DOE/RL-2011-82
Draft A

Proposed Plan for Remediation of 100-KR-1, 100-KR-2, and 100-KR-4 Operable Units

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

U.S. DEPARTMENT OF ENERGY | Richland Operations Office

P.O. Box 550
Richland, Washington 99352

Approved for Public Release;
Further Dissemination Unlimited

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Proposed Plan for Remediation of the 100-KR-1, 100-KR-2, and 100-KR-4 Operable Units, DOE/RL-2011-82, Draft A

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

Public Comment Period

Month Day to Month Day, Year

Please read this Proposed Plan and review related documents in the Administrative Record.

Please submit your comments on this Proposed Plan by mail or e-mail on or before (Date).

See page X for more information about public participation and contact information.

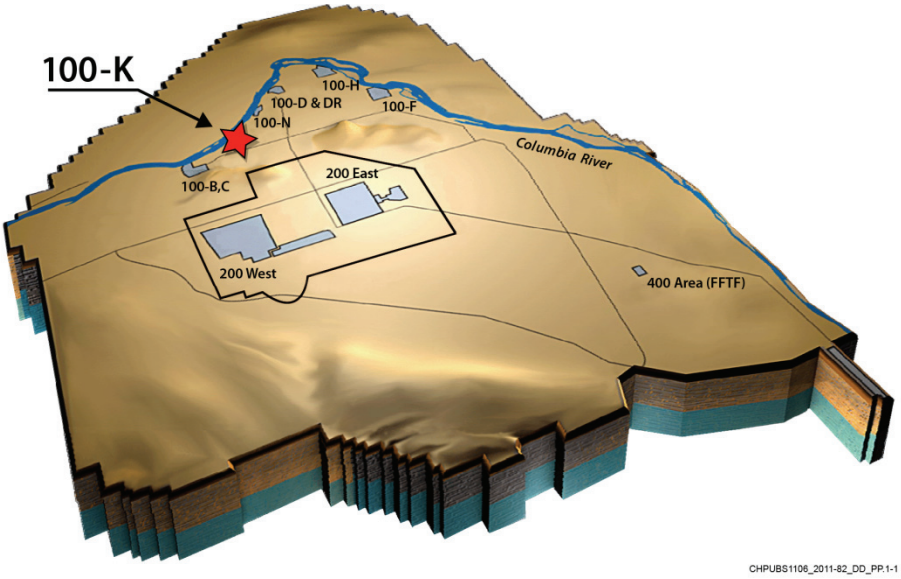

Figure 1. 100-K Location within the Hanford Site River Corridor

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The U.S Department of Energy (DOE) and the U.S Environmental Protection Agency (EPA) invite comments from Tribal Nations and the public on this **Proposed Plan** for cleanup of Hanford Site's 100-K area (Figure 1) along the Columbia River near Richland, Washington. This includes remediation of 100-KR-1 and 100-KR-2 source **Operable Units (OUs)** and 100-KR-4 groundwater OU. This Proposed Plan summarizes the cleanup alternatives considered and recommends a **preferred alternative** for implementation. Bolded text indicates where definitions are provided in the glossary.

Input received from Tribal Nations and the public on the Proposed Plan will help DOE and EPA choose the best way to deal with the contaminated waste sites and groundwater present at 100-K. Written comments can be submitted by e-mail or U.S. mail. Comments will be accepted during the 30-day public comment period. For specific information regarding how to participate, see the *Community Participation section at the end of this Proposed Plan.*

As described in later sections of this Proposed Plan, and in detail in the *100-K Remedial Investigation and Feasibility Study Report* (DOE/RL-2010-97), the following three remedial action alternatives were developed and a detailed and comparative evaluation performed to identify a preferred alternative:

- Alternative 1—No Action. Under this alternative, all current and planned **interim remedial actions (IRAs)** would be terminated and no additional remedial actions would be taken. The **"National Oil and Hazardous Substances Pollution Contingency Plan"** (NCP) requires consideration of a No Action Alternative to compare against other remedial action alternatives.
- Alternative 2—Remove, Treat, and Dispose (RTD) and Groundwater Pump-and-Treat Optimized with Other Technologies. This alternative allows for use of multiple technologies for remediating waste sites and groundwater. The remedial technologies are identified at each waste site, depending on the nature and extent of contamination and the results of a cost effectiveness analysis. They include RTD and in specific instances, soil flushing supplemented with bioinfiltration. Addition of soil flushing supplemented with bioinfiltration has been identified as a contingency for all sites if needed to achieve cleanup levels. Remedial technologies for total petroleum hydrocarbon contaminated sites include RTD, bioventing, and land farming.

  Groundwater remediation optimizes operation of the existing pump-and-treat systems by including bioremediation (biological injection and biological infiltration), with air stripping for locations where carbon-14 exceeds cleanup levels. Existing **institutional controls (ICs)** would be extended and modified as necessary to control 100-K access and groundwater use until cleanup are met.

- Alternative 3—RTD and Expanded Groundwater Treatment. RTD is used for waste site remediation. The existing groundwater pump-and-treat system is expanded with additional extraction and injection wells and a new treatment plant. This alternative also treats carbon-14 with air stripping. Existing ICs would be extended and modified as necessary to control 100-K access and groundwater use until cleanup levels are met.

Based on the results of the detailed and comparative evaluation, the preferred remedial alternative is Alternative 2—RTD and Groundwater Pump-and-Treat Optimized with Other Technologies. This alternative protects human health and the environment while meeting the statutory requirements for cost effectiveness, utilization of permanent solutions, preference for treatment, and compliance with **Applicable or Relevant and Appropriate Requirements (ARARs)**.

The IRAs already underway for soil and groundwater will continue to address contaminated **vadose zone** and groundwater until they are replaced by the selected remedial alternative identified in the 100-K **Record of Decision (ROD)**, the next step in this process. The ROD will include remedy decisions for the 100-KR-4 Groundwater Operable Unit and all waste sites contained in the 100-KR-1 and 100-KR-2 Source Operable Units, including waste sites that have already been remediated under the interim action ROD. Remedy decisions will ensure that cleanup levels have been met for all waste sites in 100-K.

DOE, as the lead agency and the party responsible for conducting the cleanup, is issuing this Proposed Plan per the public participation requirements described under Section 117 (a) of the ***Comprehensive Environmental Response, Compensation, and Liability Act of 1980*** **(CERCLA)**, which is commonly referred to as "Superfund," and Section 300.430(f) (2) and (3) of the **"National Oil and Hazardous Substances Pollution Contingency Plan" (NCP—40 CFR 300)**. CERCLA establishes broad federal authority for the cleanup of Superfund sites, and the NCP defines the requirements and expectations for the cleanup. Figure 2 shows the steps in the CERCLA decision process leading up to a ROD.

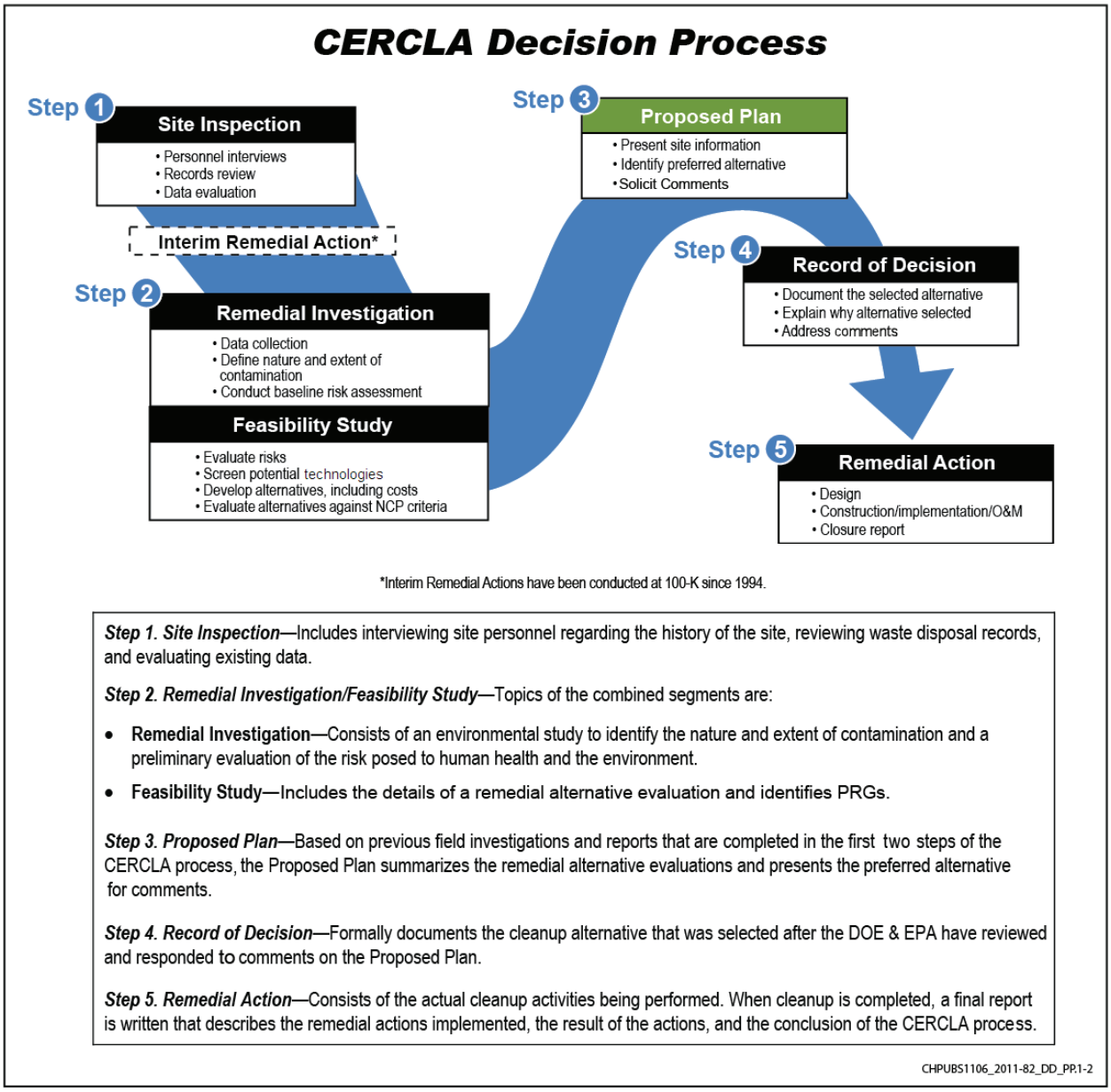


Figure 2. CERCLA Decision Process

This Proposed Plan was prepared in consultation with EPA. Following consultation with Tribal Nations and consideration of public comments, DOE and EPA will issue a ROD identifying the selected alternative for implementation. The Responsiveness Summary section in the ROD will include responses to these comments.

Introduction

The DOE Hanford Site is a 1,517 km^2 (586 mi^2) federal facility located within the semiarid shrub-steppe Pasco Basin of the Columbia Plateau in south-central Washington State. Past nuclear materials production and processing at the Hanford Site released hazardous substances to the environment, resulting in areas of contaminated soil and groundwater that pose a risk to human health and the environment. Cleanup of Hanford Site releases is a complex and challenging undertaking that has been organized into three major

components: River Corridor, Central Plateau, and Tank Waste. The River Corridor spans approximately 570 km^2 (220 mi^2) along the Columbia River (Figure 3).

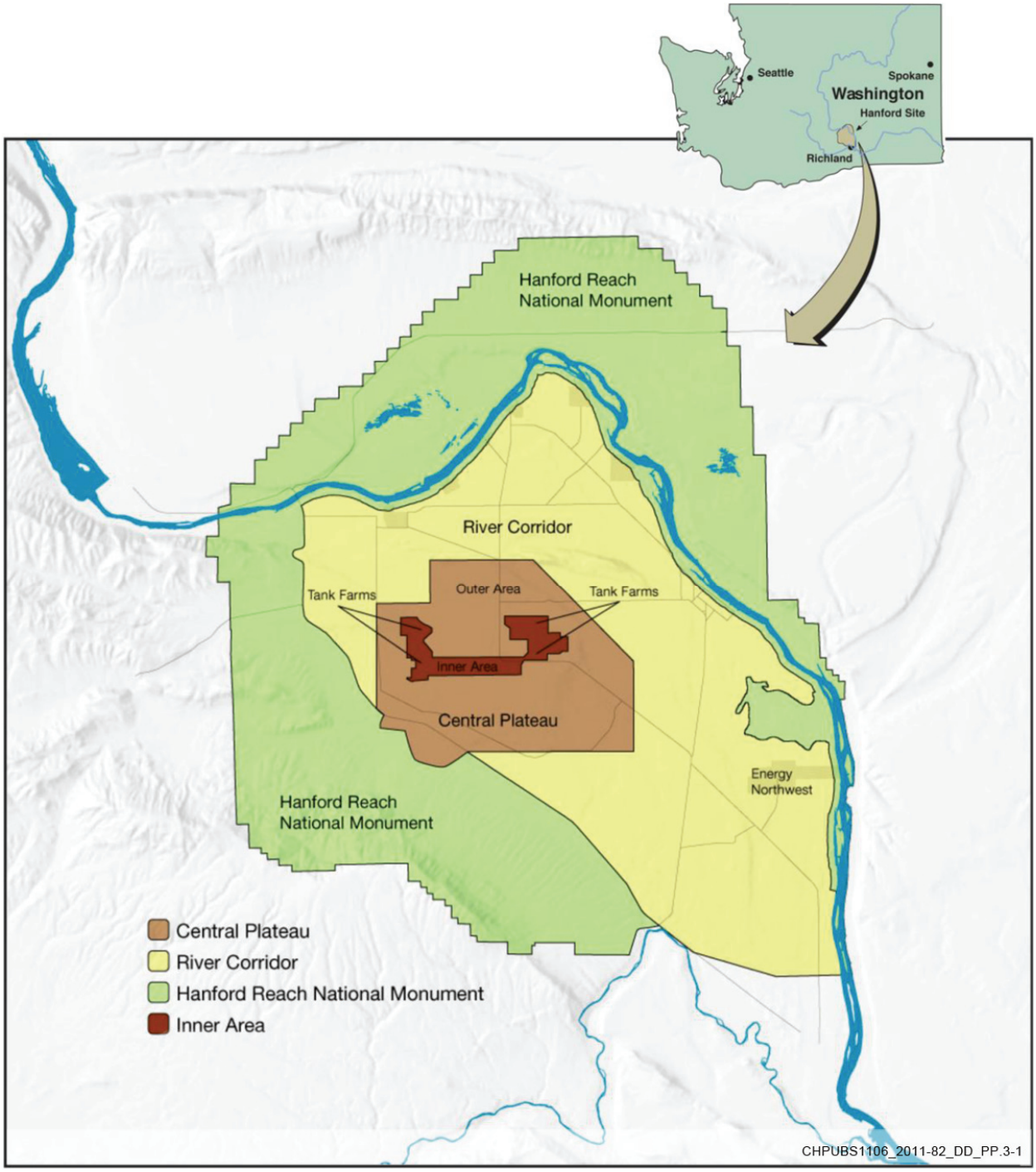


Figure 3. Principal Components of Hanford Site Cleanup Completion Framework

Cleanup of the River Corridor has been a top priority for DOE due to the proximity of hundreds of waste sites to the Columbia River, which is recognized as a critical resource for the people and ecology of the Pacific Northwest. IRAs were initiated in 100-K, and in other OUs within the River Corridor, in 1994 to

focus on removal of contaminated soil and **debris** from waste sites that exhibited the greatest risks to groundwater and the Columbia River. IRAs were also implemented to cleanup existing groundwater contamination with the objective of addressing immediate threats to the Columbia River. IRAs in the River Corridor are not yet complete. To date, approximately 8 million tons of contaminated soil and debris have been removed from nearly 300 waste sites in the River Corridor. In addition, more than 3.4 billion gallons of contaminated groundwater has been processed through pump-and-treat systems. Figure 4 presents a chronology of key 100-K activities and decision documents that have been prepared and implemented since the Hanford Site was added to the **National Priorities List (NPL)** in 1989 and anticipates the ROD.

The **Tri-Parties** established a strategy to develop cleanup decisions for the River Corridor that are protective of human health and the environment. Completing the RI/FS process while the IRAs are underway has provided and will continue to provide information to support decision making for the waste sites and groundwater contamination. The NCP and CERCLA regulations require final cleanup decisions whenever cleanup is initiated under an interim action ROD.

The River Corridor OUs were divided into six geographic areas, as depicted in Figure 5**.** The areas were organized in this manner to define manageable portions of the River Corridor that align with an operational function or historical use (e.g., reactor areas). The OU RODs will establish cleanup levels and any associated actions required to complete the cleanup process for waste sites and groundwater. This Proposed Plan presents 100-K cleanup recommendations and is the first of six Proposed Plans that DOE will issue.

The 100-K area includes two deactivated nuclear reactors (Figure 6) and support facilities that produced plutonium from 1955 to 1971. Reactor operations generated liquid and solid wastes that contained chemicals and **radionuclides**. Onsite waste disposal and processing activities during reactor operations resulted in contamination of vadose zone and groundwater.

The environmental impacts associated with the ultimate disposition of the reactors were evaluated in *Addendum (Final Environmental Impact Statement): Decommissioning of Eight Surplus Production Reactors at the Hanford Site, Richland, Washington* (DOE/EIS-0119F). The Environmental Impact Statement (EIS) ROD ("Record of Decision: Decommissioning of Eight Surplus Production Reactors at the Hanford Site, Richland, Washington," hereinafter called the NEPA ROD [58 FR 48509]), documented the selection of interim safe storage (ISS) for the reactors. ISS includes provision for installing a weather resistant shell to isolate the reactor core until remedial activities are conducted.

The environmental consequences of the reactor one-piece removal and dismantlement documented in the "Amended Record of Decision for the Decommissioning of Eight Surplus Production Reactors at the Hanford Site, Richland, WA" (75 FR 43158), issued on July 23, 2010. The specific reactor path forward will be addressed in a separate CERCLA decision.

Decontamination and decommissioning of inactive facilities has also been implemented under the *Action Memorandum for the Non Time Critical Removal Action for the 105-KE and 105-KW Reactor Facilities Ancillary Facilities*, [EPA, 2007] and *Action Memorandum for the Non Time Critical Removal Action for the 100 K Ancillary Facilities*, [EPA, 2005]. Since its original construction, 100-K has contained 111 facilities, including two reactors, storage buildings, offices, retention basins, maintenance shops, process plants, an electric substation, storage tanks, pump stations, and outfall structures. Until the structures are removed, vadose zone remediation cannot be completed. Therefore, these facilities (including contaminated pipelines associated with them) are undergoing removal to clear the way for IRA and final remedial actions that focus on waste site and the overall vadose zone contamination.

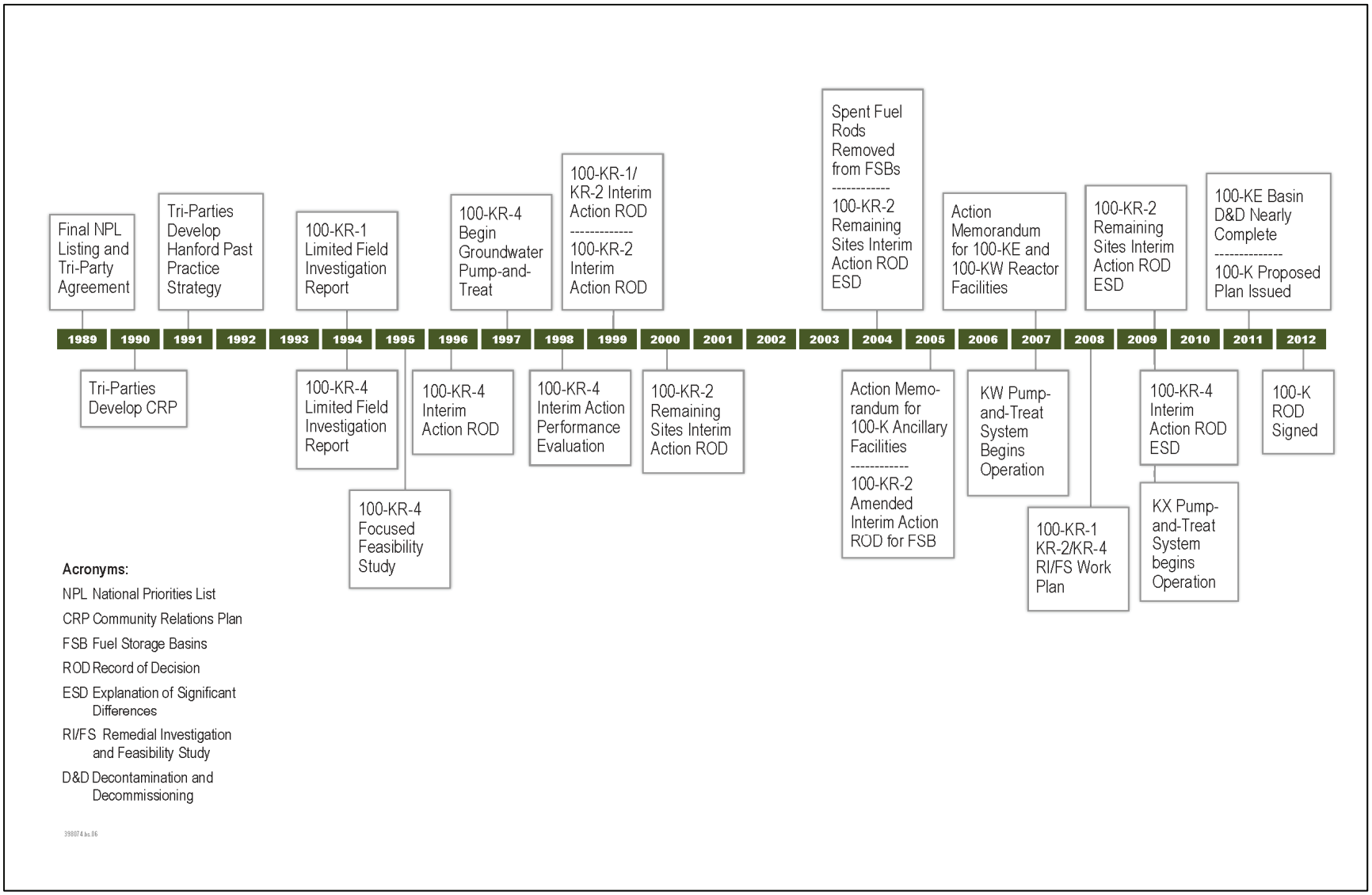


Figure 4. 100-K Timeline

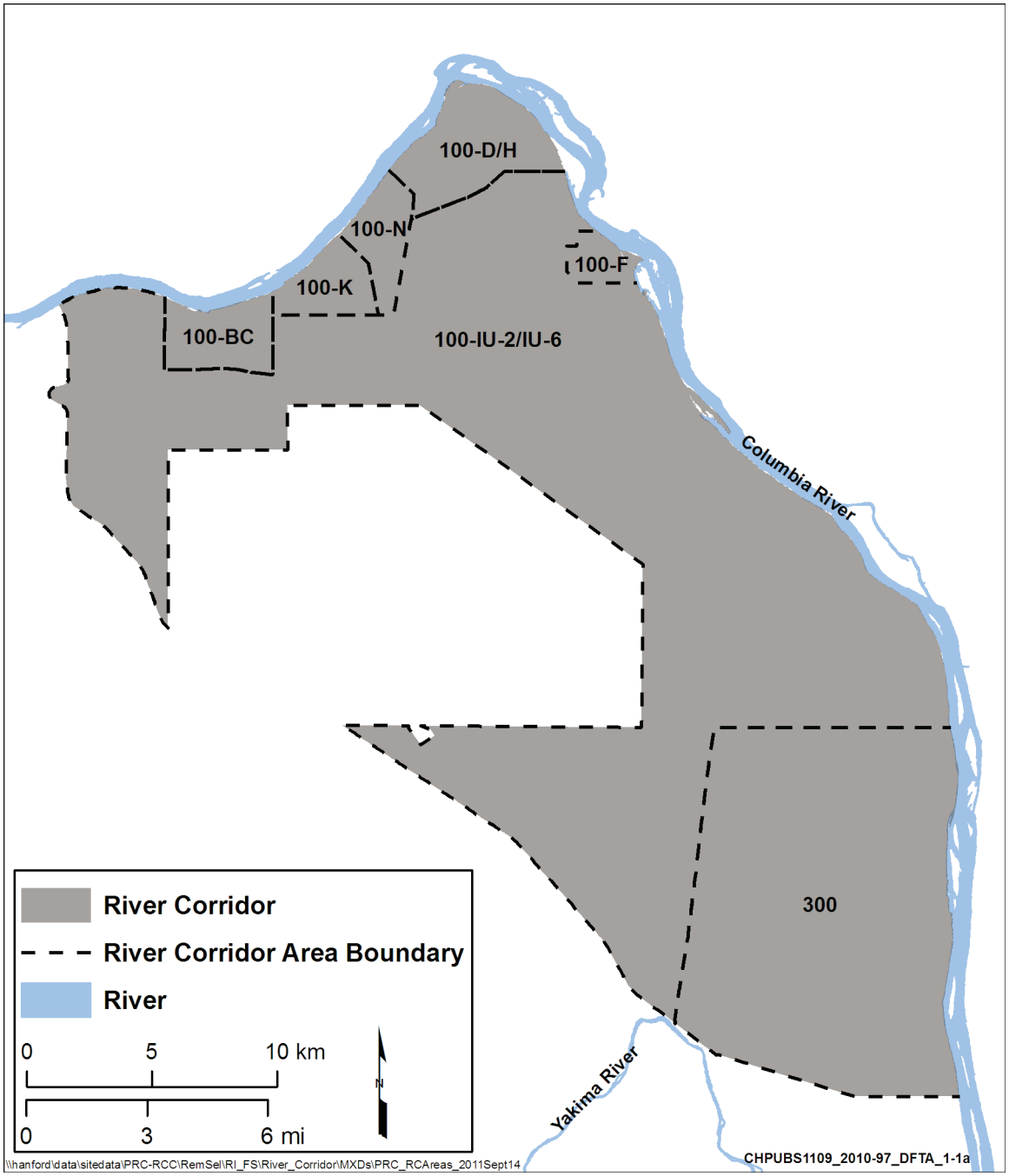
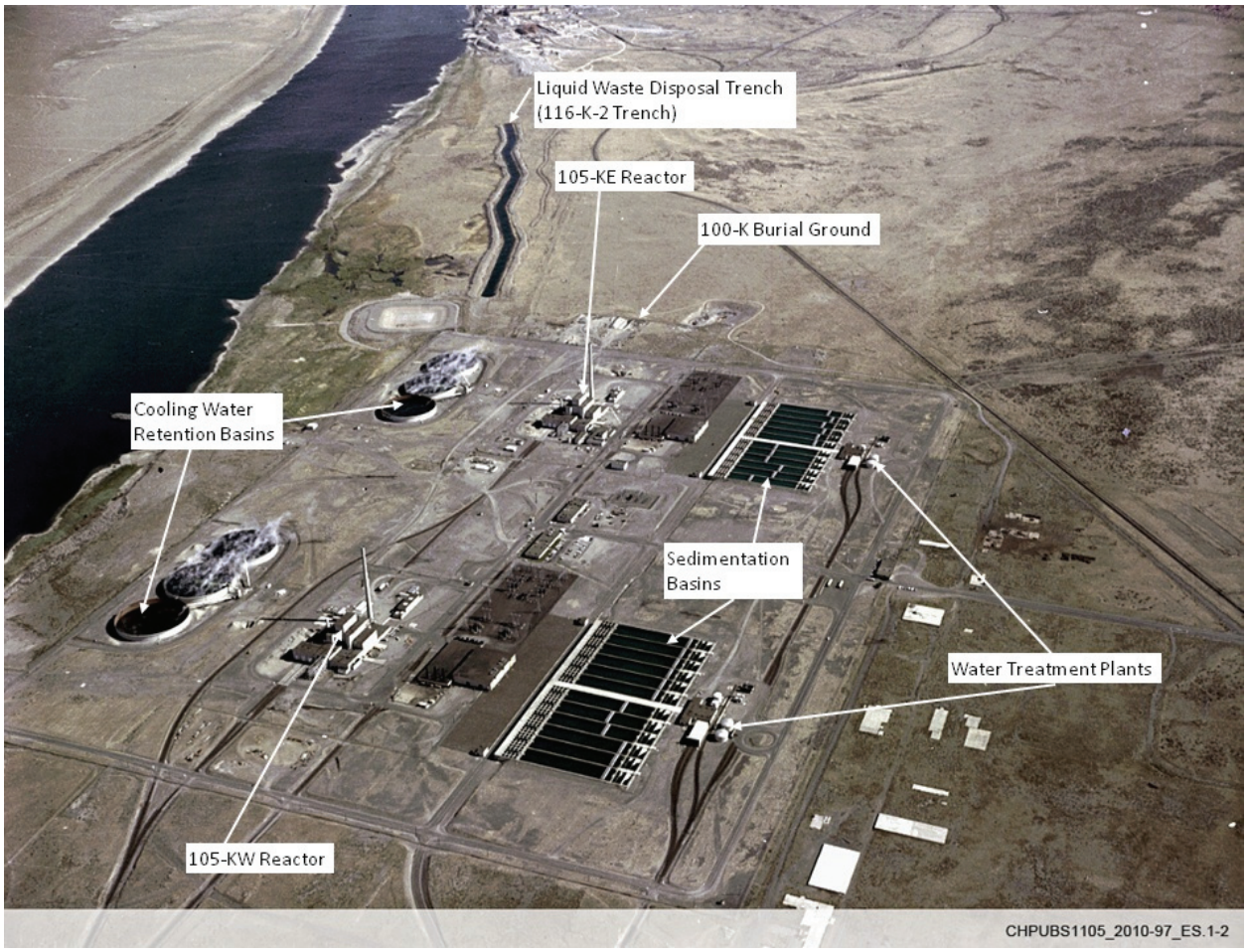


Figure 5. River Corridor Cleanup Decision Areas



Modified from Source: 37465-10CN, 9/11/1964

Figure 6. 100-K East and West Reactor Area

The content and recommendations contained in this Proposed Plan are based on the recently completed **Remedial Investigation and Feasibility Study (RI/FS)** presented in DOE/RL-2010-97, *Remedial Investigation/ Feasibility Study for the 100-KR-1, 100-KR-2, and 100-KR-4 Operable Units*. The RI/FS Report concluded that the IRAs have been successful at addressing many 100-K waste sites with few exceptions. Groundwater IRAs have also been successful in containing a large portion of the hexavalent chromium plume (Figure 7) and limiting hexavalent chromium from entering the river.

Site Background

Information and knowledge about the Hanford Site and specifically 100-K that is important to support remedy selection is provided below with details contained in the RI/FS report (DOE/RL-2010-97).

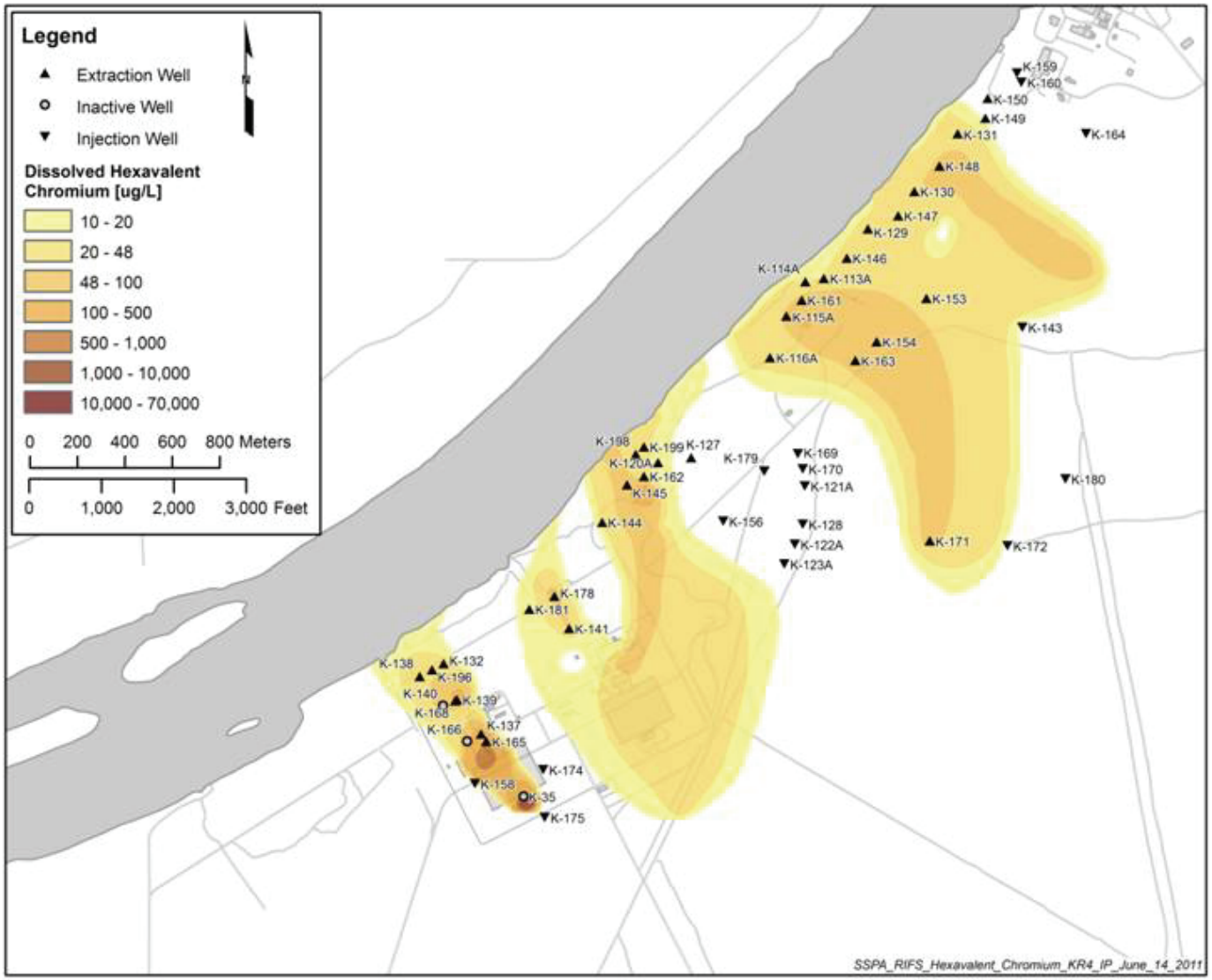


Figure 7. 100-KR-4 Groundwater Hexavalent Chromium Plume Map, 2012 projection

Hanford Site

The Hanford Site encompasses approximately 1,517 km^2 (586 mi^2) in the Columbia Basin in south-central Washington State. The Hanford Site is culturally rich. Historically, Native Americans inhabited the lands both within and around the Hanford Site. Settlers presence in the mid-Columbia region began in 1805 with the arrival of the Lewis and Clark Expedition along the Columbia and Snake Rivers. In the late 19th and early 20th centuries, intensive settlement and farming began on the Hanford Site. Farmstead communities existed from 1880 to 1943, primarily in the uplands adjacent to the Columbia River. The area became one of the premier orchard regions in the state following formation of the Hanford Irrigation and Development Company in 1905.

The farming landscape was abruptly halted in 1943 when the federal government took possession of the land to produce weapons-grade plutonium as a part of the Manhattan Project. The Hanford Site was chosen because of its remoteness, the availability of water from the Columbia River, and access to electricity from hydropower plants at the Bonneville and Grand Coulee Dams. The Hanford Site's plutonium production mission continued throughout the Cold War period until the early 1990s.

In July 1989, EPA placed the Hanford Site 100, 200, 300, and 1100 Areas on the NPL (40 CFR 300, Appendix B). Since being placed on the NPL, the Hanford Site's mission has been refocused to environmental cleanup. The NPL represents the nation's highest ranked hazardous waste sites prioritized based on their known or potential threat to release hazardous substances, pollutants, or contaminants to the environment. The NPL is intended to guide EPA in identifying hazardous waste sites that warrant remediation. The **Tri-Party Agreement** (Ecology et al., 1989), signed in 1989, established agency roles and a schedule for cleanup decisions and actions at the Hanford Site.

100-K Description

100-K (Figure 8) encompasses 9 km^2 (3.5 mi^2) adjacent to the Columbia River in the northern portion of the Hanford Site situated between 100-BC and 100-N (Figure 1). This section of the Columbia River is within the Hanford Reach, an important ecological, cultural, historical, and recreational feature. The Reach extends from the Priest Rapids Dam downstream to the slack waters of Lake Wallula, created by McNary Dam.

Construction of the two reactors began in September 1952 and operation began in 1955. These reactors were the largest single-pass cooling water reactors built at Hanford, with 60 percent more fuel rods than the earlier reactor designs, higher initial and final power ratings, and higher numbers of fuel elements. The reactors also used a larger amount of cooling water and inert cover gases (source of carbon-14) to dissipate reactor heat. Over 568,000 liters per minute (150,000 gallons per minute) of cooling water were used to cool each reactor. This flow rate eventually increased to more than 757,000 liters per minute (200,000 gallons per minute) as the reactor power ratings increased. Of the cooling water used, more than 80 percent was discharged to the retention basins and then to the Columbia River though underwater pipelines. The remainder was discharged to liquid effluent waste sites and in some cases valves and conveyance pipelines leaked to the vadose zone. The 105-KW and 105-KE Reactors were shut down in 1970 and 1971, respectively.

Decontamination, cleaning, condensate, and laboratory solutions were discharged to French drains or to one of the other liquid waste disposal sites, depending on the contaminant concentrations, types, and amounts. The largest high volume liquid waste disposal facility was the 116-K-2 Trench, also known as the Mile Long Trench. Solid wastes were placed in burial grounds (*Estimates of Solid Waste Buried in 100 Area Burial Grounds* [WHC-EP-0087]; *Historical Events—Reactors and Fuels Fabrication* [RL-REA-2247]). Contaminant releases identified at 165 waste sites resulted in several comingled contaminant plumes in groundwater.

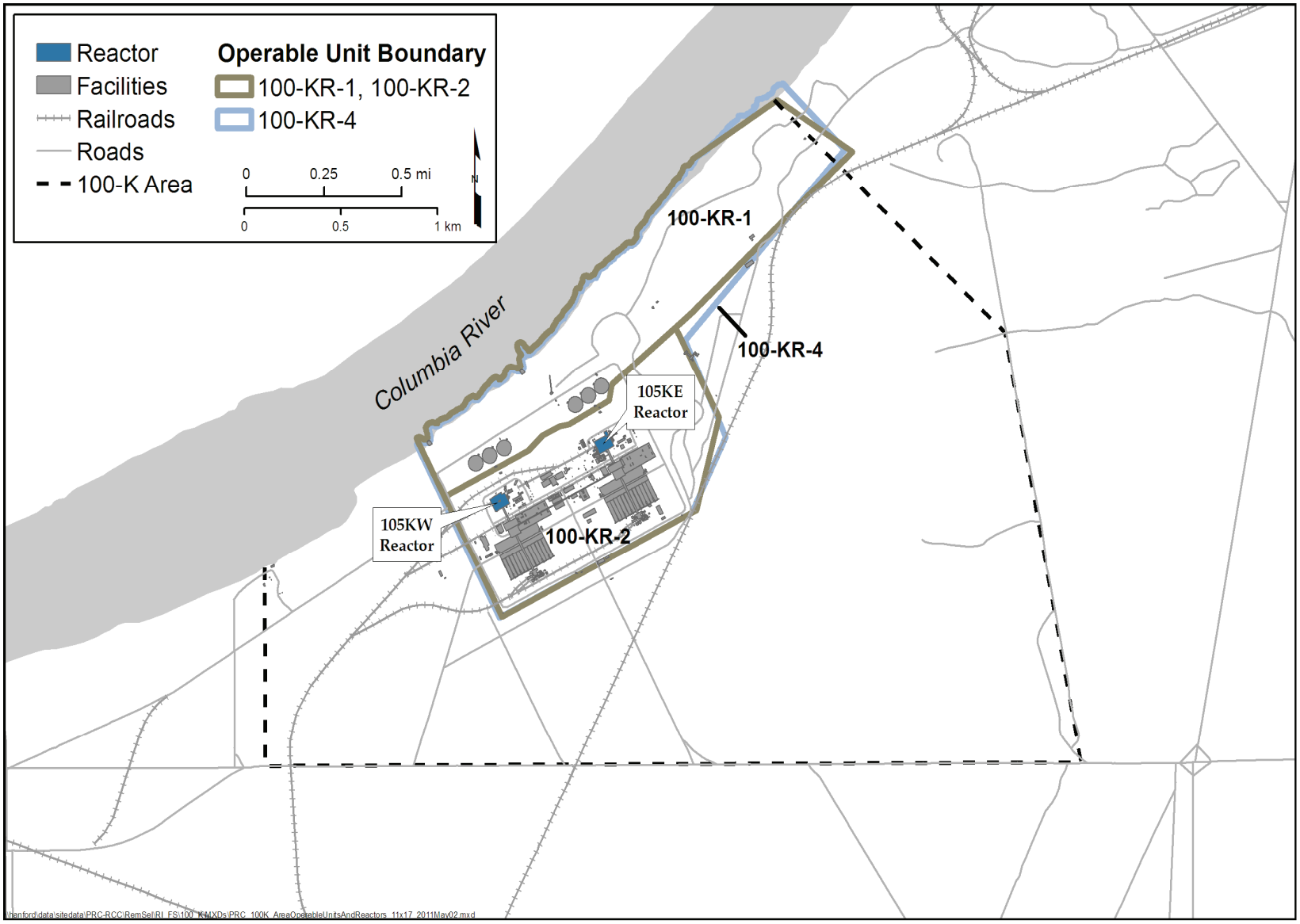


Figure 8. 100-K Boundaries

Most of 100-K consists of land with little or no below ground structures or indication of past or present hazardous constituent(s) releases. This land is referred to as the nonoperational area. There is potential for contaminant transport into the nonoperational areas through five mechanisms that were identified in the RI/FS Report (DOE/RL-2010-97): material disposal, spread by animals, stack emissions, blowing dust or vegetation, and overland flows. Evaluation of these mechanisms during the 100-K RI/FS has increased DOE's confidence that all waste sites have been identified and that residual contamination in the nonoperational area is insignificant and not above concentration causing potential risks to human health and the environment.

After reactor shutdown, decontamination and decommissioning activities began in 1974. Buildings were demolished, surplus equipment was salvaged or redeployed, and active operations were maintained at minimal levels (WHC-EP-0478, *Summary of the Hanford Site Decontamination, Decommissioning, and Cleanup FY1974 through FY1990*). A number of facilities were used to support 105-N Reactor operations, including the 100-KE and 100-KW Fuel Storage Basins. Fuel rods from the 105-N Reactor were stored in both the 100-KE and 100-KW basins, and a water supply system was maintained to provide radiation shielding water and removed by 2004. Little additional demolition occurred between 1990 and 2008. Decontamination and decommissioning of the 105-KE and 105-KW Fuel Storage Basins is ongoing.

What are the contaminants at this site?

The primary 100-K contaminant is hexavalent chromium in groundwater. Other contaminants detected in groundwater that exceed federal **drinking water standards (DWS)**, **Washington State Model Toxic Control Act (MTCA) groundwater cleanup levels (CULs)**, or **Ambient Water Quality Standards (AWQS)** include carbon-14, strontium-90tritium, hexavalent chromium, total chromium, nitrate, and trichloroethene. Contaminants present in the vadose zone include radionuclides, metals, anions, and some organics.

What caused the current contamination at the site?

Reactor operations generated waste streams containing radionuclide and chemical contaminants. The primary contaminant source was the reactor cooling water. Water for reactor cooling was pumped from the Columbia River and treated to remove particulates. Sodium dichromate was added to the cooling water at the water treatment plants to inhibit corrosion in the reactor. A concentrated sodium dichromate solution was brought to the site by railcar where it was transferred to tanks and mixed so that a 2 milligram per liter (mg/L) sodium dichromate concentration was achieved in cooling water. This concentration correlates to 0.7 mg/L hexavalent chromium. During sodium dichromate solution transfer from the railcars to the storage tanks, some fluids were discharged into a nearby French drain, and unintentional spills resulted in high concentrations of hexavalent chromium in the vadose zone and groundwater at these locations.

Cooling water from the reactors was discharged to the retention basins or to the liquid effluent waste sites. Cooling water was transferred through underground pipelines to the retention basins. The basins were used for heat reduction and short-lived radionuclide decay prior to river discharge or diversion to the 116-K-1 Crib or the 116-K-2 Trench. The high temperature cooling water caused thermal stress on the retention basin valves, allowing cooling water to leak from the retention basins to the crib and trench. Releases of cooling water resulted in a widespread groundwater mound centered beneath the crib and head end of the trench.

Chemicals (acids and solvents) used in routine reactor maintenance were ultimately discharged to disposal sites.

What previous investigations have occurred and what were the results?

Initial investigations results are presented in DOE/RL-93-78, *Limited Field Investigation Report for the 100-KR-1 Operable Unit*, and DOE/RL-93-79, *Limited Field Investigation Report for the 100-KR-4 Operable Unit*. These limited field investigations (LFIs) characterized the nature and extent of contamination and determined that hexavalent chromium in groundwater was entering the Columbia River at concentrations considered toxic to aquatic organisms. Based on these findings, IRAs were implemented to remediate waste site sources of contamination and to treat hexavalent chromium contaminated groundwater.

What has been done to remediate the contamination?

Waste site cleanup began in 2002 under the interim action ROD (EPA/ROD/R10-99/039, 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). These interim actions consisted primarily of RTD, followed by backfill and revegetation to protect human health and the environment. Excavated material is transported to the Environmental Restoration and Disposal Facility (ERDF) located in the Hanford Site 200 Area. Between 2002 and the summer of 2011, 16 waste sites were remediated. Over one million tons of soil and debris have been removed from the waste sites. A significant achievement is cleanup of the 116 K-2 Trench in 2006, resulting in a remediated area of 21,521 m^2 (70,610 ft^2). The IRAs will continue until final remedies are selected and implemented.

Groundwater cleanup was initiated in 1997 under the 1996 100-KR-4 interim action ROD with the startup of the first (KR-4) pump-and-treat system. The use of pump-and-treat was expanded under an interim action ROD Explanation of Significant Differences (ESD) to include two additional systems. Three pump-and-treat systems are currently operating (Table 1).

Table 1. Summary of Pump-and-Treat Systems

Pump-and-Treat Systems	Startup	Capacity (gpm)	Volume Pumped through 2010 (million gallons)	Hexavalent Chromium Removed (lbs)
KR-4	1997	300	1,500	782
KX	2009	600	450	185
KW	2007	200	280	303

What previous efforts have been made by the Tri-Parties to involve Tribal Nations and the public in matters related to site cleanup?

The Tribal Nations, the public, and the Hanford Advisory Board (HAB) are routinely informed on the progress of IRAs through regular updates and placement of documents in the **Administrative Record**, including the *Integrated 100 Area Remedial Investigation/Feasibility Study Work Plan* (DOE/RL-2008-46) and the *Integrated 100 Area Remedial Investigation/Feasibility Study Work Plan Addendum 2 100-KR-1, 100-KR-2, and 100-KR-4 Operable Units* (DOE/RL-2008-46-ADD2). Public participation was conducted to support the decision process for the interim RODs. Updates on hexavalent chromium pump-and-treat operations, presented in the annual monitoring and performance reports, represents another example.

The **Community Relations Plan** (Ecology et al., 2002) outlines stakeholder and public involvement processes and opportunities. The HAB advises the Tri-Parties on cleanup issues. HAB input on this Proposed Plan was reviewed to ensure it is responsive to HAB values, principles, and issues. The HAB River and Plateau Committee addresses River Corridor and Central Plateau issues.

Communication and consultation with the Tribal Nations is a priority for DOE and is coordinated through the DOE Richland Operations Office (DOE-RL). Where possible, briefings to Tribal Nations are done through existing forums, such as the monthly Tribal Nations, State of Oregon, and DOE groundwater and vadose zone meetings. DOE-RL works with the Tribal Nations to ensure ongoing communication and involvement in the River Corridor decision-making process.

The Tri-Parties Community Relations Plan serves as the basis for public involvement efforts.

Site Characteristics

The topography is relatively flat inland from the Columbia River. Ground surface elevations range from approximately 166 m (545 ft) above mean sea level (AMSL) near the southern boundary to 119 m (390 ft) along the river. Elevation changes are greatest at the Columbia River bank.

The ground surface near the river is characterized as a large-scale flood bar (Hanford formation) overlain by a thin veneer of windblown sand (Figure 9). The Hanford formation is the uppermost named geologic unit. It was deposited during the Pleistocene epoch by cataclysmic Ice Age floodwaters that drained from glacial Lake Missoula. The reactors, ancillary facilities, and disposal sites were constructed within or over Hanford formation materials. The Ringold Formation underlies the Hanford formation. The Ringold upper mud (RUM) generally represents an aquitard within the 100 Area, but is locally described to include a discontinuous upper transmissive zone (fine sand in otherwise silt to clay unit). Where the Hanford formation thins near the Columbia River shoreline, the Ringold Formation is exposed along the riverbank.

The unconfined aquifer lies within the sedimentary deposits of the Hanford formation and Ringold unit E. The thickness of the unconfined aquifer, which varies considerably, is estimated to range from less than 1 m (3 ft) to approximately 30 m (90 ft). Groundwater generally flows southeast to northwest, essentially perpendicular and toward the Columbia River, at an average rate of 36.5 to 110 m/year (120 to 360 ft/year).

Groundwater flow, especially near the river, is strongly influenced by river stage, which is directly controlled by the upstream Priest Rapids Dam. The rise and fall of the river stages creates a dynamic zone of interaction between groundwater and river water, affecting groundwater flow patterns, contaminant transport rates, contaminant concentrations, and attenuation rates within the system.

What roads, buildings, and land uses are present on the site?

The principal structures include the two reactors, new potable water treatment plant, parts of the water treatment infrastructure, IRA groundwater treatment systems, and multiple support buildings. While most of these structures are planned to be removed, the two reactor buildings, 105-KE and 105-KW, will be placed in ISS for up to 75 years before the final remediation decision is implemented allowing radionuclide activity levels to decrease to levels suitable for final decommissioning.

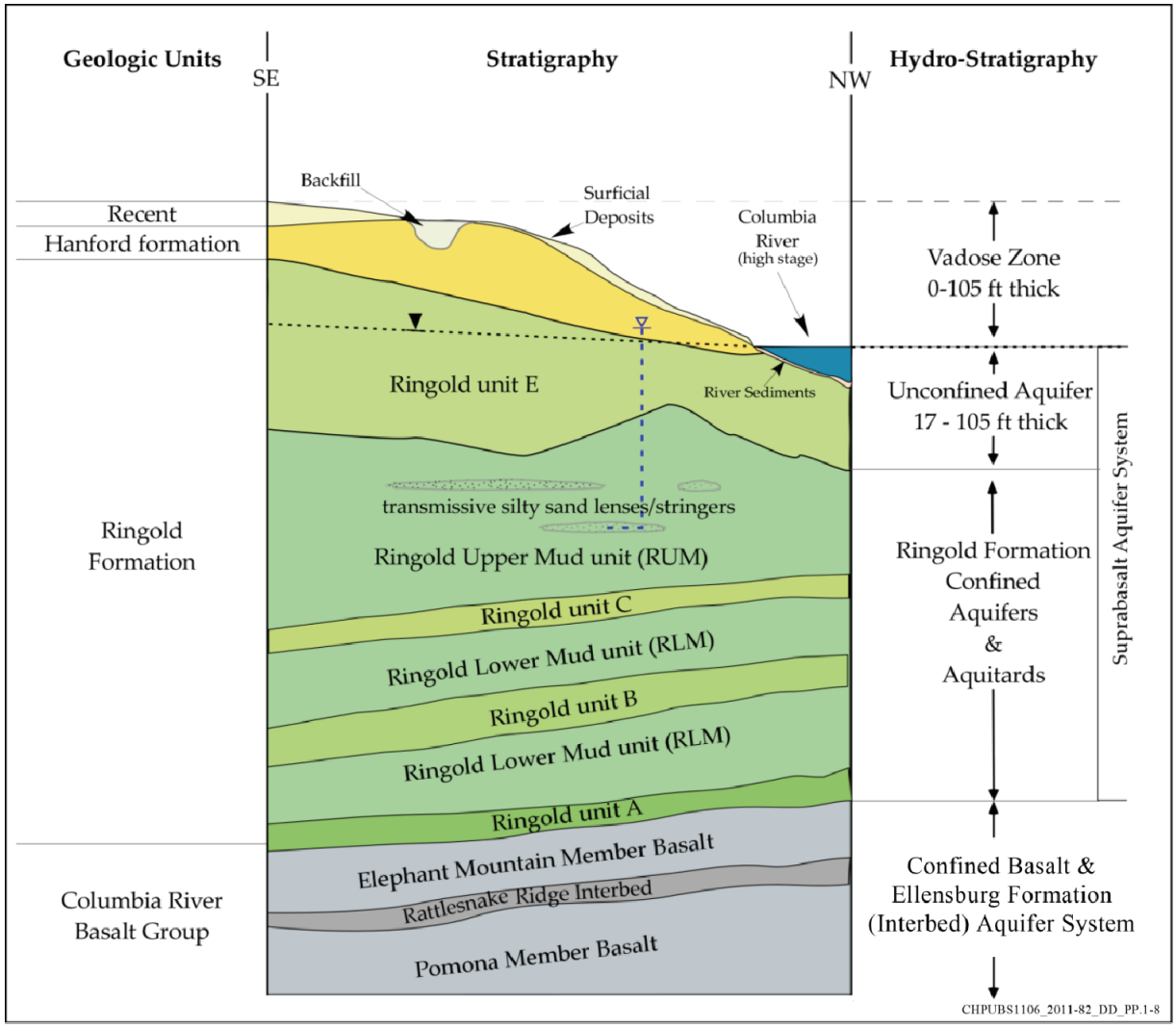


Figure 9. Generalized Geology and Hydrostratigraphy of 100-K

Following deactivation of the 105-KE and 105-KW Reactors in 1970 and 1971, respectively, many facilities remained active for the long-term storage of spent nuclear fuel in the 105-KE and 105-KW Fuel Storage Basins. Several buildings support the treatment centers associated with the 100-KR-4 groundwater pump-and-treat system. Because of these ongoing activities, only 39 of 111 total facilities have been demolished or removed as of May 2011.

Current land use consists of facilities support, remediation activities, and undeveloped land. Facilities support includes maintenance of existing structures, roads, and grounds. Undeveloped land comprises a large portion of the open space in 100-K. The undeveloped areas are the least disturbed and contain minimal infrastructure.

The Columbia River and the north shoreline is used for recreational activities such as hunting, fishing, and boating, and supports a large variety of aquatic and riparian animals and plants.

What geographical or topographical factors had a major impact on remedy selection?

The Hanford Reach was set aside by presidential proclamation as a national monument in 2000. The Hanford Reach National Monument (HRNM) includes lands along the south shore of the Columbia River, reaching approximately one-quarter mile inland, and overlaps a portion of the 100-K OUs (Figure 3). The

near shore lands include sensitive ecological and cultural areas which need to be protected during investigation and cleanup activities. Protection of the Columbia River is one of the key factors influencing IRA and final remedial action decisions.

How much and what type of contamination is present?

Sources of contamination to the vadose zone and groundwater from Hanford Site operations include liquid, slurry, and solid wastes generated during the operation of the reactors and support facilities, and unplanned releases of both liquid and solid wastes (Chapters 4 and 5 of 100-K RI/FS). The liquid effluent streams were generated as cooling water, steam condensate, and unplanned releases. The contaminants related to the cooling water include hexavalent chromium, strontium-90, and various short-lived radionuclides. Liquid waste streams were discharged to cribs, trenches, the retention basins, and the Columbia River. The solid waste sources include the buildings, burial sites, and solid waste disposal sites. Burial ground waste consists primarily of debris that contains radioactive solid waste from the 105-KE, 105-KW, and 105-N Reactors. Burial ground waste also includes zirconium cladding hulls and basin sludge from the 105-N Reactor. There are 165 waste sites in 100-K (Figure 10).

Sodium dichromate was introduced into cooling water to inhibit corrosion to the reactors. It is mobile in the environment, widely distributed, and has the potential to adversely impact human health and the environment. Total and hexavalent chromium are present in the groundwater (Figure 11) at concentrations exceeding DWS and ambient water quality standards (AWQS). AWQS are of importance in groundwater due to the potential for contaminated groundwater to enter the river. The 116-K-2 Trench was the main liquid waste disposal site during reactor operations from 1955 to 1971. It is estimated that 300,000 kg (about 661,000 lb) of sodium dichromate were discharged to this trench.

Tritium and carbon-14 were generated during reactor operations and discharged to the 116-KE-1 and 116-KW-1 Gas Condensate Cribs. Tritium was also released from the 105-KE and 105-KW Fuel Storage Basins, and at the 116-KE-3 and 116-KW-2 Cribs. Tritium has been detected in groundwater at monitoring wells downgradient of the 118-K-1 Burial Ground. Tritium exceeds the 20,000 pCi/L DWS in groundwater near the southwestern portion of the 116-K-2 Trench and near the northern edge of the KW Reactor area. Carbon-14 is found in groundwater associated with the 115-KE and 115-KW gas condensate facilities. Carbon-14 exceeds the 2,000 pCi/L DWS at two localized areas downgradient of the gas condensate cribs.

Strontium-90 was discharged to the vadose zone at the 105-KE and 105-KW Fuel Storage Basins and related 116-KW-2 and 116-KE-3 Cribs. Strontium-90 has been found in groundwater near the 116-K-2 Trench. Groundwater concentrations exceeding the 8 pCi/L DWS have been observed at a monitoring well located downgradient of the 116-KE-3 Crib.

A localized trichloroethene groundwater plume is associated with the 105-KW Reactor maintenance activities.

The cooling gas condensate contained substantial quantities of ammonia, generated at about one to four pounds per day during reactor operation ("Ammonia Generation Rate in K Reactor Gas—Its Effect and Proposed Remedies" [DUN 2018]). Soil microorganisms readily oxidize ammonia to nitrate under moist aerobic conditions. Other possible sources of nitrate may have been septic systems near the reactor facilities. Nitrate concentrations near the Gas Condensate Cribs show stable to decreasing trends in groundwater.

Prior to Hanford Site operations, farmers applied pesticides containing lead arsenate in orchards. Concentrations of arsenic and lead detected in soil sampling performed by Ecology have been consistent with orchard lands in other parts of the state. Arsenic is not routinely detected in 100 Area groundwater above naturally occurring concentrations and lead concentrations are below the DWS of 15 µg/L.

What are the source materials in 100-K that constitute principal threats?

The NCP (40 CFR 300.430[a][l][iii][A]) establishes an expectation that treatment will be used to address the principal threats posed by a site wherever practicable. Principal threat wastes are those source materials 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. Where the toxicity and mobility of source material combine to pose a potential human health **excess lifetime cancer risk (ELCR)** greater than 10^{-3}, treatment alternatives should be identified (*A Guide to Principal and Low-Level Threat Wastes* [EPA 9380.3-06FS]).

Based on information presented in the RI/FS report, the waste sites and groundwater are not considered a principal threat waste. The 100-K principal threats source materials are associated with the reactors and associated fuel storage basin. These materials are being addressed through the existing CERCLA decisions, as identified in Figure 4.

Scope and Role

As described in the introduction, 100-K is part of the overall cleanup strategy for the River Corridor. Three OUs are addressed in this Proposed Plan. Two of the OUs (100-KR-1 and 100-KR-2) are waste site or source operable units where contaminated soil occurs. The third OU (100-KR-4) underlies the two source OUs and includes all contaminated groundwater associated with 100-K operations.

An integrated 100-K ROD for soil and groundwater is required to determine whether additional actions are required where IRAs have been completed, and to implement final remedial actions where necessary. Through the use of defined treatment technologies, the cleanup actions identified in the preferred alternative will permanently reduce the mobility, toxicity, and volume of contaminated media present in 100-K, thereby providing long-term protection of human health and the environment while meeting the statutory requirements for remedy selection, and compliance with ARARs.

Summary of Site Risks

The 100-K RI/FS included additional human health risk evaluations to supplement the findings of the *River Corridor Baseline Risk Assessment* (RCBRA) (DOE/RL-2007-21). The RCBRA assessed human health risks associated with exposure to residual contamination present at 13 waste sites where IRAs have been completed. The RCBRA evaluated a rural residential exposure scenario where a hypothetical resident could be exposed to radionuclides through direct contact and food ingestion, and to chemicals through direct contact. The RCBRA determined that residual cumulative cancer risks from chemicals at remediated waste sites were less than 1×10^{-5}. Residual cumulative cancer risks for radionuclides was less than 2×10^{-4} at two remediated waste sites and the remaining remediated waste sites with risks less than 1×10^{-4}. However, when radioactive decay is accounted for, no further action is necessary. Noncancer **hazard indices** (HI) for chemicals did not exceed the 1.0 threshold.

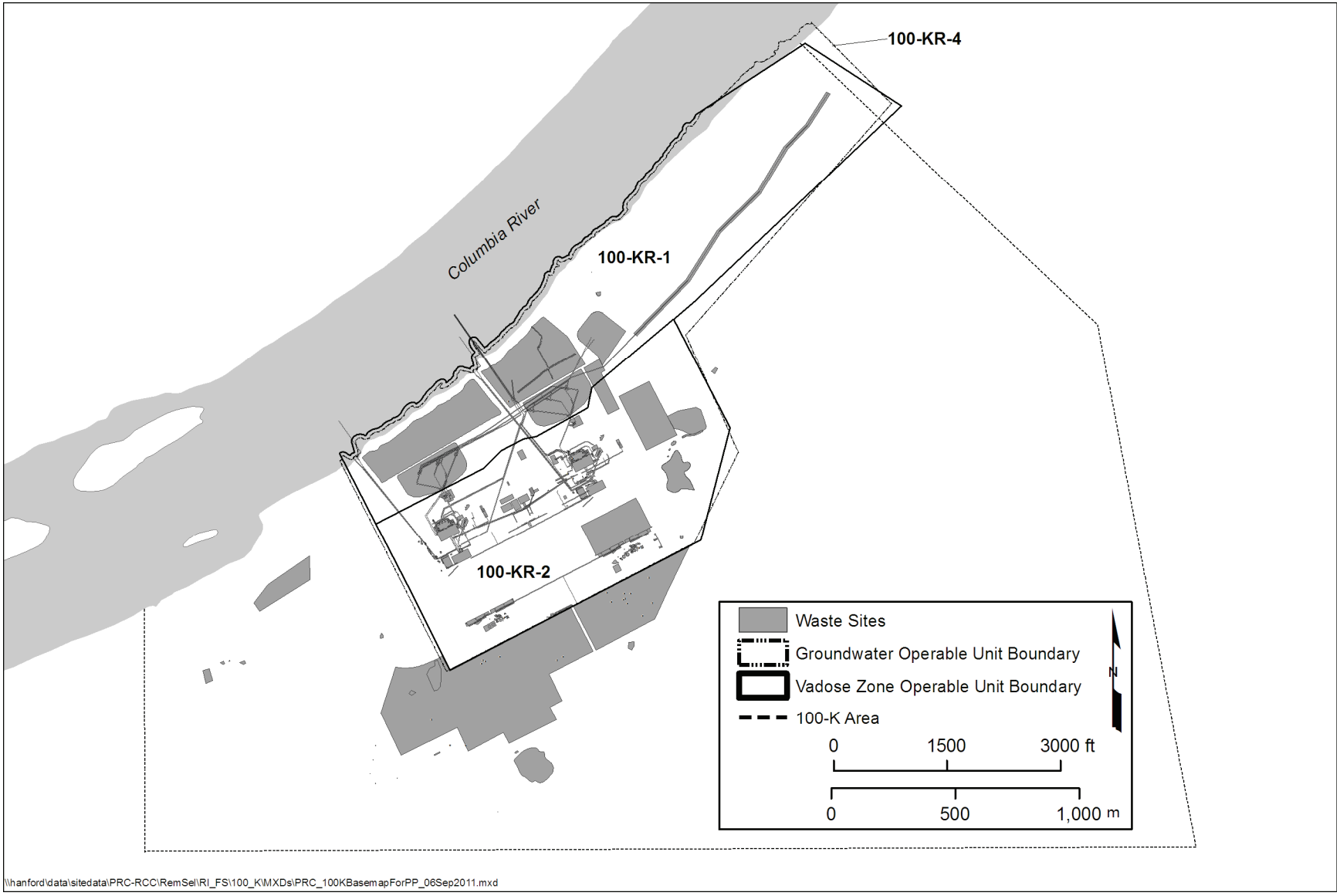


Figure 10. 100-K Waste Site Map

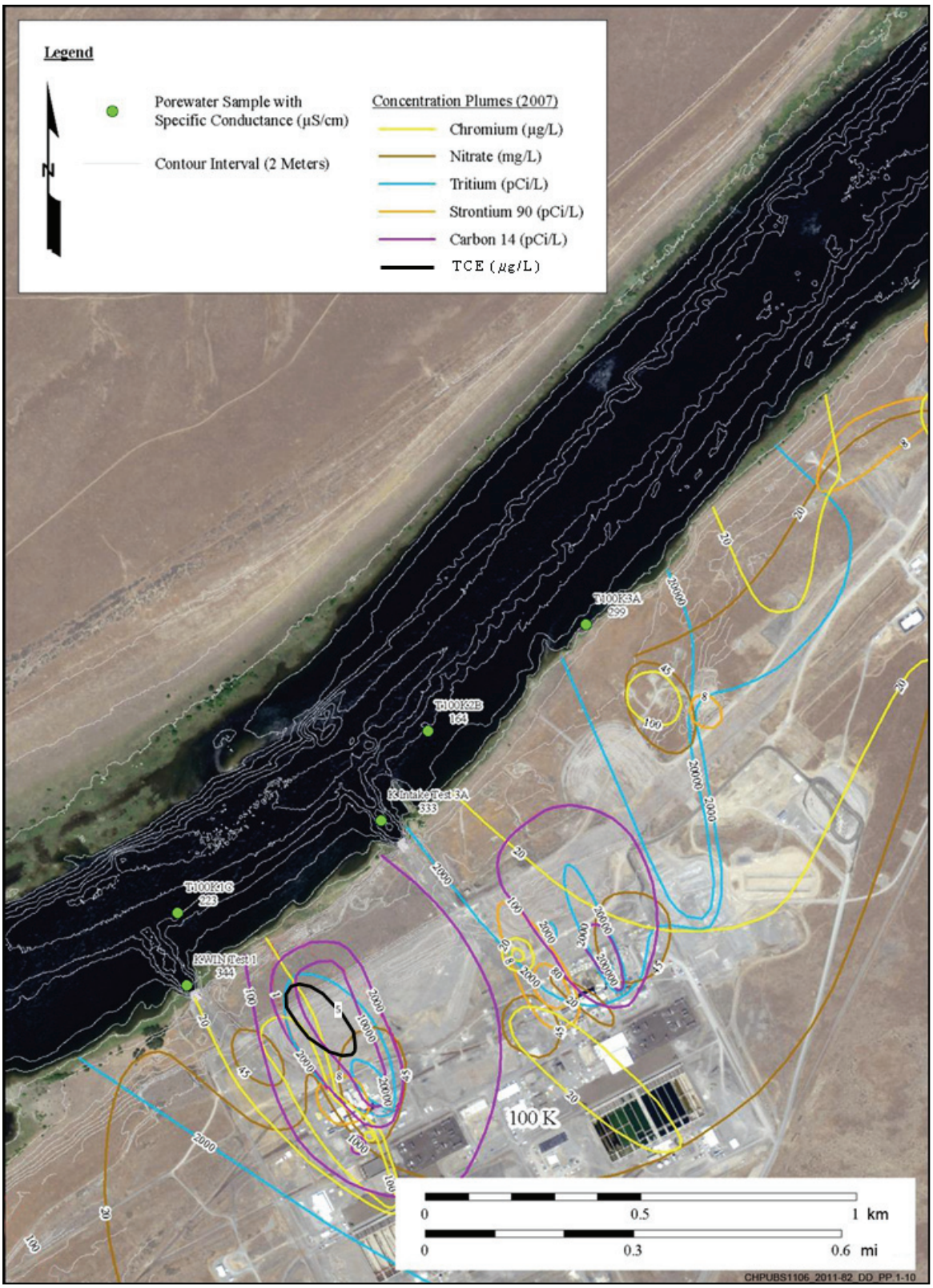


Figure 11. 100-K Groundwater Plume Map

The supplemental risk evaluation presented in the RI/FS report (DOE/RL-2010-97) verified a basis for action at waste sites identified in the interim action RODs where cleanup has not yet occurred. The risk assessment also evaluated sites where IRAs have been completed and included that information in developing **Preliminary Remediation Goals (PRGs)** that are protective of human health and the environment.

What are the contaminants of concern in each medium?

The contaminants of concern (COCs) are what drive remedial actions. The COCs in vadose zone (Table 2) include radionuclides, metals, inorganic anions, semivolatile organics, and polychlorinated biphenyls (PCBs). The COCs in groundwater (Table 2) include radionuclides, metals, and anions. Ancillary facilities and burial grounds are currently being remediated through existing CERCLA decisions. Those actions will continue until completed. The COCs at these facilities are comparable to those found in the vadose zone and groundwater.

Table 2. Vadose Zone and Groundwater COCs Based on Process Knowledge and the RI/FS Report

Radionuclides	Metals	Inorganic Anions
Americium-241	Antimony	Nitrate (as Nitrogen)*
Carbon-14*	Arsenic	Nitrite (as Nitrogen)
Cesium-137	Barium	Sulfate
Cobalt-60	Boron	**Organics and Polychlorinated Biphenyls**
Europium-152	Cadmium	Total Petroleum Hydrocarbons (diesel range, motor oil)
Europium-154	Chromium, total*	Ethylene Glycol
Europium-155	Chromium Hexavalent*	Trichloroethene*
Plutonium-238	Copper	Aroclor 1016
Plutonium-239/240	Lead	Aroclor 1221
Sr-90*	Manganese	Aroclor 1232
Tritium*	Mercury	Aroclor 1242
Uranium-233/234	Nickel	Aroclor 1248
Uranium-235	Selenium	Aroclor 1254
	Vanadium	Aroclor 1260
	Zinc	

Source: From Table 8-1 in DOE/RL-2010-97.

* Identifies a groundwater COC

What are the assumptions for land and groundwater use?

Under 50 USC 2582, DOE was assigned the authority to establish future land use for the Hanford Site. DOE involved Tribal Nations and stakeholders during the 1990s under the ***National Environmental Policy Act of 1969*** **(NEPA)** and the *State Environmental Policy Act of 1971* Environmental Impact Statement (EIS) process to evaluate future land use alternatives. This process was conducted in coordination with nine cooperating agencies and resulted in the *Final Hanford Comprehensive Land Use Plan Environmental Impact Statement* (DOE/EIS-0222-F).

The 1999 Hanford Comprehensive Land Use Plan (CLUP) EIS Record of Decision (ROD) (DOE/EIS-0222-F) designated future land use at the 100-K area as Conservation (Mining). Conservation is a primary purpose but allows for limited mining for governmental purposes only. Remediation activities are considered a pre-existing land use in this designation. DOE may allow recreational use (such as hiking, biking, hunting, and bird watching) of the surface areas once remediation is completed. Institutional controls will continue where needed to protect human health.

The NCP establishes an expectation to "return useable ground waters to their beneficial uses wherever practicable, within a timeframe that is reasonable given the particular circumstances of the site" (40 CFR 300.430[a][1][iii][F]). EPA generally defers to state definitions of groundwater classification provided under EPA endorsed Comprehensive State Groundwater Protection Programs (EPA/540/G 88/003). Under EPA's groundwater classification program, 100-K groundwater would be designated Class IIB, groundwater that is not a current source of drinking water, but is a potential future source.

Regulatory processes provide opportunities for agencies, Tribal Nations, and the public to participate in decision making. Values under NEPA, cultural considerations under the *National Historic Preservation Act of 1966*, and land use considerations, such as consistency with the Hanford Comprehensive Land Use Plan, are considered in cleanup decisions under the Tri-Party Agreement.

Tribal fishing rights are recognized on rivers within the ceded lands, including the Columbia River, which flows through Hanford. In addition to fishing rights, the Tribal Nations retained the privilege to hunt, gather roots and berries, and pasture horses and cattle on open and unclaimed lands. It is the position of DOE that Hanford is not open and unclaimed land. While reserving all rights to assert their respective positions, the Tribal Nations are participants in DOE's land use planning process, and DOE considers Tribal Nation concerns in that process.

The Presidential Proclamation in 2000 that established the HRNM generally mandated more restrictive uses within the HRNM boundaries than those DOE adopted in the Hanford CLUP. This mandate was to preserve the natural and cultural resources for which the HRNM was established. The U.S. Fish and Wildlife Service has developed a comprehensive conservation plan for management of the HRNM.

Who are the potentially exposed populations and exposure pathways for current and future risk scenarios?

Based on the formally designated land use and existing institutional controls, there are currently no complete exposure pathways for risk to human populations. Nevertheless, for purposes of assessing potential risks in the absence of remediation and controls, hypothetical land use and human exposure scenarios were evaluated in the RI/FS Report supplemental risk evaluation:

Residential Scenario. The residential exposure scenario represents a baseline condition and would not reflect actual future exposures. The HRNM was established for protecting the biological, historical, and scientific objects present in the River Corridor. To ensure continued protection of natural and cultural

resources in perpetuity, under authority of the *Antiquities Act of 1906 (16 USC 431-433)*, the HRNM cannot be developed for residential or commercial use in the future.

Residential National Monument Worker Scenario. Future land use is predominantly conservation (mining). This scenario evaluates potential exposure to workers as they lead tours, conduct ecological education, or perform similar activities. When not working, they live in an onsite residence owned by the Federal Government. They are assumed to obtain drinking water from an offsite source.

Casual Recreational User Scenario. Casual recreational users would participate in activities such as walking and picnicking in areas along the Columbia River where paths and benches are likely to exist. They are assumed to be exposed entirely in an outdoor environment where drinking water is obtained from an offsite source.

Groundwater. Groundwater is currently contaminated, and withdrawal is prohibited because of ICs placed on it by DOE. Under current site use conditions, no complete human exposure pathways to groundwater exist. Regardless of land use designations, groundwater will not become a future source of drinking water until cleanup criteria are met and groundwater is restored to beneficial use. Groundwater in the supplemental risk evaluation was evaluated assuming potential use for drinking water; therefore, COC concentrations were compared to DWSs. Groundwater COC concentrations were also compared to aquatic criteria because under the baseline condition (no IRA pump-and-treat) groundwater would discharge to the Columbia River via riverbank seeps and upwelling through the river bottom. Comparison of groundwater COC concentrations to DWS and aquatic criteria supports the basis for action determination.

What is the summary of the supplemental soil and groundwater risk evaluation?

The RI/FS supplemental risk evaluation included an evaluation of human health risks for the residential, residential national monument worker, and casual recreational user exposure scenarios for up to three decision units within the vadose zone identified as shallow (less than 4.6 m [15 ft]) soil, overburden soil, and deep soil (greater than 4.6 m [15 ft]). The supplemental risk evaluation included cleanup verification data from the 16 IRA waste sites. Additionally, several of the residential exposure assumptions used in the RCBRA were updated for the RI/FS supplemental risk evaluation to reflect the latest EPA risk assessment guidance as identified in the RI/FS Chapter 6.

Residential cumulative ELCR associated with exposure to radionuclides within shallow soil (top 4.6 m [15 ft]) slightly exceeded the upper end of the CERCLA target risk range (10^{-4} to 10^{-6}) at one remediated waste site; however, no individual radionuclides exceed the upper end of the CERCLA risk range. Residential monument worker and casual user ELCR associated with exposure to radionuclides in shallow zone soil fell within the CERCLA target risk range. The residential monument worker and casual user exposure scenarios represent the reasonably anticipated future land use and no further action is warranted.

While residents are unlikely to be exposed to contaminants in deep soil below 4.6 m (15 ft), ELCR was assessed to identify the need for future controls on deep excavation. The ELCR associated with residential exposure to radionuclides in deep vadose zone material exceeded the upper end of the CERCLA target risk range at three waste sites. Radionuclides associated with historic waste disposal contribute a majority of the ELCR. However, most have a short half-life and will decay to levels corresponding to EPA's target risk range within 10 and 140 years. These results indicate the need for controls to limit potential for future exposure by restricting deep soil excavation and drilling activities within defined areas.

Groundwater was evaluated as a potential drinking water source using the 90th percentile exposure point concentration (EPC) for each contaminant. Contaminant concentrations in groundwater were compared

with federal and state DWSs, and the WAC 173-340-720 groundwater cleanup levels for carcinogenic and noncarcinogenic effects. This comparison indicates that concentrations of chromium (total), hexavalent chromium, nitrate, and tritium are greater than the federal and state DWS. Although the 90th percentile EPC did not exceed the DWS, concentrations of carbon-14, strontium-90, and trichloroethene occur in localized areas at concentrations above the DWS. Concentrations of all nonradiological carcinogenic groundwater contaminants are less than the "Human Health Risk Assessment Procedures" (WAC 173-340-708) risk threshold of 1×10^{-5} for multiple hazardous substances and within the CERCLA target risk range. The **Hazard Index (HI)** for groundwater noncancer COCs is 3.1, which is greater than the EPA and WAC 173-340 target HI of 1. The primary contributor to the noncancer HI is hexavalent chromium. Based on the results of the supplemental groundwater risk evaluation, concentrations of chromium (total), hexavalent chromium, nitrate, carbon-14, strontium-90, tritium, and trichloroethene are present at levels that warrant remedial action.

Contaminant concentrations in groundwater were also compared with surface water standards for protection of human health and aquatic organisms because groundwater discharges to the Columbia River when the pump-and-treat systems are not operating. This comparison indicates the 90th percentile EPC for chromium (total) exceeds the AWQC and hexavalent chromium is exceeds the AWQS. Based on the results of the supplemental groundwater risk evaluation, chromium (total) and hexavalent chromium are present at levels that warrant remedial action.

Risk drivers have not been quantitatively determined for unremediated waste sites through a risk assessment evaluation. For the purpose of alternatives evaluation, a preliminary evaluation of the risk drivers has been made based on knowledge of the process that was performed at the sites and remediation results at similar sites in the River Corridor. The remedial approaches for the major risk drivers are developed for each alternative and presented in the Remedial Alternatives section of this Proposed Plan.

What is the summary of the ecological risk assessment?

Sixteen interim remediated waste sites with upland habitats were evaluated for potential ecological risks. The results of the assessment determined that unacceptable risks to wildlife remain due to the presence of mercury at four waste sites (100-K-30, 100-K-31, 100-K-32, and 100-K-33).

The ecological risk assessment presented in the RI/FS Report also summarized ecological risks in riparian and nearshore areas, based on the analysis presented in the RCBRA and risk in the Columbia River developed for the Columbia River Component. The RCBRA evaluated risks to an array of assessment endpoints using multiple measures of exposure, effect, and ecosystem/receptor characteristics at representative nearshore study sites. The study sites were selected to represent locations that may be adjacent to or directly affected by known contaminated media (groundwater seeps and springs, soil, sediment). The assessment conducted in the RCBRA has been supplemented with a conceptual model depicting the relationships between sources and riparian and near shore media (soil, sediment, pore water and surface water). The conceptual model is presented in Chapter 4 of the RI/FS Report. Based on the information developed for the conceptual model, carbon-14 and hexavalent chromium were identified as contaminants of ecological concern present at levels that warrant remedial action.

Remedial Action Objectives

RAOs describe what a proposed remedial action is expected to accomplish. RAOs generally include information on the media and contaminant specific PRGs to be achieved by the remedial action for each COC. PRGs were developed for COCs present in vadose zone (Table 3) and groundwater (Table 4). The

RAOs, which are based on existing River Corridor regulatory documents (e.g., interim action RODs), were expanded to include all media and resources as follows:

1. **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.

2. **RAO 2.** Prevent unacceptable risk to human health and ecological exposure to surface water containing contaminant concentrations above federal and state standards and risk-based thresholds.

3. **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.

4. **RAO 4.** Prevent unacceptable risk to human health and ecological receptors from exposure to the upper 4.6 m (15 ft) of soil contaminated with nonradiological constituents at concentrations above the unrestricted land use criteria for human health (provided in MTCA B) or soil contaminant levels for ecological receptors.

5. **RAO 5.** Prevent unacceptable risk to human health and ecological receptors from exposure to upper 4.6 m (15 ft) of soils and to structures and debris contaminated with radiological constituents.

   – Prevent exposure to radiological constituents at concentrations at or above a dose rate limit that causes an excess cancer lifetime risk threshold of 10^{-6} to 10^{-4} above background for the rural residential exposure scenario.

   – Protect ecological receptors based on a dose rate limit of 0.1 rad/day for terrestrial wildlife populations, which is a “to be considered” criterion.

Preliminary Remediation Goals

PRGs were used to assess the effectiveness of the selected remedial alternatives to meet the RAOs during the FS process. PRGs provide the basis for identifying cleanup levels in the ROD. PRGs for 100-KR-1/KR-2 soil and 100-KR-4 groundwater are presented in Tables 3 and 4, respectively.

Table 3. Summary of 100-K Operable Unit Proposed Cleanup Levels in vadose zone based on Human Health, Groundwater Protection, Surface Water Protection, and Ecological PRGs

COC	Hanford Site Background Concentration[a]	Proposed Shallow Cleanup Levels (<=15 ft bgs)		Proposed Groundwater and Surface Water Protection Cleanup Levels	
		PRG	Exposure Driver	PRG	Exposure Driver
Radionuclides pCi/g					
Americium-241	--	155	Direct Human Health	9,990	100:0 Contaminant Source Model GWP
Carbon-14	--	32	Ecological Mammal	80	100:0 Contaminant Source Model GWP
Cesium-137	1.1	4.4	Direct Human Health	143,128	100:0 Contaminant Source Model GWP

Table 3. Summary of 100-K Operable Unit Proposed Cleanup Levels in vadose zone based on Human Health, Groundwater Protection, Surface Water Protection, and Ecological PRGs

COC	Hanford Site Background Concentration[a]	Proposed Shallow Cleanup Levels (<=15 ft bgs)		Proposed Groundwater and Surface Water Protection Cleanup Levels	
		PRG	Exposure Driver	PRG	Exposure Driver
Cobalt-60	0.0084	3.1	Direct Human Health	198,457	100:0 Contaminant Source Model GWP
Europium-152	--	3.7	Direct Human Health	133,202	100:0 Contaminant Source Model GWP
Europium-154	0.033	4.4	Direct Human Health	39,961	100:0 Contaminant Source Model GWP
Europium-155	0.054	327	Direct Human Health	399,606	100:0 Contaminant Source Model GWP
Nickel-63	--	608	Direct Human Health	9,438	100:0 Contaminant Source Model GWP
Plutonium-238	0.0038	236	Direct Human Health	9,990	100:0 Contaminant Source Model GWP
Plutonium-239/ 240	0.025	203	Direct Human Health	9,990	100:0 Contaminant Source Model GWP
Total beta radiostrontium (Sr-90)	0.18	2.3	Direct Human Health	1,518	100:0 Contaminant Source Model GWP
Tritium	--	420	Ecological Mammal	1,127	100:0 Contaminant Source Model GWP
Uranium-233/234	1.1	133	Direct Human Health	38	100:0 Contaminant Source Model GWP
Uranium-235	0.11	16	Direct Human Health	38	100:0 Contaminant Source Model GWP
Chemicals (mg/kg)					
Antimony	0.13	32	Direct Human Health	22	100:0 Contaminant Source Model SWP
Arsenic	6.5	20[b]	WAC 173-340-900, Table 740-1, Method A	20[b]	WAC 173-340-900, Table 740-1, Method A
Barium	132	358	Ecological Invertebrate	83,286	100:0 Contaminant Source Model SWP
Boron	3.9	30	Ecological Plant	8,999	100:0 Contaminant Source Model GWP
Cadmium	0.56	9.8	Ecological Plant	25	100:0 Contaminant Source Model SWP
Chromium	18.5	109	Ecological Avian	--[c]	--

Table 3. Summary of 100-K Operable Unit Proposed Cleanup Levels in vadose zone based on Human Health, Groundwater Protection, Surface Water Protection, and Ecological PRGs

COC	Hanford Site Background Concentration[a]	Proposed Shallow Cleanup Levels (<=15 ft bgs)		Proposed Groundwater and Surface Water Protection Cleanup Levels	
		PRG	Exposure Driver	PRG	Exposure Driver
Copper	22	58	Ecological Invertebrate	660	100:0 Contaminant Source Model SWP
Cr(VI)	--	2.0[d]	DOE/RL 96-17 SWP RAG	2.0[d]	100:0 Contaminant Source Model SWP
Lead	10.2	156	Ecological Avian	211	100:0 Contaminant Source Model SWP
Manganese	512	1,260	Ecological Plant	--[c]	--
Mercury	0.013	0.30	Ecological Plant	1.2	100:0 Contaminant Source Model SWP
Nickel	19	38	Ecological Plant	--[c]	--
Selenium	0.78	1.4	Ecological Mammal	34	100:0 Contaminant Source Model SWP
Vanadium	85	89	Ecological Plant	--[c]	--
Zinc	68	621	Ecological Plant	9,101	100:0 Contaminant Source Model SWP
Nitrate	52	340,361	Ecological Mammal	1,808	100:0 Contaminant Source Model SWP
Nitrite	--	24,000	Direct Human Health	133	100:0 Contaminant Source Model GWP
Sulfate	237	--	--	10,045	100:0 Contaminant Source Model GWP
Aroclor 1016	--	24,000	Ecological Avian	--[c]	--
Aroclor 1221	--	0.50	Direct Human Health	0.0014	100:0 Contaminant Source Model SWP
Aroclor 1232	--	0.50	Direct Human Health	0.0014	100:0 Contaminant Source Model SWP
Aroclor 1242	--	0.50	Direct Human Health	--[c]	--
Aroclor 1248	--	0.32	Ecological Mammal	--[c]	--
Aroclor 1254	--	0.50	Direct Human Health	--[c]	--
Aroclor 1260	--	0.50	Direct Human Health	--[c]	--
Ethylene glycol	--	160,000	Direct Human Health	--[e]	--
Total petroleum hydrocarbons–diesel range	--	200	Ecological Invertebrate	--[e]	--

Table 3. Summary of 100-K Operable Unit Proposed Cleanup Levels in vadose zone based on Human Health, Groundwater Protection, Surface Water Protection, and Ecological PRGs

COC	Hanford Site Background Concentration[a]	Proposed Shallow Cleanup Levels (<=15 ft bgs)		Proposed Groundwater and Surface Water Protection Cleanup Levels	
		PRG	Exposure Driver	PRG	Exposure Driver
Total petroleum hydrocarbons–motor oil (high boiling)	--	2,000	Direct Human Health	--[e]	--

a. Hanford Site background values for nonradionuclides: DOE/RL-92-24, Vol. 1, Rev. 4, Hanford Site Background: Part 1, Soil Background for Nonradioactive Analytes, ECF-Hanford-11-0038, Soil Background Data for Interim Use at the Hanford Site (DOE/RL-2010-97); Hanford Site background values for radionuclides: DOE/RL-96-12, Rev. 0, Hanford Site Background: Part 2, Soil Background for Radionuclides.

b. Arsenic PRG is compared to the WAC 173-340-900, Table 740-1, Method A, soil cleanup level for unrestricted Land Use.

c. For calculated soil activities or PRGs protective of groundwater, STOMP 1-D predicts these analytes will not reach peak groundwater concentration within 10,000 years assuming that 100% of the vadose zone is contaminated.

d. Cr(VI) PRG is set to the interim action RAG of 2.0 mg/kg (DOE/RL-96-17).

e. A GWP or SWP PRG is not calculated because a groundwater cleanup level or MCL is not available for this analyte.

Table 4. Proposed Cleanup levels for 100-KR-4 Groundwater based on PRGs

COC	Units	90th Percentile EPC	Drinking Water Standard	WAC 173-340-720 Cleanup Levels		AWQC		WAC 173-201A	CFR 131 Water Quality Standard		Proposed Cleanup Level[a]
				Non-Carcinogens at HQ = 1	Carcinogens at 1 × 10-5 Risk Level	Freshwater					
						CMC (acute)	CCC (chronic)	CCC (chronic)	CMC (acute)	CCC (chronic)	
Carbon-14	pCi/L	1,470	2,000	--	--	--	--	--	--	--	2,000
Strontium-90	pCi/L	7.3	8	--	--	--	--	--	--	--	8
Tritium	pCi/L	34,500	20,000	--	--	--	--	--	--	--	20,000
Chromium	µg/L	121	100	24,000	--	570	65	156	550	180	65
Hexavalent Chromium[b]	µg/L	117	--	48	--	16	11	10	15	10	10
Trichloroethene	µg/L	3.8	5	--	4.9	--	--	--	--	--	4.9
Nitrate[c]	µg/L	71,700	45,000	113,600	--	--	--	--	--	--	45,000

Notes: DWS from 40 CFR 141.

a. The final cleanup levels achieved at the conclusion of the RA will correspond to an ELCR less than 1 × 10 6 and HI of less than 1.

b. There is no DWS specific to hexavalent chromium.

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

AWQC = ambient water quality criteria
COC = contaminant of concern
CCC = criterion continuous concentration
CMC = critical maximum concentration
DWS = drinking water standard
ELCR = excess lifetime cancer risk
EPA = U.S. Environmental Protection Agency
HI = hazard index
N/A = not applicable
OU = operable unit
RA = remedial action

Summary of Remedial Alternatives

Per the approach summarized below, remedial action alternatives were developed in the RI/FS report based on the results of a detailed technology screening. The following alternatives include a range of technology groupings that address vadose zone soil and groundwater collectively:

- **Alternative 1:** No Action
- **Alternative 2:** RTD and Groundwater Pump-and-Treat, Optimized with Other Technologies
- **Alternative 3:** RTD and Expanded Groundwater Treatment

Waste Site Alternative Development Approach

As described in the RI/FS report, the identification of waste sites was performed following specific procedures defined in the TPA document (Ecology et al., 1989 [TPA]; and *Hanford Federal Facility Agreement and Consent Order Action Plan*). Using information maintained and tracked in the **Waste Site Information Database (WIDS)**, 165 potential waste sites were identified. Based on IRA verification sampling and data acquired during the RI/FS process, 37 waste sites were eliminated from further consideration. These sites were: classified or reclassified as "Rejected," "Not Accepted," or "Closed Out," identified as tanks that have already been removed, or identified as reactors that are addressed under a NEPA ROD (58 FR 48509).

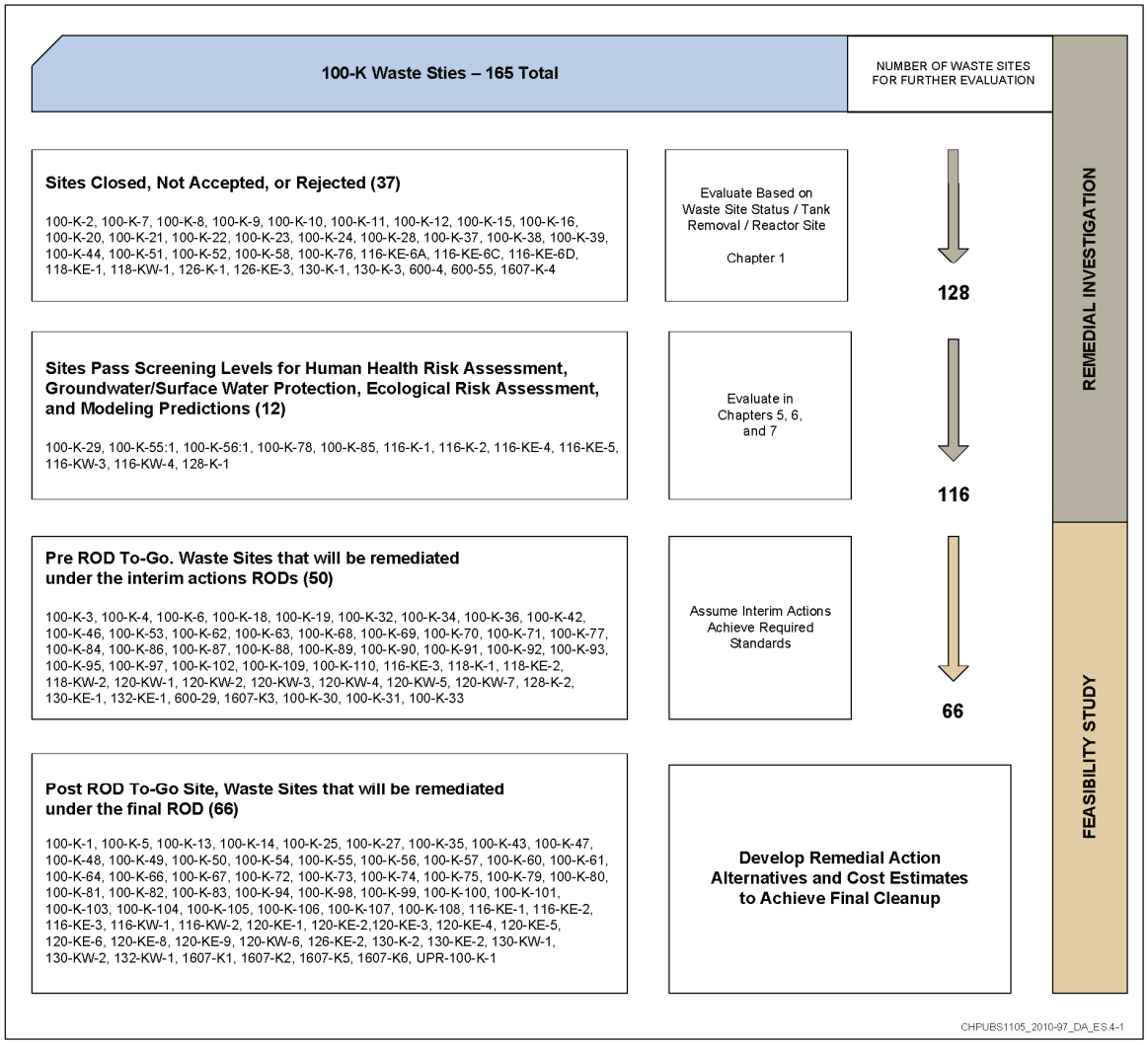
Of the 128 remaining waste sites, 16 have undergone IRA and have verification data that allowed for quantitative evaluation against the PRGs presented in the RI/FS report. The verification data indicate that IRAs have achieved PRGs at 12 sites (100-K-29, 100-K-55:1, 100-K-56:1, 100-K-78, 100-K-85, 116-K-1, 116-K-2, 116-KE-4, 116-KE-5, 116-KW-3, 116-KW-4, and 128-K-1). Three of these sites (116-K-1, 116-K-2, and 100-K-56:1) were shown to have concentrations of COPCs above the upper range of the regulatory risk target threshold of 1×10^{-4} in samples collected at depths greater than 4.6 m (15 ft) bgs and, as a result, there is no direct exposure pathway for reasonably anticipated future land use. The contaminants at these sites will decay within 10 to 140 years and during this time, DOE or the federal government will maintain controls on the land to prevent exposure to these materials. No further evaluation of the deep waste sites was performed in the RI/FS report. Four waste sites that have undergone IRA did not achieve the ecological-risk PRG for mercury in shallow samples (100-K-30, 100-K-31, 100-K-32, and 100-K-33). Waste sites 100-K-30 and 100-K-31 are within the remediation footprint of site 120-KE-1. Alternatives for sites encompassed within the footprint of 120-KE-1 will be considered as part of this waste site. Waste sites 100-K-32 and 100-K-33 are within the remediation footprint of site 120-KW-1. Waste sites encompassed within the footprint of 120-KW-1 will be completed under interim actions as part of this waste site. Therefore, individual alternatives for 100-K-30, 10-K-31, 100-K-32, and 100-K-33 were not developed.

Of the 116 remaining waste sites, 50 are scheduled to be remediated under the Interim Action ROD (EPA/ROD/R-99/039) by the time the ROD is signed. These waste sites are identified in the RI/FS Report as **Pre-ROD To-Go Sites** and are listed in Table 5. These sites will be evaluated against the cleanup levels in the ROD, as the sites are remediated and verification data become available. Sites that do not meet thecleanup levels will be evaluated depending on the risk drivers that remain and a remedy will implemented consistent with the ROD.

The remaining 66 waste sites for which remedial actions will not be started until after the ROD is issued are identified as "**Post-ROD To-Go Sites**" and are listed in Table 5. The remedial components are specified for each waste site for Alternatives 2 and 3 and provided in Table 9-5 of the RI/FS Report (DOE/RL-2010-97) and summarized in Table 6. An evaluation of risk drivers was performed in the RI/FS Report, using process knowledge and information obtained through characterization and interim remediation of similar waste sites in the River Corridor. Table 5 lists the proposed remedial technologies,

the number of waste sites, and where proposed for implementation under Alternatives 2 and 3. Figure 13 depicts the location of the Pre- and Post-ROD To-Go Sites.

Table 5. Summary of the 165 Waste Sites Evaluated through the RI/FS Process



Common elements associated with the waste site remediation strategy include:

- Removal and treatment with disposal at ERDF or other approved disposal facility.
- Completion of existing CERCLA interim decisions for facilities and burial grounds.
- No additional remedial actions are taken at Pre ROD To Go sites where results are expected to confirm the interim actions completed under the 100 Area Remaining Sites ROD (EPA/ROD/R10 99/039) meet cleanup levels.
- ICs would be applied as necessary to extend or expand existing land use (land disturbance, excavation, and irrigation restrictions). Warning notices and entry restrictions would also be maintained.
- Temporary surface barriers would be placed over waste sites in proximity to the reactors. When the reactors are removed, the associated waste sites will be remediated.

Cultural Resources

NHPA is an ARAR for remedial actions where cultural resources are present. Remediation may have the potential to impact cultural resources. A step that will be taken prior to any remedial action occurring in 100-K includes an analysis of cultural resource impacts (Figure 12). This will include an assessment of the cultural resources present and a qualitative comparison to the risk posed by the contaminants present at a site in accordance with the *Hanford Cultural Resources Management Plan* (DOE/RL-98-10). The guidelines and strategies have been developed based on Hanford's unique history and cultural resources, and through recurring discussions with the State Historic Preservation Office (SHPO) and the Native American Tribes and Nations regarding the nature and extent of protective and mitigative measures that are needed.

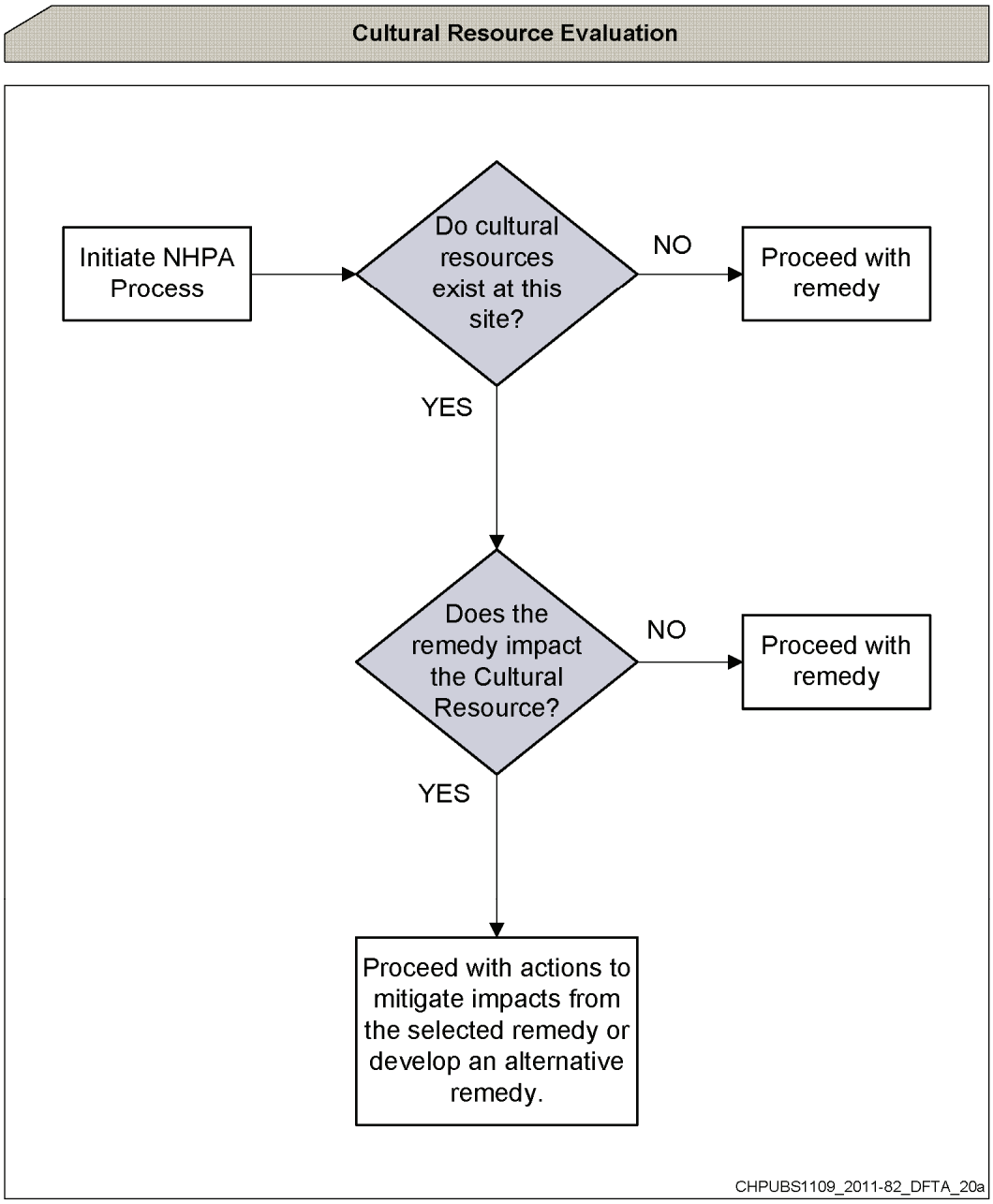


Figure 12. Cultural Resource Evaluation

Table 6. Waste Site Remedial Technologies

Technology	Number of Post ROD To-Go Waste Sites Where Used*	
	Alternative 2	Alternative 3
RTD	63	66
Landfarming	2	0
Bioventing	2	0
Soil Flushing supplemented with Bioinfiltration	15	0
Soil Flushing	3	0
Temporary Surface Barrier	4	4
Institutional Controls	66	66

* At some waste sites, multiple technologies may be used when more than one risk driver category is present.

Orchard Lands

The River Corridor includes approximately 3,359 ha (8,300 ac) of historical (pre-Hanford) farmsteads of which approximately 2,023 ha (5,000 ac) were cultivated as orchards. A 90-ac orchard existed within the boundaries of 100-K. Lead arsenate was commonly applied as a pesticide within orchards. Often, this type of application has been demonstrated to result in low-to-moderate concentration, shallow-soil contamination that is dispersed over large areas (areawide contamination). Hanford operations resulted in some waste sites being located within, or intersecting, orchard land boundaries.

Historical orchard lands within the River Corridor that have not been impacted by waste disposal activities or releases related to Hanford Site operations are not identified as waste sites and are not addressed by any of the remedial alternatives identified in this Proposed Plan. The RI/FS provides details on the locations of the historic orchard lands. These lands will be managed and addressed consistent with area wide soil contamination practices in other parts of Washington State (e.g., *Area-Wide Task Force Report* [Ecology, 2003]) taking into consideration land use. Management of these lands includes the use of institutional controls to reduce potential for exposure. Where Hanford operations have resulted in waste sites that are collocated with former orchard areas, the waste sites will be addressed only to their boundary and not into surrounding or underlying soil contamination resulting from former orchard use.

Groundwater Alternative Development Approach

As was done with the waste sites, a risk management approach was applied in developing remedial action alternatives for the groundwater COC plumes. The groundwater COCs lie largely within the extent of the hexavalent chromium plumes. The extraction well network installed for the pump-and-treat systems for remediating the hexavalent chromium plumes will capture these contaminants. Alternatives development include the following approaches:

- Carbon-14 will be treated where concentrations are greater than the DWS. Carbon-14 is found mainly in K-West and at low concentrations in a small area in K-East. In both areas, the plume is within the capture zone of the recovery wells and plume migration is sufficiently controlled. Modeling results suggest that carbon-14 concentrations will decline over time and recovery of the plume is expected.

- Tritium, nitrate, strontium-90, and trichloroethene are being co-extracted from groundwater, along with the chromium and carbon-14 plumes, and will achieve DWS upon injection.

- Total chromium is a COC. However, since the vast majority of total chromium in groundwater at the geochemical conditions at the site is likely Cr(VI), it will not be specifically addressed in the alternatives. Trivalent chromium, the only other form of chromium that is likely to be present, has a very low solubility, and is not likely to exist in the groundwater. Achieving the hexavalent chromium standards will also result in the total chromium standard being achieved, since they are lower than the total chromium.

- Remedy performance monitoring is conducted to evaluate effectiveness of the alternative to attain the cleanup levels.

Alternative 1—No Action

The No Action Alternative serves as a baseline for evaluating other remediation action alternatives. Under this alternative, all waste site and groundwater interim actions would be discontinued in December 2012. This includes ceasing operation of the existing IRA pump-and-treat systems and groundwater monitoring with no further remediation at the 66 “Post-ROD to Go” waste sites. Contaminant fate and transport model simulations illustrate hexavalent chromium plume behavior between 2012 and 2087 (75 years to coincide with reactor decommissioning [Figure 14]). Since the pump-and-treat systems would be shut down after 2012, hydraulic containment of the plume would be lost. Some mass removal is predicted to occur via natural flushing; however, relatively large areas with hexavalent chromium concentrations above the 10 µg/L cleanup level would remain past 2087.

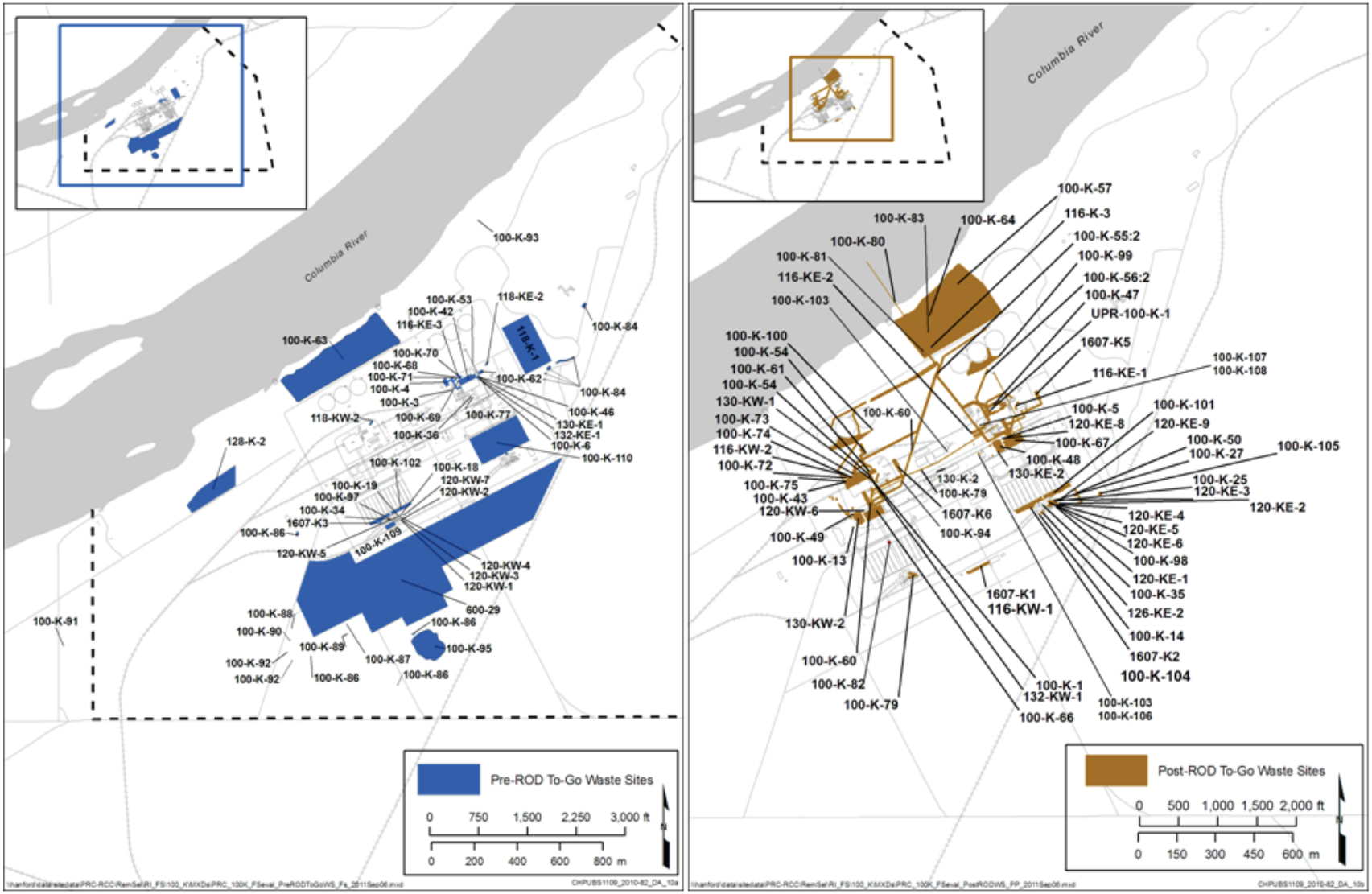


Figure 13. 100-K Pre- and Post-ROD To-Go Waste Sites

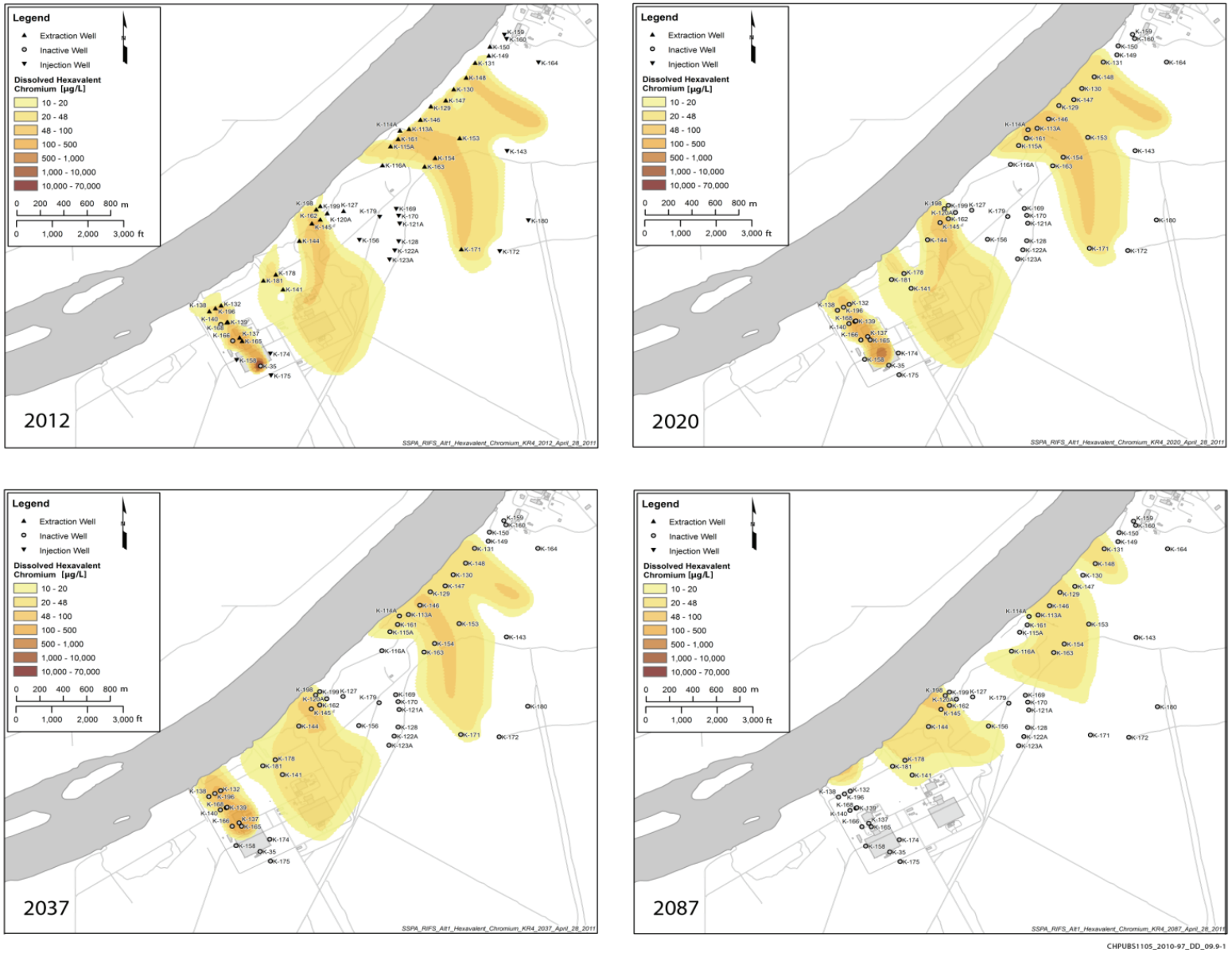


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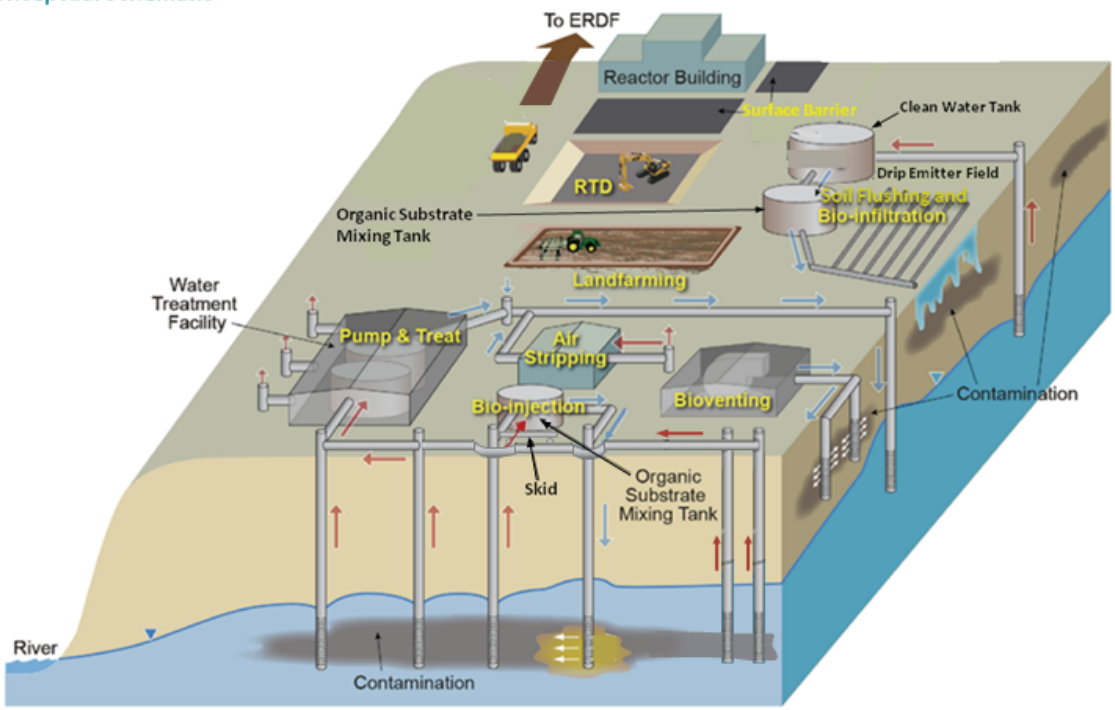
Figure 14. 100-K Hexavalent Chromium Plumes (2012 through 2087) for Alternative 1—No Action

Alternative 2—RTD and Groundwater Pump-and–Treat, Optimized with Other Technologies

Alternative 2 uses a strategy of RTD and groundwater pump-and-treat optimized with other technologies (Figure 15) to achieve cleanup requirements. An analysis was conducted in the FS to select the appropriate technology for each waste site (Table 9-5 of the RI/FS Report [DOE/RL-2010-97]).

Alternative 2: RTD and Groundwater Pump-and-Treat, Optimized With Other Technologies

Conceptual Schematic



Cost	Waste Site Treatment	Groundwater Treatment	Total
Total Present Value of Alternative (Discounted)	$422,494,000	$194,314,000	$616,808,000
Total Non-Discounted Cost	$764,611,000	$265,540,000	$1,030,151,000

Note: Waste site treatment costs include the cost for institutional controls.

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Figure 15. Alternative 2—RTD and Groundwater Pump-and-Treat Optimized with Other Technologies

For the Post-ROD To-Go waste sites, the specific components of Alternative 2 include the following:

- RTD of shallow vadose zone contamination exceeding human health and ecological cleanup levels. RTD would also include demolition of structures (e.g., buildings) when necessary.
- RTD of deep vadose zone contaminants includes excavation of contaminants to reach cleanup requirements with a contingency to implement soil flushing supplemented with bioinfiltration. This contingency is selected for specific waste sites within this PP. This contingency will also be considered for other waste sites during the RD/RAWP and evaluated during implementation. The contingency evaluation includes the following considerations:
    - Contaminant concentrations and mass

  - Contaminant location (such as depth)
  - Contaminant type (mobile and reducible by these technologies)
  - Existing groundwater contamination
  - Implementability such as considerations of building proximity
  - Cost: a comparison of RTD at depth with the implementation of soil flushing and bioinfiltration

- Soil flushing at sites exceeding GWP/SWP cleanup levels for mobile contaminants (such as C-14 and hexavalent chromium) that can be recovered and treated through groundwater pump and treat.
- Surface infiltration of biological substrates (such as biological infiltration) at waste sites exceeding GWP/SWP cleanup levels for mobile and reducible contaminants (such as hexavalent chromium). This technology is implemented as a supplement to soil flushing at selected waste sites as identified .
- Land farming, bioventing, or RTD will be the technologies for sites with total petroleum hydrocarbons as the only COC exceeding RAGs. Land farming is applicable for contaminants less than 0.30 m (1 ft) bgs, bioventing is applicable for contaminants greater than 0.30 m (1 ft) bgs.
- ICs would be applied as necessary to extend or expand existing land use (land disturbance, excavation, and irrigation restrictions). Warning notices and entry restrictions would also be maintained.
- Temporary surface barriers would be placed over waste sites in proximity to the reactors. When the reactors are removed, the associated waste sites will be remediated.

For groundwater, Alternative 2 optimizes existing IRA pump-and-treat system operations by adding biological injection (bioinjection) and biological infiltration (bioinfiltration). Bioinjection would be used for specific well pairs or clusters in a closed loop fashion so potential biodegradation byproducts are not sent to the ion exchange (IX) treatment plants. Bioinfiltration may be used near the K-East and the K-West head houses to reduce hexavalent chromium that might remain in the vadose zone but is not associated with a waste site, and to enhance flushing within the groundwater plume. Bioremediation facilitates growth of biological organisms to create a reducing environment to convert hexavalent chromium into less mobile, less toxic trivalent chromium. Soil flushing with potable water or treated effluent from the pump-and-treat systems, in advance of bioinfiltration, would be used to determine if mobile contamination is present in the vadose zone. Mobilized contamination, if present, will be detected through groundwater monitoring. If contaminants are not mobilized by soil flushing, then bioinfiltration can target remediation of groundwater rather than the vadose zone. Bioinjection and bioinfiltration would also be used to reduce the volume of groundwater that must be treated via IX, thereby increasing the total capacity of the system and reducing operation and maintenance (O&M) costs. Biological treatment would also be used at potential hot spots within the aquifer to create reducing conditions, which may provide for long-term treatment of hexavalent chromium present in low permeability zones that are less amenable to pump-and-treat remediation. A cost effectiveness evaluation will be conducted to support determination to apply biological treatment.

This alternative is designed to operate until the contaminants of concern plumes (Figure 16) are substantially reduced to less than the DWS (assumed to be 2020). Groundwater plumes will be monitored for rebound following achievement of DWS. If rebound occurs, additional vadose zone remedial actions within the scope of actions selected in the ROD (e.g., soil flushing and/or biological treatment) will be evaluated.

During the course of implementing this alternative, the pump and treat system will continue operation to maintain river protection by remediating portions of the plume discharging to the river that remain above AWQS.

The groundwater extracted from within the carbon-14 plume is likely to have carbon-14 concentrations greater than the DWS. Water from these wells will be treated in an air stripper to reduce the carbon-14 to below the DWS prior to re-injection.

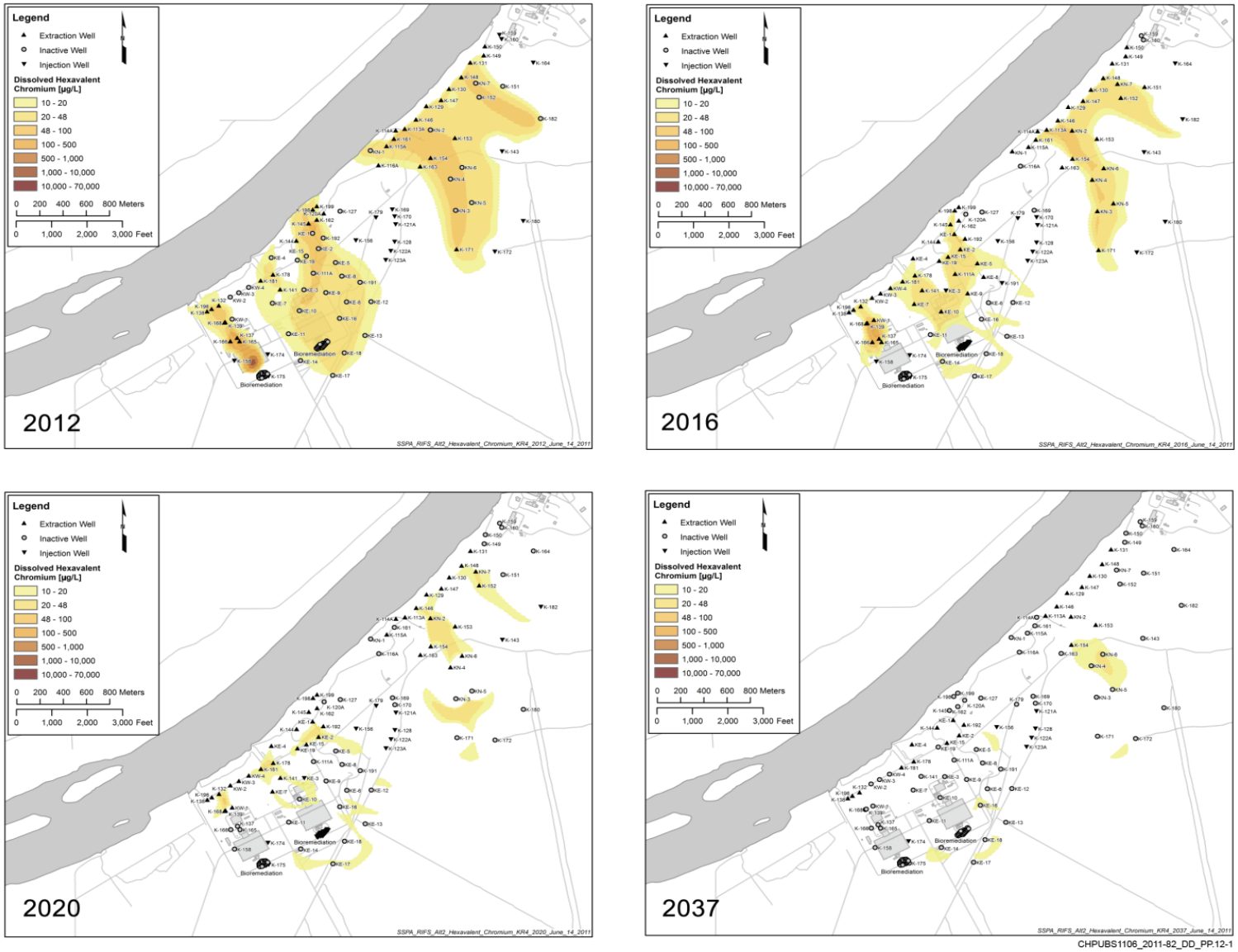

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Figure 16. 100-K Hexavalent Chromium Plumes (2012 through 2037) for Alternative 2

Alternative 3—RTD and Expanded Groundwater Treatment

Alternative 3 uses a strategy of RTD almost exclusively for waste sites to rapidly achieve cleanup requirements with the greatest degree of certainty, as well as expanded pump-and-treat for groundwater (Figure 17). The primary components of this alternative include the following:

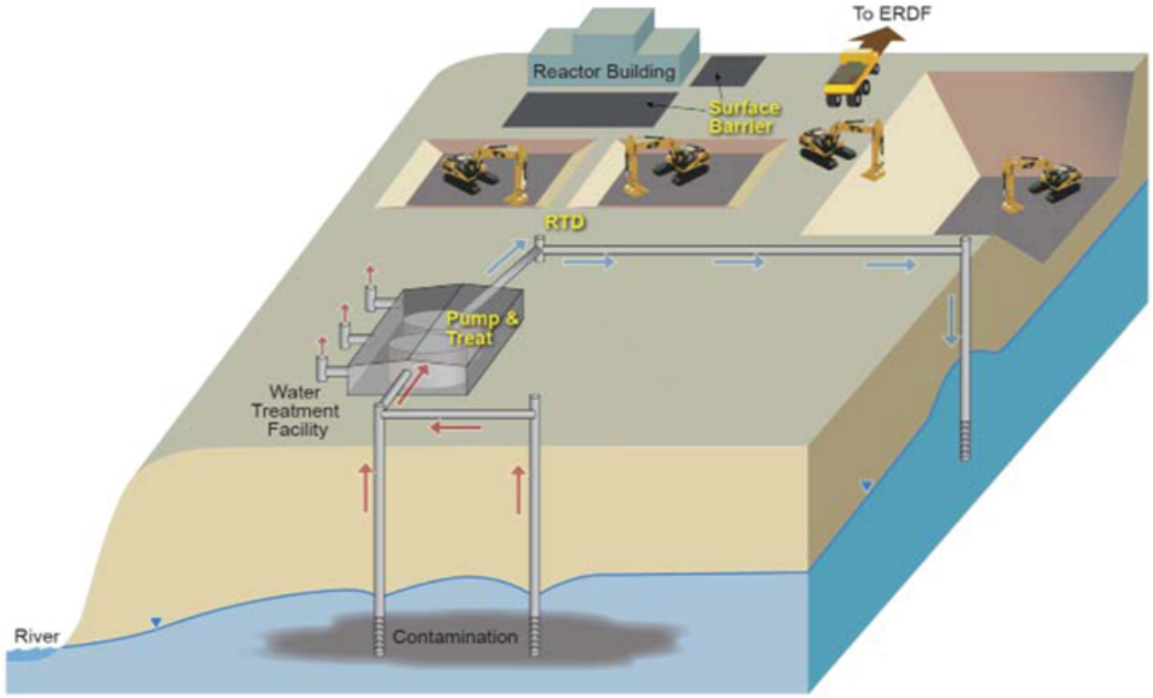
- RTD for waste sites, with excavation until cleanup levels are achieved. RTD would include demolition of structures (e.g., buildings) when necessary.
- Temporary surface barriers for waste sites near the reactors. Once the reactors are removed, the waste site would be addressed using RTD if COCs are still present at concentrations above cleanup levels.
- For contaminants of concern in groundwater, expanded pump-and-treat.
- ICs would be applied as necessary to extend or expand existing land use (land disturbance, excavation, and irrigation restrictions). Warning notices and entry restrictions would be maintained.

The groundwater extracted from within the carbon-14 plume is likely to have carbon-14 concentrations greater than the DWS. Water from these wells will be treated in an air stripper to reduce the carbon-14 to below the DWS prior to re-injection.

Figure 18 shows the layout of the expanded groundwater system, with the modeled hexavalent chromium groundwater plume in December 2012, 2016, 2020, and 2037. The modeling predicts that by 2020, the majority of plumes are below the cleanup levels with only small pockets of chromium remaining at low concentrations.

Alternative 3: RTD and Expanded Groundwater Treatment

Conceptual Schematic



Cost	Waste Site Treatment	Groundwater Treatment	Total
Total Present Value of Alternative (Discounted)	$467,525,000	$247,129,000	$714,654,000
Total Non-Discounted Cost	$812,687,000	$275,810,000	$1,088,497,000

Note: Waste site treatment costs include the cost for institutional controls.

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Figure 17. Alternative 3—RTD and Expanded Groundwater Treatment

Evaluation of Remedial Alternatives

DOE and EPA evaluated each remedial alternative against CERCLA threshold and balancing criteria to assist in identifying a preferred alternative. Following this evaluation, a comparative analysis was performed to assess the overall performance of each alternative relative to the others. Figure 19 presents the nine CERCLA evaluation criteria. The preferred alternative protects human health and the environment, complies with ARARs, and performs best relative to the balancing criteria.

The ability of a preferred alternative to meet the criterion of community acceptance (a modifying criterion) can be completed only after the review and comment period for Tribal Nations and the public, which is initiated with this document.

After completion of the formal public comment period, the Tri-Parties will consider the comments prior to issuing a ROD. The comments that are received (i.e., community acceptance) are part of the modifying criteria, as shown in Figure 19, numbers 8 and 9.

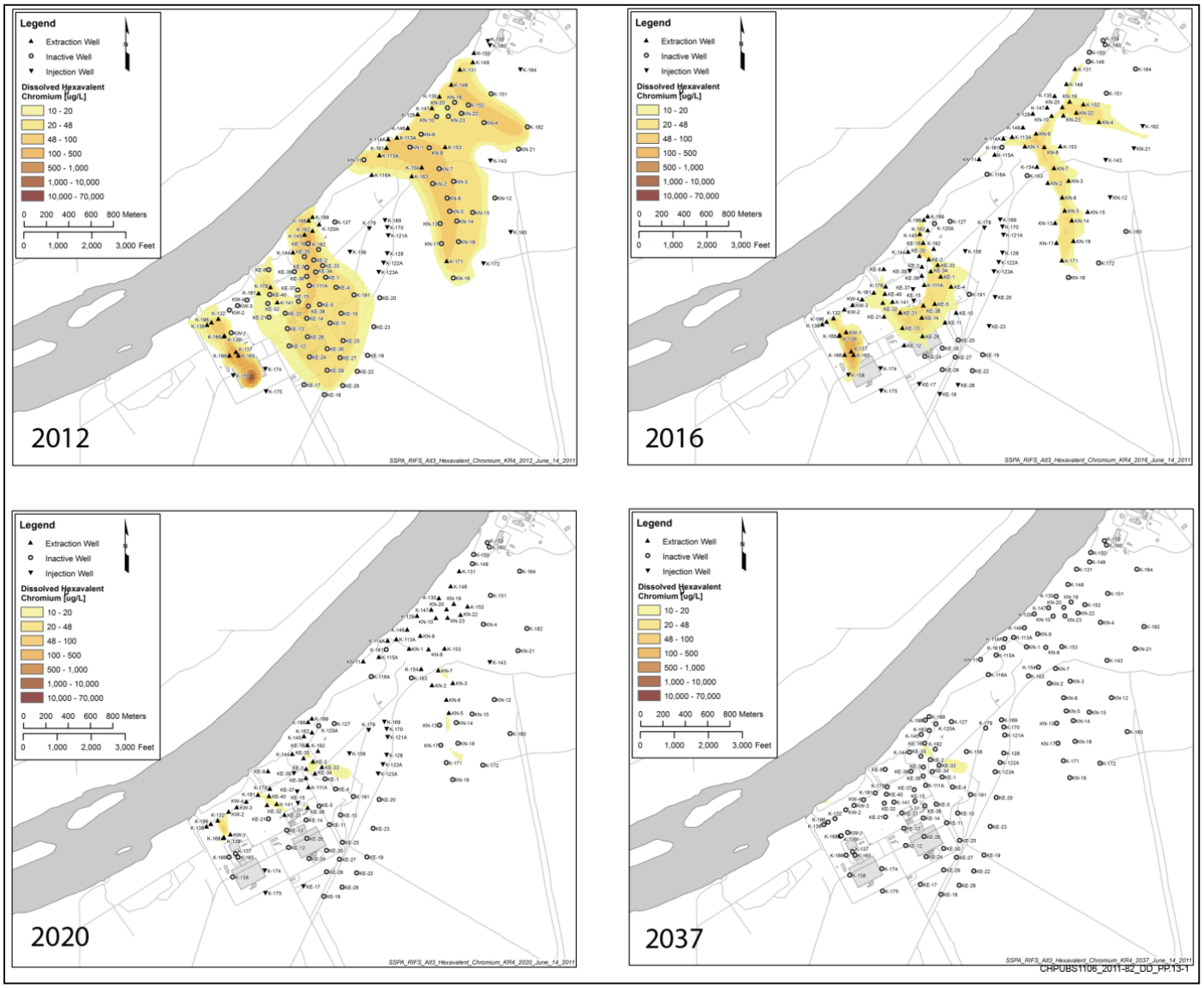

Figure 18. 100-K Hexavalent Chromium Plumes (2012 through 2037) for Alternative 3—RTD and Expanded Groundwater Treatment

Figure 19. CERCLA Evaluation Criteria

The following describes the comparative evaluation of alternatives that was used to identify the preferred alternative. The comparative evaluation is summarized in Table 7.

Table 7. Comparative Evaluation Summary for 100-K Remedial Action Alternatives

Alternatives	Overall Protection of Human Health and the Environment	Compliance with ARARs	Long-Term Effectiveness and Permanence	Reduction in Toxicity, Mobility, and Volume through Treatment	Short-Term Effectiveness	Implementability	Cost (Present Value in $ Million)	
1—No Action	**No**	**No**	**Not Evaluated**				**$0**	
2—RTD and Groundwater Pump-and-Treat Optimized with Other Technologies	Yes	Yes	◉	◉	◉	◉	Waste Sites	$423
							Groundwater	$194
							Total	$617
3—RTD and Expanded Groundwater Treatment	Yes	Yes	◉	◉	○	○	Waste Sites	$468
							Groundwater	$247
							Total	$715

Evaluation Metric:

○ = expected to perform moderately well against the criterion relative to the other alternatives with some disadvantages or uncertainty

◉ = expected to perform very well against the criterion relative to the other alternatives with minor disadvantages or uncertainty

Overall Protection of Human Health and the Environment

Alternative 1 is not protective of human health and the environment because RAOs and ARARs are not achieved in a reasonable time frame.

Alternatives 2 and 3 are expected to comply with all RAOs and, therefore, meet this threshold criterion. Proposed actions for groundwater will be designed to achieve the cleanup levels within a reasonable time frame. For impacted waste sites, treatment alternatives such as RTD, surface barriers, biological infiltration, and others are likely to effectively control or prevent significant risks. Unacceptable risks are also prevented or controlled through implementation of ICs, as needed.

Compliance with Applicable or Relevant and Appropriate Requirements

Following are the key ARARs identified:

Potential Chemical-Specific ARARs. The chemical-specific ARARs that may affect remediation are the elements of the *Washington State Administrative Code* regulations that implement the WAC 173-340, "Model Toxics Control Act – Cleanup." Within this branch of the *Washington Administrative Code*, there are detailed regulations with developing standards for remedial actions involving soil cleanup (WAC 173-340-740, "Unrestricted land use soil cleanup standards") and groundwater cleanup standards (WAC 173-340-720, "Groundwater cleanup standards"). These standards are in the form of risk-based concentrations that help establish soil and groundwater cleanup standards for nonradioactive contaminants.

Additional Washington State and Federal regulations include the following:

- WAC 173-340 (WAC 173-340-360 and WAC 173-340-700 through 7493) (2007)
- Nonzero MCL goals and MCLs promulgated under the *Safe Drinking Water Act of 1975* (SDWA) (40 CFR 141) and/or by the state of Washington (WAC 246-290)
- The AWQC developed under the Clean Water Act (Section 304) and/or promulgated by the state of Washington (WAC 173-200 and WAC 173-201)
- The Toxic Substances Control Act (implemented via 40 CFR 761)
- "National Primary and Secondary Ambient Air Quality Standards" (40 CFR 50)
- "National Emissions Standards for Hazardous Air Pollutants" (40 CFR 61)

Potential Location-Specific ARARs. Potential location-specific ARARs that have been identified include those that protect cultural, historic, and Native American sites and artifacts under the *Native American Graves Protection and Repatriation Act of 1990*, *Archaeological and Historic Preservation Act of 1974*, *National Historic Preservation Act of 1966* (NHPA), and those that protect listed endangered and threatened species or their critical habitat under the Endangered Species Act. The *Migratory Bird Treaty Act of 1918* (MTBA) has been identified as substantive standards for DOE compliance in executive orders and a Memorandum of Understanding between DOE and the U.S. Fish and Wildlife Service, and are a "to-be-considered" for CERCLA response actions when there is a potential to adversely affect protected bird species.

Potential Action-Specific ARARs. Action-specific ARARs that could be pertinent to possible remediation activities relate to waste management activities, solid and dangerous waste regulations (for management of characterization and remediation wastes and performance standards for waste left in place), and radioactive waste management under AEA regulations. The other major category of action-specific ARARs concern standards for controlling emissions to the environment.

Alternative 1 will not comply with groundwater chemical-specific ARARs due to the potential plume migration to the river. Since Alternative 1 neither complies with ARARs nor is it protective of human health and the environment (the two threshold criteria), it was not evaluated for the balancing criteria.

Alternatives 2 and 3 are expected to comply with ARARs and, therefore, meet this threshold criterion. Remedial actions and treatment systems proposed under these alternatives would be designed to meet ARARs. For groundwater, proposed remedies will be designed to achieve DWS and AWQS in a reasonable period.

Long-Term Effectiveness and Permanence

Alternative 2 and 3 both perform well for this criterion. For groundwater, Alternative 3 relies exclusively on pump-and-treat. The adequacy and reliability of pump-and-treat is demonstrated at the Hanford Site through the IRAs. Alternative 2 uses pump-and-treat enhanced with biological treatment. Design testing will be required for the biological treatment component. Alternatives 2 and 3 are expected to achieve DWS and AWQS in a reasonable time. Testing would be required to determine the adequacy and reliability of air stripping. The adequacy and reliability of ICs is also proven at Hanford, but might require long-term enforcement to mitigate risk.

For impacted waste sites, Alternatives 2 and 3 use RTD and disposal at ERDF, which are demonstrated to be adequate, effective, and reliable at the Hanford Site. Alternative 2 optimizes RTD with soil flushing supplemented with biological infiltration for waste sites with risk to groundwater/surface water. Design

testing will be required for biological treatment. Maintenance and potential repair of surface barriers may be required for optimal long-term effectiveness.

Alternatives 2 and 3 propose implementation of monitoring which will evaluate effectiveness of the proposed actions and track progress toward compliance with RAOs. The CERCLA five-year review process will evaluate the effectiveness of the remedy in protecting human health and the environment.

Reduction of Toxicity, Mobility, and Volume through Treatment

For groundwater, Alternatives 2 and 3 provide substantial reduction of TMV through pump-and-treat. Treatment of carbon-14 in groundwater is also included. These alternatives propose treatment through air-stripping where carbon-14 is extracted from groundwater extraction wells greater than the DWS.

For waste sites, Alternative 2 proposes the widest range of technologies. Reduction of TMV through treatment including biological reduction (bioinfiltration and bioinjection), biodegradation (bioventing and land farming), contaminant flushing (soil flushing), and mass transfer (air stripping), as well as physical removal of impacted media (RTD) with treatment, as needed, to meet the waste disposal criteria (RTD). Alternative 2 also proposes soil flushing for sites that exceed surface/groundwater protection for carbon-14 (specifically sites 116-KE-1 and 116-KW-1). Alternative 3 provides less reduction of TMV, by treatment, since it only uses RTD.

Short-Term Effectiveness

Alternative 2 performs better than Alternative 3. The period to meet RAOs is less in Alternative 3 than in Alternative 2; however, this benefit is offset by the greater environmental impacts under Alternative 3. Alternative 3 aggressively relies primarily on RTD for excavation and disposal of contaminated vadose zone soils at ERDF.

The impact to short term effectiveness on the environment is greatest for Alternative 3 during the construction and implementation phase of the remedy. Many large waste site areas will be exposed to the environment, machinery generated dust, the generation of remediation process waste, and considerably more greenhouse gas (GHG) emissions (from excavation equipment and transportation of material to ERDF) than Alternative 2 would produce. Potential impacts to workers and to the environment from implementing any actions onsite would be controlled and mitigated through effective HSPs and adequate PPE.

Alternative 2 better addressed the uncertainties with persistent groundwater contamination source from the vadose zone, periodically rewetted zone, or the unconfined aquifer described in the RI/FS Report (DOE/RL-2010-97) could require additional remedial actions to meet the RAOs. Should persistent groundwater contamination or rebound of contamination in the groundwater beneath a previously remediated site indicate a continuing source within the vadose zone, the site would need to be re-excavated to remove the source under Alternative 3. Alternative 2 includes options to implement other technologies (e.g., soil flushing or biological infiltration) to remediate the source with less environmental impacts.

In addition, if persistent groundwater contamination exists within the unconfined aquifer, Alternative 3 may require installation of additional extraction wells to remediate the groundwater effectively. Alternative 2 provides for biological treatment of groundwater, which could be implemented without need for additional wells.

Both alternatives will have some negative environmental impacts as follows:

- Generation of GHG from use of excavation equipment and disposal to ERDF, installation of temporary surface barriers, operation of pump and treat system.
- Waste generation from disposal of contaminated soil and spent IX resin.
- Energy consumption from process equipment.
- Potential cultural resource impacts.

Alternative 3 will have greater negative environmental impacts due to the larger excavation footprints to achieve additional depths.

Implementability

Alternative 2 performs slightly better than Alternative 3 in that it relies on a broader suite of potential technologies to be employed under the various conditions that will be encountered during the construction phase of the remedy and, therefore, is more likely to be successfully implemented.

Alternative 3 relies only on RTD/excavation and calls for the construction crews to work in and around a large amount of mobile, heavy equipment in a small, consolidated area near the existing reactor buildings. Alternative 3 also involves excavation at depths greater than 4.6 m (15 ft), which presents additional technical challenges relative to Alternative 2. Additional RTD implemented under Alternative 3 will have a greater impact on the ability to implement RTD simultaneously with construction of additional groundwater pump-and-treat facility and wells in the 100-K limited working area.

The required vendors and materials for implementation of Alternative 2 components, such as surface barriers, air stripping, and infiltration/injection activities are readily available, as is the machinery/equipment needed to implement Alternative 3.

For the biological treatment processes, specialized biological reagents would be required, but these are considered readily available. Although biological treatment of hexavalent chromium has been proven, implementation at the Hanford Site would likely require at least laboratory scale treatability testing. While air stripping is a routinely used treatment technology, using it for treating carbon-14 is not routine. Therefore, some amount of laboratory scale treatability testing would be required to determine the adequacy and reliability of air stripping for the treatment of carbon-14 in groundwater.

Cost

Estimated design, construction, O&M, and decommissioning costs were developed for Alternatives 2 and 3. Operation and maintenance costs were estimated based on a 75-year remedial period. The total estimated net present value is $617 million for Alternative 2 and $715 million for Alternative 3. These cost estimates have been prepared to meet the -30 to +50 percent range of accuracy recommended in the CERCLA RI/FS Guidance (EPA/540/G-89/004). No capital or O&M costs are associated with Alternative 1.

Overall, Alternative 2 is more cost-effective than Alternative 3.

Preferred Remedial Alternative

Based on information currently available, DOE and EPA recommend Alternative 2—RTD and Groundwater Pump-and-Treat Optimized with Other Technologies—as the preferred alternative. DOE believes Alternative 2 meets the threshold criteria and provides the best balance of tradeoffs compared with Alternative 3 with respect to the balancing and modifying criteria. DOE expects Alternative 2 to satisfy the following statutory requirements of CERCLA §121(b):

- Protect human health and the environment
- Comply with ARARs
- Be cost-effective
- Use permanent solutions and alternative treatment technologies or resource recovery technologies to the maximum extent practicable
- Satisfy the preference for treatment as a principal element

The recommendation on Alternative 2 as the preferred alternative may change in response to comments received.

National Environmental Policy Act Values

Under DOE's CERCLA/NEPA Policy, DOE relies on the CERCLA process for review of actions to be taken under CERCLA (i.e., no separate NEPA document or NEPA process is ordinarily required [Cook, 2002]). NEPA values are incorporated into DOE's CERCLA documentation (DOE O 451.1.1b, Chg 2, June 25, 2010); NEPA values include (but are not limited to) consideration of the cumulative, ecological, cultural, historical, and socioeconomic impacts of the proposed remedial action. NEPA values were incorporated into the analysis in the respective feasibility studies and the conclusions will be included in the CERCLA ROD.

For the remedies evaluated in this Proposed Plan, environmental impacts include temporary short-term disturbance (e.g., increased traffic, noise levels, and fugitive dust) of approximately 3.1 km^2 (1.2 mi^2, 760 ac) for a disturbed industrial area that has low to marginal habitat quality.

Long-term impacts identified for the remedies include potential aesthetic and visual impacts, should the backfilled areas not be adequately contoured and vegetated to blend with the surrounding area. DOE expects minimal or no long-term impacts to air quality, natural resources, and historical resources; transportation; socioeconomic values; or disadvantaged communities concerned with environmental justice.

RCRA Corrective Action

In accordance with the Tri-Party Agreement, past practice site cleanup (remediation) is intended to satisfy both CERCLA remedial action and RCRA corrective action requirements. In addition to fulfilling CERCLA requirements, this preferred remedial action is intended to fulfill DOE's corrective action obligations under RCRA and Washington State's *Hazardous Waste Management Act.* DOE and EPA agreed that the selected preferred alternative (i.e., remedy) would satisfy the requirements of both CERCLA and RCRA corrective action.

Although this is not a ***Model Toxics Control Act*** cleanup, DOE and EPA have concluded that this Proposed Plan also fulfills its seven standards for a final remedy:

- Protect human health and the environment
- Comply with the cleanup standards
- Comply with applicable state and federal laws
- Provide for compliance monitoring
- Use the permanent solution to the maximum extent practicable
- Provide for a reasonable restoration timeframe
- Consider public concerns

Community Participation

Public input is a key element in the DOE's decision-making process. 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 alternatives. The comment period for this Proposed Plan extends from MM DD, 2011, through MM DD, 2011. Comments on the preferred alternatives, other alternatives, or any element of this Proposed Plan will be accepted through MM DD, 2011. Comments are sent to **Paula Call,** U.S. Department of Energy, Richland Operations Office, at the following address:

Mail: P.O. Box 550, A7-75
Richland, WA 99352
Email: 100KRPP@rl.doe.gov

At this time, no public meeting has been scheduled. To request a meeting in your area, please contact Paula Call no later than MM/DD/YYYY.

After the comment period, DOE will consider the comments regarding the Proposed Plan and information gathered during the comment period and then make a decision. The preferred alternatives could be modified or another alternative selected. DOE and EPA will then prepare a CERCLA ROD. This ROD will identify the chosen alternative (i.e., remedy) and include a responsiveness summary containing agency responses to the comments received during the comment period.

(Month) Comment Period						
SUN	MON	TUE	WED	THU	FRI	SAT
	1	2	3	4	5	6
7	8	9	10	11	12	13
14	15	16	17	18	19	20
21	22	23	24	25	26	27
28	28	30	31			

Hanford Public Information Repository Locations

Administrative Record and Public Information Repository:
2440 Stevens Center Place,
Room 1101, Richland, WA
Phone: 509-376-2530
Web site address:
http://www2.hanford.gov/arpir/

Portland
Portland State University
Bradford Price and Millar Library
1875 SW Park Avenue
Portland, OR
Attn: Liz Paulus (503) 725-4542
Map: http://www.pdx.edu/map.html

Seattle
University of Washington
Suzallo Library
Government Publications Division
Seattle, WA
Attn: David Maack (206) 543-4664
Map: http://tinyurl.com/m8ebj

Richland
U.S. Department of Energy
Public Reading Room
Washington State University,
Tri-Cities Consolidated Information Center,
Room 101-L
2770 University Drive, Richland, WA
Attn: Janice Parthree (509) 372-7443
Map: http://tinyurl.com/2axam2

Spokane
Gonzaga University Foley Center
East 502 Boone, Spokane, WA
Attn: John Spencer (509) 323-6110
Map: http://tinyurl.com/2c6bpm

Glossary

Administrative Record: The collection of information, including reports, public comments, and correspondence, used by the Agencies to select or modify an interim or final remedial action. A list of locations where the Administrative Record is available appears in the Community Participation section of this Proposed Plan.

Air Stripping: For removal of carbon-14 from groundwater. Water is passed through an air stripper where air is injected and strips out volatile compounds or carbon dioxide from the water phase. The stripper maybe a packed tower, tray stripper, or similar device.

Ambient Water Quality Standard: the 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): ARARs represent the body of federal and state laws, regulations, and standards governing environmental protection and facility siting that are either applicable or relevant and appropriate for the situation and must be met when cleaning up sites.

Baseline Risk Assessment: A study that identifies which contaminants are present in an area and assesses the risk they pose to human health and the environment if no remedial action is taken.

Bioventing: Process that stimulates the natural biodegradation of aerobically degradable compounds in soil by providing oxygen to existing soil microorganisms. Bioventing uses low air flow rates to provide only enough oxygen to sustain microbial activity.

Bioremediation: Addition through infiltration or injection of biological carbon source (e.g., molasses, sodium lactate, emulsified oil, butane) to the subsurface to treat contaminants within vadose zone (infiltration) or groundwater (injection).Bioremediation facilitates growth of biological organisms to create a reducing environment to convert hexavalent chromium into less mobile, less toxic trivalent chromium.

Community Relations Plan: The Community Relations Plan outlines the public participation processes implemented by the Tri-Parties under authority of the Tri-Party Agreement, and identifies several ways the public can participate in the Hanford Site cleanup decision-making process.

***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 may have been released (e.g., leaked, spilled, or dumped) to the environment.

Contaminants of Potential Concern (COPCs): COPCs are hazardous substances that have been found, or are likely to be present in waste site or groundwater operable units that could cause adverse health effects to receptors. The effects depend on the amount of the contaminant present, the toxicity of the contaminant, and the way the contaminant is 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 human health and the environment.

Contaminants of Concern (COCs): Contaminants of Concern (COCs) are those contaminants which have been shown through analysis to be those that are likely to be causing risk.

Debris: Building or construction material that has been demolished.

Drinking Water Standard (DWS): the maximum allowable concentration of a chemical or radionuclide constituent in drinking water that is protective of human health. The DWS, which are described in 40 CFR 141, are also known as maximum contaminant levels (MCLs).

Environmental Restoration Disposal Facility (ERDF): is the Hanford Site's state and federally approved disposal facility for most hazardous (radioactive and nonradioactive) waste and contaminated environmental media generated under a CERCLA response action.

Excess Lifetime Cancer Risk (ELCR): An individual experiencing the reasonable maximum exposure has (for the Hanford Site) a less than 1 in 10,000 chance of developing cancer as a result of site-related exposure.

Extraction Well: A well designed to pump groundwater from the aquifer to a treatment system.

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

Hazard Index (HI): means the sum of two or more hazard quotients for multiple hazardous substances and/or multiple exposure pathways.

Hazard Quotient (HQ): A hazard quotient is a numerical expression that indicates whether the concentration of a chemical is likely to result in specific non-carcinogenic effects.

Injection Well: A groundwater well designed to receive water from a pump-and-treat system.

Institutional Controls (IC): Administrative measures to protect human health and the environment from exposure to contamination. Institutional controls are maintained until requirements are met for safe, unrestricted land use.

Interim Remedial Action: remedial actions implemented prior to final remedy selection designed to address immediate risks to human health and the environment.

Land Farming: Soil tilling and adding moisture and an amendment to stimulate natural degradation at shallow depths. Organic compounds are degraded by indigenous or inoculated microorganisms.

***Model Toxics Control Act*:** The Model Toxics Control Act (RCW 70.105D) provides state standards that set cleanup regulations (WAC 173-340) for protection of human health and the environment. The standards and requirements established to implement the Act are published in Chapter 173-340 of the *Washington Administrative Code*.

***National Environmental Policy Act of 1969* (NEPA):** The National Environmental Policy Act is a U.S. 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.

"National Oil and Hazardous Substances Pollution Contingency Plan" (NCP): The first National Contingency Plan was developed and published in 1968 to cope with potential spills in U.S. waters. Following the passage of Superfund legislation in 1980, the NCP was expanded to include the regulations covering releases at hazardous substance sites. In 1994, the NCP was revised to mirror the oil spill provisions of the *Oil Pollution Act of 1990*.

National Priorities List (NPL): A formal list of release/priority hazardous waste sites in the United States that are eligible for investigation and possible remediation (cleanup) under Superfund, also known as CERCLA (40 CFR 300, Appendix B). Sites are included on the list because of their potential risk to human health and the environment. The NPL is available on the Internet at http://www.epa.gov/superfund/sites/npl/.

No Action: Sites that can be released for unrestricted land use because they pose no unacceptable risk. A No Action alternative is required to be considered under CERCLA. It can include monitoring.

Operable Unit: A group of land disposal sites placed together for performing a remedial investigation and feasibility study and subsequent cleanup actions. The primary criteria for placing a site into an operable unit include geographic proximity, similarity of waste characteristics and site type, and the possibility for economies of scale.

Post-ROD To-Go Sites: Waste sites for which remedial actions will not be started until after the ROD is issued.

Pre-ROD To-Go Sites: Waste sites that are to be remediated under the Interim Action ROD (EPA/541/R-99/039), or are anticipated to be by the time the ROD is issued.

Preferred Alternative: The remedial action recommended, following an evaluation of all alternatives, that meets CERCLA threshold criteria (protection of human health and the environment and compliance with ARARS) and performs best with respect to the CERCLA balancing criteria.

Preliminary Remediation Goal (PRG): An ARAR specified or risk-based concentration for a contaminant that is protective of human health and/or the environment for a specified exposure pathway. PRGs are established during the feasibility study based on scientific information and are used as a target for remedial cleanup levels. Alternatives are developed and evaluated based on how well they meet PRGs. Final cleanup levels are set in the record of decision and are used during the remediation of a site.

Proposed Plan: Proposed Plans are provided to the Tribal Nations and the public by the responsible parties to present the preferred alternative and other alternatives analyzed for remedial actions at specific waste sites. Proposed Plans are based on the remedial investigation/feasibility studies for specific sites.

Pump-and-treat: A technology that extracts contaminated groundwater and treats contaminants with an assortment of specific technologies to meet cleanup levels.

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, prolonged exposure may be harmful.

Record of Decision (ROD): A legally binding public document that identifies the selected remedy to be used at a group of sites and why it was chosen. The Responsiveness Summary in the ROD contains public comments received on the Proposed Plan and the Agencies' responses.

Remedial Action Objective (RAO): A medium-specific (e.g., soil) or operable unit specific goal that describes what the remedial action is expected to accomplish. RAOs generally specify the contaminant(s) of concern, the exposure route(s), and receptor(s).

Remedial Alternatives: General or specific actions that are evaluated to determine the extent to which they can eliminate or minimize threats posed by contaminants to human health and the environment, comply with environmental laws and regulations, and meet other selection criteria.

Remedial Investigation/Feasibility Study (RI/FS): The RI/FS process as outlined in this Proposed Plan represents the methodology that the Superfund program has established for characterizing the nature and extent of risks posed by uncontrolled hazardous waste sites and for evaluating potential remedial action options.

Remedial Action: Actions performed to reduce potential harm to human health and the environment from radioactive or hazardous substances.

Remove, Treat, and Dispose (RTD): A cleanup method where soil and debris are excavated in such a way that no contaminants above the approved remedial action goals or concentration for direct exposure and groundwater protection remain at the site. Excavated material is treated (as necessary) and sent to an onsite or offsite engineered facility for disposal.

Tri-Parties: The Tri-Parties is 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 U.S. Department of Energy (DOE), U.S. Environmental Protection Agency (EPA), and Washington State Department of Ecology (Ecology) signed the *Hanford Federal Facility Agreement and Consent Order*, or Tri-Party Agreement, on May 15, 1989. The Tri-Party Agreement, as updated and modified through formal change control, is a comprehensive cleanup and compliance agreement for achieving compliance with the CERCLA remedial action provisions and with the *Resource Conservation and Recovery Act of 1976* (RCRA) treatment, storage, and disposal unit regulations and corrective action provisions. More specifically, the Tri-Party Agreement defines and prioritizes CERCLA and RCRA cleanup commitments, establishes responsibilities, provides a basis for budgeting, and reflects a converted goal of achieving full regulatory compliance and remediation, with enforceable milestones.

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

Waste Sites: Waste sites are contaminated or potentially contaminated sites from past Hanford Site operations. Contamination may occur in environmental media (e.g., soil, groundwater) or in manmade structures (facilities) or in solid waste (e.g., debris).

Waste Information Data System (WIDS): and electronic database maintained by DOE that provides interactive access to potential, rejected, accepted, and remediated waste sites.

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