treatment, and disposal

Implementability. The criterion of implementability is used to compare the technical and administrative feasibility of the remedial alternatives. This includes the ease of implementing the remedy in terms of construction and operation, as well as the availability of services and materials required to implement the alternative.

For waste sites, RTD is a common and proven remedial action used at the Hanford Site that presents minimal technical and administrative difficulties. ICs for waste site remediation have also been used extensively. Alternatives 2, 3, and 4 are all rated very good for waste site implementability.

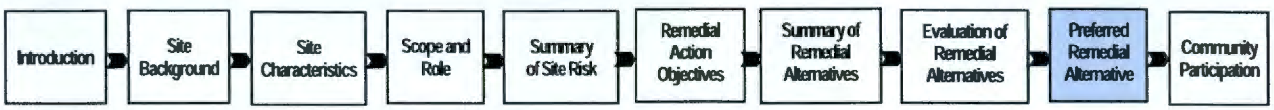
Alternatives 3 and 4 perform better than Alternative 2 under this criterion for groundwater remediation. Both rely on pump and treat for Cr(VI), which is readily implemented and has been previously used at the Hanford Site. Alternative 2 uses bioinjection as a component of the groundwater treatment. Bioinjection has been proven and implemented at other sites, but it may require specialized biological reagents and will require design testing for implementation at the 100-HR-3 OU. Alternatives 2, 3, and 4 each rely on MNA for nitrate and strontium-90 groundwater remediation.

Alternative 4 was rated the lowest for waste site implementability based on the use of RTD rather than MNA for the three shallow zone radiological waste sites and the end-capped pipeline under Alternatives 2 and 3. While RTD is readily implementable, MNA is easier to implement. Installation of additional wells under Alternatives 2 and 3 for groundwater treatment decreases the implementability of these alternatives in comparison to Alternative 4. Alternative 3 is rated higher for implementability than Alternative 2 for groundwater because of the uncertainties associated with biological injection under Alternative 2.

Cost. The costs for the alternatives are lowest for Alternative 2 and highest for Alternative 4. Estimated design, construction, operation and maintenance (O&M), and decommissioning costs were developed for each alternative. The O&M costs were estimated based on the alternative-specific remedial time frames. The total present value costs are $333 million for Alternative 2, $374 million for Alternative 3, and $430 million for Alternative 4. These cost estimates are within the -30 to +50 percent range of accuracy recommended in *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA* (EPA/540/G-89/004).

Modifying Criteria

State and community input received to date have been considered in the development of this Proposed Plan. Modifying criteria will be considered after receiving comments from the Tribal Nations and the public on this Proposed Plan and assessing further any state concerns. In the final balancing of tradeoffs between alternatives upon which the final remedy selection is based, modifying criteria and balancing criteria are both important.



Preferred Remedial Alternative

Alternative 3 (RTD [104 waste sites], MNA with ICs [5 shallow and 34 deep waste sites], Pipeline Capping with ICs [1 waste site], and No Action [153 waste sites]; Increased Capacity Pump and Treat, Additional Groundwater Wells, and MNA with ICs for groundwater) is the preferred alternative. This alternative is recommended because it achieves protection of HHE, satisfies ARARs, and compared to the other alternatives, provides the best balance of tradeoffs under the modifying criteria.

Alternative 3 uses RTD or MNA as necessary to achieve cleanup levels identified in Tables 7 and 8, as delineated by waste site in Table 6. It includes no action for 153 waste sites that already meet cleanup levels in Tables 7 and 8. One pipeline site is proposed to be capped, leaving waste in place with ICs to restrict entry and excavation. RTD is accomplished using standard construction practices for shallow and deep excavation and for secure transport of materials to ERDF, treatment as necessary to meet any LDRs, and disposal of the material at ERDF. Alternative 3 will meet all of the RAOs applicable to wastes sites (RAOs #3, #4, #5, and #6). ICs will be implemented under Alternative 3 and maintained to prevent exposure until waste sites meet UU/UE standards and EPA authorizes the removal of restrictions. The excavation restriction IC for MNA deep and shallow zone waste sites in Table 6 meets RAO #6 to prevent unacceptable risk by managing direct exposure until UU/UE levels are reached through MNA. Table 6 lists all of the waste sites in the 100-DR-1, 100-DR-2, 100-HR-1, and 100-HR-2 OUs and identifies how each would be specifically addressed under the preferred alternative.

Alternative 3 achieves substantial risk reduction for groundwater by using pump and treat and MNA as remedial technologies. These methods provide the mechanisms to restore groundwater to the cleanup levels identified in Table 9 and meet the applicable RAOs for groundwater (RAOs #1, #2, and #7). Implementation includes the installation of wells and facilities for extraction, treatment, injection and monitoring. The pump and treat system will be designed to reduce concentrations of Cr(VI) to meet cleanup levels in 12 years after implementation.

Alternative 3 is readily implementable, provides reduction in TMV through treatment, and was rated the highest for short-term effectiveness based on the time frames to achieve cleanup levels. DOE believes that the preferred alternative meets the threshold criteria and provides the best balance of tradeoffs among the other alternatives with respect to the balancing criteria. DOE expects the preferred alternative to satisfy the following statutory requirements of CERCLA Section 121(b), "Cleanup Standards," "General Rules": (1) be protective of HHE, (2) comply with ARARs (or justify a waiver), (3) be cost effective, (4) use permanent solutions and alternative treatment technologies or resource recovery technologies to the maximum extent practicable, and (5) satisfy the preference for treatment as a principal element.

The preferred alternative could be modified or another alternative selected through consideration of state acceptance and public comment on this Proposed Plan. After public comment, a CERCLA ROD will be issued, which will identify the selected remedy. A responsiveness summary containing agency responses to comments received during the public comment period will be made available with issuance of the ROD.

Community Participation

Public input is a key element in the decision-making process. The Tribal Nations and the public are encouraged to read and provide comments on any of the alternatives presented in this Proposed Plan, including the preferred alternative.

The Administrative Record for this proposed remedial action decision is available for public review on line at http://pdw.hanford.gov/arpir/ and at the repository locations listed to the right.

The comment period for this Proposed Plan extends from July 26 through August 25, 2016. Comments on the preferred alternative, other alternatives, supporting information, or any element of this Proposed Plan will be accepted through August 25, 2016. Comments should be sent to:

Mail: Kris Holmes
U.S. Department of Energy, Richland Operations Office
P.O. Box 550, MSIN A7-75
Richland, WA 99352

Email: 100DHPP@rl.doe.gov

To request a meeting in your area, please contact Kris Holmes no later than August 10, 2016. After the public comment period, the Tri-Parties will consider the comments regarding this Proposed Plan and the information gathered during the comment period.

Hanford Public Information Repository Locations

Administrative Record and Public Information Repository
2440 Stevens Center Place
Room 1101, Richland, WA 99352
Phone: (509) 376-2530
Website: http://pdw.hanford.gov/arpir/

Portland
Portland State University
Branford P. Millar Library
1875 SW Park Avenue
Portland, OR 97201-1151
Phone: (503) 725-4542
Map: http://www.pdx.edu/map.html

Seattle
University of Washington
Suzzallo & Allen Libraries
Government Publications Department
4000 15th Ave NE
Seattle, WA 98195-2900
Phone: (206) 543-4164
Map: http://tinyurl.com/m8ebj

Richland
Washington State University Tri-Cities
Consolidated Information Center
Room 101L, 2770 Crimson Way
Richland, WA 99354
Phone: (509) 372-7443
Map: http://reading-room.labworks.org/Directions.aspx

Spokane
Gonzaga University
Foley Center Library
East 502 Boone Ave.
Spokane, WA 99258
Phone: (509) 313-6110
Map: http://tinyurl.com/2c6bpm

Proposed Cleanup Levels

Table 7. 100-DR-1, 100-DR-2, 100-HR-1, and 100-HR-2 OUs Proposed Direct Contact Soil Cleanup Levels (PRGs) for Protection of Human Health

Contaminant	Hanford Site Background Concentration[a]	Proposed Cleanup Levels (≤4.6 m [15 ft] bgs)	
		PRG	Exposure Driver[b]
Radionuclides (pCi/g)			
Carbon-14	--	8.7	Residential remedial action goal (DOE/RL-96-17)
Cesium-137	1.1	4.4	Direct contact residential scenario (DOE/RL-2010-95)
Cobalt-60	0.0084	1.4	Residential remedial action goal (DOE/RL-96-17)
Europium-152	--	3.3	Residential remedial action goal (DOE/RL-96-17)
Europium-154	0.033	3.0	Residential remedial action goal (DOE/RL-96-17)
Nickel-63	--	608	Direct contact residential scenario (DOE/RL-2010-95)
Strontium-90	0.18	2.3	Direct contact residential scenario (DOE/RL-2010-95)
Technetium-99	--	1.5	Direct contact residential scenario (DOE/RL-2010-95)
Chemicals (mg/kg)			
Antimony	0.13	32	Direct contact, MTCA Method B
Arsenic	6.5	20	WAC 173-340-900, Table 740-1, Method A
Barium	132	16,000	Direct contact, MTCA Method B
Cadmium	0.56	80	Direct contact, MTCA Method B
Total chromium	19	120,000	Direct contact, MTCA Method B
Hexavalent chromium	--	240	Direct contact, MTCA Method B
Copper	22	3,200	Direct contact, MTCA Method B
Lead	10.2	250	WAC 173-340-900, Table 740-1, Method A
Mercury	0.013	24	Direct contact, MTCA Method B
Nickel	19	1,600	Direct contact, MTCA Method B
Silver	0.17	400	Direct contact, MTCA Method B
Zinc	68	24,000	Direct contact, MTCA Method B
Aroclor 1016	--	5.6	Direct contact, MTCA Method B
Aroclor 1221	--	0.19	Inhalation, MTCA Method B
Aroclor 1232	--	0.19	Inhalation, MTCA Method B
Aroclor 1242	--	0.50	Direct contact, MTCA Method B
Aroclor 1248	--	0.50	Direct contact, MTCA Method B
Aroclor 1254	--	0.50	Direct contact, MTCA Method B

Table 7. 100-DR-1, 100-DR-2, 100-HR-1, and 100-HR-2 OUs Proposed Direct Contact Soil Cleanup Levels (PRGs) for Protection of Human Health

Contaminant	Hanford Site Background Concentration[a]	Proposed Cleanup Levels (≤4.6 m [15 ft] bgs)	
		PRG	Exposure Driver[b]
Aroclor 1260	--	0.50	Direct contact, MTCA Method B
Benzo(a)pyrene	--	0.14	Direct contact, MTCA Method B
Benzo(b)fluoranthene	--	1.4	Direct contact, MTCA Method B
Benzo(k)fluoranthene	--	1.4	Direct contact, MTCA Method B
Chrysene	--	14	Direct contact, MTCA Method B
Dibenz(a,h)anthracene	--	1.4	Direct contact, MTCA Method B
Indeno(1,2,3-cd)pyrene	--	1.4	Direct contact, MTCA Method B
Pyrene	--	2,400	Direct contact, MTCA Method B

Sources:

DOE/RL-96-17, *Remedial Design Report/Remedial Action Work Plan for the 100 Area.*

DOE/RL-2010-95, *Remedial Investigation/Feasibility Study for the 100-DR-1, 100-DR-2, 100-HR-1, 100-HR-2, and 100-HR-3 Operable Units.*

WAC 173-340, "Model Toxics Control Act–Cleanup."

WAC 173-340-900, "Model Toxics Control Act–Cleanup," "Tables."

a Hanford Site background values for nonradionuclides are provided in *Hanford Site Background: Part 1, Soil Background for Nonradioactive Analytes* (DOE/RL-92-24), and *Soil Background Data for Interim Use at the Hanford Site* (ECF-HANFORD-11-0038). Hanford Site background values for radionuclides are provided in *Hanford Site Background: Part 2, Soil Background for Radionuclides* (DOE/RL-96-12).

b. MTCA standards/requirements are the current MTCA standards/requirements.

bgs = below ground surface

MTCA = Model Toxics Control Act (WAC 173-340)

PRG = preliminary remediation goal

WAC = *Washington Administrative Code*

Table 8. 100-DR-1, 100-DR-2, 100-HR-1, and 100-HR-2 OUs Proposed Soil Cleanup Levels (PRGs) for Protection of Groundwater and Surface Water

Contaminant	Proposed Groundwater and Surface Water Protection Cleanup Levels (Ground Surface to Water Table)[a]	
	100-D	100-H
	Residential Irrigation	Residential Irrigation
Radionuclides $\left(\frac{pCi}{g}\right)$		
Carbon-14	101	1,110
Cesium-137	—[b]	—[b]
Cobalt-60	—[b]	—[b]
Europium-152	—[b]	—[b]
Europium-154	—[b]	—[b]
Nickel-63	—[b]	>1,000,000
Strontium-90	29,400[c]	157,000[c]
Technetium-99	45	501
Chemicals $\left(\frac{mg}{kg}\right)$		
Antimony	—[b]	5,590
Arsenic[d]	246	20
Barium	389,000	389,000
Cadmium	1.3	15
Total chromium	—[b]	—[b]
Hexavalent chromium	2.0	2.0
Copper	4,030	1,920
Lead	—[b]	—[b]
Mercury	—[b]	17
Nickel	—[b]	150,000
Silver	18	191
Zinc	—[b]	225,000
Aroclor 1016	—[b]	260
Aroclor 1221	0.099	1.0
Aroclor 1232	0.099	1.0
Aroclor 1242	—[b]	77

Table 8. 100-DR-1, 100-DR-2, 100-HR-1, and 100-HR-2 OUs Proposed Soil Cleanup Levels (PRGs) for Protection of Groundwater and Surface Water

Contaminant	Proposed Groundwater and Surface Water Protection Cleanup Levels (Ground Surface to Water Table)[a]	
	100-D	100-H
	Residential Irrigation	Residential Irrigation
Aroclor 1248	—[b]	72
Aroclor 1254	—[b]	591
Aroclor 1260	—[b]	—[b]
Benzo(a)pyrene	—[b]	—[b]
Benzo(b)fluoranthene	—[b]	—[b]
Benzo(k)fluoranthene	—[b]	—[b]
Chrysene	—[b]	—[b]
Dibenz(a,h)anthracene	—[b]	—[b]
Indeno(1,2,3-cd)pyrene	—[b]	—[b]
Pyrene	—[b]	389,000

a. Soil cleanup levels for the protection of groundwater and surface water were calculated based on site-specific data and specific parameters using the Subsurface Transport Over Multiple Phases (STOMP) code (compliant with WAC 173-340-747, "Deriving Soil Concentrations for Groundwater Protection") with a one-dimensional model for all contaminants. The cleanup levels for contaminated soil in the top 4.6 m (15 ft) will be the more protective (whichever is the lowest value) of the human health (Table 7) or groundwater and surface water protection (Table 8). For contaminated soil at depths deeper than 4.6 m (15 ft) bgs, cleanup levels are protective of groundwater and surface water. Table 8-3 in the *Remedial Investigation/Feasibility Study for 100-DR-1, 100-DR-2, 100-HR-1, 100-HR-2, and 100-HR-3 Operable Units* (DOE/RL-2010-95) presents details on the cleanup levels. Soil cleanup levels protective of groundwater and protective of surface water are provided on a unit-length basis. To apply these soil cleanup levels, divide the listed value by a representative length across the waste site decision unit in the general direction of groundwater flow to obtain the cleanup value for evaluation use. (Note that this scaling is not applicable to soil cleanup levels for arsenic and Cr(VI), the cleanup levels for these two analytes are in units of mg/kg.)

b. The cleanup level for groundwater and surface water protection is not identified because model predictions indicate that there is no breakthrough of the analyte within 1,000 years; therefore, the analyte will not impact groundwater or surface water at levels that pose a risk. For total chromium, two different types of chromium are evaluated in the RI/FS: Cr(VI), which is soluble and mobile; and total chromium, being represented by the insoluble and immobile trivalent chromium. Trivalent chromium is not expected to impact groundwater. At some locations where Cr(VI) is distributed across the entire vadose zone, total chromium found collocated with Cr(VI) is determined to be protective of groundwater with the removal of Cr(VI) to meet soil PRGs. The Cr(VI) PRG is provided separately from total chromium.

c. Strontium-90 cleanup levels were calculated based on a model that assumes a distribution across the entire vadose zone. This is because of data indicating that strontium-90 was distributed throughout the vadose zone at some locations in these operable units.

d. This value is not scaled by the representative waste site decision unit dimension in the general direction of groundwater flow.

bgs = below ground surface
Cr(VI) = hexavalent chromium
PRG = preliminary remediation goal
RI/FS = remedial investigation/feasibility study
WAC = *Washington Administrative Code*

Table 9. Proposed Cleanup Levels for 100-HR-3 OU Groundwater for All Alternatives (other than No Action)

COC	Units	Proposed Cleanup Level	Basis for Cleanup Level
Hexavalent chromium[a]	µg/L	10/48	WAC 173-201A/WAC 173-340-720
Total chromium[b]	µg/L	65/100	40 CFR 131/DWS
Nitrate[c]	µg/L	45,000	DWS
Strontium-90	pCi/L	8	DWS

Sources:

DWS from 40 CFR 141, "National Primary Drinking Water Regulations."

40 CFR 131, "Water Quality Standards."

WAC 173-201A, "Water Quality Standards for Surface Waters of the State of Washington."

WAC 173-340-720, "Model Toxics Control Act–Cleanup," "Groundwater Cleanup Standards."

a. Cleanup levels for hexavalent chromium are 10 µg/L where groundwater discharges to surface water and 48 µg/L in the upland groundwater.

b. Cleanup levels for total chromium are 65 µg/L where groundwater discharges to surface water and 100 µg/L in the upland groundwater.

c. Nitrate may be expressed as nitrate-nitrogen (NO_3-N) or as nitrate (NO_3). The DWSs for NO_3-N and NO_3 are 10,000 and 45,000 µg/L, respectively.

CFR = *Code of Federal Regulations*

COC = contaminant of concern

DWS = drinking water standard

WAC = *Washington Administrative Code*

Acronym List

ARAR	applicable or relevant and appropriate requirement
bgs	below ground surface
CERCLA	*Comprehensive Environmental Response, Compensation, and Liability Act of 1980*, as amended
CFR	*Code of Federal Regulations*
COC	contaminant of concern
COPC	contaminant of potential concern
CRC	Columbia River Component
Cr(VI)	hexavalent chromium
DOE	U.S. Department of Energy
DWS	drinking water standard
Ecology	Washington State Department of Ecology
ELCR	excess lifetime cancer risk
EPA	U.S. Environmental Protection Agency
ERDF	Environmental Restoration Disposal Facility
ESD	explanation of significant differences
FS	feasibility study
HHE	human health and the environment
HRNM	Hanford Reach National Monument
IC	institutional control
LDR	land disposal restriction
LFI	limited field investigation
MNA	monitored natural attenuation
MTCA	*Model Toxics Control Act—Cleanup* (WAC 173-340)
N/A	not applicable
NCP	National Contingency Plan ("National Oil and Hazardous Substances Pollution Contingency Plan" [40 CFR 300])
NEPA	*National Environmental Policy Act of 1969*
O&M	operation and maintenance
OU	operable unit
PRG	preliminary remediation goal
RAO	remedial action objective

RCBRA	River Corridor Baseline Risk Assessment
RCRA	*Resource Conservation and Recovery Act of 1976*
RI	remedial investigation
ROD	Record of Decision
ROM	rough-order-of-magnitude
RTD	removal, treatment, and disposal
RUM	Ringold Formation upper mud (unit)
TMV	toxicity, mobility, or volume
Tri-Parties	DOE, EPA, and Ecology
Tri-Party Agreement	*Hanford Federal Facility Agreement and Consent Order* (Ecology et al., 1989a)
UU/UE	unlimited use/unrestricted exposure
USFWS	U.S. Fish and Wildlife Service
WAC	*Washington Administrative Code*

Glossary

Administrative Record: Collection of information (including reports, public comments, and correspondence) that contains the documents that form the basis for selection of a response action. A list of locations where the Administrative Record is available appears in the "Community Participation" section of this Proposed Plan.

Ambient water quality criteria: As defined by EPA, "…the suggested maximum allowable concentration of a chemical in surface water for the protection of aquatic life and human health."

Applicable or relevant and appropriate requirements (ARARs): "Applicable requirements" mean those cleanup standards, standards of control, and other substantive requirements, criteria, or limitations promulgated under federal environmental or state environmental or facility siting laws that specifically address a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance found at a CERCLA site. Only those state standards that are identified by a state in a timely manner and that are more stringent than federal requirements may be applicable. "Relevant and appropriate requirements" mean those cleanup standards, standards of control, and other substantive requirements, criteria, or limitations promulgated under federal environmental or state environmental or facility siting laws that, while not "applicable" to a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance at a CERCLA site, address problems or situations sufficiently similar to those encountered at the CERCLA site that their use is well suited to the particular site. Only those state standards that are identified in a timely manner and are more stringent than federal requirements may be relevant and appropriate.

Attenuation rate: The rate at which concentrations of a contaminant decrease because of natural processes such as radioactive decay, oxidation/reduction, biodegradation, and/or sorption.

Aquitard: A zone within an aquifer that does not yield water easily.

Baseline risk assessment: A study to characterize the current and potential threats to HHE if no remedial action is taken at the site. It is also used to help establish acceptable exposure levels for use in developing remedial alternatives and to determine the need, or basis, for action.

Bioremediation: Treatment that uses naturally occurring organisms to break down hazardous substances into less toxic or nontoxic substances. Bioremediation may occur on its own or may be enhanced through the addition of nutrients, oxygen, etc., that help encourage the growth of the pollution-metabolizing organisms within the medium.

***Code of Federal Regulations* (CFR):** The codification of the general and permanent rules published in the *Federal Register* by the executive departments and agencies of the federal government. It is divided into 50 titles that represent broad areas subject to federal regulation. Each volume of the CFR is updated once each calendar year.

***Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA):** Also known as the Superfund Act, CERCLA is the federal law that establishes a program to identify, evaluate, and remediate sites where hazardous substances, pollutants, or contaminants have been released (e.g., leaked, spilled, or dumped) to the environment or where there is a substantial threat of such a release.

Contaminant of concern (COC): Radionuclides and chemicals that exceed risk threshold values and are addressed by cleanup actions at the site.

Contaminant of ecological concern: A contaminant that has the potential to pose possible ecological risk at a site.

Contaminant of potential concern (COPC): Hazardous substances, pollutants, or contaminants that have been found, or are likely to be present, that could potentially represent risk to HHE. The effects depend upon the amount of the contaminant present, the toxicity of the contaminant, and the way the contaminant is or might be contacted. COPCs are evaluated to develop a list of contaminants that should be considered for remediation and to screen out contaminants that are unlikely to be a threat to HHE.

Drinking water standard (DWS): The maximum allowable concentration of a chemical or radionuclide constituent in drinking water that is protective of human health. The DWSs, described in 40 CFR 141, "National Primary Drinking Water Regulations," are also known as maximum contaminant levels.

Environmental Restoration Disposal Facility (ERDF): The Hanford Site onsite CERCLA-approved facility for the disposal of hazardous (radioactive and nonradioactive) waste and contaminated environmental media in accordance with CERCLA response action decision documents and ERDF waste acceptance criteria.

Excess lifetime cancer risk (ELCR): Potential carcinogenic effects that are characterized by estimating the additional ("excess") probability of cancer incidence in a population of individuals for a specific lifetime from projected contamination intakes (and exposures) and chemical-specific, dose response data (i.e., slope factors).

Explanation of significant differences (ESD): Differences in the remedial action that significantly change but do not fundamentally alter the remedy selected in the ROD with respect to scope, performance, or cost.

Exposure point concentration: An exposure point concentration is the value that represents a conservative estimate of the chemical concentration available from a particular medium (e.g., soil or groundwater) or route of exposure (e.g., ingestion or inhalation).

Extraction well: A well designed to pump groundwater from the aquifer to the surface.

Groundwater: Water in a saturated zone or geologic stratum beneath the land surface or beneath a surface water body.

Hazard index: The sum of more than one hazard quotient for multiple substances and/or multiple exposure pathways. The hazard index is calculated separately for chronic, subchronic, and shorter duration exposures. Potential noncarcinogenic (systemic) effects are characterized by comparing projected intakes of chemicals to toxicity values (i.e., reference doses). The numerical risk or hazard quotient estimates that result are a ratio. The ratio of the intake over the reference dose (hazard index) is compared to unity (1.0). If the quotient is less than 1, then the systemic effects are assumed not to be of concern; if the hazard quotient is greater than 1, then the systemic effects are assumed to be of concern. The hazard index is the sum of hazard quotients. The hazard index is calculated by summing hazard quotients for each chemical across all exposure routes.

Hydraulic gradient: The slope of the water table along a groundwater flow path.

Injection well: A groundwater well designed to inject water into an aquifer.

Institutional control (IC): Nonengineered instruments, such as administrative and legal controls, that help to minimize the potential for exposure to contamination and/or to protect the integrity of a response action.

Interim action: Implemented before final remedy selection designed to address risks to HHE.

Interim safe storage: It consists of ensuring that facility hazardous substances are and will remain safe and secure; and reducing the footprint of the reactor building to the primary shield wall, and sealing all openings such that the facility is in an environmentally safe and secure condition prior to initiation of disposition.

Limited field investigation (LFI): An initial step in characterizing the nature and extent of contamination in the vadose zone, structures, and debris that received liquid effluent discharges.

Model Toxics Control Act (MTCA): MTCA (RCW 70.105D, "Hazardous Waste Cleanup–Model Toxics Control Act") provides Washington State's standards and statutory requirements for addressing releases and threats of releases of hazardous substances into the environment. The standards and requirements established to implement MTCA are published in WAC 173-340.

Monitored natural attenuation (MNA): MNA refers to the reliance on natural attenuation processes (within the context of a carefully controlled and monitored clean-up approach) to achieve site-specific remedial objectives within a time frame that is reasonable compared to other methods. The natural attenuation processes include a variety of physical, chemical, or biological processes that, under favorable conditions, act without human intervention to reduce the mass, TMV, or concentration of contaminants in soil and ground water. These in situ processes include, biodegradation, dispersion, dilution, sorption, volatilization, and chemical or biological stabilization, transformation, or destruction of contaminants.

***National Environmental Policy Act of 1969* (NEPA):** An environmental law that requires federal agencies to integrate environmental values into their decision-making processes by considering the environmental impacts of their proposed actions and reasonable alternatives to those actions. Federal agencies conducting CERCLA actions may rely on the CERCLA process for environmental reviews that are functionally equivalent and are not required to engage in a separate NEPA analysis, such as preparation of environmental assessments and environmental impact statements (40 CFR 1500, "Purpose, Policy, and Mandate"; O'Leary, 1994, "National Environmental Policy Act Policy Statement").

"National Oil and Hazardous Substances Pollution Contingency Plan" (NCP): The NCP (40 CFR 300) provides the organizational structure and procedures for preparing for and responding to discharges of oil and releases of hazardous substances, pollutants, and contaminants.

No action: Sites that can be released for unrestricted land use because they pose no unacceptable risk to HHE. A no action alternative is required to be considered under CERCLA in making a remedial action selection.

Operable unit (OU): A discrete portion of the Hanford Site, as identified in Section 3.3 of the *Hanford Federal Facility Agreement and Consent Order Action Plan* (Ecology et al., 1989b). An OU at the Hanford Site is a group of land disposal sites and/or contaminated groundwater grouped together for the purposes of performing an RI/FS and subsequent cleanup actions. The primary criteria for placement of a site into an OU include geographic proximity, similarity of waste characteristics and site type, and the possibility for economies of scale.

Preferred alternative: The remedial action proposed after an evaluation of a range of viable alternatives. The preferred alternative must be protective of HHE.

Preliminary remediation goal (PRG): PRGs are established during the FS, are based on readily available information, such as chemical specific ARARs or other reliable information and are modified as more information becomes available during the RI/FS.

Principal threat waste: are those source material considered to be highly toxic or highly mobile that generally cannot be reliably contained or would present a significant risk to human health or the environment should exposure occur.

Proposed Plan: A document that briefly describes the remedial alternatives analyzed, proposes a preferred remedial action alternative, and summarizes the information relied upon to select the preferred alternative. The Proposed Plan provides the public with an opportunity to comment on the preferred alternative, as well as the other alternatives under consideration.

Pump and treat: The extraction of contaminated groundwater and treatment of contaminants with one or more of an assortment of technologies.

Radionuclide: An unstable atom that emits excess energy (decays) in the form of radioactivity (rays or particles). Depending on the type and amount of decay, exposure may be harmful.

Record of Decision (ROD): The CERCLA document used to select the method of remedial action to be implemented at a site after the FS/Proposed Plan process has been completed.

Remedial action objective (RAO): Specifies contaminants and media of concern, potential exposure pathways, and remediation goals.

Remedial investigation/feasibility study (RI/FS): The RI is a process to determine the nature and extent of the problem presented by releases or threats of releases of hazardous substances, and it includes the gathering of sufficient information to determine the necessity for remedial action and to support evaluation of remedial alternatives. The FS is a study to develop and evaluate options for remedial action.

Remedial action: An action performed to reduce potential harm to HHE from radioactive or hazardous substances.

Removal, treatment, and disposal (RTD): A cleanup method where soil and debris are excavated in such a way that no contaminants above the approved remedial action levels or concentration remain. Excavated material is treated (if required for disposal) and sent to an onsite or offsite engineered facility for disposal.

Responsiveness summary: The responsiveness summary is made available with the ROD and contains the significant public comments received on the Proposed Plan and responses.

Tri-Parties: Three agencies composed of the U.S. Department of Energy (DOE), the U.S. Environmental Protection Agency (EPA), and the Washington State Department of Ecology (Ecology).

Tri-Party Agreement: The Tri-Parties signed the *Hanford Federal Facility Agreement and Consent Order* (Tri-Party Agreement) (Ecology et al., 1989a) on May 15, 1989. The general purposes of the agreement are as follows: to ensure that environmental impacts are thoroughly investigated and appropriate response actions taken as necessary to protect HHE; to provide a framework for permitting of treatment, storage, and disposal units; to ensure compliance with RCRA and the *Washington Hazardous Waste Management Act* (RCW 70.105D)for treatment, storage, and disposal units; to establish a procedural framework and schedule for developing, prioritizing, implementing, and monitoring appropriate response actions at the Hanford Site in accordance with CERCLA, the NCP, Superfund guidance and policy, and RCRA guidance and policy; and to facilitate cooperation, exchange of information, and coordinated participation of the parties in such actions.

Vadose zone: The unsaturated soil between the land surface and the groundwater.

Waste sites: Any location that may require action to mitigate a potential human health or environmental impact and includes contaminated or potentially contaminated sites from past operations. Contamination may be contained in environmental media (e.g., soil or groundwater) or in manmade structures or solid waste (e.g., debris).

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