HANFORD SITE

Third CERCLA Five-Year Review Report





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

U.S. DEPARTMENT OF ENERGY | Richland Operations Office

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Executive Summary

The Hanford Site was established in 1943 to produce nuclear materials for national defense. Many production activities resulted in the disposal of wastes containing hazardous constituents and/or radioactive materials. As a result, in July 1989, the U.S. Environmental Protection Agency (EPA) placed four sites (100, 200, 300, and 1100 Areas) of the Hanford Site on the National Priorities List (NPL) pursuant to the *Comprehensive Environmental Response, Compensation, and Liability Act* (CERCLA) (42 USC §9601 et seq.).

In anticipation of the NPL listing, the U.S. Department of Energy (DOE), EPA, and Washington State Department of Ecology (Ecology) entered into the *Hanford Federal Facility Agreement and Consent Order* (Tri-Party Agreement [TPA]) in May 1989. This agreement established a procedural framework and schedule for developing, implementing, and monitoring CERCLA response actions on the Hanford Site. The agreement also addresses *Resource Conservation and Recovery Act of 1976* (RCRA) compliance and permitting. The TPA is a legally binding agreement between the DOE, EPA, and Ecology that establishes the guidelines and framework for achieving the cleanup of the Hanford Site. Since the Hanford Site was placed on the NPL, DOE has made considerable cleanup progress.

For waste sites where hazardous substances, pollutants, or contaminants remain at the site above levels that allow for unlimited use and unrestricted exposure, CERCLA requires a review every five years to evaluate the implementation and performance of a remedy in order to determine if the remedy is or will be protective of human health and the environment. The five-year review requirement applies to all remedial actions selected under CERCLA §121. The methods, findings, and conclusions of the five-year reviews are documented in the five-year review report.

The *USDOE Hanford Site First Five-Year Review Report* documented the results of the first Hanford Site CERCLA five-year review completed by EPA Region 10 in September 2000. This report covered all portions of the Hanford Site with a CERCLA decision document and covered areas that contain hazardous substances, pollutants, or contaminants, which are to be remediated under CERCLA.

The Second CERCLA Five-Year Review Report for the Hanford Site (DOE/RL-2006-20) documented the results of the second CERCLA five-year review completed by DOE in November 2006. The report evaluated the performance of the CERCLA remedies selected in interim record of decisions (RODs), including existing institutional controls in place to prevent exposure to the public and the environment.

This report presents the five-year review of response actions at the Hanford Site implemented under the CERCLA and TPA. The purpose of this review is to evaluate implementation and performance of remedies at the Hanford Site to determine whether they are—or will be—protective of human health and the environment. This report documents the results of the third CERCLA five-year review completed by DOE in November 2011. DOE established September 30, 2010, as the end date for the inclusion of newly issued decision documents in this review. This report presents the five-year review of CERCLA response actions initiated, in progress, or completed at the DOE Hanford Site where the action resulted in hazardous substances, pollutants, or contaminants remaining on site above levels that allow for unlimited use and unrestricted exposure. DOE applied the same approach to conduct this five-year review as used in the previous two five-year reviews. This Third Five-Year Review follows the EPA and DOE guidance on how to conduct five-year reviews. The following summarizes the results of the review conducted by DOE.

100 Area NPL Site. The 100 Area NPL site contains six reactor areas (three of which contain two reactors each and three that contain one reactor each). While in operation, the nine reactors disposed of cooling water and both liquid and solid wastes in over 400 waste sites, trenches, cribs (underground drain fields), ponds, and burial grounds in the 100 Area. In addition, leaks in the reactors' wastewater piping and retention systems led to soil and groundwater contamination. The 100 Area has approximately 11 square miles (28.5 square kilometers [km^2]) of contaminated groundwater and waste disposal locations.

Final RODs have not been issued for operable units (OUs) included in the Hanford Site 100 Area NPL Site; however, eight interim action RODs have been issued and remedial investigation/feasibility studies (RI/FS) are being developed in support of the final RODs. Based on additional characterization, these interim action

RODs have been amended for several reasons, including amendments to address contaminants not previously included in the interim action ROD, to include additional waste sites for remediation, and to add new remediation technologies not originally identified by the interim action ROD. Explanations of Significant Difference (ESDs) were issued to modify the interim action ROD when DOE determined that the changes were not significant enough to require a formal interim action ROD amendment. Five of the interim action RODs in the 100 Area address soil contamination, one-interim action ROD addresses K-Basins spent fuel removal, and the other two interim action RODs address contaminated groundwater. Eighteen (18) additional CERCLA removal action decision documents, including 11 action memoranda, and 7 expedited response action approvals, have been issued to address the demolition of buildings and structures, contaminated soil removal, groundwater treatment, and landfill cleanup in the 100 Areas.

In the 100 Areas, the waste site or source interim actions are meeting the removal and interim remedial action objectives. Removal actions, primarily consisting of the demolition of buildings and placing old reactors in an 'interim safe storage' condition, have met the removal action goals as outlined in the action memoranda. During the five-year review period, approximately 135 of the waste sites in the 100 Area NPL site have been remediated to meet the cleanup levels established in the interim action RODs or action memoranda since the last five-year review. The groundwater contaminant plumes in some areas have not been addressed yet; however, all 100 Areas groundwater will be addressed in future RODs.

The review determined that most of the groundwater interim actions in the 100 Area are meeting the remedial action objectives established in the interim action RODs. However, the strontium-90 groundwater plumes at the 100-N Area and chromium removal at 100-H/D Area are exceptions. In the September 2010 interim action ROD Amendment, *Interim Remedial Action Record of Decision for the 100-NR-1/NR-2 Operable Units of the Hanford 100-N Area*, revised the selected interim remedial action for the strontium-90 remedy in the 100-NR-2 Groundwater OU, because the performance monitoring conducted while the pump-and-treat system was in operation confirmed the system's limited effectiveness in removing strontium-90 from the aquifer. This interim action ROD Amendment altered the selected remedy; the apatite permeable reactive barrier will be extended to a length of approximately 2,500 feet (760 meters), immediately adjacent and parallel to the Columbia River. This will provide increased protection of the Columbia River by immobilizing, and therefore, removing strontium-90 from the groundwater before it enters the river. The strontium-90 will remain bound within the permeable reactive barrier's apatite matrix where it will naturally decay to levels below the remedial action goal of 8 picocuries per liter (pCi/L). The apatite permeable reactive barrier will complement the existing interim remedial actions (institutional controls to control land and groundwater use, free-phase hydrocarbon removal, and groundwater monitoring) that are underway or have already been completed in the 100-NR-2 Groundwater OU. A protectiveness determination of the remedy cannot be made at this time until further information is obtained by completing the *Jet Injection Design Optimization Study for 100-NR-2 Groundwater Operable Unit* (DOE/RL-2010-68). With the completion of the optimization study and selection of the final remedy, a protectiveness determination will be made. It is expected that completion of the design optimization will take approximately two years to complete.

Two interim action remedies are currently operating in the 100-HR-3 Groundwater OU. These include the original 100-HR-3 pump-and-treat system in the 100-H Area (which treats groundwater from both the 100-D and 100-H Areas), the 100-DR-5 pump-and-treat system in the 100-D Area, and the In Situ Reduction-Oxidation Plant (REDOX) Manipulation barrier in the 100-D Area. In 2010, an RI/FS work plan addendum for the 100-D/H Area (DOE/RL-2008-46, Addendum 1) and the sampling and analysis plan (DOE/RL-2009-40) were issued by DOE-Richland Operations Office (DOE-RL) and approved by Ecology. The documents identify the data to be collected to support selection of the final remedies under CERCLA, and integrate data needs for waste sites and groundwater. The final remedy is expected to be protective of human health and the environment upon completion of the final remedy. The current interim actions ensure that exposure pathways that could result in unacceptable risks are being controlled. The *Draft River Corridor Baseline Risk Assessment Volume II Human Health Risk Assessment* issued in December 2010 (DOE/RL-2007-21, Part I, and DOE/RL-2007-21, Part II), provides risk information that will be used to support development of final cleanup decisions in the River Corridor.

200 Area NPL Site. The 200 Area NPL site contains numerous waste sites, contaminated facilities, and groundwater contamination plumes. To facilitate cleanup, these wastes sites, and contaminated facilities were divided into OUs, which have a geographic basis and include soil waste sites, structures, pipelines, and groundwater plumes. The Hanford 200 Area NPL site has four RODs in place; one interim action ROD for the 200-UP-1 Groundwater OU and one final action ROD for 200-ZP-1 Groundwater OU to address groundwater contaminants, and two RODs to address the Environmental Restoration Disposal Facility (ERDF) and contaminated soil removal at the 221-U Facility (Canyon Disposition Initiative). DOE has also issued nine action memoranda for removal actions. The ERDF facility is operating as required to meet the objectives outlined in the ROD for disposing of waste from all Hanford CERCLA activities. The first phase of the remedial actions covered by the September 2005, 221-U Facility ROD, have been implemented. Implementation of the first phase included preparation and grouting of the below grade portions of the canyon. In addition, the completed removal actions performed under the nine action memoranda, are meeting the removal action objectives (i.e., removal of the 232-Z Facility). These OUs are prioritized and scheduled for cleanup in accordance with the TPA. The RI/FSs for the reorganized 200 Area Source (soil) OUs are being developed.

RODs have not been issued for 200-PW-1, 200-PW-3, 200-PW-6, and 200-CW-5 OUs. The 200-PW-1 Source OU removal action uses a soil vapor extraction system to remove carbon tetrachloride from the soil above the 200-ZP-1 groundwater OU. This removal action has proven to be effective and will continue; and the actions for the soil cleanup will be addressed as part of the 200-PW-1 OU. A protectiveness determination of the remedy at 200-PW-1 OU cannot be made at this time until further information is obtained by completing the RI/FS process and selecting a final remedy. However, based on information to date, the removal actions will be consistent with the final remedies selected through the RI/FS and ROD processes.

Two of the four groundwater OUs (200-UP-1 and 200-ZP-1) in the 200 Area NPL have decisions in place. Each OU has their own plans of study and enforceable schedules to define the necessary groundwater cleanup actions across the 200 Area NPL site's Central Plateau. The 200-UP-1 Groundwater OU interim action uses a pump-and-treat system to remove uranium and technetium-99 from the groundwater near U Plant. The interim action ROD (EPA/ROD/R10-97/048) was amended by the *Explanation of Significant Differences for the Interim Action Record of Decision for the 200-UP-1 Groundwater Operable Unit* in 2009. The amended interim action ROD updates the remedial action objective for uranium to 300 micrograms per liter (µg/L) from 480 µg/L. The amendment also requires the installation of a pump-and-treat system to address the technetium-99 at the S/SX Tank Farm area. Construction of the S/SX pump-and-treat is underway and is scheduled to be completed in December 2011.

The 200-ZP-1 Groundwater OU interim remedial action pump-and-treat System has operated since 1994 to prevent carbon tetrachloride from spreading in the 200-ZP-1 Groundwater OU in accordance with the ROD for the *Hanford 200 Area NPL Site Interim Remedial Measure* (EPA/ROD/R10-95/114) issued in 1995. The selected remedy for the 200-ZP-1 Groundwater OU combined pump-and-treat (for the concentrated shallow portion of the plume), monitored natural attenuation, flow-path control, and institutional controls. The 2008 final *Record of Decision Hanford 200 Area 200-ZP-1 Operable Unit Superfund Site* expanded the interim remedial measure pump-and-treat system by adding additional extraction wells between fiscal year 2005 (FY05) and FY08 to addresses the entire extent of the carbon tetrachloride plume plus other contaminants of concern. More than 24,000 pounds (10,900 kilograms) of carbon tetrachloride have been removed from groundwater and treated since 1994. The interim remedial measure will continue to operate until such time that the new system comes on-line, which is expected to occur by December 2011. A protectiveness determination of the remedy at 200-ZP-1 Groundwater OU cannot be made at this time until further information is obtained after the final pump-and-treat remedy has been constructed and is operational.

300 Area NPL Site. The 300 Area NPL site is located along the Columbia River north of the Richland, Washington, city limits in the southeast portion of the Hanford Site. The 300 Area NPL site consists of three OUs: 300-FF-1; 300-FF-2; and 300-FF-5 OUs. The 300 Area includes a 0.52 square miles (1.35 km^2) industrial complex area that was used for uranium fuel fabrication and research and development activities for the Hanford Site. The 300 Area NPL Site includes an unlined liquid disposal area north of the industrial complex area, landfills, and miscellaneous disposal sites associated with operations in the industrial complex.

The 300-FF-1 and 300-FF-2 OUs address contaminated soil, debris, and landfills associated with 300 Area operations, and the 300-FF-5 OU covers the contaminated groundwater under the 300-FF-1 and 300-FF-2 OUs.

CERCLA decision documents for the 300 Area include one ROD (EPA/ROD/R10-96/143) selecting final actions for contaminated soil waste sites in 300-FF-1 OU, and interim actions for groundwater in the 300-FF-5 OU; one interim action ROD (EPA/ROD/R10-01/119) for contaminated soil remediation in 300-FF-2 OU; one expedited response action approval; and four action memoranda. The primary cleanup actions in progress, or that are planned to be performed, are to remove, treat if necessary, and dispose of contaminated soil, debris, piping, landfills, and engineered structures; and decontamination and/or demolition of buildings.

Remedial actions selected in the 300-FF-1 ROD (EPA/ROD/R10-96/143) were completed and a remedial action report was issued documenting the completion. The remedy is considered protective of human health and the environment because cleanup standards were met and are within the acceptable risk range.

The 300-FF-2 OU cleanup activities identified in the interim action ROD (EPA/ROD/R10-01/119) for contaminated soil remediation are still in progress at waste sites, as well as demolition of surplus facilities in the 300 Area. The final remedy at 300-FF-2 is expected to be protective of human health and the environment upon completion of the final remedy. The current interim actions ensure that exposure pathways that could result in unacceptable risks are being controlled.

Source removal actions in the 300 Area to remediate contaminated soil waste sites through the remove, treat, and dispose remedy were, and are, designed to be consistent with final cleanup actions, including applicable or relevant and appropriate requirement (ARARs). It is anticipated that the residual human health and environmental risks from these waste sites will achieve the required risk levels when the removal action is completed. For these areas, additional final remedial actions are not anticipated; therefore, the remedy is expected to be protective of human health and the environment, and in the interim, exposure pathways that could result in unacceptable risks are being controlled until a final remedy is selected through the RI/FS process. There is no evidence of ecological harm; however, DOE is conducting an ecological risk assessment to verify that any residual risks have been adequately addressed. Draft C of the *River Corridor Baseline Risk Assessment Volume II Human Health Risk Assessment* was issued in December 2010 (DOE/RL-2007-21, Part I, and DOE/RL-2007-21, Part II), and provides risk information that will be used to support development of final cleanup decisions in the River Corridor.

The 300-FF-5 OU includes groundwater contamination originating from waste sites identified in the 300-FF-1 and 300-FF-2 OUs. Groundwater contamination originating from waste sites in the 200 Area NPL migrating beneath the 300 Area NPL Site are not included in the 300-FF-5 OU. The remediation approach identified in the interim action ROD (EPA/ESD/R10-00/524) for contaminated groundwater in the 300 Area is to monitor the groundwater to ensure that contamination levels are attenuating through natural processes in a reasonable time. Therefore, the remedy at 300-FF-5 Groundwater OU is not protective because the interim remedy selected of monitoring the expected attenuation of the uranium is not predicted to meet the groundwater cleanup standards. As a result, the remedial actions and remedial action objectives for the final remedy are being evaluated. Further information will be obtained by completing the *River Corridor Baseline Risk Assessment*. It is expected that these actions will be completed by 2016, at which time a protectiveness determination will be made. In April 2010, the *300 Area Remedial Investigation/Feasibility Study Sampling and Analysis Plan for the 300-FF-1, 300-FF-2 and 300-FF-3 Operable Units*, DOE/RL-2009-45 was issued. In the interim, exposure pathways that could result in unacceptable risks are being controlled. Institutional controls are in place preventing the use of the groundwater. Selection of more effective remedies is anticipated in the near future.

1100 Area NPL Site. The remedial actions selected for the 1100 Area OUs have been completed; the 1100 Area NPL Site was deleted from the NPL List in 1996. The remedy selected remains protective of human health and the environment. Asbestos waste disposed in the Horn Rapids Landfill is still in place and remains secure. DOE will continue to maintain the integrity of the cap and fencing at the Horn Rapids Landfill per the Superfund Site Closeout Report requirements. Because contamination was left in place, the 1100 Area will continue to be included in future five-year reviews. An ESD for the Hanford 1100 Area ROD was issued in September 2010, to modify the institutional controls requirements to be consistent with the current EPA guidance.

Issues and Actions. During the course of conducting this review, some issues were noted and corrective actions identified. A summary of the issues and follow up actions is provided in Table 1.

Table 1 combines two of the tables recommended in the *EPA Comprehensive CERCLA Five-Year Review Guidance*, Listing Issues, Listing Recommendations, and Follow-up Actions tables. The table for Listing Issues includes columns for addressing whether the issue(s) affects current or future protectiveness. The table for Listing Recommendations and Follow-up Actions also has columns for addressing whether the recommendations or actions affect current or future protectiveness; the combined table includes those same columns. In addressing whether the issues and recommendations or actions affect protectiveness, DOE asked two questions:

Does this issue/action currently affect the protectiveness of the remedy?

Will this issue/action affect the protectiveness of the remedy in the future?

Protectiveness Statements. The completed interim remedies at the Hanford Site are protective of human health and the environment except for certain groundwater constituents in the 100 Areas (strontium-90 and chromium). Final remedies are expected to be protective of human health and the environment upon completion, and, in the interim, exposure pathways that could result in unacceptable risks are being controlled. The remedies comply with the decision documents and are functioning as intended. Data used to determine the protectiveness is referenced in this report and hyperlinked to the document location in the Hanford Site Administrative Record. The data includes the physical condition of the site, inspections, groundwater monitoring information, closure verification reports, waste acceptance criteria, and compliance documentation for the requirements set forth in RI/FS documents.

Table 1. CERCLA Five-Year Review Issues and Actions

Issues and Actions	Affects Current Protectiveness[1] (Yes / No)	May Affect Future Protectiveness[2] (Yes / No)	TPA Lead Regulator	Action Due Date
100 Area				
Issue 1. Permeable reactive barrier test has not been conducted in the upper vadose zone.	No	Yes		
Action 1.1. Initiate permeable reactive barrier test to determine implementability and effectiveness of the sequestration technology.	No	Yes	Ecology	9/30/2015
Issue 2: Recent data indicates a low spot in the surface of the Ringold Upper Mud in the 100-HR-3 OU that may trap hexavalent chromium in the aquifer, which in combination with a likely continuing vadose source of hexavalent chromium at the adjacent 100-D-100 waste site results in persistent hexavalent chromium concentrations in groundwater southeast of the 182-D Reservoir	No	Yes		
Action 2.1: Remove, treat, and dispose of the chromium source discovered in the deep vadose zone at 100-D-100.	No	Yes		4/30/2014
Issue 3: Leakage and spills from the 182-D Reservoir and export water system may contribute to movement of contaminants into the vadose zone.	No	Yes		
Action 3.1: Complete the engineering export water scoping study to evaluate whether the 182-D Reservoir and export water system is necessary to support the Hanford Cleanup Mission.	No	Yes		3/31/2012
300 Area				
Issue 4. Remediation approach in interim action ROD (EPA/ESD/R10-00/524) for natural attenuation is not effective in meeting groundwater remediation goals in the 300 Area.	Yes	Yes		
Action 4.1. Submit proposed plan for a ROD to support meeting groundwater remediation goals.	Yes	Yes	EPA	12/31/2011

[1]Does this issue/action currently affect the protectiveness of the remedy?

[2]Will this issue/action affect the protectiveness of the remedy in the future?

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Acronyms

AEA	Atomic Energy Act
AR/PIR	Administrative Record/Public Information Repository
ARAR	applicable or relevant and appropriate requirement
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act of 1980
CFR	Code of Federal Regulations
CY	Calendar Year
D&D	decontamination and decommissioning
DDT	dichlorodiphenyl trichloroethane
DOE	U.S. Department of Energy (also USDOE)
DOE-ORP	U.S. Department of Energy, Office of River Protection
DOE-RL	U.S. Department of Energy, Richland Operations Office
DWS	Drinking Water Standard
Ecology	Washington State Department of Ecology
EE/CA	Engineering Evaluation/Cost Analysis
EPA	U.S. Environmental Protection Agency
ERDF	Environmental Restoration Disposal Facility
ESD	explanation of significant differences
FFTF	Fast Flux Test Facility
FY	fiscal year
km	kilometer
LLWMA	Low-Level Waste Management Area
MCL	maximum contaminant level
MCLG	maximum contaminant level guidelines
mg/L	milligrams per liter
mrem	millirem
MTCA	Model Toxic Control Act
NPL	National Priorities List
OU	Operable Unit
pCi/L	picocuries per liter
PFP	Plutonium Finishing Plant
ppm	parts per million
PUREX	Plutonium/Uranium Extraction (Plant)
RCRA	Resource Conservation and Recovery Act of 1976
RD/RA	Remedial Design/Remedial Action
REDOX	reduction/oxidation (Plant)
RI/FS	remedial investigation/feasibility study
RFI/CMS	RCRA facility investigation/corrective measures study
ROD	record of decision
SDWA	Safe Drinking Water Act
TPA	Hanford Federal Facility Agreement and Consent Order, aka Tri-Party Agreement
TSD	treatment, storage, and disposal
µg/L	micrograms per liter
USC	United States Code
WAC	Washington Administrative Code
WMA	waste management area

1 INTRODUCTION

This report presents the five-year review of response actions at the DOE Hanford Site in accordance with CERCLA (42 USC §9601 et seq.) and the TPA. The purpose of a five-year review is to evaluate the implementation and performance of a remedy in order to determine if the remedy is or will be protective of human health and the environment. The methods, findings, and conclusions of the five-year reviews are documented in this report. This report also identifies any issues found during the review and associated actions to address the issues.

1.1 Authority

The Hanford Site is a federal facility managed by DOE. Through Executive Order 12580, the President of the United States delegated many of the management responsibilities to Executive Branch agencies, including DOE. Under Executive Order 12580, DOE is designated as the lead agency responsible for conducting response actions (removal and remedial) at facilities under its control, including the Hanford Site. The CERCLA and Executive Order 12580 mandate that the DOE, as the federal lead agency, conduct response actions (removal and remedial) at the Hanford Site. One of the responsibilities of a lead agency is to conduct reviews on the status of response actions no less frequently than once every five years for waste sites where contamination remains that prohibits unrestricted use to determine whether the selected remedy(ies) at a site remain protective of human health and the environment. DOE is required to implement five-year reviews in a manner consistent with the CERCLA and the *National Oil and Hazardous Substances Pollution Contingency Plan* (40 Code of Federal Regulations [CFR] 300).

1.2 Community Notification and Involvement

On March 8, 2010, DOE notified the public of its intent to conduct the *Hanford Site Third CERCLA Five-Year Review Report* and solicited their input on this review in accordance with CERCLA requirements (42 USC § 9601 et seq.) and the EPA's *Comprehensive Five-Year Review Guidance*. DOE briefed the Tribal Nations, State of Oregon, Natural Resources Trustee Council, and the Hanford Advisory Board on the scope, schedule, and progress of this five-year review. A 45-day public feedback process was held on the draft document prior to its finalization and submission to EPA by November 6, 2011.

1.2.1 Purpose and Scope

This five-year review provides the following:

- Evaluates the performance of selected remedies for CERCLA source and groundwater OUs that required active remediation or no action(s) during the review period in the 100, 200, 300, and 1100 areas on the Hanford Site and determines whether they are protective of human health and the environment.
- Verifies that immediate threats have been addressed where the OU has a remedial action that is still in the Remedial Action Construction phase, Remedial Action Operation phase, or where a removal action is in progress and that the selected remedy will be protective when complete.
- Verifies that the selected remedy remains protective where a removal or remedial action site is in the long-term operation and maintenance phase.
- Recommends actions to improve performance to achieve protectiveness.

1.2.2 Review Process

The review process for source and groundwater remediation OUs is included in the following activities.

Data Gathering and Review. The first step in producing this *Hanford Site Third CERCLA Five-Year Review Report* was data gathering to perform the review for OUs with active removal or remedial actions. Data gathered and reviewed included performance and operational requirements, compliance and findings, recommendations, and action items from *The Second CERCLA Five-Year Review Report for the Hanford Site* (DOE/RL-2006-20). The data gathered and reviewed for performance and operational requirements included action memorandums, RODs, ROD amendments, ESDs, and Remedial Design/Remedial Action (RD/RA) work plans. The data gathered and reviewed for compliance with the interim remedial action objectives included waste management plans, sampling and analysis plans, groundwater monitoring data, closeout verification packages, and remaining sites verification packages needed to assess compliance of the ongoing removal or remedial action. In addition, findings, recommendations, and action items from *The Second CERCLA Five-Year Review Report for the Hanford Site* (DOE/RL-2006-20) were gathered as part of the initial review because these issues could constitute additional requirements beyond those in the performance and operational requirements, and compliance data. Together, this data provided the technical basis for performing this five-year review.

Site Visits and Field Evaluation. Representatives from DOE, EPA, Ecology, and DOE contractor staff performed field evaluations as necessary. DOE and regulatory personnel are actively involved in oversight of the cleanup activities and are frequently in the field inspecting the DOE contractors' work; because of this ongoing activity, additional special site visits and field evaluations were not needed. When necessary, field evaluations were conducted with the DOE contractor performing the work under consideration to review potential issues identified during the data gathering and review portion.

Development of Draft Technical Assessments and Recommendations. When a record of decision has been issued and the remedial actions have been implemented for an OU, initial assessments and recommendations to address issues were prepared for review. After review and discussions within DOE, these draft technical assessments and recommendations were provided to Ecology and EPA for their review and comment.

Support for Action Item Discussions. Discussions to address outstanding recommendations or performance issues were initiated between DOE and the lead regulatory agency. Action items resulting from these discussions are included in this report.

Development of the Protectiveness Statements. A review of the OUs in each NPL site was completed. The reviewers used the three technical assessment questions provided in the EPA guidance to evaluate the success in implementing the selected remedies against the remedial action objectives and cleanup criteria established in the ROD. Once the review of all the OUs for each NPL site was completed, DOE, following EPA guidance and with input from Ecology and EPA, prepared statements on the protectiveness of the completed and ongoing remedial actions for each of the four Hanford NPL sites (100, 200, 300, and 1100 areas). If EPA and DOE do not agree on a protectiveness statement for each NPL site, EPA has the option of preparing its own protectiveness statement.

Next Five-Year Review. The Hanford NPL sites require ongoing five-year reviews to meet the statutory mandate. The next five-year review will cover the period from October 2010 through September 2015, with the final five-year review report issued by November 2016.

1.3 Background and Chronology

The Hanford Site was established in 1943 to produce nuclear materials for national defense, is owned by the U.S. Government, and managed by the DOE-RL and DOE Office of River Protection (DOE-ORP). The city of Richland adjoins the southeastern portion of the Hanford Site boundary and is the nearest population center. In early 1943, the U.S. Army Corps of Engineers selected the Hanford Site as the location for plutonium production for national defense. For over 20 years, activities were primarily dedicated to the continuation of plutonium production and managing the waste generated. In later years, activities became increasingly diverse, involving research and development for advanced reactors and renewable energy technologies. The end of the Cold War brought the shutdown of the Hanford Site's plutonium production and management facilities.

When the Hanford Site cleanup project was initiated in 1989 with the signing of the TPA, efforts were initiated to characterize known and suspected contamination. Early RI/FS and RCRA facility investigation/corrective measures study (RFI/CMS) work plans indicated it would require 7 to 10 years of characterization before cleanup alternatives could be evaluated and decisions made.

Based on past Hanford Site waste disposal practices and knowledge of spills and releases to the environment, it was known that there were adverse environmental impacts that might cause the Hanford Site to qualify for listing on the CERCLA NPL. The DOE initiated a preliminary assessment/site investigation that included a comprehensive review of historical records including facility operating records; data from groundwater, surface water, soil, and air monitoring and sampling; aerial photographs; interviews with workers; and walking the Hanford Site to identify potentially disturbed areas. Using the information gathered, EPA determined that the Hanford Site qualified for inclusion on the NPL and four areas of the Hanford Site (100, 200, 300, and 1100 areas) were listed.

The preliminary assessment/site investigation identified that some contaminants posed a potential threat of exposure to human health and the environment. As a result, DOE established a 'bias for action' approach to the cleanup. The 'bias for action' allowed DOE, with regulatory agency approval, to conduct removal actions in areas that posed a potential immediate threat to human health and the environment. The 'bias for action' resulted in interim removal actions before fully characterizing the type, level, and extent or degree of contamination and before developing final CERCLA remedy selection RODs.

1.3.1 Physical Characteristics

The Hanford Site covers approximately 586 square miles (1,518 km^2) adjacent to the city of Richland, Benton County, Washington. The original site was 670 square miles (1,740 km^2) and included buffer areas across the river in Grant and Franklin counties (Battelle 2002). Some of this land has been returned to private use and is covered with orchards, and irrigated fields. The Hanford Site is divided into numerically designated areas (100, 200, 300, 400, 600, 700, and 1100 areas). These areas served as the location for reactor, chemical separation, and related activities for the production and purification of special nuclear materials and other nuclear activities. The reactors are located along the Columbia River in the 100 Area (River Corridor). The reactor fuel reprocessing units are in the 200 Areas, which are on a plateau approximately 8.8 miles (11 km) from the Columbia River (Central Plateau). The 300 Area, located adjacent to and north of Richland, contained the reactor fuel manufacturing plants and the research and development laboratories (River Corridor). The 400 Area, 5 miles (8 km) northwest of the 300 Area, contains the Fast Flux Test Facility (FFTF), which was designed for testing liquid metal reactor systems. The 600 Area covers all locations not specifically given an area designation. The 700 Area includes the administrative offices located in Richland, including the Federal Building. The 1100 Area, located in North Richland, is the Port of Benton's Richland Industrial Center, which contained offices associated with administration, maintenance, transportation, and materials procurement and distribution.

During the period that the site produced nuclear material for national defense, many activities resulted in the disposal of waste containing hazardous constituents and/or radioactive materials. Consequently, these releases may result in adverse impacts to human health and the environment unless addressed through the response actions to remediate the environmental impacts to the maximum extent possible.

1.3.2 Land and Resource Use

DOE completed the *Final Hanford Comprehensive Land-Use Plan Environmental Impact Statement* (DOE/EIS-0222-F) in September 1999. A ROD was issued on November 2, 1999 (64 FR 61615), which adopted the Preferred Alternative discussed in the Environmental Impact Statement. The land-use plan documents the current land-use designations that DOE has determined are appropriate for the Hanford Site. Most of the interim RODs were issued prior to issuance of the land-use planning document. For these interim RODs, the land use for the 100 Area NPL OUs was based on unrestricted use, and the 200 Area and 300 Area NPLs was based on industrial use. Figure 1 represents the DOE future land-management values, goals, and objectives. The land-use plan consists of several key elements including a land-use map that addresses the Hanford Site as five geographic areas (Wahluke Slope, Columbia River Corridor, Central Plateau, all other areas of the site, and the Fitzner/Eberhardt Arid Lands Ecology Reserve). The key elements of the land-use plan depict the planned future uses, a set of land-use designations defining the allowable uses for each area of the Hanford Site, and the planning and implementing policies and procedures that will govern the review and approval of future land uses. Together these four elements create the Hanford Comprehensive Land-Use Plan. Much of the land is undeveloped, providing a buffer area for the smaller operational areas. In addition, public access to the Hanford Site is restricted.

The land-use designations within the River Corridor include high-intensity recreation, low-intensity recreation, conservation (mining), preservation, and industrialization. The *Hanford Reach National Monument Comprehensive Conservation Plan and Environmental Impact Statement* will ensure that designated areas are free of facility development within the Hanford Reach National Monument. This will serve conservation, restoration, protection, and recreation purposes. Under the comprehensive conservation plan, limited public use or development of the designated monument area would be allowed.

The ROD for the *Hanford Comprehensive Land-Use Plan Environmental Impact Statement* designates the portion of the Central Plateau that includes the 200 Area as Industrial-Exclusive land use.

1.3.3 History of Contamination, Initial Responses, and Basis for Taking Actions

When the Hanford Site was placed on the NPL on November 3, 1989, it was divided into four NPL sites: the 100, 200, 300, and 1100 areas (Figure 2). Each NPL site was further divided into OUs to simplify the response actions. An OU is a grouping of individual sites based primarily on geographic area or common waste sources; soil and groundwater contamination are addressed in separate OUs (Figures 2 and 3). Approximately 1,200 waste management units are located within the boundaries of the Hanford Site. This includes approximately 1,000 past-practice units. Past-practice units are located in geographic areas (100, 200, 300, and 1100 areas) and other areas of the Hanford Site. These NPL sites are based on the extent of contamination present at the Hanford Site and did not conform to the area designations commonly used at the Hanford Site.

Other areas of the Hanford Site include Energy Northwest Columbia Generating Station, the US Ecology Commercial Low-Level Radioactive Disposal site, and the National Science Foundation Laser Interferometer Gravitational-Wave Observatory, operated by the California Institute of Technology and the Massachusetts Institute of Technology. These areas are leased to other government organizations by DOE and are not included in the Hanford CERCLA activities.

In anticipation of the NPL listing, DOE entered into the TPA. The TPA is a legally binding agreement among DOE, EPA, and Ecology that established regulatory guidelines and the framework for achieving the cleanup. For each OU, the TPA designates either EPA or Ecology as the lead regulatory agency. DOE is the lead agency by federal law to implement CERCLA (42 U.S.C. 9615(2)(d)).

The scope of the TPA is broader than this five-year review. The TPA addresses regulated RCRA units as well as the cleanup of past-practice units required under RCRA and/or CERCLA. Active RCRA treatment, storage, and disposal (TSD) units, such as the Hanford Site tank farms, are not part of this review. Although this five-year review does not include RCRA TSD activities, the Tri-Parties are integrating the closure of inactive treatment storage, and disposal facilities with CERCLA waste site cleanup as intended by the TPA. The Tri-Parties also are applying a strategy for groundwater cleanup that integrates the authorities and requirements of the *Atomic Energy Act* (AEA), CERCLA, and RCRA (*Hanford's Groundwater Management Plan: Accelerated Cleanup and Protection* (DOE/RL-2002-68).

Figure 1. DOE Preferred Alternative for Land Use

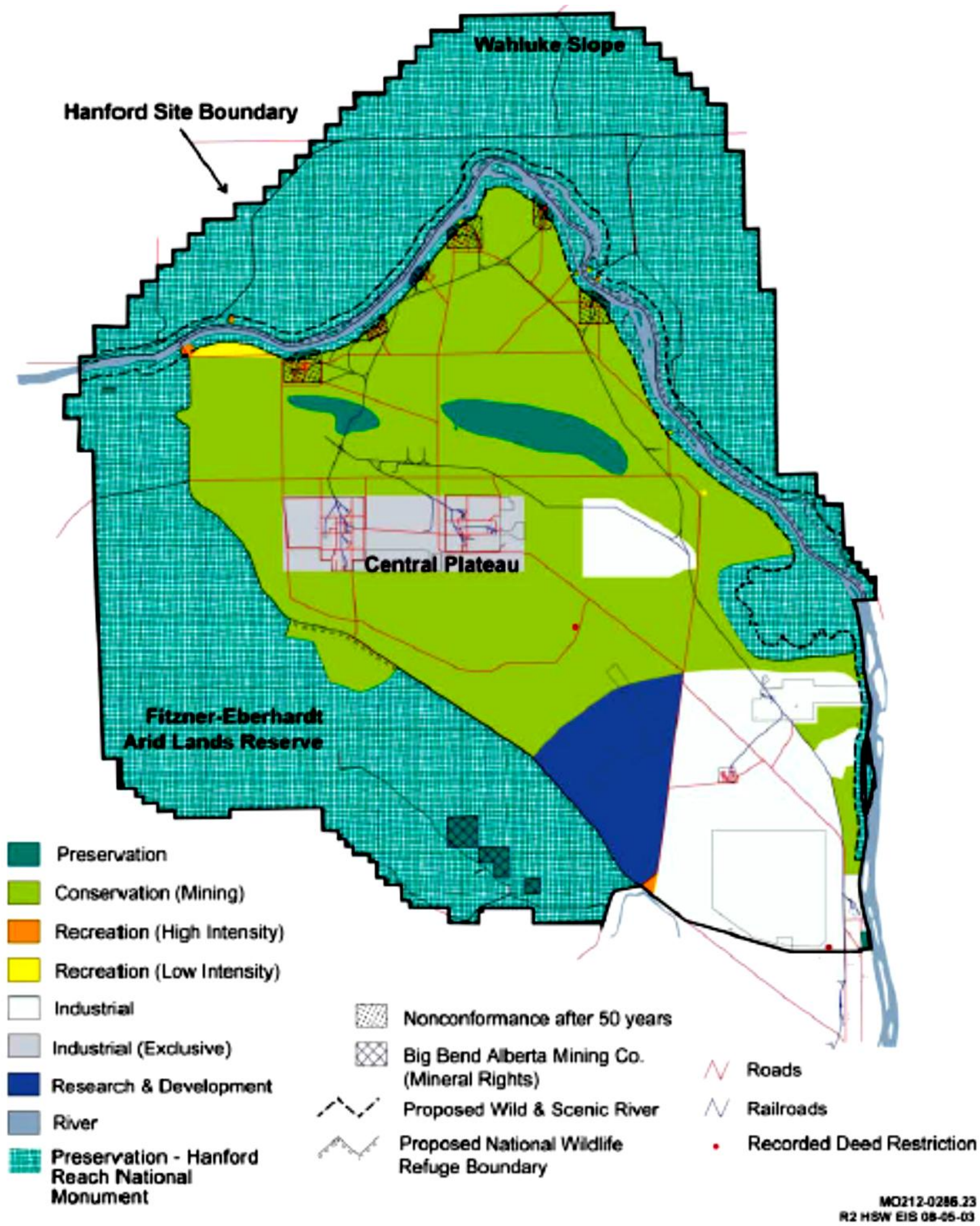


Figure 2. National Priorities List Designations

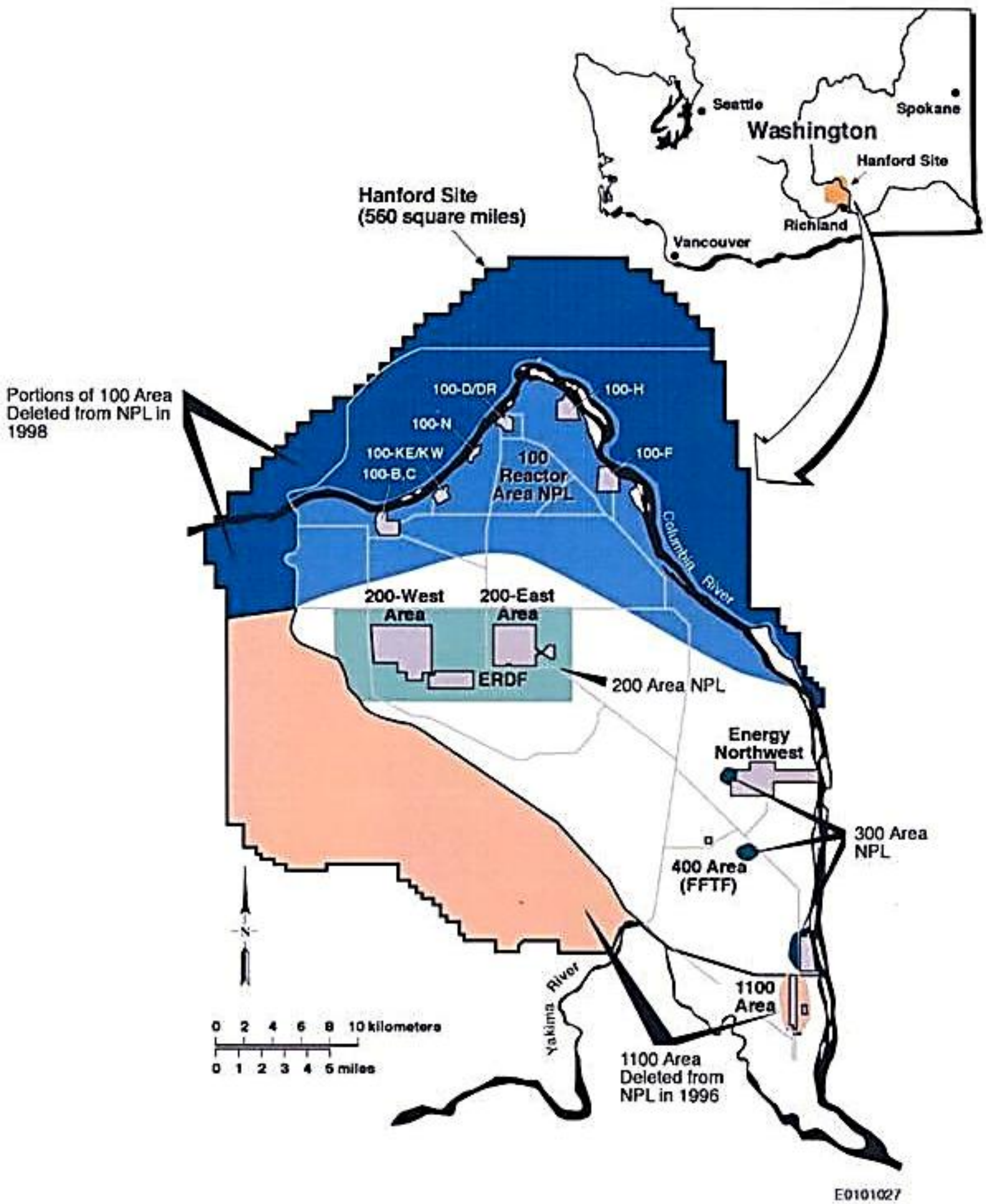
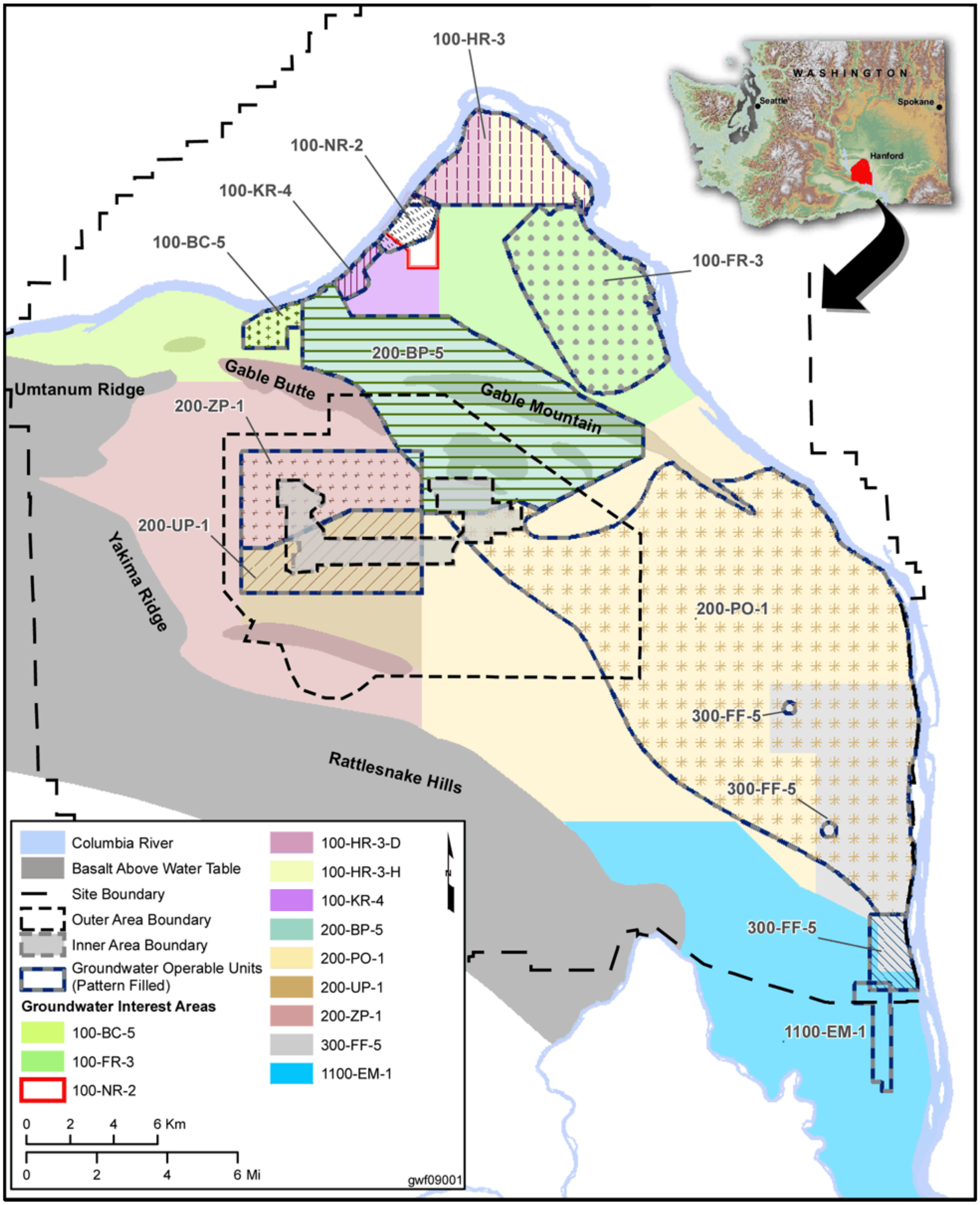


Figure 3. Groundwater Operable Units



The TPA also allows EPA and Ecology an option to perform independent five-year reviews. EPA exercised this option in Calendar Year (CY) 2000 and the first CERCLA five-year review of response actions for the Hanford Site was initiated. In April 2001, EPA released the *USDOE Hanford Site First Five-Year Review Report,* which provides the results of the first five-year review.

Consistent with CERCLA and Executive Order 12580, the second and third five-year reviews were conducted by DOE. In the first five-year review conducted by EPA in 2000, the performance of the remedies selected in interim action RODs was evaluated, including the existing institutional controls to prevent exposure to the public and the environment, and it was concluded that the selected remedies were protective, or will be protective, when the remedial action was completed. EPA identified deficiencies and corrective actions to address the deficiencies. DOE applied the same approach in conducting the 2005/2006 second and 2010/2011 five-year reviews that EPA used and followed the EPA *Comprehensive Five-Year Review Guidance* (EPA 540-R-01-007), dated June 2001 and the DOE, Office of Environmental Management *Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) Five-Year Review Guide,* dated March 2002.

Because sufficient information about the severity and extent of contamination was not available to support final decisions, interim action decision documents were developed (interim action RODs, expedited response action approvals, and action memorandums). During interim cleanup actions, samples are collected and analyzed to evaluate the progress of the action and to enable a more complete understanding of the types, levels, and extent of the contamination and more complete remedial actions.

These remedial actions addressed the contaminants of greatest concern in the areas where the environmental threat was known to be highest. As a result, cleanup focused for several years in areas that posed the highest risk to the Columbia River (River Corridor). The focus has been on activities intended to protect the Columbia River through contaminant source removal actions and groundwater pump-and-treat systems designed to remove source contaminants in the soil and groundwater.

1.3.4 Trigger for Five-Year Review

The five-year review is required by CERCLA §121 (c) and *National Oil and Hazardous Substances Pollution Contingency Plan* (40 CFR 300) because hazardous substances, pollutants, or contaminants remain, at the site above levels that allow for unlimited use and unrestricted exposure The statute and regulation triggers for the 2011 five-year review consider recommendations and findings of the 2001 *USDOE Hanford Site First Five-Year Review Report* and the 2006 *The Second CERCLA Five-Year Review Report for the Hanford Site*.

The *USDOE Hanford Site First Five-Year Review Report* included all portions of the site that have a CERCLA decision document; e.g., a ROD or an action memorandum where hazardous substances, pollutants, or contaminants remain above levels that allow for unlimited use and unrestricted exposure. Interim remedial actions were reviewed equally with remedial actions for the purposes of the five-year review.

The Second CERCLA Five-Year Review Report for the Hanford Site generally followed the approach taken in the first five-year review and addressed those past decisions made and activities initiated, terminated, or completed in the intervening period.

This third five-year review follows the most recent EPA *Comprehensive Five-Year Review Guidance* and format, and focused on the general areas described below consistent with *DOE Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) Five-Year Review Guide* and EPA *Comprehensive Five-Year Review Guidance*. The DOE established September 30, 2010, as the ending period for the inclusion of newly issued decision documents for this third five-year review.

1.3.5 Assessing Risk Input Factors

In assessing the risk input factors, the following items were evaluated:

- Future land use and associated exposure pathways.
- Site conditions such as degree to which remedy performance is based on the original assumption(s).

- Contaminant toxicity.
- Whether the remedy is operational and functional by evaluating those parameters that the TPA agencies established as appropriate indicators of performance via RODs and action memoranda; i.e., performance assessment of the remedy for completed actions, ongoing long-term remedial actions, and interim remedial actions.
- Assumptions critical to the effectiveness of remedial measures or the protection of human health and the environment for the remedial decisions to determine, given the current information, whether these assumptions are still valid. These critical assumptions include assumptions regarding:
  - Whether corrective measures are required to address any identified deficiencies.
  - Whether there are opportunities to optimize the long-term performance of the remedy or reduce life-cycle costs such as expediting attainment of remedial objectives, transitioning response phases, and scaling back monitoring.

In determining the protectiveness of the remedies, DOE-RL considered the following three questions:

- *Is the remedy functioning as intended by the decision document?*
- *Are the exposure assumptions, toxicity data, cleanup levels, and remedial action objectives used at the time of remedy selection still valid?*
- *Has any other information come to light that could call into question the protectiveness of the remedy?*

Closure and corrective actions at closed or closing RCRA TSD units were integrated with the remedial actions evaluated in this five-year review. The RCRA/CERCLA interface is described in the TPA, Part I, Article IV. The affected OUs (and specific TSD units) include the 100-DR-1 (100-D Ponds, 100-HR-1, 183-H Solar Evaporation Basins TSD unit), 100-NR-1 (1301-N, 1325-N, 1324-N and 1324-NA TSD units), and the 300-FF-1 (300 Area Process Trenches TSD unit).

The ROD is the decision document that selects a remedial action to address identified risks. An action memorandum is the decision document used to select a removal action. The five-year review process evaluates the implementation, and performance of the remedies selected in the action memoranda and RODs that are, or will be, protective when completed. The purpose of the five-year report is to present the results of the review, identify whether the actions are protective, and recommend appropriate corrective actions when the remedy is not protective.

The chronology for the RODs and action memoranda for the Hanford Site is provided in Section 2.3 (100 Area), Section 3.2 (200 Area), and Section 4.2 (300 Area). The chronology contains the RODs, action memoranda, and other CERCLA decision documents that are the subjects of this report. These documents are hyperlinked and are available at the TPA Administrative Record/Public Information Repository (AR/PIR). This five-year review includes interim remedial actions consistent with EPA and DOE guidance.

1.3.6 Response Actions

1.3.6.1 100 Area

The 100 Area consists of six nuclear reactor areas principally contaminated with radionuclides, metals, and other hazardous substances. There are 22 OUs in the 100 Area, 17 source OUs and five groundwater OUs. In addition to the immediate reactor areas, there are outlying waste sites whose contaminants are similar. The primary cleanup actions in progress, or that are planned, are to remove, treat if necessary, and dispose of contaminated soil, debris, piping, landfills, and engineered structures; decontaminate and/or demolish buildings; capture and/or treat contaminated groundwater; and remove spent nuclear fuel and associated waste from water-filled basins that have a history of leaks. Furthermore, institutional controls are an additional element in many of the selected remedies.

There are no final RODs issued for 100 Area NPL OUs; however, eight interim action RODs have been issued. Based on additional characterization, some of these RODs have been amended to address other contaminants or areas not originally included; ESDs have been issued for other areas to explain less significant changes. Five RODs address soil contamination; one ROD addresses the removal of spent fuel at K Basins; and two RODs address groundwater contamination. Seventeen additional CERCLA decision documents address demolition of buildings and structures, soil removal, groundwater treatment, and landfill cleanup in the 100 Area, including 10 action memoranda and seven expedited response action approvals.

Interim actions have been successful in meeting the removal action and interim remedial action objectives. Approximately 135 of the contaminated soil sites in the 100 Area NPL Site have been remediated to meet the cleanup levels established in the interim action RODs. Several removal actions have been completed in the 100 Area (i.e., building demolition and placing the 105-C, 105-D, 105-DR, 105-F, and 105-H reactors in an 'interim safe storage' condition). Some groundwater interim actions also are meeting the remedial action objectives established in the interim action RODs. Noted exceptions are the strontium-90 plume at 100-N Area, and the chromium plume at 100-D and 100-H Areas. The final remedy selected through the RI/FS process documented in future RODs will address groundwater contaminant plumes that have not yet been addressed.

The source removal actions to remediate areas of contaminated soil through the remove, treat, and dispose remedy have been designed to be consistent with final cleanup actions, including ARARs. It is anticipated that the residual human health and environmental risks for these areas will achieve the required risk levels when the remediation is completed. For these areas, DOE believes the selected interim remedy is protective or will be protective when completed. The *River Corridor Baseline Risk Assessment Volume II Human Health Risk Assessment*, issued in December 2010 (DOE/RL-2007-21, Part 1 and DOE/RL-2007-21, Part 2), provides risk information to support development of final cleanup decisions in the River Corridor.

This five-year review determined that the groundwater interim actions in the 100 Area are meeting the remedial action objectives established in the interim action RODs; however, the strontium-90 groundwater plumes at the 100-N Area and chromium removal at 100-H/D areas are exceptions. In the September 2010 ROD Amendment, *Interim Remedial Action Record of Decision for the 100-NR-1/NR-2 Operable Units of the Hanford 100-N Area*, the selected interim remedial action was revised for the strontium-90 remedy in the 100-NR-2 Groundwater OU; the performance monitoring conducted while the pump-and-treat system was in operation confirmed the system's limited effectiveness in removing strontium-90 from the aquifer. This interim action ROD amendment altered the selected remedy; the apatite permeable reactive barrier will be extended to approximately 2,500 feet (760 meters) immediately adjacent and parallel to the Columbia River. This will provide increased protection of the Columbia River by immobilizing, and therefore, removing strontium-90 from the groundwater before it enters the river. Strontium-90 will remain bound within the permeable reactive barrier's apatite matrix where it will naturally decay to levels below the remedial action goal of 8 pCi/L. The apatite permeable reactive barrier will complement the existing interim remedial actions (institutional controls to control land and groundwater use, free-phase hydrocarbon removal, and groundwater monitoring) that are underway or have been completed in the 100-NR-2 Groundwater OU; therefore, the modified remedy selected in this ROD amendment is protective of human health and the environment.

Pump-and-treat systems in the 100-D, 100-H, and 100-K areas have been expanded to meet the interim remedial action objectives. Expansion of the pump-and-treat technology and supporting technologies to cover the plumes more thoroughly, and developing improved data on performance of the pump-and-treat and apatite sequestration technologies, the remedies selected in the final RODs for the 100 Area OUs will more completely address the human health and environmental risks. The protectiveness of the remedies will be evaluated in future five-year reviews.

1.3.6.2 200 Area

The 200 Area NPL Site contains numerous waste sites, contaminated facilities, and groundwater contamination plumes. To facilitate cleanup, these waste sites, contaminated facilities, and groundwater plumes were divided into source OUs that have a geographic basis and include types of soil waste sites, structures and pipelines, and groundwater OUs. The source OUs contain approximately 900 soil waste sites and associated structures, as well as numerous facilities requiring deactivation and decommissioning (D&D). In addition, the 200 Area NPL Site contains four groundwater OUs; 200-ZP-1 and 200-UP-1 are in 200 West Area and 200-BP-5 and 200-PO-1 are in 200 East Area. These groundwater OUs are prioritized and scheduled for cleanup in accordance with the TPA.

The 200 Area NPL Site has four RODs; one interim action ROD for 200-UP-1 OU and one final action ROD for 200-ZP-1 OU to address groundwater contaminants (200-ZP-1 OU has an interim ROD previously issued), and two RODs address the ERDF, and contaminated soil removal at the 221-U Facility (Canyon Disposition Initiative). DOE also issued nine action memoranda for removal actions. The ERDF facility is operating as required to meet the objectives outlined in the ROD for disposing the waste from Hanford CERCLA activities. The first phase of remedial actions covered by the 221-U Facility ROD have been initiated which includes preparation and the actual grouting of the below-grade structures of the 221-U Facility canyon. In addition, the construction of the 200-ZP-1 OU pump-and-treat facility (commonly call the 200 West Pump-and-Treat Facility) was started in FY 2009. Completed removal actions performed under the nine action memoranda, are meeting the removal action objectives (i.e., removal of the 232-Z Facility). These OUs are prioritized and scheduled for cleanup in accordance with the TPA. The RI/FSs for the 200 Area Source (soil) OUs are currently under underway.

The 200-PW-1 Source OU removal action uses a soil vapor extraction system to remove carbon tetrachloride from the soil above the 200-ZP-1 Groundwater OU. This removal action has proven to be effective and will continue; and the actions for the soil cleanup will be addressed as part of the 200-PW-1 Source OU. A protectiveness determination for the soil vapor extraction system removal action is being deferred until a final remedy is selected through the RI/FS process; however, based on information to date, DOE believes the removal actions will be consistent with the final remedies selected through the RI/FS and ROD processes.

The 200-UP-1 Groundwater OU interim action uses a pump-and-treat system to remove uranium and technetium-99 from the groundwater near U Plant. The interim action ROD (EPA/ROD/R10-97/048) was amended by the *Explanation of Significant Differences for the Interim Action Record of Decision for the 200-UP-1 Groundwater Operable Unit* in 2009. The amended interim action ROD updates the remedial action objective for uranium to 300 µg/L from 480 µg/L. The amendment also requires installing a pump-and-treat system to address technetium-99 at the S/SX Tank Farm area. Construction of the S/SX pump-and-treat is underway and is scheduled to be completed in December 2011. A protectiveness determination for the vapor extraction system interim remedy is being deferred until a final remedy is selected through the RI/FS process.

The 200-ZP-1 Groundwater OU interim remedial action pump-and-treat system has operated since 1994 to prevent carbon tetrachloride from spreading in the 200-ZP-1 Groundwater OU, in accordance with the *Record of Decision for the U.S. DOE Hanford 200-ZP-1 Operable Unit, 200 Area NPL Site Interim Remedial Measure* issued in 1995. The selected interim remedy for the 200-ZP-1 Groundwater OU combined pump-and-treat (to address the concentrated shallow portion of the plume), monitored natural attenuation, flow-path control, and institutional controls. More than 24,000 pounds (10,900 kilograms) of carbon tetrachloride have been removed from groundwater and treated since 1994. The interim remedial measure will continue to operate until the new system comes on-line, which is expected to occur by December 2011.

The 2008 final ROD for 200-ZP-1 expanded the interim remedial measure pump-and-treat system by adding extraction wells between FY05 and FY08 to addresses the entire extent of the carbon tetrachloride plume plus the other contaminants of concern.

1.3.6.3 300 Area

The 300 Area NPL Site is located along the Columbia River north of the Richland, Washington, city limits southeast portion of the Hanford Site. The 300 Area NPL Site consists of three OUs: 300-FF-1, 300-FF-2, and 300-FF-5. The 300 Area contains a 0.52 square miles (1.35 km^2) industrial complex area that was used for uranium fuel fabrication and research and development activities for the Hanford Site. The 300 Area NPL Site includes an unlined liquid disposal area north of the industrial complex area, landfills, and miscellaneous disposal sites associated with operations in the industrial complex. The 300-FF-1 and 300-FF-2 OUs contain contaminated soil, debris, and landfills associated with 300 Area operations, and the 300-FF-5 OU covers the contaminated groundwater under the 300-FF-1 and 300-FF-2 OUs.

The CERCLA decision documents for the 300 Area include one ROD (EPA/ROD/R10-96/143) that selected final actions for contaminated soil waste sites in 300-FF-1 OU, and interim actions for groundwater in the 300-FF-5 OU; one interim action ROD (EPA/ROD/R10-01/119) for contaminated soil remediation in 300-FF-2 OU; one expedited response action approval; and four action memoranda. Primary cleanup actions in progress, or planned to be performed, are to remove, treat if necessary, and dispose of contaminated soil, debris, piping, landfills, and engineered structures; and decontamination and/or demolition of buildings.

The 300-FF-1 OU remedial actions selected in the 300-FF-1 ROD (EPA/ROD/R10-96/143) were completed and a remedial action report was issued documenting the completion. The remedy is considered protective because the contaminated soil remedial action under the final ROD met all of the remedial action objectives.

The 300-FF-2 OU cleanup activities identified in the interim action ROD (EPA/ROD/R10-01/119) for contaminated soil remediation in 300-FF-2 OU are still in progress at waste sites, as well as demolition of surplus facilities in the 300 Area.

The source removal actions in the 300 Area to remediate contaminated soil waste sites through the remove, treat, and dispose remedy are designed to be consistent with final cleanup actions, including ARARs. It is anticipated that the residual human health and environmental risks from these waste sites will achieve the required risk levels when the removal action is completed. The final remedy at 300-FF-2 OU is expected to be protective of human health and the environment upon completion of the final remedy. The current interim actions ensure that exposure pathways that could result in unacceptable risks are being controlled.

The 300-FF-5 OU includes groundwater contamination originating from waste sites identified in the 300-FF-1 and 300-FF-2 OUs. Groundwater contamination originating from waste sites in the 200 Area NPL migrating beneath the 300 Area NPL Site are not included in the 300-FF-5 OU. The remediation approach identified in the interim action ROD (EPA/ESD/R10-00/524) for contaminated groundwater in the 300 Area is to monitor groundwater to ensure contamination levels are attenuating through natural processes in a reasonable time. The CERCLA five-year review performed in 2006 identified that natural attenuation was not effective in meeting groundwater remediation goals in an acceptable period. The *Remedial Investigation Work Plan for Hanford Site Releases to the Columbia River* (DOE/RL-2008-11, Rev. 0) is to be revised during 2011 to characterize this transport. In addition, an RI/FS is underway to assess and recommend alternative remediation approaches. The remedy is considered protective because institutional controls are in place preventing the use of the groundwater until a final remedy is selected through the RI/FS process to bring the uranium concentrations to below drinking water standards (DWS). Selection of more effective remedies is anticipated in the near future.

1.3.6.4 1100 Area

The 1100 Area contained four OUs: 1100-EM-1, 1100-EM-2, 1100-EM-3, and 1100-IU-1. The remedial actions selected for the 1100 Area OUs have been completed and the 1100 Area NPL Site was removed from the NPL List in 1996. The remedy remains protective of human health and the environment.

The Horn Rapids Landfill (1100-EM-1) was used for asbestos disposal and was closed in accordance with the asbestos regulations. Asbestos waste disposed in the Horn Rapids Landfill is still in place and remains secure. Per Superfund Site Closeout Report requirements, institutional controls are in place. In addition, a fence, signage, and existing cap are maintained.

Additional sampling performed at the Horseshoe Landfill (1100-IU-1) between 1998 and 2003 detected residual dichlorodiphenyl trichloroethane (DDT) in the soil in portions of the landfill above the cleanup level for DDT (1 ppm [0.1 mg/L]) after completing the initial remedial action. EPA issued a memo-to-file in May 2005 to document non-significant changes to the *Record of Decision Hanford 1100 Area* to allow removal of the DDT contaminated soil. Based on ecological protection, a DDT cleanup level of 0.75 ppm (0.750 mg/L) was selected to be protective of human health and the environment. Previous groundwater monitoring indicated trichloroethylene contamination; however, recent monitoring has showed that these levels are not over the cleanup standard. Additional cleanup actions have taken place to achieve the cleanup goals and standards. No further review for the 1100 Area is included in this report.

1.3.7 Progress Since 2006 Five-Year Review

Assessing progress since the 2006 review involves examining issues and recommendations identified in the second five-year review to ensure previously identified vulnerabilities are appropriately tracked. Table 1, *CERCLA Five-Year Review Issues and Actions*, provides a list of the current issues and actions. The issues and actions are discussed further in the individual sections for the 100, 200, 300, and 1100 areas.

1.3.8 Institutional Controls

Institutional controls have been a critical element of Hanford Site operations since the site was created as part of the Manhattan Project. Due to the nature of the Manhattan Project, and later nuclear materials production activities, public access to the Hanford Site was prohibited and was strictly controlled using signs, fences, sophisticated monitoring technology, and armed patrols.

More recently, with the change in mission from nuclear materials production to environmental cleanup, the need for some of the more aggressive institutional controls has been reduced. However, to protect physical assets and to protect the public from inadvertent exposure to potential hazards, access to the Hanford Site is controlled with institutional controls.

To ensure the institutional controls required under CERCLA are effectively implemented, the DOE prepared a *Site Wide Institutional Controls Plan for Hanford CERCLA Response Actions*. This plan lists the existing Hanford institutional controls and controls required by interim action RODS and RODs. These institutional controls help to protect DOE employees, DOE contractors, and one or more of the following groups:

- Non-DOE entities using DOE land: Individuals who are associated with an organization, other than DOE or their contractors that are located on the Hanford Site or are conducting activities on the Hanford Site.
- Hanford Site visitors: Individuals who access the Hanford Site for a site-related purpose (e.g., public tour).
- Inadvertent intruders: Individuals who inadvertently access the site (e.g., inadvertent access to the Hanford Site along the Columbia River shoreline for recreational purposes).
- Environmental Receptors: Fish, wildlife, and plant populations that inhabit the Hanford Site, as well as their habitats.

Initially, the Hanford Site institutional controls plan required that DOE conduct annual reviews of the institutional controls. Later, the Hanford Site institutional controls plan was revised requiring that DOE perform assessments and brief the EPA and Ecology during the September Unit Manager's Meeting, with a Hanford Site review conducted as part of the CERCLA five-year review.

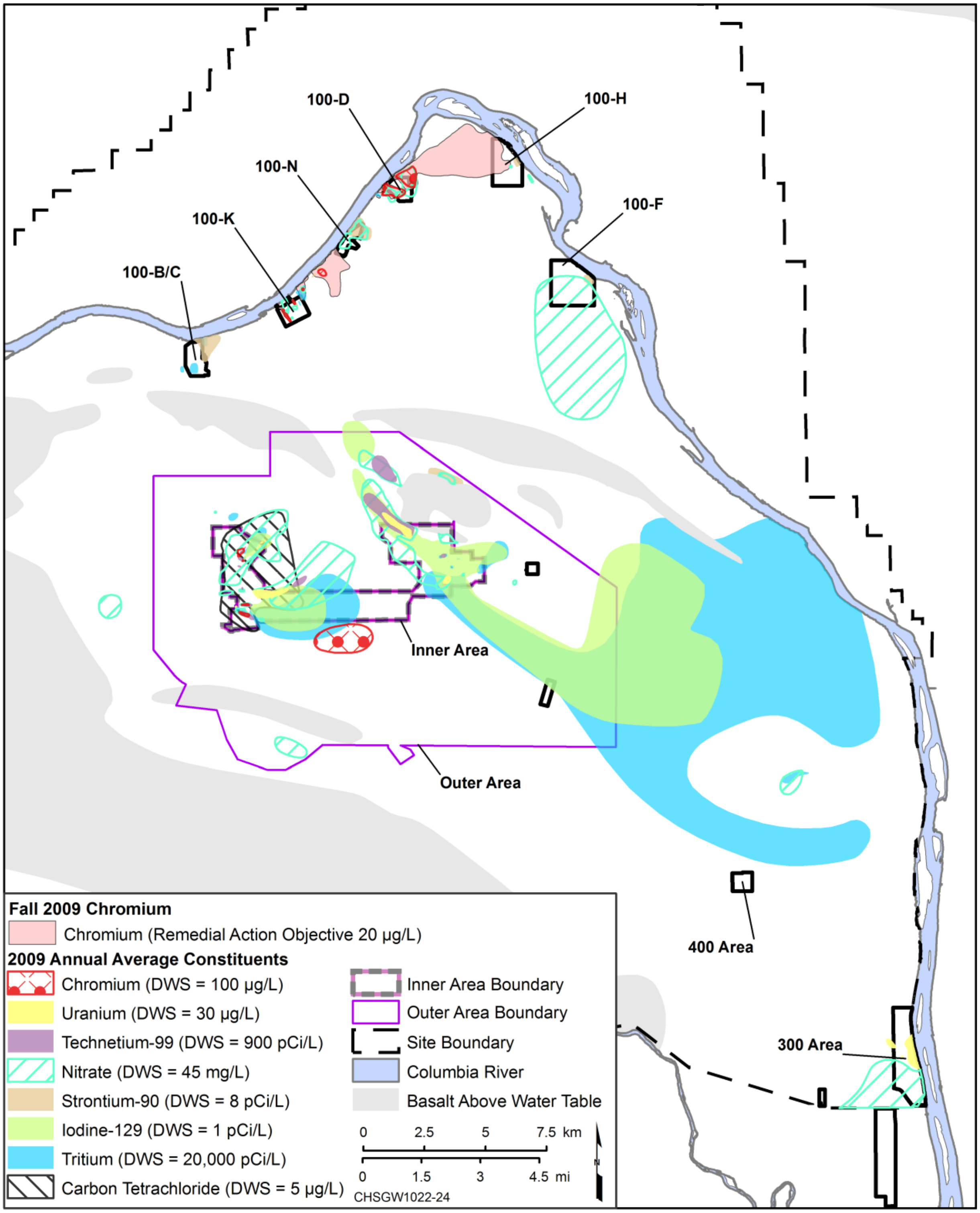
Five assessments of institutional controls were performed since the time of the last five-year review. Summaries of these reviews follow.

1.3.8.1 Observations

The 2006 River Corridor institutional controls assessment focused on three questions:

- *Are institutional controls requirements being properly reflected in waste site closeout documents?*
- *Do subcontractor documents require that signage on new haul roads be maintained during remediation?*
- *Is access control maintained and warning signs posted along access roads for 300 Area waste sites?*

Figure 4. Major Hanford Site Groundwater Plumes



The assessment found the institutional controls to be acceptable, with the exception of no physical barriers preventing access to a roadway in the northwest portion of the 300 Area main industrial complex. In response to the assessment results, a fence with a locking gate was installed to control access.

The 2007 River Corridor institutional controls assessment evaluated:

- Trespass events at waste sites during CY06 (there were no trespass events identified).
- Adequacy of Excavation Permits for selected 100 Area active waste sites within the Hanford Reach Study Act area (quarter mile of the Columbia River shoreline).
- A field inspection of signage within the Hanford Reach Study Act area.
- The status of 300 Area institutional controls established in response to the 2006 assessment.

The assessment found the institutional controls to be acceptable, with the exception of a Spanish language shoreline sign at the 100-F Area that had blown over. The sign was subsequently reinstalled.

The 2008 River Corridor institutional control assessment evaluated:

- Trespass events at waste sites during CY07 (there were none)
- Access control/entry restrictions
- Excavation control (e.g., excavation permits)
- Field inspection of institutional controls at 100 Area waste sites within the 100-IU-2 and 100-IU-6 OU, three waste sites in the 300 Area, and ERDF

The assessment found that ample institutional control signage was present at all waste sites evaluated; however, the signs at the three 300 Area waste sites did not include the exact language specified in the RD/RA work plan for the 300 Area. These signs were subsequently corrected. All other elements evaluated were found to be acceptable.

The 2009 river corridor institutional controls assessment evaluated:

- Trespass events at waste sites during CY08 (there were none).
- Access control/entry restrictions.
- Excavation control (e.g., excavation permits).
- Implementation of corrective actions from the 2008 institutional controls review (e.g., correct signage in place at the 300 Area waste sites).
- Field inspection of institutional controls at entrances to active 100 Area waste sites within 100-B/C, 100-D, 100-H, and 100-N Areas and the 618-13 waste site in the 300 Area.

The assessment found all elements to be acceptable, except for a sign at the west entrance to the 100-D Area that did not have the exact language specified in the RD/RA work plan for the 100 Area. A sign with the specified verbiage was subsequently installed.

The 2010 river corridor institutional controls assessment evaluated:

- Trespass events at waste sites during CY09 (there were none).
- Access control/entry restrictions.
- Excavation control (e.g., excavation permits).
- Field inspection of institutional controls on entrances to active waste sites within 100-B/C, 100-K, 100-H, 100-D, 100-N, 100-IU-2 and 100-IU-6 Areas; the 300 Area North waste sites; and shoreline signage at 100-B/C, 100-K, 100-N, 100-D, 100-F, 100-H, 300 Area.

All elements evaluated were acceptable, except for specified verbiage was not present on signage at two entrances to 100-IU-6 OU waste sites and the English language signage shoreline site at 100-F had blown over. Both conditions were corrected.

Table 3 summarizes the site wide institutional controls currently in use at the Hanford Site.

Table 2. Institutional and Access Controls

Control	Mechanism	Objective	Who it Protects
Warning Notices	Signs	• Provide visual identification and warning of hazardous or sensitive areas.	DOE employees, DOE contractors, Hanford Site visitors, and inadvertent intruders
Entry Restrictions	Procedural Requirements for Access	• Control human access to hazardous or sensitive areas. • Ensure adequate training for those who enter hazardous or sensitive areas. • Avoid disturbance and exposure to hazardous waste. • Provide a basis for the enforcement of access restrictions.	DOE employees, DOE contractors, Hanford Site visitors, and inadvertent intruders
	Fencing	• Prevent unauthorized human access to hazardous or sensitive areas. • Provide protective barriers to standard industrial hazards. • Provide visual warnings.	DOE employees, DOE contractors, Hanford Site visitors, and inadvertent intruders
Land Use Management	Land Use and Real Property Controls	• Ensure that use of the land is compatible with any hazards that exist. • Ensure that any changes in use of the land are adequately assessed before being allowed. • Ensure that the record of the property documents restrictions that will apply beyond change in ownership or management of the property.	DOE employees, DOE contractors, Hanford Site visitors, Non-DOE entities using DOE land, and Environmental receptors
	Excavation Permits	• Avoid unplanned disturbance or infiltration. • Inform and protect workers regarding potential exposure to hazardous waste. • Avoid the creation of potential pathways for the migration of hazardous waste.	DOE employees, DOE contractors, Non-DOE entities using DOE land
Groundwater Use Management	Groundwater Controls	• Ensure proper use of groundwater.	DOE employees, DOE contractors, Hanford Site visitors, non-DOE entities using DOE land
Waste Site Information Management	Administrative	• Maintain and provide access to information on the location and nature of contamination.	DOE employees, DOE contractors, and Hanford Site visitors

2 100 AREA

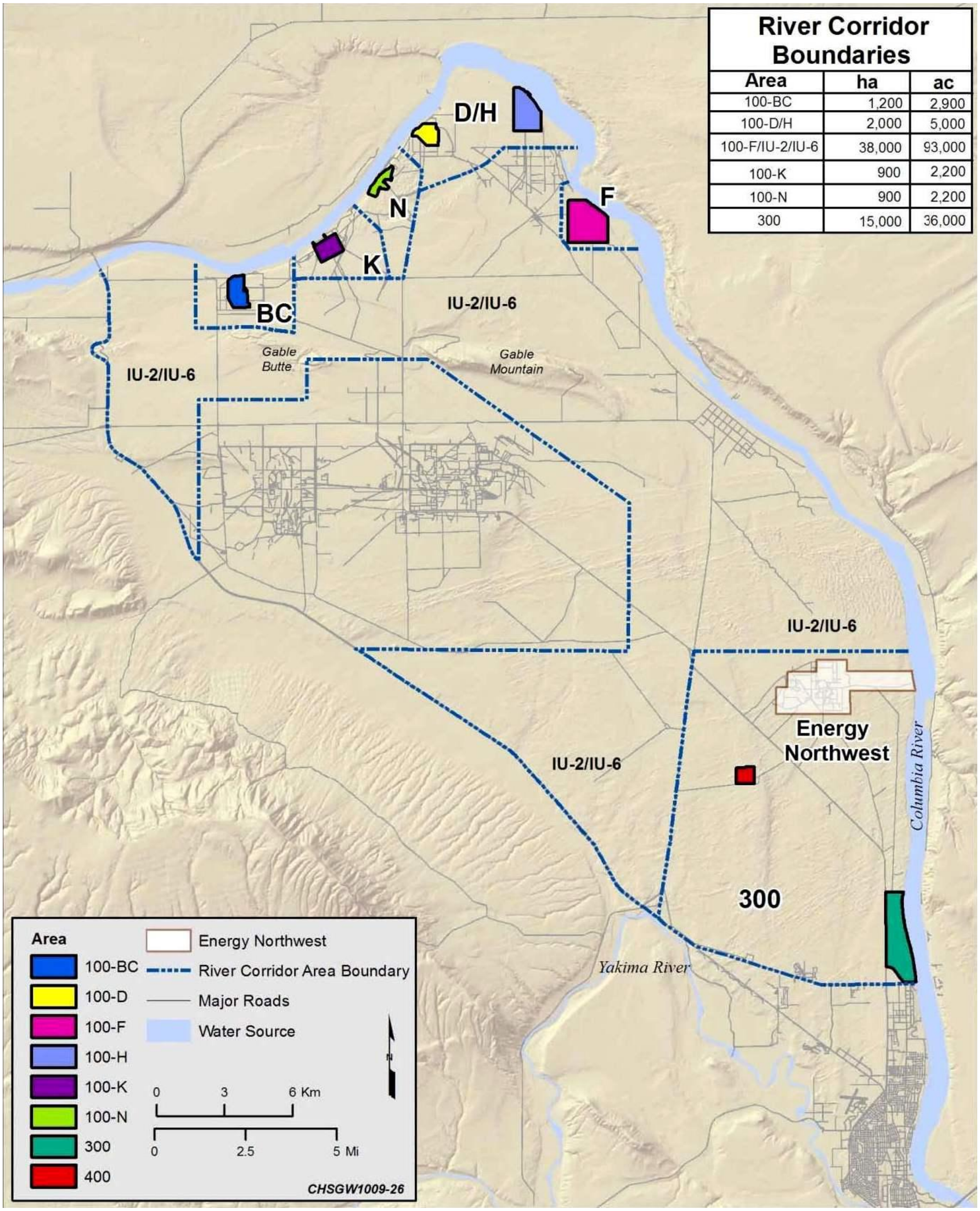
2.1 Introduction

The 100 Area NPL Site consists of nine retired plutonium production reactors, numerous support facilities, and solid and liquid waste disposal sites that have contaminated groundwater and soil. The 100 Area borders the river and is part of the River Corridor (Figure 5). The River Corridor has been divided into six geographic decision areas to achieve final source and groundwater remedy decisions (100-B/C, 100-K, 100-N, 100-D/H, 100-F/100-IU-2/100-IU-6 Area, and 300 Area). Table 4 lists the 22 OUs in 100 Area.

Table 3. 100 Area Operable Units

OU	Brief Description
100-B/C Area	
100-BC-1	soil, buildings, and landfills in the 100-BC reactor area
100-BC-2	soil, buildings, and landfills in the 100-BC reactor area
100-BC-5	groundwater under the 100-BC area
100-D/H Area	
100-DR-1	soil, buildings, and landfills in the 100-D Reactor area
100-DR-2	soil, buildings, and landfills in the 100-D Reactor area
100-HR-1	soil, buildings, and landfills in the 100-H Reactor area
100-HR-2	soil, buildings, and landfills in the 100-H Reactor area
100-HR-3	groundwater under and between the 100-D/DR and 100-H Reactor areas
100-F, 100-IU-2, and 100-IU-6 Area	
100-FR-1	principally soil sites contaminated by liquid discharges
100-FR-2	soil, buildings, and landfills in the 100-F Reactor area
100-FR-3	groundwater under the 100-F Reactor area
100-IU-1	Riverland Railroad wash station
100-IU-2	White Bluffs town site area
100-IU-3	North Slope (also known as Wahluke Slope)
100-IU-4	buried sodium dichromate drums
100-IU-5	pickling acid cribs
100-IU-6	Hanford Town Site area
100-K Area	
100-KR-1	principally soil sites contaminated by liquid discharges
100-KR-2	soil, buildings, and landfills in the 100-K Reactor area
100-KR-4	groundwater under the 100-k area
100-N Area	
100-NR-1	soil, buildings, and landfills in the 100-N Reactor area
100-NR-2	groundwater underneath the 100-N area and the shoreline site

Figure 5. River Corridor Boundaries



2.2 Background

Nine nuclear plutonium production reactors were constructed in the six reactor areas. Eight reactors (constructed between 1944 and 1955) used Columbia River water for once-through cooling. Water was then discharged back to the river or liquid waste disposal sites in the soil. The discharged cooling water contained radioactive materials and hazardous waste constituents. Onshore discharge of this liquid waste created contaminated soil (source) sites, vadose zone, and groundwater.

The 100-N Reactor differed from the other eight reactors due to its dual purpose of producing electricity, tritium, and special nuclear material. The process of using the heat for electricity generation eliminated the need for large volumes of cooling water to be discharged to the Columbia River. Water was re-circulated through the reactor to produce superheated steam in a primary closed loop system. A secondary system produced steam that was re-circulated through the turbine generator. Cooling water from the Columbia River was circulated through a tertiary system and was not exposed to radioactive materials.

The primary and secondary loop systems were fed via a 'feed-and-bleed' process. This process caused the recirculation water to accumulate much higher concentrations of radionuclides than the other 100 Area reactors, so the soil that received the discharges from the 'feed-and-bleed' system had higher concentrations of contaminants than the liquid waste disposal sites in the other 100 Areas. The discharges resulted in contaminated soil (source) sites, vadose zone, groundwater, and surface water. The 100-NR-1 OU is also different from the other OUs because it has soil sites that are contaminated with petroleum and sites contaminated with both petroleum and hazardous substances. The petroleum releases resulted in contaminated soil (source) sites, vadose zone, groundwater, and surface water.

Other contamination and cleanup needs in the 100 Area NPL Site include contaminated structures such as buildings, buried pipelines, buried waste, buried and exposed disposal cribs, disposal trenches, river structures, shoreline sites, and unplanned releases. Spent nuclear fuel from the reactors in the 100 Area was previously stored in two water-filled basins in the 100-K Area but it has been removed. Remedial actions are ongoing to complete the cleanout and ultimate demolition of the basins.

The contaminated groundwater in the 100 Areas reactor sites has been grouped into five OUs, specifically 100-HR-3 OU (100-D/DR and 100-H Reactor Sites), 100-KR-4 OU (100-KE and 100-KW Reactors), 100-NR-2 OU (100-N Reactor), 100-BC-5 (includes 100-B and 100-C Reactor Sites), and 100-FR-3 (100-F Reactor). The 200-BP-5 OU extends into the southern portion of the 100 Area NPL Site, but is discussed in the 200 Area NPL Site section of this five-year review. The annual Hanford Site groundwater monitoring report (*Hanford Site Groundwater Monitoring and Performance Report for 2009*, *Volumes 1 & 2,* DOE/RL-2010-11,) provides detailed information for all groundwater monitoring.

Contaminated waste sites and buildings are grouped geographically into 17 soil (source) OUs: 100-BC-1, 100-BC-2, 100-KR-1, 100-KR-2, 100-NR-1, 100-DR-1, 100-DR-2, 100-HR-1, 100-HR-2, 100-FR-1, 100-FR-2, 100-IU-1, 100-IU-2, 100-IU-3, 100-IU-4, 100-IU-5, and 100-IU-6. These source OUs contain about 400 waste sites, each of which can be categorized as containing one of five different types of contamination: soil, structures, debris, liquid disposal, or landfills.

The selected interim remedies for the source OU waste sites generally consist of excavating contaminated soil or materials, treating it to meet the waste acceptance criteria for an onsite landfill known as ERDF, and disposing of the soil and material in ERDF. This remedy is called the remove, treat, and dispose remedy. Remedial action objectives and cleanup standards under the remove, treat, and dispose remedy are very similar, and in many cases identical, for the source OUs. Vadose zone contamination (i.e., contamination in the soil between the ground surface and upper-most groundwater level) is considered part of the source OU cleanup effort.

One of the remedial action objectives for source OU waste sites is to ensure that underlying groundwater is protected from contamination in the vadose zone which, if not addressed, could migrate and cause groundwater to be contaminated in excess of the DWS or surface water quality standards. Typically, this is addressed by removing contamination present above cleanup levels established for groundwater protection.

2.2.1 Physical Characteristics

The 100 Area NPL Site is the north portion of the Hanford Site. The Columbia River flows through the 100 Area NPL Site. The 100 Area River Corridor sites are 100-B/C, 100-K, 100-N, 100-D/H, and 100-F/100-IU-2/100-IU-6 Areas (Figure 5). The portion north and east of the Columbia River is commonly called the North (or Wahluke) Slope and contained contaminants remaining from anti-aircraft missile bases. This portion of the 100 Area was removed from the NPL in 1998. The portion south and west of the river is the site of six reactor areas (100-B/C, 100-D/DR, 100-F, 100-H, 100-K East and West, and 100-N, with two reactors each at 100-B/C, 100-D/DR, and 100-K, and one each at 100-F, 100-H, and 100-N Areas) and numerous other waste sites primarily associated with Hanford Site construction and operation. It encompasses approximately 26 square miles (67.4 km^2) directly adjacent to the Columbia River.

2.2.2 Land Use

Interim cleanup levels are based on proposed land use in the interim action RODs. Since most of these interim RODs were issued prior to a final land use determination, an unrestricted land use scenario was used to develop the interim cleanup levels. Final cleanup levels will be based on future anticipated land use. The DOE expects that future land use will be as described in the *Record of Decision: Hanford Comprehensive Land-Use Plan Environmental Impact Statement (HCP EIS)*, the 1999-ROD (64 FR 61615; November 12, 1999).

2.3 Chronology

The early cleanup actions for the 100 Area are documented in interim action RODs. These early actions helped to cleanup the site and provided information about where contamination exists and how it moves through soil and groundwater. Observations made during these early actions help to evaluate past cleanup activities and develop future cleanup activities.

The implementation of the selected interim remedy to meet the interim remedial action objectives generally includes the following steps.

- Remove contaminated soil, structures, and debris from 100 Area source waste sites using the 'observational approach'. The observational approach uses observational and analytical screening during remediation to guide the extent of excavation. Remediation proceeds until it can be demonstrated through a combination of field screening and verification sampling that cleanup goals have been achieved
- Treat the waste as required to meet applicable waste disposal criteria
- Dispose of contaminated materials at ERDF
- Backfill excavated areas and re-vegetate
- Remediate contaminated groundwater

2.4 Progress Since 2006 Review

100 Areas General Soil Site Remediation Progress. Since the 2006 five-year review, 94 waste sites have been interim remediated or closed within the 100 Area with completion of the action approved by the lead regulatory agency. Approval is documented through approval of the waste site reclassification forms included in the waste site cleanup verification package or remaining sites verification package. In accordance with the TPA, the status and other descriptive information on each waste site is maintained in the Waste Information Data System, an electronic database.

Approximately 2.3 million tons (2.1 million metric tons) of CERCLA remediation waste have been removed from waste sites in the 100 Area since the 2006 five-year review. Some waste sites in the shadow of the reactor buildings are being left in place until final disposition of the reactor building. The observational approach that uses data collected during the interim remedial action to guide the extent of the excavation has been used very successfully at these waste sites. This method compares sampling data against cleanup standards to determine the physical extent of excavation required to meet the interim remedial action goals. Further information is provided in the individual OU discussions.

100 Areas General Groundwater Remediation Progress. Since the 2006 five-year review, continuous groundwater remediation has been underway. Pump-and-treat systems have been underway in the 100-D, 100-H, 100-K, and 100-N areas. In-situ barriers were implemented in the 100-D and 100-N areas. Further information is provided in the individual OU discussions.

2.5 100 and 300 Crosscutting Issues and Actions from the 2006 Five-Year Review

Below are the crosscutting issues identified in the 2006 five-year review and response actions taken to resolve the issues for the 100 Area OUs.

100 and 300 Area Crosscutting Issues	Actions Taken/Actions Proposed
Issue 1. Additional risk assessment information is needed to evaluate the interim actions prescribed within the RODs and to develop final cleanup decisions.	
Action 1-1. Submit Draft A of the *River Corridor Baseline Risk Assessment Report*.	*Risk Assessment Report for the 100 Area and 300 Area Component of the River Corridor, Draft A* was submitted in June 2007 (DOE/RL-2007-21) to meet TPA Milestone M-16-72. This completed Action 1-1 from the 2006 five-year review.
Action 1-2. Submit draft sampling and analysis plan for Inter-Areas Shoreline Assessment.	Draft A of the sampling and analysis plan for Inter-Areas Shoreline Assessment was submitted in 2006. This completed Action 1-2. The Inter-Areas Shoreline Assessment sampling was completed in accordance with the plan and results will be reflected in Draft B of the risk assessment report.
Issue 2. A strategy to obtain the final RODs and integrate the waste sites, deep vadose zone, and groundwater has not been developed and agreed upon with the regulator agencies.	
Action 2-1. Submit Draft A of the River Corridor Strategy for Achieving Final Cleanup Decision in the River Corridor. The document will identify issues for integration and provide alternatives for future milestone discussions between the Tri-Parties for a final ROD in the River Corridor.	The Tri-Parties met in 2009 and agreed upon a strategy on how to obtain final decision for 100/300 Area OUs by providing integrated RI/FS documents for surface, vadose zone, and groundwater for geographic areas in the 100/300 Areas. The *Integrated 100 Area RI/FS Work Plan* contains this integrated strategy. Subsequent addenda have been approved establishing the data needs for geographic areas in the 100/300 Areas, and sampling and analysis plans developed to gather the necessary data.

2.6 Technical Assessment

The purpose of the five-year review is to determine whether the remedy at a site is or will be protective of human health and the environment (Table 5). Technical assessments are provided for each unit in their specific sections.

Table 4. Operable Units with Functioning Remedy

100-BC-1	100-DR-1	100-FR-1	100-HR-1	100-IU-1	100-IU-4	100-IU-6	100-KR-2	100-KR-4
100-BC-2	100-DR-2	100-FR-2	100-HR-2	100-IU-3	100-IU-5	100-KR-1	100-KR-3	100-NR-1

2.7 Protectiveness Statement

2.7.1 Source Operable Units

Cleanup has occurred, or is ongoing, for the 100 Area Source (soil) OUs under interim action RODs. Protectiveness statements have been made for each OU for which a ROD has been issued. All of the contaminants of potential concern are addressed and ARARs were established for the contaminants of concern. Interim remedial action objectives consistent with the ARARs were identified in the RODs. The cleanup that is occurring under these interim action RODs has not been completed for all of the waste sites within the OU. In addition, broader areas, such as the river shoreline that were evaluated in Draft C of the *River Corridor Baseline Risk Assessment Volume II Human Health Risk Assessment*, issued in December 2010

(DOE/RL-2007-21, Part 1 and DOE/RL-2007-21, Part 2), have not been included in the interim action RODs. Protectiveness statements for the interim remedies have been made for the individual source OUs.

2.7.2 Groundwater Operable Units

Operations of the interim remedies are ongoing for the 100 Area Groundwater OUs under the interim action RODs. Protectiveness statements have been made for each OU for which a ROD has been issued. Interim remedies at 100-HR-3 and 100-NR-2 Groundwater OU are not performing as expected. Identified contaminants of potential concern are being addressed and ARARs were established for the contaminants of concern. Interim remedial action objectives consistent with the ARARs were identified in the RODs.

The groundwater contaminant plumes in some areas have not been addressed and will be addressed in future RODs. The groundwater interim actions in the 100 Area are not final remedial actions. The interim actions are designed to keep selected principle threat contaminants from reaching the Columbia River. Consequently, the protectiveness of the selected remedies for groundwater remediation cannot be evaluated through the same logic. There may be contaminants other than the selected principle threat contaminates addressed in the interim actions that may need to be addressed in the final RODs. Protectiveness statements for the interim remedies have been made for the individual groundwater OUs with interim remedies.

2.8 100-B/C Area

2.8.1 Background

The 100 B/C Area consists of the 100-BC-1 and 100-BC-2 Source OUs, and 100-BC-5 Groundwater OU. 100-BC-1 and 100-BC-2 Source OUs include contaminant sources, while the 100-BC-5 Groundwater OU includes groundwater contamination. Figure 6 shows a map of the 100-B/C Area and the associated OUs.

The B Reactor was constructed in 1943 and operated from 1944 through 1968; and as the world's first industrial-scale nuclear reactor, the National Park Service designated B Reactor as a National Historic Landmark on August 25, 2008. The B Reactor building is under consideration by the National Park Service for preservation as a museum, and the DOE offers seasonal tours of B Reactor. The C Reactor was constructed in 1951 and operated from 1952 until 1969. Besides B Reactor, the only active facilities in the 100-BC-1 and 100-BC-2 Source OUs are those used as part of the ongoing remedial actions (e.g., field office trailers) and the facilities that extract and treat water from the Columbia River and transport treated water to other 100 Area and 200 Area facilities.

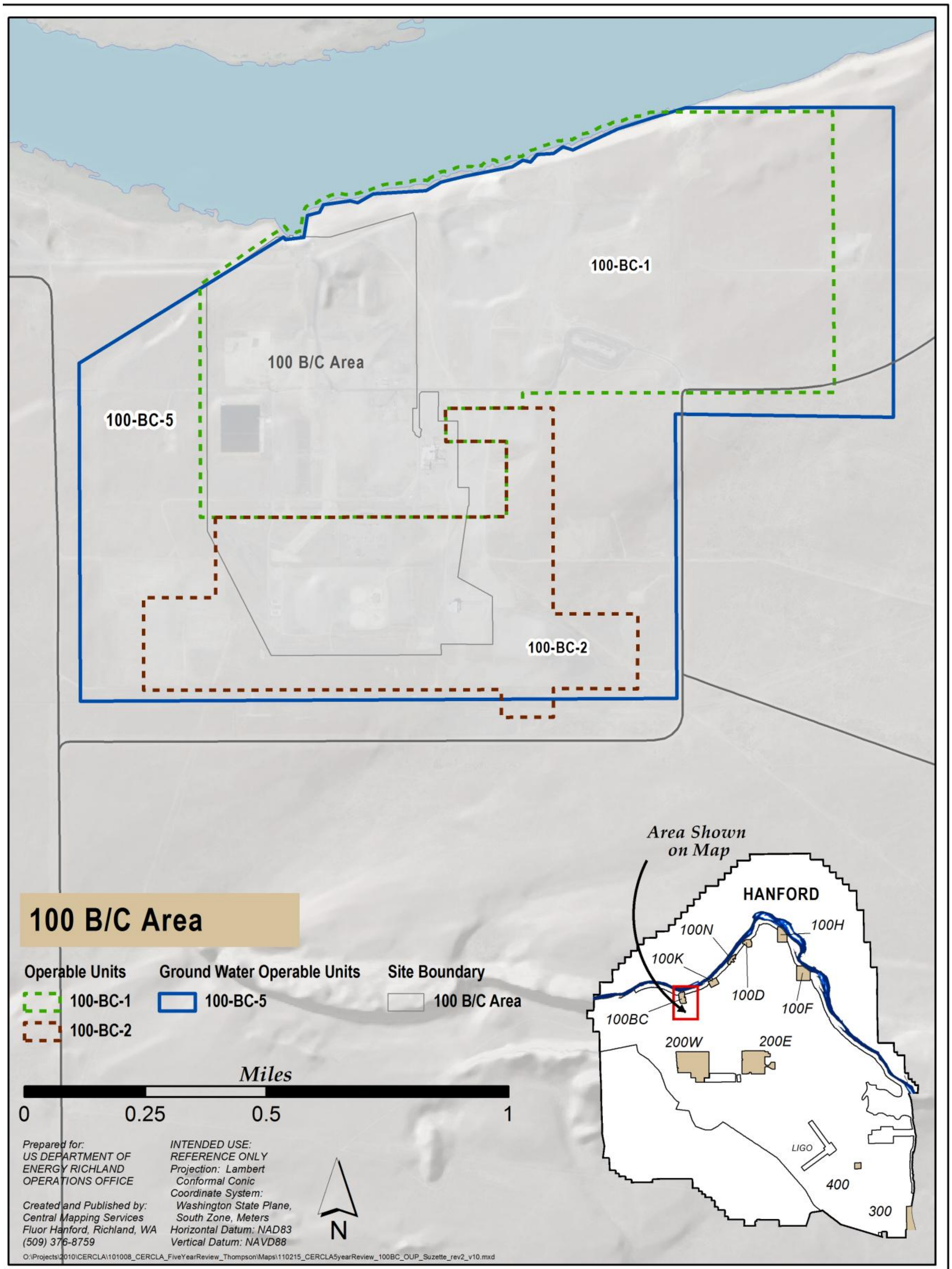
2.8.2 Chronology

The following information summarizes the chronology of significant decision documents relevant to CERCLA response actions in the 100-B/C Area.

100-BC-1 and 100-BC-2 Operable Units

9/28/1995	EPA/ROD/R10-95/126	Interim Action ROD: 100-BC-1, 100-DR-1, and 100-HR-1 OU Interim Remedial Actions
1/29/1997	DOE/AR D197045200	Action Memorandum: 100 B/C Area Ancillary Facilities and the 108-F Building Removal Action
4/4/1997	EPA/AMD/R10-97/044	Interim Action ROD Amendment: 100-BC-1, 100-DR-1, and 100-HR-1 OU Interim Remedial Actions
7/15/1999	EPA/ROD/R10-99/039	Interim Action ROD: 100-BC-1, 100-BC-2, 100-DR-1, 100-DR-2, 100-FR-1, 100-FR-2, 100-HR-1, 100-HR-2, 100-KR-1, 100-KR-2, 100-IU-2, 100-IU-6, and 200-CW-3 OUs interim remedial actions
9/25/2000	EPA/ROD/R10-00/121	Interim Action ROD: 100-BC-I, 100-BC-2, 100-DR-I, 100-DR-2, 100-FR-2, 100-HR·2, 100-KR-2, OU Interim Remedial Actions (100 Area landfills)
12/2001	AR/PIR D8979346	Action Memorandum: 100 Area NPL 105-B Reactor Facility
11/14/2007	08-AMRC-0033	ESD: Interim Action ROD 100 Area Remaining Sites (100-BC-1, 100-BC-2,100- DR-1, 100-DR-2, 100-FR-2, 100-HR-2, and 100-KR-2 OUs
8/2009	DOE/EPA/Ecology	ESD: Interim Action ROD 100 Area Remaining Sites (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)

Figure 6. 100-B/C Area



2.8.3 100-BC-1 and 100-BC-2 Operable Units

This section describes the interim remedial actions conducted in the 100-B/C Source OUs.

2.8.3.1 Background

This cleanup action consists of the excavation and removal of contaminated soil, the pipelines that transported the liquid waste, structures, and associated debris, including any unanticipated material that was part of the engineered structure or otherwise deposited at the site, followed by treatment as necessary, and disposal to ERDF. Generally, this cleanup action includes implementation of institutional controls before and during execution of the remove, treat, and dispose remedy, and following completion of remedy if necessary.

2.8.3.2 Chronology

The interim selected remedy in the 1995 interim action ROD was removal of contaminated soil and debris, treatment as necessary, and disposal of the waste in ERDF. In addition, the 100 Area and 200 Area Interim Action ROD also called for removal, treatment, and disposal of contaminated soil for waste sites in 100-B/C Area. Work has been ongoing since 1995.

2.8.3.3 Remedial Action

In cases where, based on an evaluation of balancing factors and public input, a decision is made to leave contamination in place above levels allowing for unrestricted land use, ongoing institutional controls are required to ensure protection of human health and the environment. In November 2007, an ESD to the 100 Area Burial Grounds ROD was issued establishing an institutional control prohibiting irrigation at the 118-B-1 Burial Ground for 140 years. Prohibiting irrigation will allow the tritium to decay and help prevent additional tritium contamination of the groundwater. This action was necessary due to the presence of tritium contamination in a discrete portion of the burial ground at levels above the remedial action objective for protection of groundwater and the Columbia River. Based on an evaluation of CERCLA criteria, the institutional control was imposed in lieu of requiring additional excavation.

The interim remedial action objective for 100-BC-1 and 100-BC-2 Source OUs is listed below.

100-BC-1 and 100-BC-2 Operable Units Remedial Action Objectives

Remedial Action Objective 1	Protect human and ecological receptors from exposure to contaminants in soil, structures, and debris by dermal exposure, inhalation, or ingestion of radionuclides, inorganics, or organics. Protection will be achieved by reducing concentrations of, or limiting exposure pathways to, contaminants in the upper 15 feet (4.6 meters) of the soil exposure scenario. The levels of reduction will be such that the total dose for radionuclides does not exceed 15 millirem per year above Hanford Site background for 1,000 years following remediation and State of Washington *Model Toxic Control Act* (MTCA) Method B levels for inorganics and organics.
Remedial Action Objective 2	Control the sources of groundwater contamination to minimize the impacts to groundwater resources, protect the Columbia River from further adverse impacts, and reduce the degree of groundwater cleanup that may be required under future actions. This remedial action objective will be achieved by protection of groundwater that has not been impacted such that contaminants remaining in the soil after remediation do not result in an adverse impact to groundwater that could exceed maximum contaminant levels (MCLs) and non-zero maximum contaminant level guidelines (MCLGs) under the Safe Drinking Water Act (SDWA). The SDWA MCL for radionuclides will be attained at a designated point of compliance beneath or adjacent to the waste site in groundwater. The location and measurement of the point of compliance is to be defined by EPA and Ecology. Monitoring for compliance will be performed at the defined point.
Remedial Action Objective 3	To the extent practicable, return soil concentrations to levels that allow for unlimited future use and exposure. Where it is not practicable to remediate to levels that will allow for unrestricted use in all areas, institutional controls and long-term monitoring will be required.

2.8.3.4 Progress Since 2006 Review

All of the identified 100-B/C Area waste sites, including cribs, ditches, trenches, and retention basins (including waste sites recently identified) have been remediated and backfilled with clean soil, with the exception of two sites (100-C-7 and 100-C-7:1) which have hexavalent chromium contamination in the deep vadose zone. Remediation of the 10 solid waste burial grounds is now complete, following remediation of the 118-B-1 and 118-C-1 Burial Grounds in 2007. Spent nuclear fuel discovered in these two sites was shipped to K Basins in 2007.

During excavation of the 100-C-7 waste site in the south-central 100-B/C Area, chromium contamination remained at the bottom of the excavation. A characterization borehole was drilled in August 2005 to determine the depth of contamination. A grab sample of groundwater showed low but detectable concentrations of chromium. Additional characterization was performed at 100-C-7 and new waste site 100-C-7:1 in 2007 and the results showed hexavalent chromium above groundwater cleanup levels throughout the vadose zone. DOE has decided to excavate the sites as necessary to remove hexavalent chromium contamination, recognizing that excavation will likely go the entire 85 feet (25.9 meters) to groundwater. Remediation of the sites was initiated in 2010 with removal of concrete structures around the waste sites. Excavation of the waste sites began in the fourth quarter of 2010. Remediation is scheduled to be completed by December 2012.

Finally the 100-B/C remaining sites, including 100-B-19 (multiple areas), 100-B-21, 100-B-25, 100-B-27, 100-B-28, and some smaller ancillary sites, were remediated in 2009. Chromium contamination at the 100-B-27 site was successfully removed down to groundwater. Excavation and load out of the remaining sites were completed in 2009 and backfill and re-vegetation were completed in early 2010.

Since the 2006 five-year review, interim remedies were implemented on the following waste sites. The results are documented in Waste Site Cleanup Verification Packages and Remaining Waste Sites Verification Packages.

100-BC-1 Operable Unit		
100-B-14:1 Process Sewer Main	100-B-22:2 Water Treatment Facilities	118-C-3:3 French Drains
100-B-14:2 Sanitary Sewer Pipelines	100-B-23 Surface Debris	120-B-1 Battery Acid Sump
100-B-18 Debris Pile	100-B-25 Spillway/Outfall Structures	126-B-3 Coal Pit
100-B-19 Contaminated Soil Areas	100-B-27 Sodium Dichromate Spill	128-B-2 Burn Pit
100-B-20 Underground Tank	100-B-28 Pipeline	128-B-3 Dump Site
100-B-21:2 Miscellaneous Pipelines	100-B-32 Soil Contamination Area	128-C-1 Burning Pit
100-B-21:3 Asbestos Wrapped Pipe	100-B-33 Soil Contamination Area	1607-B2 Septic Tank System
100-B-21:4 Pipeline from Sump	116-C-3 Chemical Waste Tanks	600-233 Electrical Lay down Area
100-BC-2 Operable Unit		
100-B-1 Surface Chemical and Soil Waste Dumping Areas	100-C-9:1 Underground Pipelines	118-B-1 Solid Waste Burial Ground
100-B-31 Garnet Sand	100-C-9:2 Sanitary Sewer Pipelines	118-B-6 Burial Ground
		118-C-1 Burial Ground

2.8.3.5 Technical Assessments

The purpose of the five-year review is to determine whether the remedy at a site is, or upon completion will be, protective of human health and the environment. The following is the technical assessment response of the 100-BC-1 and 100-BC-2 Source OUs interim remedy concerning the technical assessment questions provided in the EPA guidance. The following also establishes a framework for organizing and evaluating data and ensuring that all relevant issues are considered when determining the protectiveness of the remedy.

Is the remedy functioning as intended by the decision documents?

The interim remedy is functioning within the specified remedial action objectives. The remove, treat, and dispose action has proven to be functioning at a depth of 15 feet (4.6 meters) for the direct exposure pathway, and has also been demonstrated to be protective of groundwater and the river throughout the soil column based on modeling scenarios developed for use in implementing the interim action RODs. Additionally, for sites where contamination extends below 15 feet (4.6 meters), the engineered structure (at a minimum) is remediated to achieve remedial action objectives. Verification sampling after completion of excavation has indicated that the soil contamination has been removed to meet the cleanup requirements of the interim action ROD and has been sent to ERDF for disposal. The final ROD will address additional exposure scenarios and additional models for evaluating contaminant migration pathways.

Are the exposure assumptions, toxicity data, cleanup levels, and remedial action objectives used at the time of remedy selection still valid?

The exposure assumptions, toxicity data, cleanup levels, and the interim remedial action objectives used at the time of remedy selection are still valid for all OUs.

Has any other information come to light that could call into question the protectiveness of the remedy?

No new information has come to light that could call into question the protectiveness of the remedy for these OUs.

2.8.3.6 Protectiveness Statements

The final remedy at 100-BC-1 OU is expected to be protective of human health and the environment upon completion of the final remedy. The current interim actions ensure that exposure pathways that could result in unacceptable risks are being controlled.

2.8.4 100-BC-5 Operable Unit

A ROD has not been issued for 100-BC-5 Groundwater OU. The 100-BC-5 OU will be in the 100-BC Area final ROD that is scheduled for issuance in CY12. This section describes the activities being conducted in the 100-BC-5 Groundwater OU.

2.8.4.1 Background

Groundwater contaminants consist of strontium-90, tritium, nitrate, and hexavalent chromium. A ROD for groundwater remediation has not been established for this area. Previous assessments have not identified groundwater conditions that warrant interim remedial measures, assuming that the source control measures will meet expected final remedial action objectives designed to reduce contaminant recharge to the aquifer.

2.8.4.2 Chronology

There has been no interim action decision documents issued for the 100-BC-5 Groundwater OU. A final RI/FS work plan will be issued to support the final CERCLA decision process.

2.8.4.3 Remedial Actions

Routine groundwater sampling requirements are defined in the groundwater sampling and analysis plan (*100-BC-5 Operable Unit Sampling and Analysis Plan*, DOE/RL-2003-38), as modified by the TPA Change Notices TPA-CN-240 and TPA-CN-293. Scheduled sampling occurred as planned for wells and seeps.

In March 2010, the RI/FS work plan (*Integrated 100 Area Remedial Investigation/Feasibility Study Work Plan, Addendum 3: 100-BC-1, 100-BC-2, and 100-BC-5 Operable Units*, DOE/RL-2008-46) and sampling and analysis plan (*Sampling and Analysis Plan for the 100-BC-1, 100-BC-2, and 100-BC-5 Operable Units Remedial Investigation/Feasibility Study*, DOE/RL-2009-44) were signed by EPA and DOE. The documents are related to the *Integrated 100 Area Remedial Investigation/Feasibility Study Work Plan* (DOE/RL-2008-46). The documents describe the data to be collected to support selection of final remedies under CERCLA and the approach integrates data needs for waste sites and groundwater. The plans were implemented during the beginning of CY10. The data and results will be reported in an RI/FS report, which will lead to the selection of alternatives for final action site cleanup.

100-B/C Area Remedial Action Objective

Remedial Action Objective 2	Control the sources of groundwater contamination to minimize the impacts to groundwater resources, protect the Columbia River from further adverse impacts, and reduce the degree of groundwater cleanup that may be required under future actions. Protection will be such that contaminants remaining in the soil after remediation do not result in an adverse impact to groundwater that could exceed MCLs and non-zero MCLGs under the SDWA. The SDWA MCL for radionuclides will be attained at a designated point of compliance beneath or adjacent to the waste site in groundwater. The location and measurement of the point of compliance will be defined by EPA and Ecology. Monitoring for compliance will be performed at the defined point. Protection of the Columbia River from adverse impacts so contaminants remaining in the soil after remediation do not result in an impact to groundwater and, therefore, the Columbia River, that could exceed the ambient water quality criteria under the Clean Water Act for protection of fish. Since there are no ambient water quality criteria for radionuclides, MCLs will be used. The protection of receptors (aquatic species, with emphasis on salmon) in surface waters will be achieved by reducing or eliminating further contaminant loadings to groundwater so receptors at the groundwater discharge in the Columbia River are not subject to additional adverse risks. Measurement of compliance will be at a near-shore well, in the downgradient plume. The location and measurement will be defined by EPA and Ecology.

2.8.4.4 Progress Since 2006 Review

A ROD for groundwater remediation has not been established for this area. Four wells that were proposed during early stages of RI/FS work plan preparation were moved forward and installed in 2009 and early 2010. Six additional wells are proposed under the RI/FS addendum (DOE/RL-2008-46). These wells will be added to the *100-BC-5 Operable Unit Sampling and Analysis Plan* after completion.

2.8.4.4.1 Chromium

Figure 7 contains the plume map for chromium in the 100-B/C Area. As part of a study of groundwater upwelling in the river channel, porewater samples were collected from depths of approximately 0.98 feet (0.3 meters) in the river bottom at 22 locations along the 100-B/C segment of shoreline. Chromium concentrations up to 112 µg/L were detected at locations beneath the deepest part of the river channel. In some cases, these concentrations were greater than those currently measured in the groundwater. Additional analysis results have not repeated these high chromium concentrations

In response to the unexpected porewater results, DOE took the following actions.

- Prioritized sampling of 100-B/C Area aquifer tubes in Fall 2009 (results were in trend with previous samples).
- Sampled three wells near the shoreline one additional time in Fall 2009 (results were in trend with previous samples).
- Expedited drilling of four of the RI/FS proposed wells in an area of particular interest. Characterization results were consistent with the previous interpretation of the chromium plume.
- Added work scope to the RI/FS work plan addendum to install three aquifer tube clusters and conduct additional porewater sampling.

2.8.4.4.2 Strontium-90

A wedge-shaped plume of strontium-90 extends from the central 100-B/C Area north toward the Columbia River (Figure 8). The DWS for strontium-90 is 8 pCi/L. The plume has not changed significantly for more than 15 years. Former contaminant sources for the strontium-90 included the 116-B-11 Retention Basin, 116-B-1 Trench, and 116-C-1 Trench. The highest concentration during CY09 was 29 pCi/L in a well near the 116-B-1 Trench. Long-term trends are steady or declining.

Strontium-90 levels in four aquifer tubes exceeded the DWS during the report period, with a maximum of 25 pCi/L. Other tubes have concentrations above the DWS; however, concentrations in these tubes have declined since 1999.

Strontium-90 appears to be limited to the upper portion of the unconfined aquifer. A well that is screened in a water-bearing zone of the Ringold upper mud unit has consistently had no detectable strontium-90, while its shallow counterpart well had levels above the DWS.

2.8.4.4.3 Tritium

The unconfined aquifer beneath the 100-B/C Area is contaminated with tritium at concentrations that exceed the DWS (20,000 pCi/L) in several wells (Figure 9). Tritium was present in effluent discharged to former cribs near the B Reactor and near the river. The 118-B-1 Burial Ground in the southwestern 100-B/C Area was another source of contamination.

In the northern 100-B/C Area, only one well and aquifer tube had tritium concentrations above the DWS during the five-year review period. Recent increases in tritium concentrations in the well (to 47,000 pCi/L in 2009) and in the aquifer tube (to 29,000 pCi/L in October 2009), may represent the pulse of tritium previously detected in another well in 2005 and 2006.

Tritium concentrations in two portions of the southern 100-B/C Area exceed the DWS. Because the area has only three monitoring wells, these plumes are not well defined. The tritium concentration fell below the DWS in one of the wells, located near the 118-B-1 Burial Ground. Two other wells continued to have tritium concentrations above the DWS. Characterization groundwater samples from a new well completed in early 2010 also showed tritium levels above the DWS. The tritium plume map (Figure 10) reflects the presence of tritium at the water table in the new well location. DOE will continue to monitor the new wells for tritium and other constituents.

2.8.4.5 Technical Assessment

A technical assessment has not been performed because a ROD has not been issued for the 100-BC-5 Groundwater OU.

2.8.4.6 Protectiveness Statement

A protectiveness determination of the remedy at 100-BC-5 Groundwater OU cannot be made at this time until further information is obtained. Further information will be obtained by completing the RI/FS process and selecting a final remedy. The RI/FS work plan addendum (DOE/RL-2008-46) was implemented in 2010 to gather the necessary data. Ten new wells are currently being installed as part of the CERCLA final RI/FS work plan. The wells will be drilled to the bottom of the unconfined aquifer and one well will be screened within the Ringold upper mud unit. Geologic and groundwater chemistry data from the new wells will be used to help characterize the hydrogeology and contaminant distribution, to support the final CERCLA remedy for the 100-B/C Area. It is expected that these actions will be completed by 2016, at which time a protectiveness determination will be made.

Figure 7. 100-B/C Area Average Dissolved Chromium Concentrations

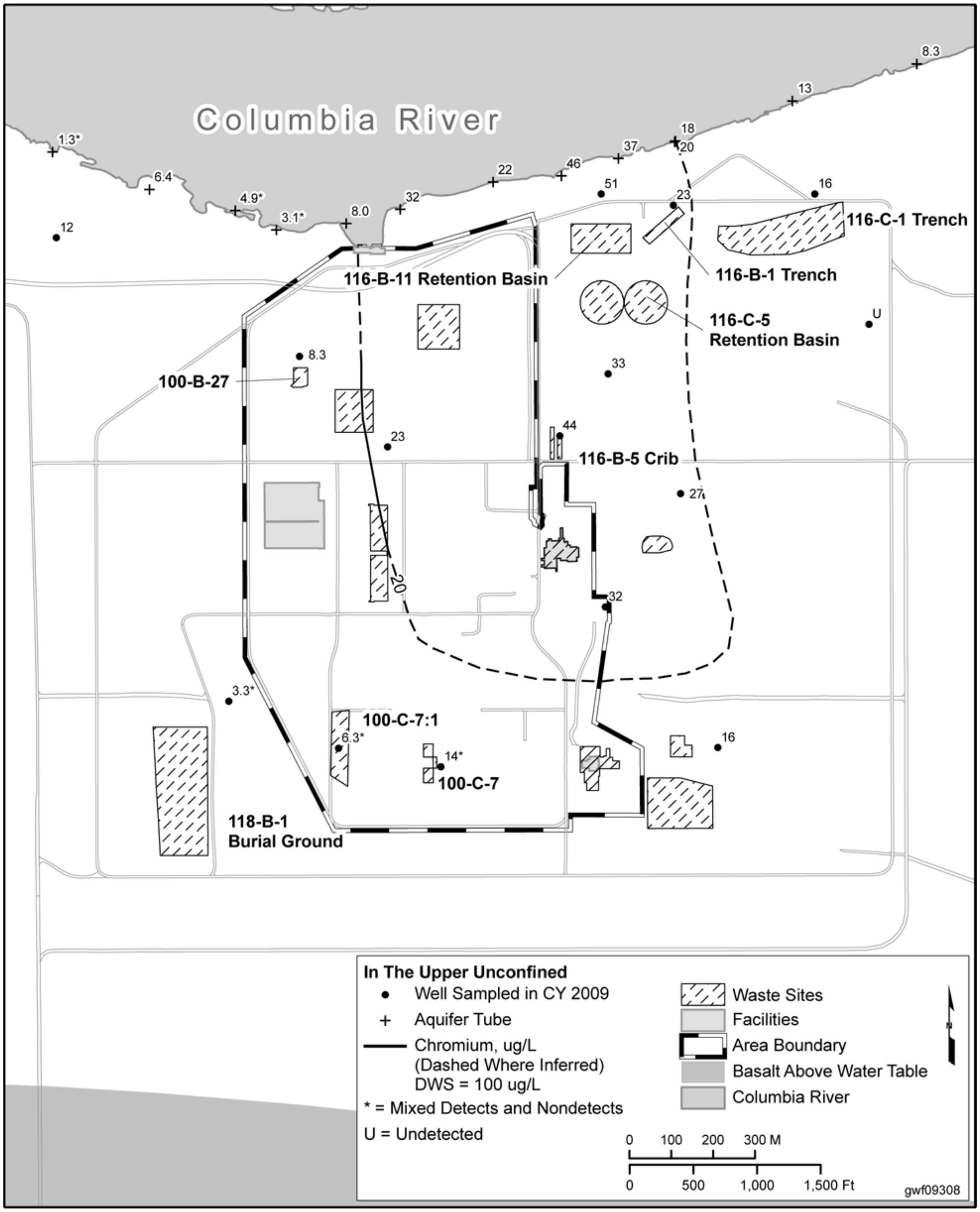


Figure 8. 100-B/C Area Strontium-90 Plume Concentrations

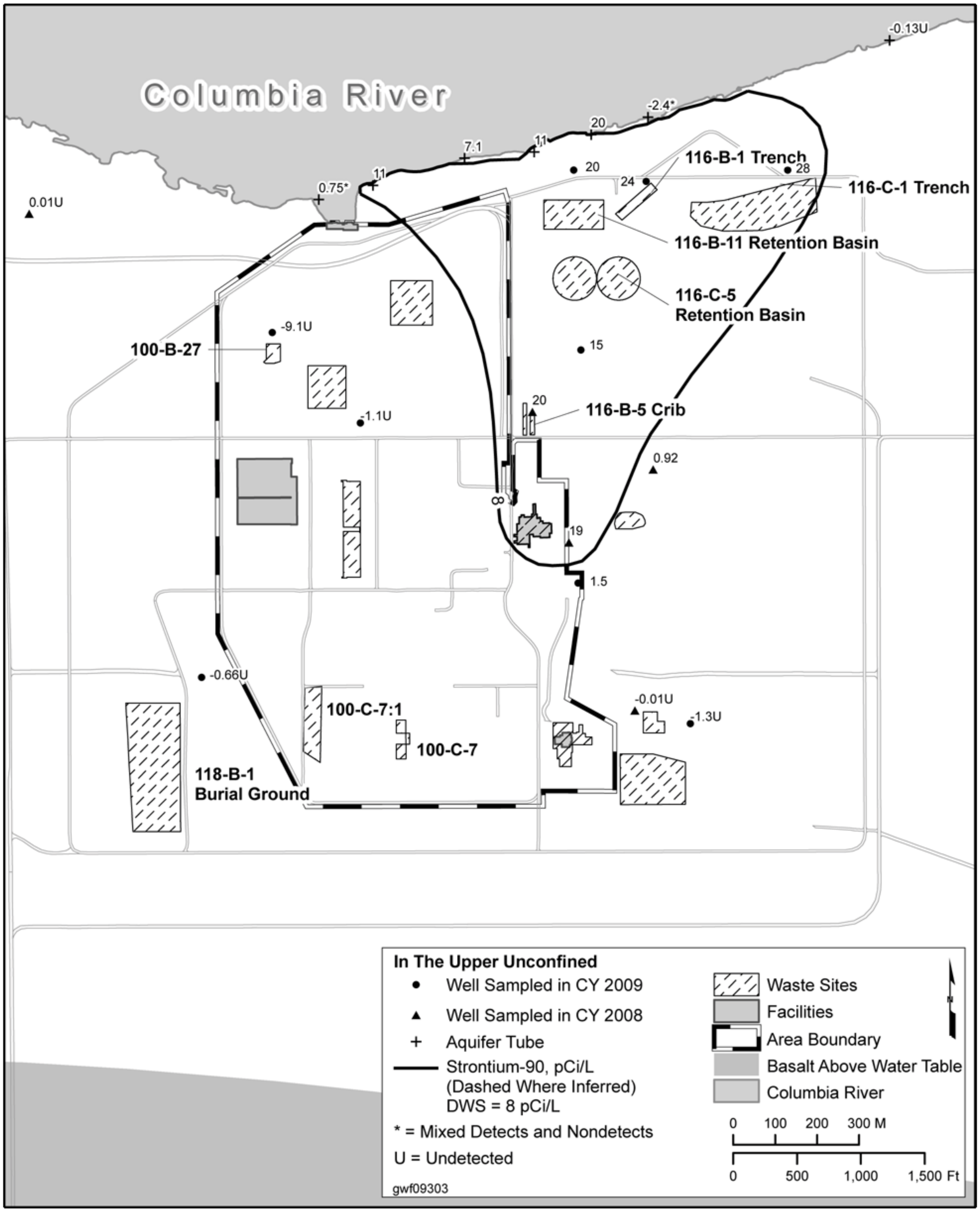


Figure 9. 100-B/C Area, Upper Portion of Unconfined Aquifer Average Tritium Concentrations

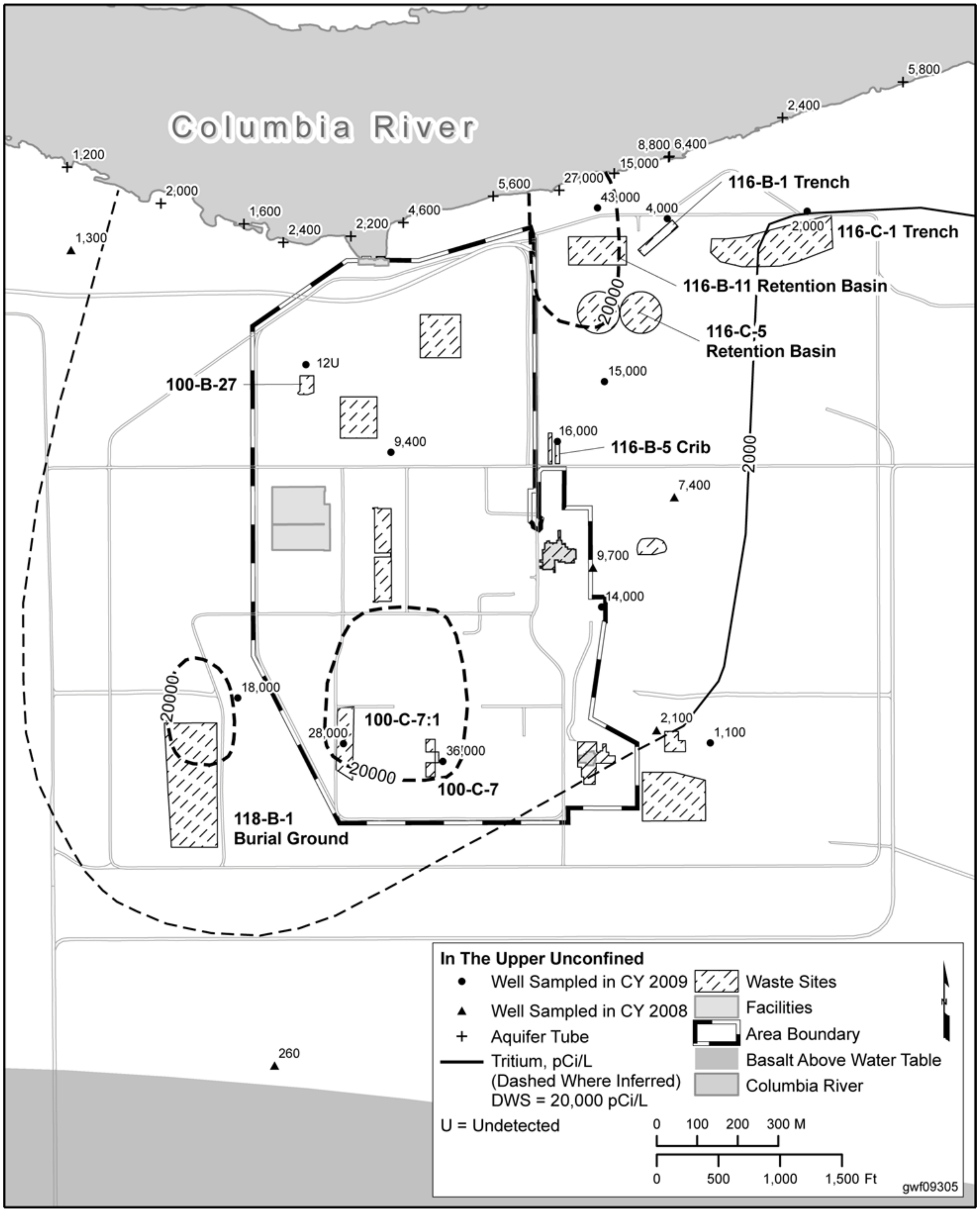
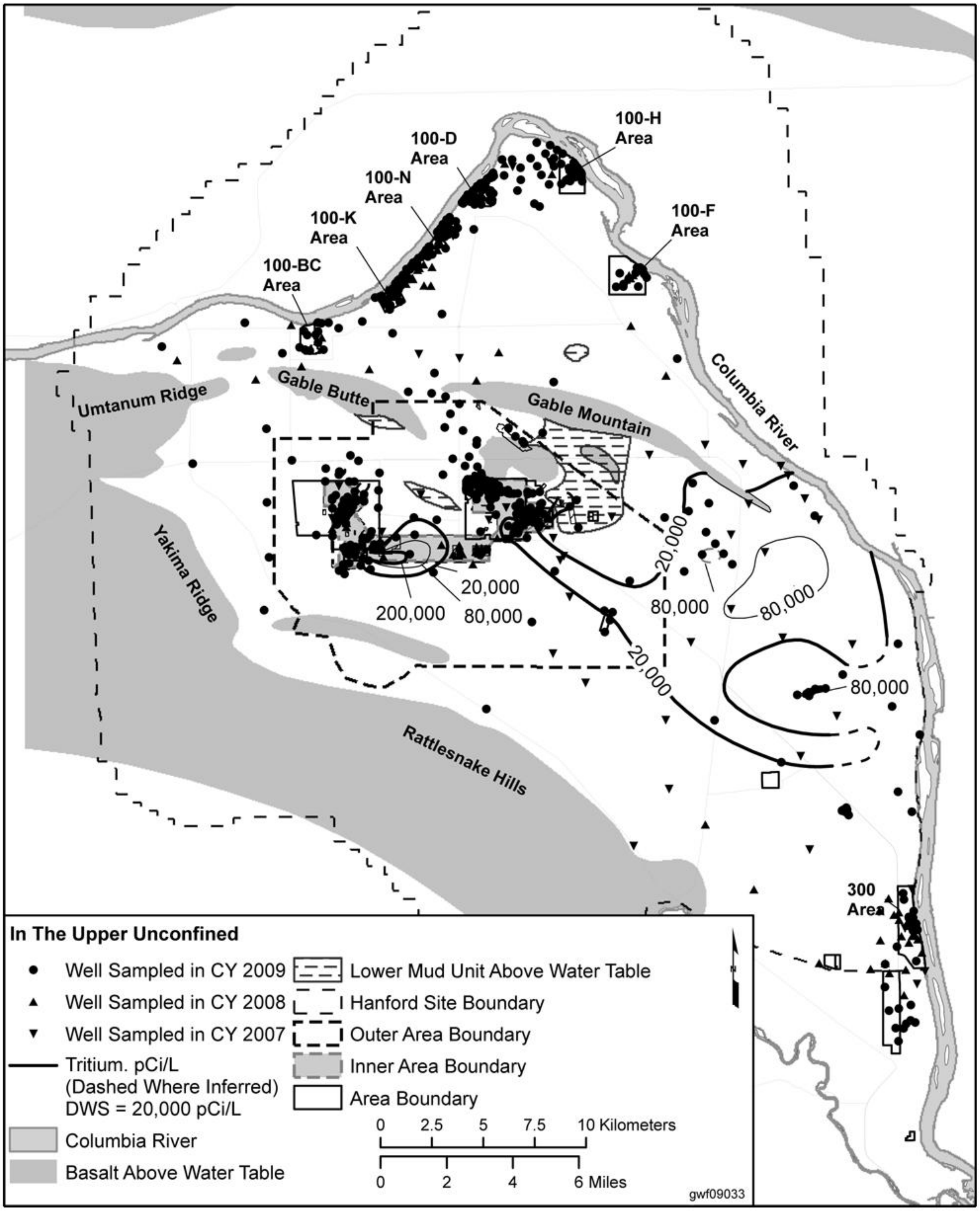


Figure 10. Average Tritium Concentrations, Upper Portion of Unconfined Aquifer



2.9 100-D/H Area

The 100-D/H Area includes 100-D Area (105-D Reactor associated with the 100-DR-1 OU and the 105-DR Reactor associated with the 100-DR-2 OU) and 100-H Area (100-HR-1 and 100-HR-2 Source OUs, 100-HR-3 Groundwater OU, and the area in the known as the 'Horn' area between 100-D and 100-H Areas). Figure 11 shows a map of the 100-D/H Area.

2.9.1 100-D Area

This section describes the CERCLA response actions in the 100-D Area.

2.9.1.1 Background

100-DR-1 and 100-DR-2 Source OUs are located in the 100-D Area; the groundwater under 100-Dis included in the 100-HR-3 Groundwater OU.

2.9.1.2 Chronology

The following information summarizes the chronology of significant decision documents relevant to CERCLA response actions in the 100-D Area.

100-DR-1 and 100-DR-2 Operable Units

9/28/1995	EPA/ROD/R10-95/126	Interim Action ROD: 100-BC-1, 100-DR-1, and 100-HR-1 OU Interim Actions
3/26/1996	EPA/ROD/R10-96/134	Interim Action ROD: 100-HR-3 and 100-KR-4 OUs
1/29/1997	DOE/AR D197045200	Action Memorandum 100 B/C Area Ancillary Facilities and the 108-F Building Removal Action
4/4/1997	EPA/AMD/R10-97/044	Interim Action ROD Amendment: 100-BC-1, 100-DR-1, and 100-HR-1 OU Interim Actions
7/15/1999	EPA/ROD/R10-99/039	Interim Action ROD: 100-BC-1, 100-BC-2, 100-DR-1, 100-DR-2, 100-FR-1, 100-FR-2, 100-HR-1, 100-HR-2, 100-KR-1, 100-KR-2, 100-IU-2, 100-IU-6, and 200-CW-3 OUs Interim Actions
9/25/2000	EPA/ROD/R10-00/121	Interim Action ROD: 100-BC-I, 100-BC-2, 100-DR-I, 100-DR-2, 100-FR-2, 100-HR·2, 100-KR-2, OU Interim Actions (100 Area Burial Grounds)
4/2003	AR/PIR/D1499872	ESD: 100-HR-3 OU ROD
2/2004	AR/PIR/D4855290	ESD: Interim Action ROD 100 Area Remaining Sites (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)
11/14/2007	08-AMRC-0033	ESD: Interim Action ROD 100 Area Burial Grounds (100-BC-1, 100-BC-2, 100-DR-1, 100-DR-2, 100-FR-2, 100-HR-2, and 100-KR-2)
8/2009	DOE/EPA/Ecology	ESD: Interim Action ROD 100 Area Remaining Sites (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)
4/2010	DOE/RL-2010-22	Action Memorandum General Hanford Site Decommissioning Activities

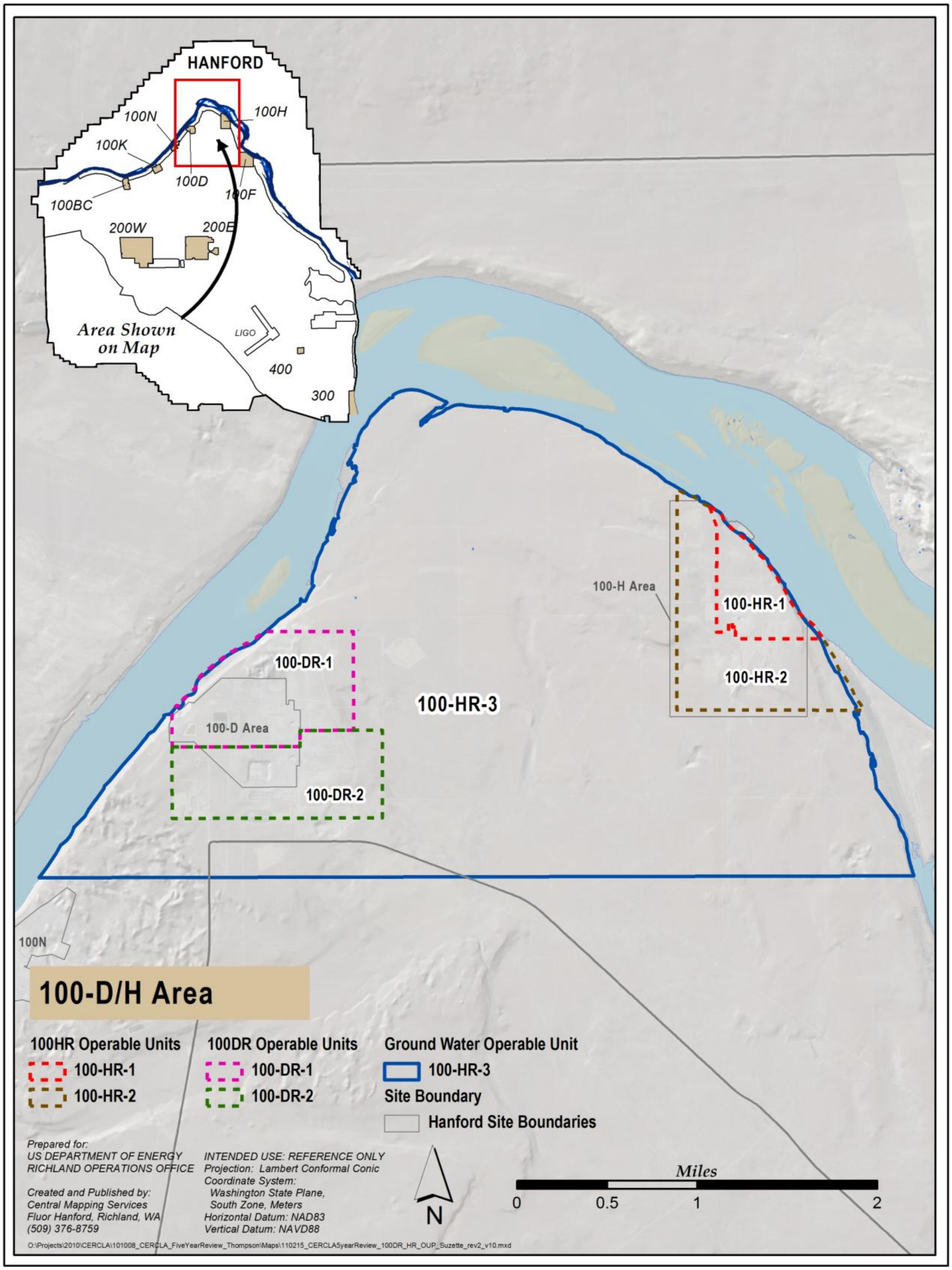
2.9.2 100-DR-1 and 100-DR-2 Operable Units

This section describes the interim remedial actions in the 100-D Area Source OUs.

2.9.2.1 Background

This interim cleanup action consists of the excavation and removal of contaminated soil, the pipelines that transported the liquid waste, structures, and associated debris, including any unanticipated material that was part of the engineered structure or otherwise deposited at the site, followed by treatment as necessary, and disposal to ERDF. Generally, this cleanup action includes implementation of institutional controls before and during execution of the remove, treat, and dispose remedy. In cases where a decision is made, based on an evaluation of balancing factors and public input, to leave contamination in place above levels allowing for unrestricted land use, ongoing institutional controls are required to ensure protection of human health and the environment.

Figure 11. 100-D/H Area



2.9.2.2 Chronology

Since the first interim remedy for waste sites was issued in 1995, waste site remediation has been ongoing. The selected remedy in the 1995 interim action ROD requires institutional controls for any sites where waste is left in place that precludes unrestricted use. This primarily applies to waste sites that have deep zone contamination subjected to a balancing factors analysis, as allowed by the ROD.

2.9.2.3 Remedial Actions

Remediation at high priority 100-D Area liquid waste sites was completed before the term of this five-year review; previously excavated sites were backfilled and re-vegetated during the period ending September 30, 2005. Remediation activities for the remaining soil sites have been ongoing since 2006.

Remediation of landfills began in 2007 and excavation and load-out of waste material from the landfills was completed in 2010. Verification sampling and site closeout for the landfills is in progress. Work on high priority chromium waste sites identified since the 2006 five-year review will be initiated during CY11.

100-D Area Remedial Action Objectives

Remedial Action Objective 1	Protect human and ecological receptors from exposure to contaminants in soils, structures, and debris by dermal exposure, inhalation, or ingestion of radionuclides, inorganics, or organics. Protection will be achieved by reducing concentrations of, or limiting exposure pathways to, contaminants in the upper 15 feet (4.6 meters) of the soil exposure scenario. The levels of reduction will be such that the total dose for radionuclides does not exceed 15 millirem per year above the Hanford Site background for 1,000 years following remediation and State of Washington MTCA Method B levels for inorganics and organics.
Remedial Action Objective 2	Control the sources of groundwater contamination to minimize the impacts to groundwater resources, protect the Columbia River from further adverse impacts, and reduce the degree of groundwater cleanup that may be required under future actions. Protection will be such that contaminants remaining in the soil after remediation do not result in an adverse impact to groundwater that could exceed MCLs and non-zero MCLGs under the SDWA. The SDWA MCL for radionuclides will be attained at a designated point of compliance beneath or adjacent to the waste site in groundwater. The location and measurement of the point of compliance will be defined by EPA and Ecology. Monitoring for compliance will be performed at the defined point. Protection of the Columbia River from adverse impacts so contaminants remaining in the soil after remediation do not result in an impact to groundwater and, therefore, the Columbia River, that could exceed the ambient water quality criteria under the Clean Water Act for protection of fish. Since there are no ambient water quality criteria for radionuclides, MCLs will be used. The protection of receptors (aquatic species, with emphasis on salmon) in surface waters will be achieved by reducing or eliminating further contaminant loadings to groundwater so receptors at the groundwater discharge in the Columbia River are not subject to additional adverse risks. Measurement of compliance will be at a near-shore well, in the downgradient plume. The location and measurement will be defined by EPA and Ecology.

2.9.2.4 Progress Since 2006 Review

Since the 2006 five-year review, the following waste sites implemented interim remedies that and are documented in Waste Site Cleanup Verification Packages and Remaining Waste Sites Verification Packages.

100-DR-1 Operable Unit

100-D-2 lead sheeting waste site	100-D-45 buried VSR thimble site	120-D-2 waste acid reservoir
100-D-9 boiler fuel oil tank	100-D-61 debris piles	132-D-2 filter building
100-D-29 effluent line leak	100-D-79 posted soil contamination areas	132-D-3 pumping station
100-D-31:5 disposal pipeline	116-DR-8 seal pit crib	132-D-4 stack foundation
100-D-31:6 sewer pipelines	118-D-6:2 fuel storage bin	1607-D2:2 replacement drain field
100-D-32 Burial Ground #6	118-D-6:3 fuel storage bin	1607-D4 septic system
100-D-42 buried VSR thimble site		

100-DR-2 Operable Unit		
100-D-15 debris north and south of the 100-D Area perimeter road	100-D-47 burial ground	118-DR-1 burial ground
100-D-27,151-D substation unplanned release	100-D-47 burial ground	126-DR-1 clearwell tank pit/clearwells
100-D-43 buried VNR thimble site	118-D-5 burial ground	132-DR-1 pumping station

There are two hexavalent chromium groundwater plumes, a north plume and a south plume, indicative of the possibility of different sources. It now appears likely that the original source of the southern plume was near the 100-D-12 waste site. Significant accomplishments and developments regarding the 100-D Area hexavalent chromium source sites since the 2006 five-year review include the following.

- An extensive effort was recently made to conduct historical research review of documents, photographs, and construction activities performed in 2007 and 2008 did not identify the sodium dichromate sources contributing to groundwater contamination.
- Literature and drawing reviews or field discoveries have identified additional waste sites that may represent chromium sources, particularly the 100-D-73, 100-D-77, 100-D-100, and 100-D-104 waste sites.
- Remediation activities have occurred at the 100-D-30, 100-D-56:1, and 100-D-56:2 hexavalent chromium source sites.
- Subsurface characterization of the 100-D-100 hexavalent chromium waste site was completed to 15 feet (4.6 meters) below ground surface.
- The North Chromium Plume investigation work was completed, including collection of vadose zone data (*Report on Investigation of Hexavalent Chromium Source in the Northern 100-D Area*, DOE/RL-2010-40).
- The 100-D-12 waste site was included for specific investigation in the CERCLA remedial investigation work plan.

2.9.2.5 Technical Assessment

The purpose of the five-year review is to determine whether the remedy at a site is, or upon completion will be, protective of human health and the environment. The following is the technical assessment response of the 100-DR-1 and 100-DR-2 OU interim remedy concerning the technical assessment questions provided in the EPA guidance. The following also establishes a framework for organizing and evaluating data and ensuring that all relevant issues are considered when determining the protectiveness of the remedy.

Is the remedy functioning as intended by the decision documents?

The interim remedy is functioning within the specified remedial action objectives. The remove, treat, and dispose action has proven to be functioning at a depth of 15 feet (4.6 meters) for the direct exposure pathway, and has also been demonstrated to be protective of groundwater and the river throughout the soil column based on modeling scenarios developed for use in implementing the interim action RODs. Verification sampling after completion of excavation has indicated that the soil contamination has been removed and has been sent to ERDF for disposal. The final ROD will address additional exposure scenarios and additional models for evaluating contaminant migration pathways.

Are the exposure assumptions, toxicity data, cleanup levels, and remedial action objectives used at the time of remedy selection still valid?

The exposure assumptions, toxicity data, cleanup levels, and the interim remedial action objectives used at the time of remedy selection are still valid for all OUs.

Has any other information come to light that could call into question the protectiveness of the remedy?

No new information is known that could call into question the protectiveness of the interim remedy for these OUs.

2.9.2.6 Protectiveness Statement

The final remedy at 100-DR-1 and 100-DR-2 OUs is expected to be protective of human health and the environment upon completion of the final remedy. The current interim actions ensure that exposure pathways that could result in unacceptable risks are being controlled.

2.9.3 100-H Area

This section describes the CERCLA interim response actions in the 100-H Area, which include the 100-HR-1 and 100-HR-2 Source OUs and the 100-HR-3 Groundwater OU. The 100-HR-3 Groundwater OU encompasses the groundwater under both the 100-D and 100-H Areas.

2.9.3.1 Background

The H Reactor complex was constructed after World War II. The H Reactor operated from 1949 to 1965. Currently, there are no active facilities, operations, or liquid discharges within the 100-H Area. The 100-HR-1 and 100-HR-2 Source OUs, include contaminant sources, while the 100-HR-3 Groundwater OU includes the contamination present in the underlying groundwater in the 100-D and 100-H Areas, and the area in the Horn. Figure 11 shows a map of the 100-H Area and the associated OUs.

2.9.3.2 Chronology

The following information summarizes the chronology of significant decision documents relevant to CERCLA response actions in the 100-H Area.

100-HR-1 and 100-HR-2 Operable Units

9/28/1995	EPA/ROD/R10-95/126	Interim Action ROD: 100-BC-1, 100-DR-1, and 100-HR-1 OU Interim Actions
3/26/1996	EPA/ROD/R10-96/134	Interim Action ROD: 100-HR-3 and 100-KR-4 OUs
4/4/1997	EPA/AMD/R10-97/044	Interim Action ROD Amendment: 100-BC-1, 100-DR-1, and 100-HR-1 OU Interim Actions
7/15/1999	EPA/ROD/R10-99/039	Interim Action ROD: 100-BC-1, 100-BC-2, 100-DR-1, 100-DR-2, 100-FR-1, 100-FR-2, 100-HR-1, 100-HR-2, 100-KR-1, 100-KR-2, 100-IU-2, 100-IU-6, and 200-CW-3 OUs Interim Actions
9/25/2000	EPA/ROD/R10-00/121	Interim Action ROD: 100-BC-1, 100-BC-2, 100-DR-1, 100-DR-2, 100-FR-2, 100-HR·2, 100-KR-2, OU Interim Actions (100 Area Burial Grounds)
2/2004	AR/PIR/D4855290	ESD: 100 Area Remaining Sites Interim Action ROD
11/14/2007	08-AMRC-0033	ESD: Interim Action ROD 100-BC-1, 100-BC-2, 100-DR-1, 100-DR-2, 100-FR-2, 100-HR·2, 100-KR-2, OU Interim Actions (100 Area Burial Grounds)
8/2009	DOE/EPA/Ecology	ESD: Interim Action ROD 100 Area Remaining Sites (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)
4/2010	DOE/RL-2010-22	Action Memorandum: General Hanford Site Decommissioning Activities

2.9.4 100-HR-1 and 100-HR-2 Operable Units

Remediation of all the high-priority 100-H Area liquid waste sites, including cribs, ditches, trenches, and retention basins, is complete. Remediation of remaining waste sites was initiated in 2008. Excavation of the burial grounds was complete in FY09 and excavation of the remaining sites was complete in FY10, with the exception of 132-H-3 and 600-151. Excavation of the latter site was delayed in FY10 due to eagle nesting limitations and cultural and ecological reviews, but the site has since been excavated. Excavation of the 132-H-3 waste site continues as of June 2011. Closeout sampling and documentation for the burial grounds and remaining waste sites continued in FY10.

Between August 2007 and May 2008 an 'orphan sites' evaluation was conducted to identify any previously unidentified waste sites at 100-H. Based on this evaluation, 16 new waste sites were discovered that may require remediation. These sites are subject to further review or characterization to determine the need for cleanup. Additionally, 13 groups of non-hazardous debris (e.g., wood waste, uncontaminated concrete, miscellaneous non-hazardous trash) were documented as potential material to be removed and disposed of as part of miscellaneous restoration activities.

2.9.4.1 Background

This cleanup action consists of the excavation and removal of contaminated soil, the pipelines that transported the liquid waste, structures, and associated debris, including any unanticipated material that was part of the engineered structure or otherwise deposited at the site, followed by treatment as necessary, and disposal to ERDF. Generally, this cleanup action includes implementation of institutional controls before and during execution of the remove, treat, and dispose remedy. In cases where a decision is made, based on an evaluation of balancing factors and public input, to leave contamination in place above levels allowing for unrestricted land use, ongoing institutional controls are required to ensure protection of human health and the environment.

2.9.4.2 Chronology

Since the first interim remedy for waste sites was issued in 1995, waste site remediation has been ongoing. The selected remedy in the 1995 interim action ROD requires institutional controls for any sites where waste is left in place that precludes unrestricted use.

2.9.4.3 Remedial Actions

Remediation of all the high-priority 100-H Area liquid waste sites, including cribs, ditches, trenches, and retention basins has been completed. Remediation of the remaining waste sites was initiated in FY08. Excavation of the burial grounds was complete in FY09, and excavation of the remaining sites was complete in 2010, with the exception of 132-H-3 and 600-151. Excavation of the latter site was delayed due to eagle nesting limitations, cultural, and ecological reviews. Closeout sampling and documentation for the burial grounds and remaining waste sites continued in FY10.

Between August 2007 and May 2008 an orphan sites evaluation was conducted to identify any previously unidentified waste sites at 100-H. Based on this evaluation, 16 new waste sites were discovered that may require remediation. These sites are subject to further review or characterization to determine the need for cleanup. Additionally, 13 groups of non-hazardous debris (e.g., wood waste, uncontaminated concrete, miscellaneous non-hazardous trash) were documented as potential material to be removed and disposed of as part of miscellaneous restoration activities.

The orphan sites, 'candidate sites', (e.g., sites that may require remediation, depending on sample results) identified in the 1999 *Interim Action Record of Decision for the U.S. Department of Energy Hanford 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*, 2004 *Explanation of Significant Differences for 100 Area Remaining Sites Interim Remedial Action Record Of Decision*, 2009 *Explanation of Significant Differences for the 100 Area Remaining Sites Interim Remedial Action Record of Decision*, and other discovery waste sites, represent approximately 37 confirmatory sampling sites at 100-H; of these, approximately half have been sampled or evaluated and determined to require remediation. Cleanup activities have been undertaken or completed at approximately half the sites identified as requiring remediation.

2.9.4.4 Progress Since 2006 Review

Since the 2006 five-year review, the following waste sites have been remediated and are documented in Waste Site Cleanup Verification Packages and Remaining Waste Sites Verification Packages.

100-HR-1 Operable Unit

132-H-1 Reactor Stack Burial Site	100-H-9 French Drain	100-H-14 Surface Contamination
118-H-6:2 Below Grade Structures/Soils	100-H-11 Expansion Box French Drain	100-H-31 PCB in Soil
118-H-6:3 Fuel Storage Basin and Soils	100-H-12 Expansion Box French Drain	100-H-10 French Drain
118-H-6:6 Deep Zone Side Slopes	100-H-13 French Drain	132-H-1 Reactor Stack Burial Site

100-HR-2 Operable Unit		
100-H-37 Mud Dauber Contamination Area	132-H-2 Filter building	600-152 Military Septic Tanks
118-H-5 Thimble Pit		

2.9.4.5 Technical Assessments

The purpose of the five-year review is to determine whether the remedy at a site is, or upon completion will be, protective of human health and the environment. The following is the technical assessment response of the 100-HR-1 and 100-HR-2 OU interim remedy concerning the technical assessment questions provided in the EPA guidance. The following also establishes a framework for organizing and evaluating data and ensuring that all relevant issues are considered when determining the protectiveness of the remedy.

Is the remedy functioning as intended by the decision documents?

The interim remedy is functioning within the specified remedial action objectives. The removal, treatment, and disposal remedy is removing source contaminants. The final ROD will address the final cleanup levels for the source contaminants.

Are the exposure assumptions, toxicity data, cleanup levels, and remedial action objectives used at the time of remedy selection still valid?

The exposure assumptions, toxicity data, cleanup levels, and interim remedial action objectives used at the time of remedy selection are still valid for all OUs.

Has any other information come to light that could call into question the protectiveness of the remedy?

No new information has become known that could call into question the protectiveness of the remedy for these OUs.

2.9.4.6 Protectiveness Statement

The final remedy at 100-HR-1 and 100-HR-2 OUs is expected to be protective of human health and the environment upon completion of the final remedy. The current interim actions ensure that exposure pathways that could result in unacceptable risks are being controlled.

2.9.5 100-HR-3 Operable Units

This section describes the interim remedial actions being conducted in the 100-HR-3 Groundwater OU.

2.9.5.1 Background

This section also describes groundwater remedial actions for the 100-D/H-Area portion of the 100-HR-3 Groundwater OU, which includes the groundwater beneath the 100-D Area, 100-H Area, and the Horn.

2.9.5.2 Chronology

In 1996, the *Record of Decision for the USDOE Hanford 100-HR-3 and 100-KR-4 Operable Units Interim Remedial Actions* (EPA/ROD/R10-96/134) remedy involved plume capture and removing hexavalent chromium from groundwater via a pump-and-treat system. Groundwater is extracted via wells near the Columbia River, the chromium is removed, the chromium-contaminated water is treated, and the treated water is discharged to the upgradient aquifer. This remedial action is in progress at selected portions of the chromium plume in the D, K, and H reactor areas. The remedial action is prioritized based on the location with the highest contaminant concentration of hexavalent chromium. The Tri-Parties agreed that a better understanding of the nature and extent of the chromium plume is needed in the area. No action has been taken in the remaining portion of the areas where the contamination is above the current remedial action objectives, pending the evaluation of the success of these selected activities. The principal threat being addressed is the ecological risk to aquatic organisms living in the river gravels where contaminated groundwater up wells into the Columbia River. The cleanup standard is 10 µg/L of hexavalent chromium. Contaminant levels in the groundwater near the Columbia River that discharges into the river have been measured at over 2,000 µg/L hexavalent chromium.

In 1999, the *Record of Decision for the U.S. Department of Energy Hanford 100-HR-3 Operable Unit Interim Remedial Action* was issued. This ROD amendment alters the selected remedy action specified in the interim action ROD for the 100-HR-3 OU by deploying an innovative new technology, In Situ REDOX Manipulation for remediation of this recently characterized hexavalent chromium plume in the 100-D Area.

In 2003, the *Record of Decision Amendment Explanation of Significant Difference for 100-HR-3 Operable Unit Interim Remedial Action* was issued. This ESD was issued to provide notice of revisions to the project schedule and cost estimate associated with the In Situ REDOX Manipulation groundwater remedial action at the Hanford Site's 100-HR-3 OU. The original schedule and cost estimate for the remedial action was identified in the 2000, *Remaining Sites Explanation of Significant Difference Record of Decision*, to the 1996 *Interim Remedial Action Record of Decision (ROD) for the 100-HR-3 OU*. This ESD identifies revisions to the cost estimates associated with In Situ REDOX Manipulation and explains that the addition of an evaporation pond invokes an additional ARAR.

In 2009, the *Explanation of Significant Differences for the 100 Area Remaining Sites Interim Remedial Action Record of Decision* was issued.

In 2010, the *Non-Significant Change for the 100-HR-3 and 100-KR-4 Operable Units Interim Action Record of Decision* regarding supplemental actions for the in situ reduction oxidation manipulation barrier performance for the 100-HR-3 groundwater operable unit interim remedy was issued.

2.9.5.3 Remedial Actions

Hexavalent chromium is the principal contaminant of concern in groundwater in the 100-D and 100-H Areas. Other contaminants include strontium-90, technetium-99, tritium, uranium, and nitrate.

Three CERCLA interim action remedies are currently operating in the 100-HR-3 OU. These include the original 100-HR-3 pump-and-treat system in the 100-H Area (which treats groundwater from both the 100-D and 100-H areas), the 100-DR-5 pump-and-treat system in the 100-D Area, and the In Situ REDOX Manipulation barrier in the 100-D Area. These original pump-and-treat systems are being enhanced with two new systems, called DX and HX pump-and-treat systems.

In 2010, an RI/FS work plan addendum for the 100-D/H Area (DOE/RL-2008-46, Addendum 1) and the sampling and analysis plan (DOE/RL-2009-40) were issued by DOE-RL and approved by Ecology. The documents identify the data to be collected to support selection of final remedies under CERCLA and the approach integrates data needs for waste sites and groundwater. The draft work plan addendum, sampling, and analysis plan for the 100-D/H Area was revised in response to Ecology's comments and implemented in FY10. A total of 10 boreholes, 15 groundwater wells, five test pits, and six aquifer tubes are proposed for installation in 2010 under the work plan. The data and results will be reported in an RI/FS report, which will lead to the selection of alternatives for final action site cleanup.

The following are the interim remedial action objectives for the 100-HR-3 OU.

100-HR-3 Operable Unit Remedial Action Objectives

Remedial Action Objective 1	Protection of aquatic receptors in the river bottom substrate from contaminants in groundwater entering the Columbia River
Remedial Action Objective 2	Protection of human health by preventing exposure to contaminants in the groundwater
Remedial Action Objective 3	Provide information that will lead to the final remedy

2.9.5.4 Progress Since 2006 Review

The following progress has been made in the 100-D Area and 100-H of the 100-HR-3 Groundwater OU since the 2006 five-year review and includes system operations, operation, and maintenance information as applicable.

Chromium concentrations in the upper most aquifer throughout the 100-H Area groundwater plume continue to decline and are below the DWS, though some rebound has occurred during the rebound study and aquifer test conducted in the last quarter of 2009. There is also contamination in the groundwater below the Ringold upper mud formation and will be addressed in the final RI/FS. Chromium concentrations in three of four near-river compliance wells continue to decline, but are still above the aquatic protection criteria. Several of the aquifer tubes have achieved the aquatic protection criteria, while others continue to decline and are approaching the criteria.

Secondary contaminants uranium, technetium-99, and nitrate have also declined, with only a few wells now exceeding the maximum contaminant levels (MCLs). Strontium-90 also exceeds the MCLs in isolated wells adjacent to 107-H Retention Basins. These constituents are being considered in the final RI/FS process. Additional information is included in the contaminant description text.

The Tri-Parties have agreed that they need a better understanding of the nature and extent of the chromium plume in the area. Characterization efforts are underway as supplemental investigations, the RI/FS process, and as part of the installation of the new 100-H Area pump-and-treat system.

The pump-and-treat systems for 100-D/H have been expanded to include two new systems called DX and HX. Further information regarding the performance of the 100-HR-3 OU groundwater pump-and-treat systems can be found in the annual groundwater report (DOE/RL-2010-11).

All major chromium soil waste sites within 100-H Area have had interim remedies implemented. These actions, in conjunction with the pump-and-treat operations, have remediated much of the groundwater beneath 100-H Area to concentrations below the interim remedial action objectives. However, contamination has begun migrating into the 100-H Area from the 'Horn' between 100-D and 100-H Areas (Figure 12). In addition, chromium has migrated below the Ringold upper mud unit (Figure 13). Final remedial action objectives and cleanup levels will be established in the final ROD for 100-D and 100-H Areas.

2.9.5.5 Technical Assessment

The purpose of the five-year review is to determine whether the remedy at a site is, or upon completion will be, protective of human health and the environment. The following is the technical assessment response of the 100-HR-3 interim remedy concerning the technical assessment questions provided in the EPA guidance. The following also establishes a framework for organizing and evaluating data and ensuring that all relevant issues are considered when determining the protectiveness of the remedy.

Is the remedy functioning as intended by the decision documents?

The interim remedy is not functioning within the specified remedial action objectives. The In Situ REDOX Manipulation barrier has not functioned as well as the conceptual site model indicated. While the pump-and-treat systems have removed chromium in the groundwater, contamination has continued to migrate into the horn area between 100-H and 100-D.

Are the exposure assumptions, toxicity data, cleanup levels, and remedial action objectives used at the time of remedy selection still valid?

The exposure assumptions, toxicity data, cleanup levels, and interim remedial action objectives used at the time of remedy selection are still valid for the OUs.

Has any other information come to light that could call into question the protectiveness of the remedy?

The current remediation does not include a portion of the chromium plume (e.g., northern portion toward the Columbia River shoreline known as the 'Horn' (Figure 12). The new D Area pump-and-treat system (began operations in the fall of 2010) and the new HX pump-and-treat system (began operations in Fall 2011) are designed to treat the complete 100-D, 100-H, and 'Horn' plumes. Further characterization as part of the expanded pump-and-treat system construction, as well as the RI/FS process, are significantly aiding the understanding of contaminant distribution throughout 100-HR-3 OU.

Within the 100-D and 100-H Area, groundwater flow is generally toward the Columbia River. Inland from the Columbia River and in eastern portions of the 100-D Area, flow direction changes to a northeasterly direction. Northeast of the 100-D Area, groundwater flow becomes easterly across the Horn area and toward the

100-H Area. Groundwater from the 100-D Area discharges to the Columbia River, as does the groundwater within and northeast of the 100-H Area.

In 2010, the *Integrated 100 Area Remedial Investigation/Feasibility Study Work Plan Addendum 1*: 100-D/H Decision Unit (DOE/RL-2008-46) and the *Sampling and Analysis Plan for the 100-DR-1, 100-DR-2, 100-HR-1, 100-HR-2* (DOE/RL-2009-40), and 100-HR-3 OUs RI/FS) were approved by Ecology. The documents identify the data to be collected to support selection of final remedies under CERCLA and the approach integrates data needs for waste sites and groundwater. A total of 10 boreholes, 15 groundwater wells, five test pits, and six aquifer tubes were proposed for installation under the work plan in 2010. The data and results will be reported in an RI/FS report, which will lead to selection of alternatives for final cleanup actions.

2.9.5.5.1 Pump-and-Treat Operations

Pump-and-treat operations have been carried out since 1997 in selected portions of the chromium plume in the 100-D Area. The location of the remedial action is based on the highest concentration of hexavalent chromium and the Tri-Parties agree that they need a better understanding of the nature and extent of the chromium plume in the area (Figure 14). The 100-D Area (100-DR-5) system has removed about 550 pounds (250 kilograms) of dissolved chromium through 2009. An expansion of the pump-and-treat system called DX is being constructed.

Approximately 80 percent of the pressurized water lines in the 100-D Area have been cut and capped, greatly reducing potential water line leakage as a contaminant driving force; however, the potential for leakage still exists. In February 2010, a major water leak near the 182-D Reservoir discharged at least 10,000 gallons of raw water to the ground and adjacent waste sites; therefore, additional work to identify and remove potential water sources, including the 182-D reservoir, is needed.

The 100-HR-3 pump-and-treat system was specified as an interim action for the 100-HR-3 OU to protect the Columbia River and groundwater (*Declaration of the Record of Decision for the 100-HR-3 and 100-KR-4 Operable Units*, EPA/ROD/R10-96/134). The system initially consisted of two extraction wells in the 100-D Area and six extraction wells in the 100-H Area, but the extraction system has been reconfigured several times. Water from both the 100-D and 100-H Areas has been treated and injected in the 100-H Area. Some of the upgrades currently in progress for the treatment system will add water treatment capabilities within the 100-D Area.

2.9.5.5.2 In Situ REDOX Manipulation Barrier

The remedy in the *Interim Remedial Action Record of Decision Amendment for 100-HR-3 Operable Unit* is in situ treatment of a chromium plume in the 100-D Area (100-HR-3 OU) and is consistent with the remedial action objectives identified in the 1996 *Record of Decision for the USDOE Hanford 100-HR-3 and 100-KR-4 Operable Units Interim Remedial Actions* (EPA/ROD/R10-96/134). This remedial action installed a permeable reactive barrier upgradient to groundwater discharging to the Columbia River.

The barrier, called the In Situ REDOX Manipulation barrier, was installed to reduce chemically dissolved hexavalent chromium in groundwater to trivalent chromium, which is a much less soluble and less toxic species. The In Situ REDOX Manipulation barrier has not performed as expected in capturing the hexavalent chromium. Remedial action monitoring is described in the *Remedial Design Report and Remedial Action Work Plan for the 100-HR-3 Groundwater Operable Unit In Situ REDOX Manipulation* (DOE/RL-99-51). The reduction oxidation treatment zone is approximately 680 meters long (aligned parallel to the Columbia River) and approximately 100 to 200 meters inland. The treatment zone was designed to reduce the concentration of hexavalent chromium in groundwater to no more than 20 µg/L at seven compliance wells located between the treatment zone and the river.

Since the 2006 five-year review, the barrier performance has decreased. DOE has concluded that the barrier alone is not protective and has recommended that the barrier no longer be maintained. An expanded pump-and-treat system has been proposed to protect the Columbia River by adding extraction wells downgradient of the barrier.

Figure 12. Area between 100-D and 100-H Areas (known as the 'Horn')

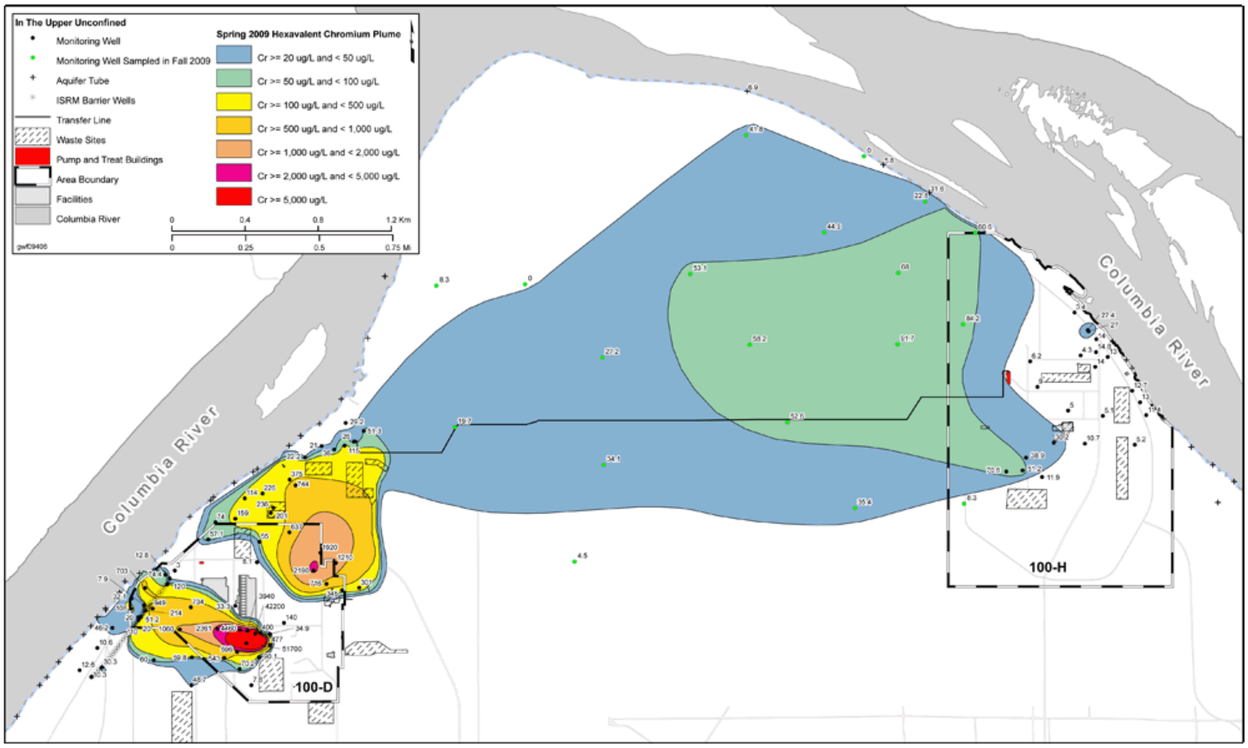


Figure 13. 100-H Area Chromium Groundwater Plume

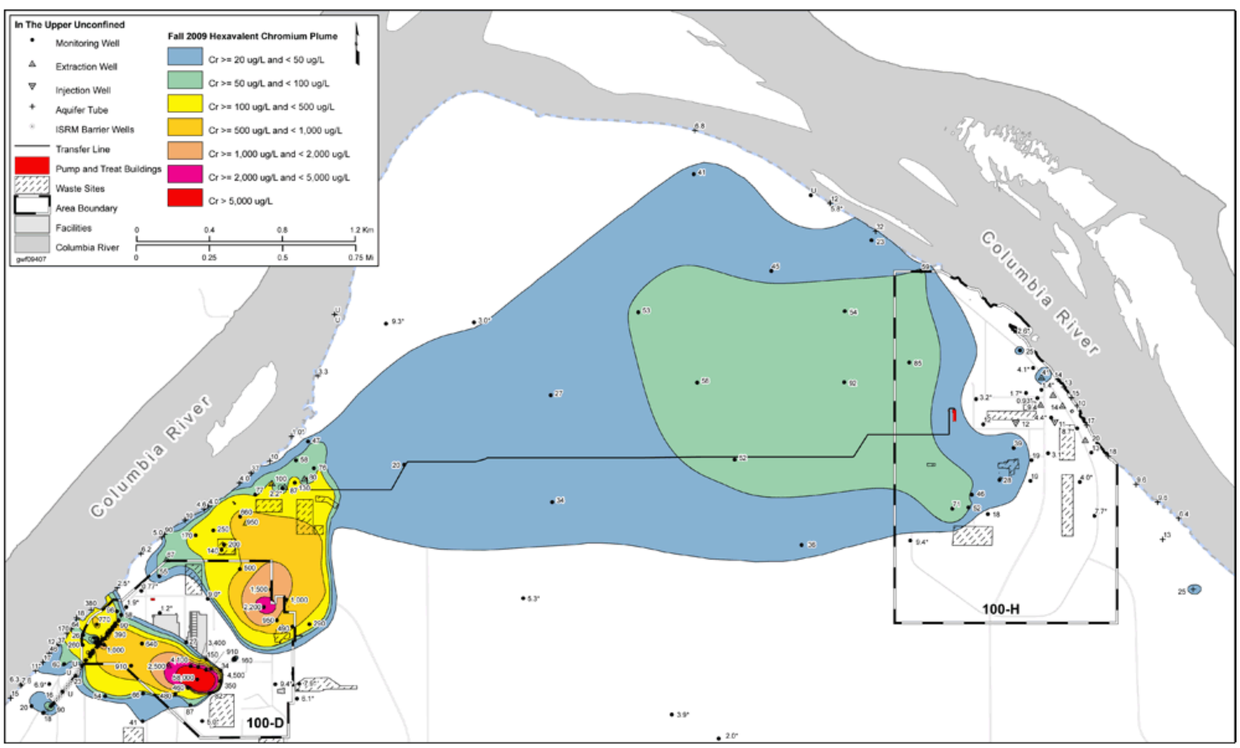
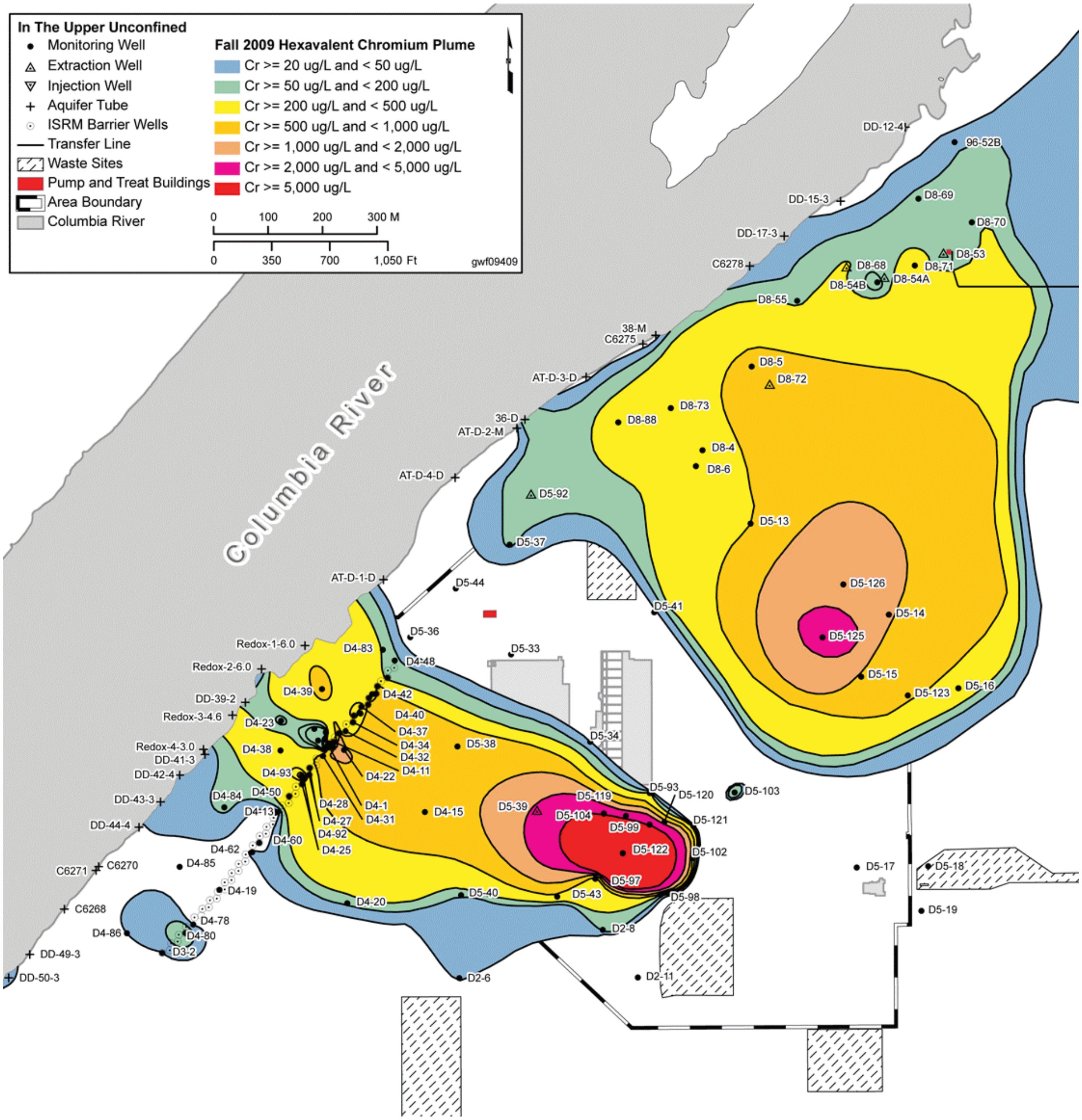


Figure 14. 100-D Area Chromium North and South Plumes



2.9.5.5.3 Zero–Valent Iron Injection

The In Situ REDOX Manipulation barrier was completed in 2002 to intercept hexavalent chromium contamination in the unconfined aquifer in the 100-D Area and chemically reduce the chromium to non-toxic, relatively immobile trivalent chromium using sodium dithionite as the reductant. An independent technical panel recommended injection of micron-sized zero-valent iron in 2004 to renew reducing conditions in the aquifer and mend portions of the barrier.

Seven zero-valent iron materials were evaluated in 2008 and 2009 for the ability to move into the aquifer, chemically reduce groundwater, and move into the aquifer (*Treatability Test Report on Mending the In Situ REDOX Manipulation Barrier Using Nano-Sized Zero Valent*, DOE/RL-2009-35). A zero-valent iron compound was injected into a well within the In Situ REDOX Manipulation barrier over five days in August 2008. A network of monitoring wells surrounding the test site was monitored to determine the extent of iron injection. The data showed that zero-valent iron rapidly appeared in wells 9.9 feet (3 meters) downgradient and upgradient, but did not affect groundwater in wells 42.2 feet (12.8 meters) away. The injection modestly decreased hydraulic conductivity, by a factor of 2.7.

2.9.5.5.4 In Situ Biostimulation Test

A in situ biostimulation treatability test at the 100-D Area was completed in FY09 (*Hanford 100-D Area Biostimulation Treatability Test Results*, PNNL-18784). The purpose of bio-stimulation for the 100-D Area is to induce the reduction of chromate, nitrate, and oxygen and to remove these compounds from the groundwater. For the treatability test, molasses was selected as a commercially available soluble substrate. A commercially available, emulsified vegetable oil was selected as the immiscible substrate.

Test data indicated that each substrate was successfully distributed to the target radius from the injection well. Microbial activity and the ability to reduce the targeted species were observed throughout the monitored zone, and low oxygen, nitrate, and chromium concentrations were maintained for the duration of monitoring. Aquifer permeability reduction within the test zone was moderate. The injected substrate and associated organic degradation products persisted for a period of approximately one year.

Hexavalent chromium is the principal contaminant of concern in groundwater in the 100-D and 100-H Areas. The co-contaminants are strontium-90, technetium-99, tritium, uranium, and nitrate.

2.9.5.5.5 Chromium

2.9.5.5.5.1 Horn Area Plume

The Horn area is located in the northern portion of the Hanford Site, south of the Columbia River, and encompasses the area of the 100-HR-3 OU between the 100-D and 100-H Areas. Groundwater generally flows toward the northeast across the entire Horn area.

Hexavalent chromium is widespread in the 100-HR-3 OU, but levels above 20 µg/L outside the Horn area have been diminishing in recent years in response to treatment and attenuation. Chromium in the Horn area was not well characterized prior to FY07; however, the Horn area was studied extensively in FY07 and FY08 to characterize chromium groundwater contamination and possible deep chromium contamination. The study involved installing 21 groundwater monitoring wells and 18 aquifer tubes.

The Horn area plume is believed to have originated in the 100-D Area and subsequently moved across the Horn area. Recent sampling results for the new wells and other nearby wells show continuous hexavalent chromium in the Horn area between the 100-D and 100-H areas. High concentrations of hexavalent chromium are restricted to the area immediately adjacent to the 100-D Area, and the majority chromium contamination underlies much of the 100-D Area in two distinct plumes. The northern plume likely originates from cribs and trenches in the central 100-D Area, while the southern plume originates near the former chromate transfer station. The target cleanup levels for hexavalent chromium for the 100-HR-3 groundwater interim actions are 22 µg/L for the pump-and-treat systems and 20 µg/L for the In Situ REDOX Manipulation barrier system (*Interim Action Record of Decision for the 100-BC-1, 100-BC-2, 100-DR-1, 100-DR-2, 100-FR-1, 100-FR-2, 100-HR-1, 100-HR-2, 100-KR-1, 100-KR-2, 100-IU-2, 100-IU-6, and 200-CW-3 Operable Units*

(EPA/ROD/R10-99/039); and *Interim Remedial Action Record of Decision Amendment: 100-HR-3 Operable Unit*, (EPA/AMD/R10-00/122).

2.9.5.5.5.2 Southern 100-D Area Plume

The southern plume of the 100-D Area extends from a source area near the former chromate transfer station to the Columbia River. The highest concentration portion of the plume lies south and southwest of the 182-D reservoir and west of the 183-DR filter plant. The southern plume underlies the portion of 100-D Area where concentrated sodium dichromate solutions were delivered by railcar and unloaded for mixing into the cooling water system. Significant sites include the 100-D-12 French drain, located at the sodium dichromate railcar transfer station, where the open ends of transfer hoses and pipes were sheathed in between unloading operations. The high chromium concentrations in the southern plume likely reflect the unloading of concentrated solutions in this area. Additional waste sites of interest near the southern plume include 100-D-30, 100-D-56, 100-D-77, 100-D-100, and 100-D-104. The core of the chromium plume has concentrations exceeding 58,000 µg/L.

The In Situ REDOX Manipulation barrier intercepts this southern chromium plume and reduces concentrations of portions of the plume, preventing it from extending to the Columbia River. The northeastern half of the barrier continues to have the greatest number of wells with concentrations greater than 20 µg/L. Overall, the barrier performance in FY09 was slightly less effective than in the past. During FY09, 58 percent of the barriers monitoring wells had concentrations less than 20 µg/L compared to 64 percent for FY08. Chromium concentrations have decreased since the barrier was installed in the late 1990s, but remained above the cleanup standard in FY09.

In 100-D Area aquifer tubes, concentrations of hexavalent chromium in FY09 were at the lower end of the historical range. Chromium concentrations downgradient of the In Situ REDOX Manipulation barrier have decreased since the late 1990s, but remained above the cleanup standard in FY09.

2.9.5.5.5.3 Northern 100-D Area Plume

The 100 µg/L contour of the northern plume extends north and west from cribs and trenches near the former D Reactor. The northern plume is located near the 105-D Reactor building and north towards the river. Operationally, the northern plume is located underneath the downstream end of the sodium dichromate distribution system with generally less concentrated solutions. A number of waste sites near the northern plume are under investigation for the RI/FS (DOE/RL-2008-46, Addendum 1). These include the 116-D-1A and 116-D-1B Trenches, 116-D-7 retention basin, 116-DR-1 and 116-DR-2 Trench, 116-DR-9 retention basin and the 118-D-6 fuel storage basin. At lower concentrations, the plume extends eastward to the 100-H Area. Concentrations were low from 1999 to 2003, because of dilution from nearby leaking water lines, which were repaired in 2004, *Hanford Site Groundwater Monitoring for Fiscal Year 2004* (PNNL-15070). Concentrations began to increase in 2004 and reached a maximum of 2,450 µg/L in May 2007. Concentrations subsequently declined to approximately 1,000 µg/L in FY08 and varied between approximately 700 and 1,100 µg/L during the five-year review period. The shape and concentrations of the plume have not changed appreciably since the 2006 five-year review.

Chromium concentrations in aquifer tubes downgradient of the northern plume have declined since the late 1990s. Four of the five-aquifer tube clusters used to monitor the northern plume had at least one result exceeding the 10 µg/L aquatic standard during the five-year review period.

2.9.5.5.6 Strontium-90

In May 2009, strontium-90 concentration at 100-D observed was 6.4 pCi/L, which is below the DWS of 8 pCi/L. The areas near the former retention basins in the north and near the 105-D Reactor in the central 100-D Area has a history of strontium-90 detected in groundwater. A well near the former retention basins has had concentrations ranging from two to 14 pCi/L since 1998. Concentrations were 4.7 pCi/L in November 2008 and 5 pCi/L in June 2009. Wells near the former 105-D Reactor were not sampled for strontium-90 recently. Strontium-90 was detected in only one aquifer tube in the 100-D Area in 2009. The highest concentration was 3.5 pCi/L, but a duplicate result was non-detect. Strontium-90 is identified as a co-contaminant in the *Interim Remedial Action Record of Decision Amendment for 100-HR-3*, but is not being addressed by the interim remedy.

The distribution of strontium-90 in the 100-H Area has not significantly changed in recent years, and concentrations continued to exceed the 8 pCi/L DWS in several wells. The highest concentration detected was 110 pCi/L. In 2009, eight aquifer tubes were sampled for strontium-90 in the 100-H Area. Positive detections were found in only one aquifer tube.

2.9.5.5.7 Technetium-99 and Uranium

No positive detections for technetium-99 were found in any of the samples analyzed in 2009 for the 100-D Area.

During the five-year review period, 102 uranium analyses were performed in the 100-D Area wells. All of these analyses were for unfiltered samples and all of the results were above detection limits. The highest result was 4.29 µg/L in November 2009. A duplicate sample was collected at the same time with a uranium concentration of 3.63 µg/L. The values for wells were higher than in November 2008, but both values are less than the Hanford Site background for uranium (14.4 µg/L) and the DWS (30 µg/L).

In the 100-H Area, both technetium-99 and uranium were detected in groundwater downgradient of the former 183-H Solar Evaporation Basins. Concentrations of the constituents were less than the DWSs of 900 pCi/L and 30 µg/L, respectively.

During 2009, uranium was positively detected in all samples analyzed from the 100-H Area. All of the uranium results were for unfiltered samples. The highest result was 14.4 µg/L in December 2009. This is an increase from FY08 results but remains less than the DWS.

In 2009, three aquifer tubes were sampled for technetium-99 and uranium in the 100-H Area. Technetium-99 was not positively detected in any sample. Uranium was detected at low levels in all three aquifer tubes.

2.9.5.5.8 Tritium

Tritium concentrations remained below the 20,000 pCi/L DWS in wells in the 100-D Area, except for one well that exceeded the DWS in November 2008 and 2009 (25,000 pCi/L for both sample events). Another well had one sample slightly above the DWS, at 21,000 pCi/L. The tritium contamination is believed to have originated as part of the 100-N Area tritium plume to the south. A peak of contamination moved past the well in the late 1990s, but concentrations in this well remained steady for the five-year review period and remained below the DWS. Tritium concentrations are elevated in aquifer tubes in the southern portion of the 100-D Area shoreline. The highest tritium aquifer tube concentration in 2009 was 19,000 pCi/L. In general, tritium concentrations are declining. The source of this contaminant also is believed to be the 100-N Area.

Except for the wells in the Horn area, upgradient of the 100-H Area, that have tritium concentrations greater than 2,000 pCi/L, with a maximum of 4,900 pCi/L, the tritium concentrations do not exceed concentrations of 5,000 pCi/L in the 100-H Area wells. The highest concentration for the previous five quarters was 11,000 pCi/L in the southern 100-H Area. All of these concentrations are less than the DWS.

2.9.5.5.9 Nitrate

The nitrate plume has two lobes with nitrate concentrations continuing to exceed the DWS (45 mg/L). During FY09, a maximum concentration of 95 mg/L was detected in a well in the southern 100-D Area. The southern portion of the nitrate plume is intercepted by the In Situ REDOX Manipulation barrier, which chemically reduces the nitrate. Nitrate concentrations in 100-D Area aquifer tubes were all below the DWS. Nitrite was detected in some of the wells monitoring the In Situ REDOX Manipulation barrier in late 2008. Only one analytical result exceeded the 3.3 mg/L DWS (3.8 mg/L) at that time.

Nitrate concentrations exceeded the 45 mg/L DWS in only one monitoring well in the 100-H Area. The highest concentration was 47.8 mg/L in the southern 100-H Area. Aquifer tubes in the southern portion of the 100-H Area and farther downstream have had nitrate levels near or above the 45 mg/L DWS in recent years. The highest value in 2009 was 46 mg/L in an aquifer tube. The aquifer tubes in this region are likely affected by a nitrate plume observed in groundwater monitoring wells in the southeastern 100-H Area.

2.9.5.5.10 Sulfate

Sulfate concentrations remained greater than 100 mg/L beneath much of the southern 100-D Area. Concentrations were below the secondary DWS (250 mg/L) in 2009, with a maximum concentration of 205 mg/L, with the exception of those wells influenced by the In Situ REDOX Manipulation barrier. Previous injections of sodium dithionite solution at the barrier increased sulfate concentrations to levels above the DWS in the In Situ REDOX Manipulation barrier and in some downgradient wells and aquifer tubes. Overall, the concentrations are declining. Sulfate concentrations in 100-D Area aquifer tubes are generally low, except downgradient of the In Situ REDOX Manipulation barrier. The latter tubes are affected by residual chemicals injected into the aquifer and have elevated sulfate concentrations. The highest concentration in 2009 was 584 mg/L which is the highest sulfate concentration ever detected in an aquifer tube.

2.9.5.5.11 Gross Beta

Samples from several wells in the In Situ REDOX Manipulation barrier were analyzed for gross beta and some wells continued to have concentrations exceeding the 50 pCi/L DWS during the five-year review period, with the highest value (130 pCi/L) in November 2008. Concentrations have been declining in this well since 2003. Analysis of a previous sample from a nearby well within the In Situ REDOX Manipulation barrier showed that the gross beta is due to naturally present potassium-40 in the injected solution (*Hanford Site Groundwater Monitoring for Fiscal Year 1999*, PNNL-13116).

The strontium-90 contamination causes gross beta concentrations to exceed the 50 pCi/L DWS in the 100-H Area. The highest gross beta concentration was 74 pCi/L.

2.9.5.5.12 New Contaminants

Potential new contaminants may be identified based on groundwater sampling, including from the latest three rounds of RI/FS sampling. This sampling identified the presence of organic contaminants such as carbon tetrachloride and chloroform. Dissolved oxygen is being monitored because of the *Interim Remedial Action Record of Decision Amendment for 100-HR-3*.

2.9.5.6 Protectiveness Statement

The remedy at 100-HR-3 Groundwater OU is not protective because the existing interim remedies are not meeting the remedial action objectives. Since the 2006 five-year review, for the 100-HR-3 Groundwater OU, chromium has migrated to the groundwater from soil site sources, resulting in soil and groundwater contamination. Test pits, boreholes, and aquifer response to the rising water table associated with high river stage in the 100 Area have documented that chromium is present in the deep vadose zone. While the majority of source remediation has been completed in the 100-D Area, all of the sources of contamination in the vadose zone are yet to be identified and delineated. It is typical in the 100 and 300 Areas to observe increased contamination levels in the groundwater following sustained high Columbia River water levels. The high river water levels raise the groundwater table and wet portions of the deep vadose zone. These temporary wettings of the contamination in the deep vadose zone may result in pulses of contamination in the groundwater. This potential pulsing may suggest that these deep vadose zone chromium residues continue to act as a reserve for future contamination of the groundwater. Further information will be obtained by completing the RI/FS process and selecting a final remedy, at which time a protectiveness determination will be made. Expanded pump-and-treat systems are being implemented in both the 100-H and 100-D areas.

2.10 100-F, 100-IU-2, and 100-IU-6 Operable Units

This section describes the OUs in the 100-F Area and the 600 Area.

2.10.1 Background

The 105-F Reactor was constructed from 1943 to 1945 and operated from 1945 to 1965. Most of the facilities associated with F Reactor, other than the biological research facilities, were also retired in 1965. The 100-FR-1 and 100-FR-2 Source OUs include contaminant sources, while the 100-FR-3 Groundwater OU includes the contamination in the underlying groundwater.

The 600 Area contains construction support facilities that were used during the Hanford Works Project as well as sites associated with the pre-Hanford works agricultural community. To address effectively the remediation efforts, the 600 Area was originally divided into 13 OUs. Six of the OUs have since been designated as 200 Area waste groupings, waste sites in three of the OUs (1100-IU-1, 100-IU-1, and 100-IU-3) were deleted from the NPL, two OUs (100-IU-4 and 100-IU-5) were closed out via a No Action ROD, and two OUs (100-IU-2 and I00-IU-6) are undergoing cleanup (Figure 15).

This cleanup action consists of the excavation and removal of contaminated soil, the pipelines that transported the liquid waste, structures, and associated debris, including any unanticipated material that was part of the engineered structure or otherwise deposited at the site, followed by treatment as necessary, and disposal to ERDF. Generally, this cleanup action includes implementation of institutional controls before and during execution of the remove, treat, and dispose remedy. In cases where a decision is made, based on an evaluation of balancing factors and public input, to leave contamination in place above levels allowing for unrestricted land use, ongoing institutional controls are required to ensure protection of human health and the environment

2.10.2 Chronology

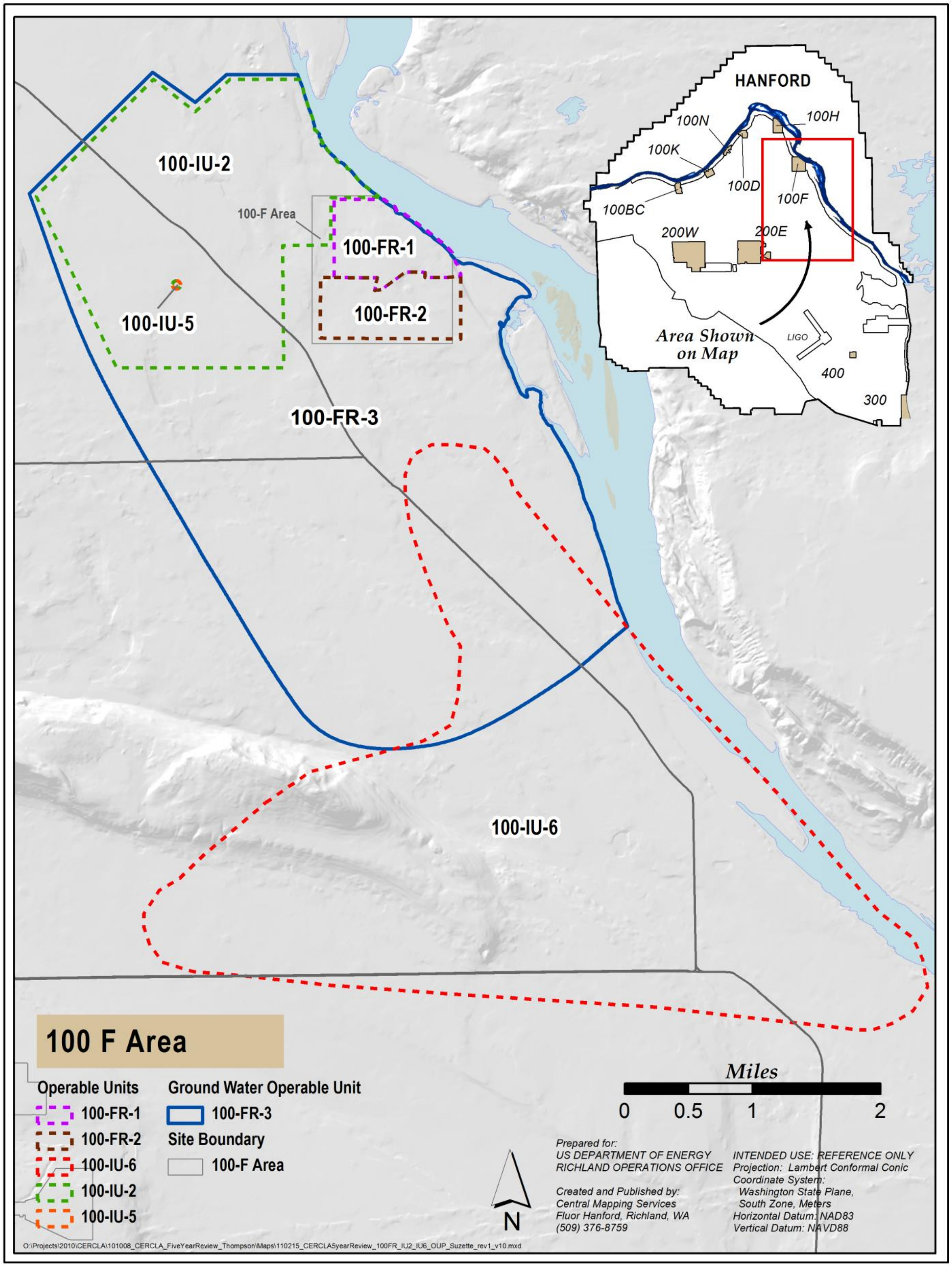
The following information summarizes the chronology of significant decision documents relevant to CERCLA response actions in the 100-F Area and 100-IU-2 and 100-IU-6 OUs.

100-F Area and 600 Area (100-F, 100-IU-2, and 100-IU-6 Operable Units)

1/29/1997	DOE/AR D197045200	Action Memorandum: 100 B/C Area Ancillary Facilities and the 108-F Building Removal Action
7/15/1999	EPA/ROD/R10-99/039	Interim Action ROD: 100-BC-1, 100-BC-2, 100-DR-1, 100-DR-2, 100-FR-1, 100-FR-2, 100-HR-1, 100-HR-2, 100-KR-1, 100-KR-2, 100-IU-2, 100-IU-6, and 200-CW-3 OUs Interim Remedial Actions
6/15/2000	EPA/ESD/R10-00/045)	ESD: 100 Area Remaining Sites ROD
9/25/2000	EPA/ROD/R10-00/121	Interim Action ROD: 100-BC-I, 100-BC-2, 100-DR-I, 100-DR-2, 100-FR-2, 100-HR·2, 100-KR-2, OU Interim Remedial Actions (100 Area Burial Grounds)
2/2004	AR/PIR/D4855290	ESD: 100 Area Remaining Sites Interim Remedial Action ROD
11/14/2007	08-AMRC-0033	ESD: Interim Action ROD 100 Area Remaining Sites (100-BC-1, 100-BC-2,100- DR-1, 100-DR-2, 100-FR-2, 100-HR-2, and 100-KR-2 OUs [100 Area Burial Grounds])
8/2009	DOE/EPA/Ecology	ESD: Interim Action ROD 100 Area Remaining Sites (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)

The *100 Area Burial Grounds Record of Decision* (EPA/ROD/R10-00/121) was issued in 2000 for 45 burial grounds located in the 100 Area, and the selected remedy is to remove, treat if necessary, and dispose of contaminated soil, structures, and associated debris to ERDF to meet the remedial action objectives. Also included in the remedy are backfilling, re-vegetation, and institutional controls.

Figure 15. 100-F, 100-IU-2, and 100-IU-6 Area



The *Explanation of Significant Differences for the 100 Area Remaining Sites ROD*, 100-IU-6 OU, (EPA/ESD/R10-00/045), issued in 2000, added the 600-23 and JA Jones #1 waste sites to this OU through a mechanism called the Plug-in Approach. The Plug-in Approach allows the selected remedy in the ROD, to be applied to similar, but separate sites that meet specific criteria as defined in the ROD.

The *Explanation of Significant Difference 100 Area Remaining Sites Interim Remedial Action Record of Decision* was issued in 2004 to add 28 waste sites, add new ARARs, and revise the annual institutional control requirements in the selected remedy to be consistent with the reporting requirement contained in the *Sitewide Institutional Controls Plan for Hanford CERCLA Response Actions* (DOE/RL-2001-41).

The *100 Area Burial Grounds Record of Decision Explanation of Significant Difference* was issued in 2007 and used a 'balancing factor' evaluation to eliminate the need for additional excavation of tritium contamination in soil below 15 feet (4.6 meters) at the 118-B-1 Burial Ground. The evaluation demonstrated that when irrigation was prohibited at the waste site, tritium will not reach groundwater in concentrations that exceed DWSs. In conjunction with this determination, the ESD established an institutional control prohibiting irrigation at the site for 140 years, except as authorized to support re-vegetation activities.

The *100 Area Remaining Sites Record of Decision Explanation of Significant Difference* was issued in 2009 and recognized 76 additional 100 Area waste sites to be 'plugged in' to the remove, treat, and dispose remedy selected in the Remaining Sites ROD, identified an additional 87 candidate sites for remove, treat, and dispose (i.e., sites that may plug in to the remove, treat, and dispose remedy, but will require additional characterization), and documented completion of 14 additional waste sites remediated under the Remaining Sites ROD. The ESD also established a process for use of annual fact sheets in lieu of ESDs to document future remediation of waste sites or candidate sites under the Remaining Sites ROD, provided the cumulative estimated cost of the additional remediation work does not exceed greater than 50 percent of the total estimate provided in the original ROD.

2.10.2.1 Remedial Action

All of the high-priority 100-F Area surface cleanup action liquid waste sites, including cribs, ditches, trenches, and retention basins, have been remediated and backfilled with clean soil. Remaining sites, including solid waste burial grounds, were remediated between FY06 and FY08. DOE completed cleanup of 53 waste sites at 100-F Area in 2008, loading out more than 408,000 tons (370,000 metric tons) of waste; however, during the course of cleanup, 18 additional waste sites were discovered.

The interim remedial actions were designed to be inclusive of all other past-practice waste sites in the 100 Areas not already covered by the *Interim Action Record of Decision for the 100-BC-1, 100-BC-2, 100-DR-1, 100-DR-2, 100-FR-1, 100-FR-2, 100-HR-1, 100-HR-2, 100-KR-1, 100-KR-2, 100-IU-2, 100-IU-6, and 200-CW-3 Operable Units* (EPA/ROD/R10-99/039), referred to as the Remaining Sites ROD, , with the exception of the 100 Area solid waste burial grounds. Cleanup levels are consistent with the remedial action objectives. The 1999 ROD identified 46 sites for the remove, treat, and dispose remedy. The 2000 ESD has increased this to 48 sites. In addition to the observational approach to characterization during remove, treat, and dispose remediation, this ROD uses a 'plug-in approach'. The plug-in approach applies to more than 160 additional waste sites (and future discovery waste sites). These sites are candidates for remove, treat, and dispose remediation; however, further sampling is required to determine if there is a need for remedial action. If remediation is needed, they will be plugged into the remove, treat, and dispose remedy.

Remedial action objectives to protect human health and the environment include the following components.

100-FR-1,100-FR-2, 100-IU-2, 100-IU-6 Area Remedial Action Objectives

Remedial Action Objective 1	Protect human and ecological receptors from exposure to contaminants in soil, structures, and debris by dermal exposure, inhalation, or ingestion of radionuclides, inorganics, or organics. Protection will be achieved by reducing concentrations of, or limiting exposure pathways to, contaminants in the upper 15 feet (4.6 meters) of the soil exposure scenario. The levels of reduction will be such that the total dose for radionuclides does not exceed 15 millirem/year above Hanford Site background for 1,000 years following remediation and State of Washington MTCA Method B levels for inorganics and organics.
Remedial Action Objective 2	Control the sources of groundwater contamination to minimize the impacts to groundwater resources, protect the Columbia River from further adverse impacts, and reduce the degree of groundwater cleanup that may be required under future actions. Protection will be such that contaminants remaining in the soil after remediation do not result in an adverse impact to groundwater that could exceed MCLs and non-zero MCLGs under the SDWA. The SDWA MCL for radionuclides will be attained at a designated point of compliance beneath or adjacent to the waste site in groundwater. The location and measurement of the point of compliance will be defined by EPA and Ecology. Monitoring for compliance will be performed at the defined point. Protection of the Columbia River from adverse impacts so contaminants remaining in the soil after remediation do not result in an impact to groundwater and, therefore, the Columbia River, that could exceed the ambient water quality criteria under the Clean Water Act for protection of fish. Since there are no ambient water quality criteria for radionuclides, MCLs will be used. The protection of receptors (aquatic species, with emphasis on salmon) in surface waters will be achieved by reducing or eliminating further contaminant loadings to groundwater so receptors at the groundwater discharge in the Columbia River are not subject to additional adverse risks. Measurement of compliance will be at a near-shore well, in the downgradient plume. The location and measurement will be defined by EPA and Ecology.

Characterization, remediation, backfill, and re-vegetation of the 600-149:2 Small Arms Range waste site was completed in CY09. DOE is just now preparing to perform a survey for 600-149:1 and the newly created 600-349 waste site adjacent to 600-149. Remediation of the 100-IU-2 and 100-IU-6 remaining sites began in CY09. Excavation and load out activities for the remaining sites are anticipated to be completed in early 2011. Work also began in the non-operational geographical area of the River Corridor known as Segment 1 in CY10 (the waste sites discovered in this area were added to 100-IU-2/6). The Segment 1 activities included remediation of six sites, removal of nonhazardous miscellaneous debris from 10 areas, and removal of 3.6 miles (5.79 km) of abandoned railroad.

2.10.2.2 Progress Since 2006 Review

The following waste sites have been remediated since the 2006 five-year review.

100-FR-1 Operable Unit

100-F-26:10 sanitary sewer pipelines	100-F-33 aquatic biology fish ponds	128-F-2 burn pit
100-F-26:12 sewer pipeline	100-F-38 soil contamination area	132-F-1 feed and sheep barns
100-F-26:13 underground pipelines	100-F-42 spillway	141-C animal barns
100-F-26:14 influent pipelines	100-F-43 PNL outfall spillway	1607-F1 sanitary sewer system
100-F-26:15 miscellaneous pipelines	116-F-15 radiation crib	1607-F-3 septic tank
100-F-26:4 south process pipelines	116-F-16 outfall	1607-F4 septic system
100-F-26:7 underground pipelines	116-F-8 outfall	1607-F-5 septic tank
100-F-26:8 underground pipelines	118-F-8:4 fuel storage basin	1607-F-7 septic tank
100-F-26:9 sanitary sewer pipelines	126-F-2 clearwells	182-F reservoir
100-F-31 sanitary sewer		

100-FR-2 Operable Unit

1607-F1 septic system	100-F-20 parallel sites	118-F-5 burial ground sawdust pit
128-F-3 burn pit	118-F-1 burial ground	126-F-1 ash pit
118-F-7 burial ground	118-F-2 burial ground	118-F-6 animal farm burial ground
118-F-3 burial ground		

100-IU-2 Operable Unit

600-342 contaminated clothing area	600-343 inter areas burn site #1	600-346 100-BC vicinity ash and debris area

100-IU-6 Operable Unit

600-111 crib	UPR-600-16 fire and contamination spread	600-149:2 pistol/rifle range berm

2.10.2.3 Technical Assessment

The purpose of the five-year review is to determine whether the remedy at a site is, or upon completion will be, protective of human health and the environment. The following is the technical assessment response of the 100-FR-1, 100-FR-2, 100-IU-2, and 100-IU-6 OUs interim remedy concerning the technical assessment questions provided in the EPA guidance. The following also establishes a framework for organizing and evaluating data and ensuring that all relevant issues are considered when determining the protectiveness of the remedy.

Is the remedy functioning as intended by the decision documents?

The interim remedy is functioning within the specified remedial action objectives. The remove, treat, and dispose action has proven to be functioning at a depth of 15 feet (4.6 meters) for the direct exposure pathway, and has demonstrated to be protective of groundwater and the river throughout the soil column, based on modeling scenarios developed for use in implementing the interim action RODs. Additionally, for sites where contamination extends below 15 feet, the engineered structure (at a minimum) is remediated to achieve remedial action objectives. Verification sampling after completion of excavation has indicated that the soil contamination has been removed. The final ROD will address additional exposure scenarios and additional models for evaluating contaminant migration pathways.

Are the exposure assumptions, toxicity data, cleanup levels, and remedial action objectives used at the time of remedy selection still valid?

The exposure assumptions, toxicity data, cleanup levels, and interim remedial action objectives used at the time of remedy selection are still valid for all OUs.

Has any other information come to light that could call into question the protectiveness of the remedy?

No new information is known that could call into question the protectiveness of the remedy for these OUs.

2.10.2.4 Protectiveness Statement

The final remedy at 100-FR-1, 100-FR-2, 100-IU-2, and 100-IU-6 OUs is expected to be protective of human health and the environment upon completion of the final remedy. The current interim actions ensure that exposure pathways that could result in unacceptable risks are being controlled. Further information will be obtained by completing the *River Corridor Baseline Risk Assessment*. It is expected that these actions will be completed by 2016, at which time a protectiveness determination will be made.

2.10.3 100-FR-3 Operable Unit

A ROD has not been issued for 100-FR-3 Groundwater OU. The 100-FR-3 Groundwater OU will be in the 100-F, 100-IU-2, and 100-IU-6 Area ROD that is scheduled for issuance in CY12. This section describes the interim remedial actions being conducted in the 100-FR-3 Groundwater OU.

2.10.3.1 Background

Wells in the 100-FR-3 OU are sampled for the contaminants of concern included in *100-FR-3 Operable Unit Sampling and Analysis Plan* (DOE/RL-2003-49). The contaminants of concern are nitrate, strontium-90, tritium, trichloroethene, uranium, gross alpha, and hexavalent chromium.

2.10.3.2 Chronology

There has been no ROD issued for 100-FR-3 Groundwater OU. A final RI/FS work plan will be issued that includes the groundwater as part of an integrated decision for the surface, vadose zone, and groundwater for the 100-F Area.

2.10.3.3 Remedial Actions

An interim action ROD for groundwater remediation has not been established for this area. Previous assessments have not identified groundwater conditions that warrant interim remedial measures, assuming that the source control measures will meet established remedial action objectives designed to reduce contaminant recharge to the aquifer.

2.10.3.4 Progress Since 2006 Review

There has been no active groundwater remediation in this area since the 2006 five-year review. Groundwater sampling requirements are defined in the groundwater sampling and analysis plan (DOE/RL-2003-49), TPA Change Notice TPA-CN-228, *100-FR-3 OU Sampling and Analysis Plan*, DOE/RL-2003-49, Rev 1, and *Waste Control Plan for 100-FR-3 Operable Unit* (DOE/RL-2004-31). Since the 2006 five-year review, all of the wells have been scheduled and sampled on a routine basis. The two seeps were not always sampled since seep sampling depends on field conditions and is not always possible.

2.10.3.5 Technical Assessment

A technical assessment has not been performed since a ROD has not been issued for 100-FR-3 OU.

2.10.3.6 Protectiveness Statement

The final remedy at 100-FR-3 OU is expected to be protective of human health and the environment upon completion of the final remedy. The current interim actions ensure that exposure pathways that could result in unacceptable risks are being controlled. Further information will be obtained by completing installation of the three new wells proposed as part of CERCLA investigations (*Integrated 100 Area Remedial Investigation/Feasibility Study Work Plan: 100-F/IU-6 Decision Unit*, (DOE/RL-2008-46, Addendum 4), and the *River Corridor Baseline Risk Assessment*. It is expected that these actions will be completed by 2016. The RI/FS work plan addendum was implemented in 2010 and the necessary data was gathered. Groundwater beneath the 100-F Area is contaminated with chromium, nitrate, strontium-90, and trichloroethene at levels above the DWSs or aquatic standards. The contaminant plumes are present at the top of the aquifer. Their vertical extent is unknown because no wells are monitoring at depth in the unconfined aquifer. Two of the three wells will be drilled to the bottom of the unconfined aquifer and screened at the depth with the highest levels of contamination in water samples (or at the top of the aquifer if no significant contamination is found).

2.11 100-K Area

This section describes the OUs in the 100-K Area (Figure 16).

2.11.1 Background

The 100-K Area is comprised of the 100-KR-1 and 100-KR-2 Source OUs, and 100-KR-4 Groundwater OU. Two water-filled basins in the 100-K Area were used to store spent nuclear fuel from the nine reactors. The spent fuel has been removed from the K Basins. Remedial actions are ongoing to complete the cleanout of the basins and ultimate demolition of the basins. The KW Reactor operated from 1955 to 1970, and the KE Reactor operated from 1955 to 1971. The 100-KR-1 and 100-KR-2 Source OUs are contaminant source sites, while the 100-KR-4 Groundwater OU includes contamination in the underlying groundwater. Currently, there are several active facilities within the 100-K Area, including the 105-KW fuel storage basin.

2.11.2 Chronology

The following information summarizes the chronology of significant decision documents relevant to response actions in the 100-K Area.

100-K Area

7/15/1999	EPA/ROD/R10-99/039	Interim Action ROD: 100-BC-1, 100-BC-2, 100-DR-1, 100-DR-2, 100-FR-1, 100-FR-2, 100-HR-1, 100-HR-2, 100-KR-1, 100-KR-2, 100-IU-2, 100-IU-6, and 200-CW-3 OUs Interim Actions
9/17/1999	EPA/ROD/R10-99/059	Interim Action ROD: 100-KR-2 Operable Unit
9/25/2000	EPA/ROD/R10-00/121	Interim Action ROD: 100-BC-I, 100-BC-2, 100-DR-I, 100-DR-2, 100-FR-2, 100-HR·2, 100-KR-2, OU Interim Actions (100 Area Burial Grounds)
11/14/2007	08-AMRC-0033	ESD: Interim Action ROD 100 Area Remaining Sites (100-BC-1, 100-BC-2,100- DR-1, 100-DR-2, 100-FR-2, 100-HR-2, and 100-KR-2 OUs [100 Area Burial Grounds])
8/2009	DOE/EPA/Ecology	ESD: Interim Action ROD 100 Area Remaining Sites (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)

2.11.3 100-KR-1 Operable Unit

This section describes the waste site remediation activities associated with the 100-KR-1 Source OU.

2.11.3.1 Background

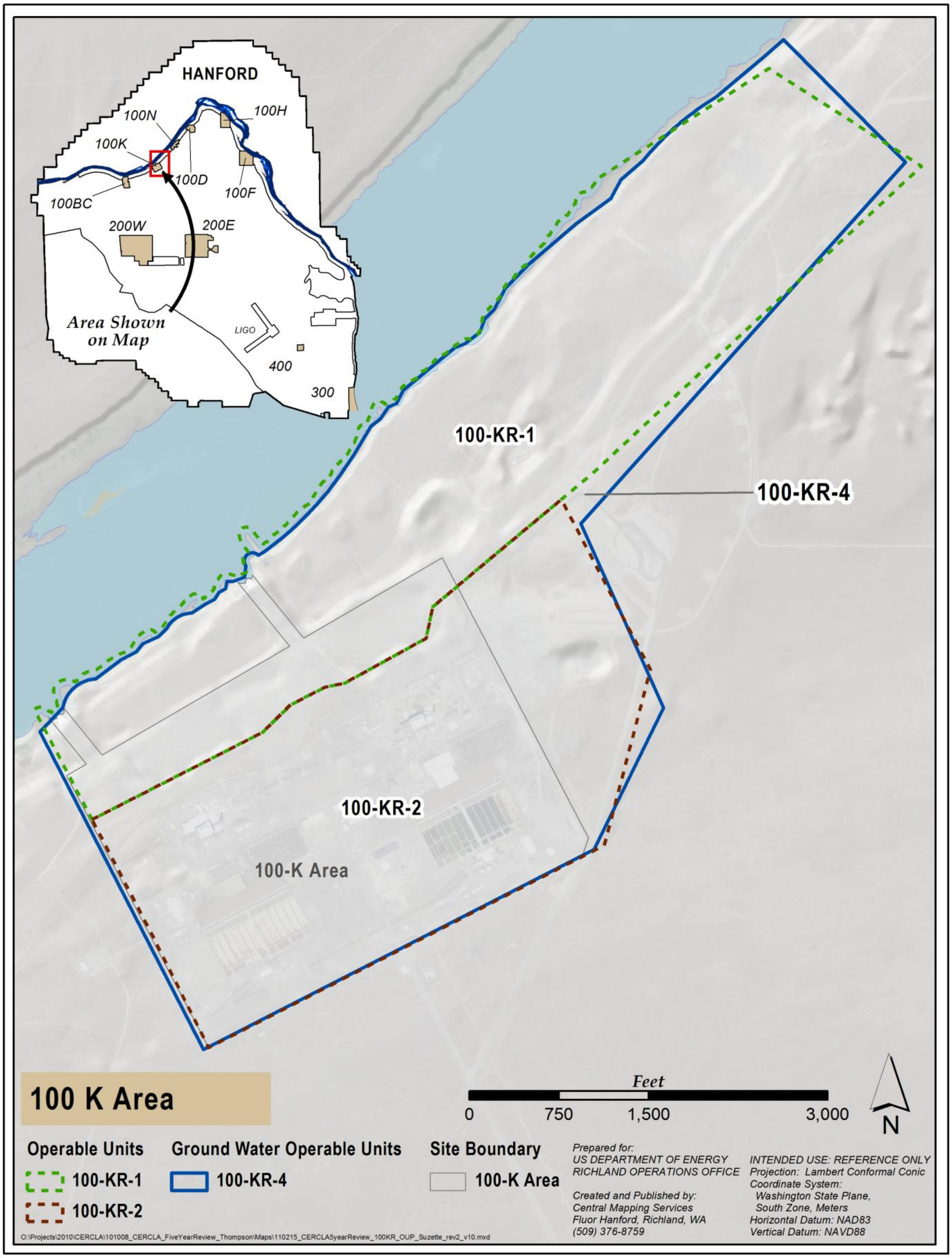
The selected remedy in the Remaining Sites ROD consists of removal, treatment, and disposal of contaminated materials, followed by waste site backfilling and re-vegetation.

2.11.3.2 Chronology

In 1999, the Remaining Sites ROD addressed contaminated soil, structures, and debris in the 100-BC-1, 100-BC-2, 100-DR-1, 100-DR-2, 100-FR-1, 100-FR-2, 100-HR-1, 100-HR-2, 100-KR-1, 100-KR-2, 100-IU-2, 100-IU-6, and 200-CW-3 OUs.

In 2004, *Explanation of Significant Differences for the 100 Area Remaining Sites Interim Remedial Action Record of Decision* (100-BC-1, 100-BC-2, 100-DR-1, 100-DR-2, 100-FR-1, 100-FR-2, 100-HR-1, 100-HR-2, 100-KR-1, 100-KR-2, 100-IU-2, 100-IU-6, and 200-CW-3 OUs), added 28 waste sites.

Figure 16. 100-K Area



2.11.3.3 Remedial Actions

The following are the interim remedial action objectives for 100-KR-1 (from the 100 and 200 Remaining Sites interim action ROD, EPA/ROD/R10-99/039).

100-KR-1 Operable Unit Remedial Action Objectives

Remedial Action Objective 1	Protect human and ecological receptors from exposure to contaminants in soils, structures, and debris by dermal exposure, inhalation, or ingestion of radionuclides, inorganics, or organics. Protection shall be achieved by reducing concentrations of, or limiting exposure pathways to contaminants in the upper 15 feet (4.6 meters) of the soil exposure scenario. The levels of reduction will be such that the total dose for radionuclides does not exceed 15 millirem/year above Hanford Site background for 1,000 years following remediation and State of Washington MTCA Method B levels for inorganics and organics.
Remedial Action Objective 2	Control the sources of groundwater contamination to minimize the impacts to groundwater resources, protect the Columbia River from further adverse impacts, and reduce the degree of groundwater cleanup that may be required under future actions. Protection shall be such that contaminants remaining in the soil after remediation do not result in an adverse impact to groundwater that could exceed MCLs and non-zero MCLGs under the SDWA. The SDWA MCL for radionuclides shall be attained at a designated point of compliance beneath or adjacent to the waste site in groundwater. The location and measurement of the point of compliance shall be defined by EPA and Ecology. Monitoring for compliance shall be performed at the defined point. Protection of the Columbia River from adverse impacts so contaminants remaining in the soil after remediation do not result in an impact to groundwater and, therefore, the Columbia River, that could exceed the ambient water quality criteria under the Clean Water Act for protection of fish. Since there are no ambient water quality criteria for radionuclides, MCLs will be used. The protection of receptors (aquatic species, with emphasis on salmon) in surface waters will be achieved by reducing or eliminating further contaminant loadings to groundwater so receptors at the groundwater discharge in the Columbia River are not subject to additional adverse risks. Measurement of compliance will be at a near-shore well, in the downgradient plume. The location and measurement will be defined by EPA and Ecology.

2.11.3.4 Progress Since 2006 Review

Since the 2006 five-year review, two separate types of CERCLA actions are ongoing in the 100-K Area. The K Basins Closure Project is removing the spent fuel that has been stored in the fuel storage basins in the 100-K Areas for over 20 years. The project includes removal of all the fuel; removal of the baskets, and racks in which the fuel was stored; removal of the sludge that has accumulated in the basins; removal of the water from the basins; and demolition and disposal of the basin structures. The other CERCLA actions in the 100-K Area that are being conducted in this OU include D&D of the ancillary buildings, placing the reactors in interim safe storage, remediating soil waste sites, and remediating the groundwater.

All of the high-priority 100-K Area liquid waste sites including cribs, ditches, trenches, and retention basins have been remediated and backfilled with clean soil. Remediation of the 118-K-1 Solid Waste Burial Ground was initiated in 2006 and is anticipated to be completed in 2012.

2.11.3.5 Technical Assessments

The purpose of the five-year review is to determine whether the remedy at a site is, or upon completion will be, protective of human health and the environment. The following is the technical assessment response of the 100-KR-1 OU interim remedy concerning the technical assessment questions provided in the EPA guidance. The following also establishes a framework for organizing and evaluating data and ensuring that all relevant issues are considered when determining the protectiveness of the remedy.

Is the remedy functioning as intended by the decision documents?

The interim remedy is functioning within the specified remedial action objectives. The remove, treat, and dispose action has proven to be functioning at a depth of 15 feet (4.6 meters) for the direct exposure pathway, and has also been demonstrated to be protective of groundwater and the river throughout the soil column based on modeling scenarios developed for use in implementing the interim action RODs. Verification sampling after completion of excavation has indicated that the soil contamination has been removed and has been sent to ERDF for disposal. The final ROD will address additional exposure scenarios and additional models for evaluating contaminant migration pathways.

Are the exposure assumptions, toxicity data, cleanup levels, and remedial action objectives used at the time of remedy selection still valid?

The exposure assumptions, toxicity data, cleanup levels, and the interim remedial action objectives used at the time of remedy selection are still valid for all OUs.

Has any other information come to light that could call into question the protectiveness of the remedy?

No new information is known that could call into question the protectiveness of the remedy for these OUs.

2.11.3.6 Protectiveness Statement

The final remedy at 100-KR-1 OU is expected to be protective of human health and the environment upon completion of the final remedy. The current interim actions ensure that exposure pathways that could result in unacceptable risks are being controlled.

2.11.4 100-KR-2 Operable Unit

This section describes the interim remedial actions associated with the 100-KR-2 OU.

2.11.4.1 Background

The K Basins Closure Project is removing the spent fuel that has been stored in the fuel storage basins in the 100-K Areas for over 20 years. The project includes removal of all of the fuel; removal of the baskets and racks in which the fuel was stored; removal of the sludge that has accumulated in the basins; removal of the water from the basins; and demolition and disposal of the basin structures. The other CERCLA actions in the 100-KE and 100-KW areas that are being conducted under the River Corridor Project include the D&D of the ancillary buildings, placing the reactors in interim safe storage, remediating soil waste sites, and remediating the groundwater.

2.11.4.2 Chronology

In September 1999, the *Interim Action Record of Decision for the USDOE Hanford 100-KR-2 Operable Unit K Basins Interim Remedial Action* was signed. The ROD presented the selected interim remedial action to mitigate the potential to release hazardous substances from the two 100-K Area spent nuclear fuel storage basins.

In September 2000, the *Record of Decision for 100-BC-1, 100-BC-2, 100-DR-1, 100-DR-2, 100-FR-1, 100-FR-2, 100-HR-2, 100-KR-2 Operable Units (100 Area Burial Grounds)* was issued. The remedy was designed to be inclusive of all other past-practice waste sites in the 100 Area not already covered by an existing CERCLA decision document, with the exception of the 100 Area solid waste burial grounds. Cleanup levels are consistent with the remedial action objectives.

In June 2005, the *K Basins Amended Record of Decision* was issued, changing the sludge disposition and how underwater debris is retrieved, treated, and disposed from both the 105-K East and 105-K West Spent Nuclear Fuel Basins. The ROD amendment requires the sludge be treated, packaged for disposal, and shipped off the Hanford Site to a national repository. The ROD amendment also amends the remedy for some of the debris, which will remain in the basins while they are partially filled with a cement based grout. The debris grouted in place will be removed in conjunction with removal of the basins. These changes will result in increased protection to human health and the environment.

2.11.4.3 Remedial Actions

The remedy requires the removal of the spent nuclear fuel, sludge, water, and debris, as well as the deactivation of the two water-filled spent nuclear fuel storage basins in the 100-K Area. Fuel will be packaged, removed from the basins, dried, and placed in storage in the 200 Area. Sludge will be packaged, removed, treated, and placed in storage in the 200 Area. Debris will be removed, treated, and disposed at ERDF. Water contaminated with radionuclides will be removed, treated, and disposed. Deactivation waste will be disposed at ERDF. This ROD does not contain specific cleanup levels. The emptied and deactivated basins resulting from this remedial action will then be remediated under the 1999 ROD for remaining sites.

The following sections provide a status of the selected remedies for the K Basins Closure Project, listed by waste stream.

2.11.4.3.1 Spent Nuclear Fuel

Spent nuclear fuel has been removed from the basins, satisfying one of the remedial action objectives identified in the 100-KR-2 OU ROD. The *K Basins Amended Record of Decision* does not amend the remedy for this waste stream.

2.11.4.3.2 Radioactive Sludge

The 100-KR-2 OU ROD directed that sludge be removed from the basins and placed in storage pending future treatment. The treatment of sludge was not included within the scope of the 100-KR-2 OU ROD. The *K Basins Amended Record of Decision* expanded the scope of the 100-KR-2 OU ROD by eliminating extended storage of the untreated sludge and requiring that (1) the sludge be treated for disposal and (2) the treated sludge is delivered to a national repository for disposal. Implementation of these provisions in the *K Basins Amended Record of Decision* is currently in progress.

2.11.4.3.3 Water

Treatment and removal of water from the K East Basin was initiated in 2004. Removal of water from the K West Basin is planned following sludge removal.

2.11.4.3.4 Debris

The 100-KR-2 OU ROD directed that debris be removed, treated as required, and disposed at ERDF as appropriate. The 100-KR-2 OU ROD did not specify the details of debris retrieval; however, the anticipated process was to be an item-by-item removal with any treatment to be completed outside the basin. The *K Basins Amended Record of Decision* expanded the scope of the 100-KR-2 OU ROD by allowing some of the debris to: (1) remain in the basins and be encased in grout; and (2) be removed as part of the demolition and removal of the basin structure.

2.11.4.3.5 Deactivation

105-KE Basin has been decommissioned and demolished. In addition, institutional controls are in place to restrict access and prevent public access until the final remedial action is completed.

There have been new ARARs introduced as appropriate for the increased scope of the *K Basins Amended Record of Decision*. No other changes in standards that were identified as ARARs for this remedial action have been changed. The K Basins remedial action will continue to be implemented as directed in the 100-KR-2 OU ROD and *K Basins Amended Record of Decision*.

100-KR-2 Operable Unit Remedial Action Objectives

Remedial Action Objective 1	• Reduce the potential for future releases of hazardous substances from the K Basins to the environment. • Remove hazardous substances from the K Basins near the Columbia River in a safe and timely manner. • Provide for safe treatment, storage, and final disposal of the spent nuclear fuel, sludge, water, and debris removed from the K Basins. • Prevent further deterioration of the spent nuclear fuel.
Remedial Action Objective 2	• Reduce occupational radiation exposure to workers at the basins.
Remedial Action Objective 3	• Address the sludge management concerns

100-KR-2 Operable Unit Remedial Action Objectives

Remedial Action Objective 4	• Develop the most cost effective site-wide approach, consistent with the CERCLA nine criteria, for treatment, storage, and disposal of sludge.
Remedial Action Objective 5	• Treat, store, and/or dispose of sludge soon after removal.

2.11.4.4 Progress Since 2006 Review

The 105-KE and 105-KW Fuel Storage Basins (K Basins) have had continuous activity since the 2006 five-year review. Fuel has been removed from the basins and sent to a facility in the 200 East Area for long-term storage. Water and sludge has been transferred from the 105-KE Basin to the 105-KW Basin, and the 105-KE Basin has been decommissioned and demolished. Final designs are being identified and evaluated to treat the sludge remaining in 105-KW Basin prior to D&D.

Since the 2006 five-year review, the following waste sites have been remediated and are documented in Waste Site Cleanup Verification Packages and Remaining Waste Sites Verification Packages.

100-KR-1 Operable Unit

116-K-2 Trench

100-KR-2 Operable Unit

100-K-55:1 Underground Pipelines	116-KW-4 Heat Recovery Station	116-KE-5 Heat Recovery Station
100-K-56:1 Underground Pipelines		

2.11.4.5 Technical Assessments

The purpose of the five-year review is to determine whether the remedy at a site is, or upon completion will be, protective of human health and the environment. The following is the technical assessment response of the 100-KR-2 interim remedy concerning the technical assessment questions provided in the EPA guidance. The following also establishes a framework for organizing and evaluating data and ensuring that all relevant issues are considered when determining the protectiveness of the remedy.

Is the remedy functioning as intended by the decision documents?

The interim remedy is continuing to function as intended in the decision document.

Are the exposure assumptions, toxicity data, cleanup levels, and remedial action objectives used at the time of remedy selection still valid?

The exposure assumptions, toxicity data, cleanup levels, and the interim remedial action objectives used at the time of remedy selection are still valid for this OU.

Has any other information come to light that could call into question the protectiveness of the remedy?

No new information is known that could call into question the protectiveness of the remedy for this OU.

2.11.4.6 Protectiveness Statement

The final remedy at 100-KR-2 OU is expected to be protective of human health and the environment upon completion of the final remedy. The current interim actions ensure that exposure pathways that could result in unacceptable risks are being controlled.

2.11.5 100-KR-4 Operable Unit

2.11.5.1 Background

The 100-KR-4 Groundwater OU includes groundwater affected by contaminant releases from facilities and waste sites within the 100-K Area. The OU boundaries extend northeast from the reactor area beneath the footprint of the former 116-K-2 trench, into the southwestern portion of the 100-NR-2 Groundwater OU, and up to the N Reactor fence line.

The primary groundwater contaminants consist of strontium‑90, carbon‑14, tritium, trichloroethane, and hexavalent chromium.

2.11.5.2 Chronology

The *100-HR-3 and 100-KR-4 Record of Decision Explanation of Significant Difference* was issued in 2009 to identify and provide public notice on significant changes to the interim action ROD. The circumstances that led to the need for an ESD are: (1) Costs for the pump-and-treat remedial actions at 100-HR-3 and 100-KR-4 OUs have exceeded the cost range identified in the amended ROD; and (2) The original 1996 ROD specified that treated water be re-injected to the aquifer upgradient of the hexavalent chromium plumes located in the 100-HR-3 and 100-KR-4 OUs to treat the plumes. Since then, the hexavalent chromium plumes have expanded and migrated in different directions. Alternate re-injection locations are needed to help contain the plumes in both of these OUs and to prevent the hexavalent chromium plume in 100-KR-4 from reaching and mixing with the strontium‑90 plume in 100-NR-2 Groundwater OU.

A number of decision documents direct the activities at the 100-KR-4 Groundwater OU. Key documents include the following:

- DOE/RL-96-84, Rev. 0 and Rev. 0A, *Remedial Design Report and Remedial Action Work Plan for the 100-HR-3 and 100-KR-4 Groundwater Operable Units Interim Action*. The work plan describes the design and operational requirements for the original 100-KR-4 pump-and-treat system.

- DOE/RL-96-90, Rev. 0, *Interim Action Monitoring Plan for the 100-HR-3 and 100-KR-4 Operable Units*. This document established the initial operational, monitoring, and sampling requirements for the 100-KR-4 Groundwater OU to demonstrate satisfactory system operations and control of the plume by the treatment system.

- EPA/ROD/R10-96/134, *Record of Decision for the USDOE Hanford 100-HR-3 and 100-KR-4* 29 *Operable Units Interim Remedial Actions*. This interim action ROD selected interim remedial actions for 100-HR-3 and 100-KR-4 OUs.

- DOE/RL-2006-52, Rev. 1, *The KW Pump-and-Treat System Remedial Design and Remedial Action Work Plan, Supplement to the 100-KR-4 OU Interim Action*. This document established the initial operational, monitoring, and sampling requirement for the 100-KW pump-and-treat system.

- DOE/RL-2006-75, Rev. 1 *Reissue, Supplement to the 100-HR-3 and 100-KR-4 Remedial Design and Remedial Action Work Plan for the Expansion of the 100-K Area Technical Assessment*. The 100-K Area pump-and-treat system was intended to contain the groundwater chromium plume while the waste sites were remediated. The primary remedial action objective is to prevent the discharge of hexavalent chromium to the Columbia River substrate at concentrations exceeding those that are considered protective of aquatic life in the river and riverbed sediments.

- 100-KR-4 Pump-and-Treat System. This document established the operational, monitoring, and sampling requirements for the new KX pump-and-treat system.

Several CERCLA documents were generated for the 100-KR-4 OU in 2009, including the following:

- DOE/RL-2006-52, Rev. 2, *The KW Pump-and-Treat System Remedial Design and Remedial Action Work Plan, Supplement to the 100-KR-4 OU Interim Action*. This document describes modifications to the KW pump-and-treat system, including additions to increase treatment capacity and the addition of new extraction and injection wells.

- DOE/RL-2008-46, Rev. 0, *Integrated 100 Area Remedial Investigation/Feasibility Study Work Plan*; and DOE/RL-2008-46, Addendum 2, Rev. 0, *Integrated 100 Area Remedial Investigation/Feasibility Study Work Plan, Addendum 2: 100-KR-1, 100-KR-2, and 100-KR-4 Operable Units*. These documents provide the basis for vadose zone and groundwater characterization needed to support preparation of an RI/FS and proposed plan and in order to reach a final ROD for the 100-K Area.

- DOE/RL-2009-41, Rev. 0, *Sampling and Analysis Plan for the 100-K Area Remedial Investigation/Feasibility Study*. This document provides specific sampling and analytical requirements for testing at 13 groundwater wells and two boreholes planned for the 100-KR-4 OU.
- DOE/RL-2009-59, *Interim Action Monitoring Plan for the 100-KR-4 Operable Unit* (decisional draft for review; in preparation). This document provides the guidance and rationale for sampling groundwater at existing and future wells used in support of the three pump-and-treat systems at the 100-KR-4 Groundwater OU. Revisions to DOE/RL-2009-59 will be needed to coordinate changes to the treatment system configurations, to add new treatment technologies, and to address emerging groundwater contaminant conditions. The document was transmitted to DOE in November 2009 for review.

TPA Change Notice TPA-CN-273, *Supplement to the 100-HR-3 and 100-KR-4 Remedial Design Report and Remedial Action Workplan for the Expansion of the 100-KR-4 Pump and Treat System* (DOE/RL-2006-75), addressed a number of required changes to improve operations at the 100-KR-4 and KX pump-and-treat systems. The changes included the following:

- Realign wells between the two systems to contain impacts of a tritium plume potentially impacting groundwater quality at KX injection wells.
- Standardize sampling of extraction, compliance and injection wells at the 100-KR-4, and KX systems.
- Identify five new wells with locations for 100-KR-4 and KX systems, plus the sampling requirements, proposed uses, and general well design.
- Delete requirement to prepare a semiannual report to status the pump-and-treat systems.

2.11.5.3 Remedial Actions

The following progress has been made in 100-K Area within the 100-KR-4 Groundwater OU since the 2006 five-year review; progress includes system operations, operation, and maintenance information as applicable. The interim remedial action objectives are as follows:

100-KR-4 Operable Unit Remedial Action Objectives

Remedial Action Objective 1	Protection of aquatic receptors in the river bottom substrate from contaminants in groundwater entering the Columbia River
Remedial Action Objective 2	Protection of human health by preventing exposure to contaminants in the groundwater
Remedial Action Objective 3	Provide information that will lead to the final remedy

2.11.5.4 Progress Since 2006 Review

Some chromium concentrations in the groundwater north and east of the 100-K Area continue to decline because of pump-and-treat operations. However, chromium concentrations are increasing along the 100-N Area and 100-K Area border.

Continued expansion of the extraction and monitoring network has been required to enhance plume capture and verify performance.

A series of modifications were made to the 100-KR-4 as described in *Supplement to the 100-HR-3 and 100-HR-4 Remedial Design Report and Remedial Action Workplan for the Expansion of the 100-KR-4 Pump and Treat System*.

A new KW pump-and-treat system was constructed and began operations in FY07 to treat hexavalent chromium contamination in the KW reactor area. The system was expanded in FY09 to increase the treatment capacity from 100 gallons per minute to 200 gallons per minute.

The KX pump-and-treat system was constructed and began operation in 2009 to treat an additional 600 gallons per minute to treat groundwater contaminated by the 116-K-2 Trench that has migrated within the N Reactor fence line.

Portions of the 100-K Area groundwater contaminated with strontium-90 and carbon-14 are likely to require future use restrictions until final remedies are in place.

Tritium concentrations are likely to remain well above the MCL in the groundwater adjacent to 100-K East Basin and the 118-K-1 Burial Ground until well after the sources are removed. The KR-4 system has been realigned to receive contaminated groundwater from three wells (199-K-144, 199-K-145, and 199-K-162) to control the tritium plume to create a partial recirculation system that should help to contain and localize tritium within a smaller area. The tritium plume is believed to be associated with the 118-K-1 Burial Ground.

The pump-and-treat system expansion to the 1,100-gallons per minute capacity is providing improved treatment of the hexavalent chromium plume. Additional system optimization is needed to provide sufficient capture to meet remedial action objectives.

2.11.5.5 Technical Assessment

The purpose of the five-year review is to determine whether the remedy at a site is, or upon completion will be, protective of human health and the environment. The following is the technical assessment response of the 100-KR-4 Groundwater OU interim remedy concerning the technical assessment questions provided in the EPA guidance. The following also establishes a framework for organizing and evaluating data and ensuring that all relevant issues are considered when determining the protectiveness of the remedy.

Is the remedy functioning as intended by the decision documents?

The interim remedy is functioning within the specified remedial action objectives.

Are the exposure assumptions, toxicity data, cleanup levels, and remedial action objectives used at the time of remedy selection still valid?

The exposure assumptions, toxicity data, cleanup levels, and the interim remedial action objectives used at the time of remedy selection are still valid for the OUs.

Has any other information come to light that could call into question the protectiveness of the remedy?

The following information has become known since the 2006 five-year review.

2.11.5.5.1 Chromium

The hexavalent chromium groundwater plume in the 100-K Area includes four separate plumes based on the likely principal sources. Figure 17 depicts chromium concentrations in the spring and fall of 2009 and shows the impact of low and high river stage on near-river contaminant distribution. Hexavalent chromium concentrations have been detected by near-river extraction and compliance wells, as well as near-river aquifer tubes. Although aquifer tubes are not accepted compliance points, they provide an opportunity to assess contaminant migration toward the Columbia River. Some of the aquifer tubes were not sampled in 2009. Chromium concentrations at extraction and compliance wells are treated by the three pump-and-treat systems. The aquatic standard for hexavalent chromium in the riverbed is 10 µg/L. The DWS for hexavalent chromium in groundwater is 100 µg/L. Not all sources of hexavalent chromium have been found.

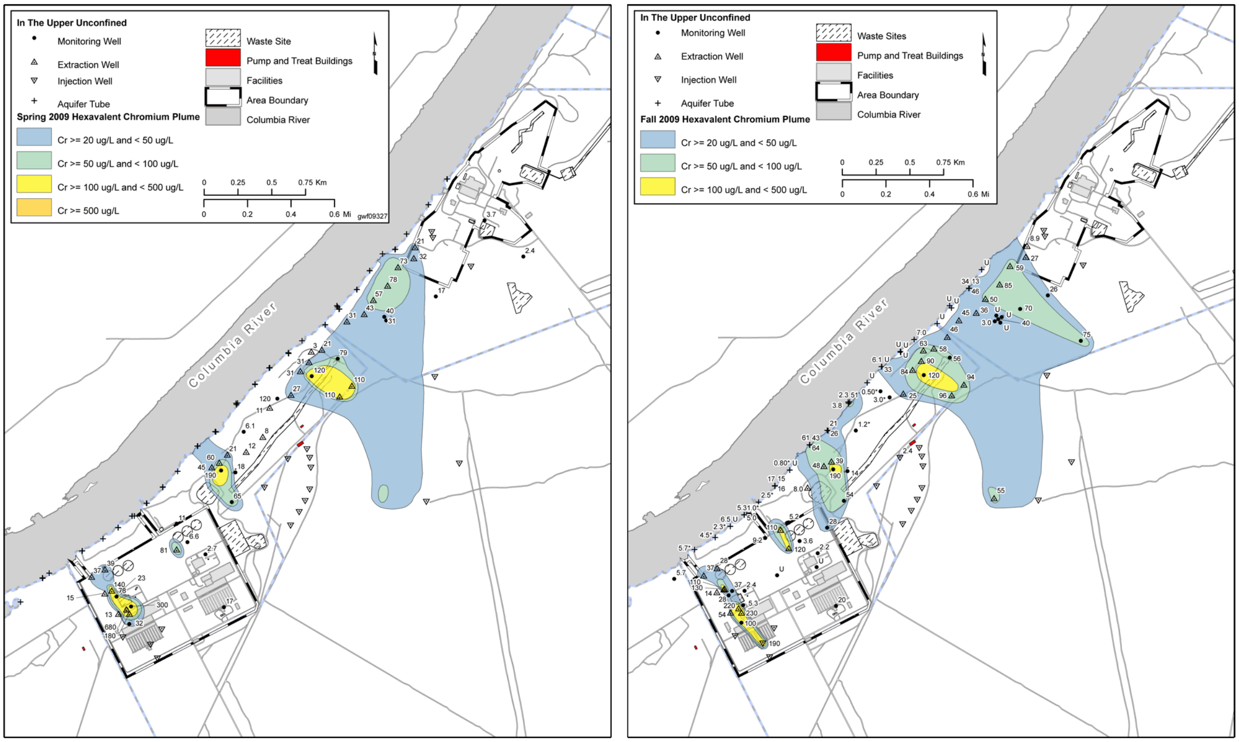
Two of the largest plumes are associated with the 116-K-2 Mile-Long Trench. The original plume has been divided at the center of the 116-K-2 Trench by the 100-KR-4 system’s 12-plus years of groundwater extraction and injection.

The third hexavalent chromium plume is located downgradient of the KE Reactor building. At times, this plume was thought to extend upgradient to the KE Reactor head house area. The source of the plume is assumed to be from leakage or spills at water treatment facilities supporting the KE Reactor. This plume is being remediated by the KX pump-and-treat system.

The fourth hexavalent chromium plume is located near the KW Reactor. High baseline hexavalent chromium concentrations in some wells (located upgradient of the KW Reactor) suggest that the plume may be attributed to an upgradient leak or spill of concentrated sodium dichromate solution, likely near the

183-KW head house, but the source has not been found at this time. This plume is being remediated by the KW pump-and-treat system.

Figure 17. 100-KR-4 Operable Unit Hexavalent Chromium Plume



2.11.5.5.2 Tritium

Tritium plumes in groundwater are associated with drainage around the 116-KW-1, 116-KE-2 gas condensate cribs, and the 118-K-1 Burial Ground. The fall 2009 results have increased as compared to baseline pre-pump-and-treat results; however, they are below DWS.

2.11.5.5.3 Strontium-90

Strontium-90 in groundwater is associated with discharges to the 116-KE-3 and 116-KW-2 cribs both during and after reactor operations. Water leaking from the KE and KW Reactor fuel rod storage sub-basin was conveyed to the crib by a pipeline. A subsurface well associated with each crib is thought to have accelerated radionuclide migration to the groundwater. Significant amounts of radionuclides have been encountered during remediation beneath the KE basin and crib. The contaminants may have been driven deeper into the vadose zone and possibly to groundwater by the use of dust-suppression water. Several significant spikes in strontium-90 have been observed at the nearby KE Reactor downgradient monitoring well 199-K-109A, as well as elevated levels at well 199-K-34 (near KW Basin). The fall 2009 results are at a lower concentration as compared to baseline pre-pump-and-treat results, but are still above DWS. The MCL for strontium-90 is 8 pCi/L.

2.11.5.5.4 Carbon-14

Carbon-14 is found in groundwater and originates from two waste sites (116-KE-1 and 116-KW-2) associated with the 115-KE and 115-KW gas condensate facilities. A liquid condensate stream containing both carbon-14 and tritium was discharged to the two cribs during reactor operations. The contaminants appear to remain in the soil column in significant quantities and are slowly draining into the aquifer, then flowing downgradient toward the Columbia River. The fall 2009 results are at a lower concentration as compared with the baseline pump-and-treat and the DWS. The MCL for carbon-14 is 2,000 pCi/L.

2.11.5.5.5 Nitrate

Nitrate is present in the groundwater wells within the 100-KR-4 OU at below-MCL concentrations (45 mg/L). The nitrate may be associated with Hanford Site reactor operations or plants, decommissioning, septic systems, or pre-Hanford agricultural activities.

2.11.5.5.6 Trichloroethene

Trichloroethene is a minor contaminant found at wells in the KW Reactor area. In FY09, the KW Reactor area wells, plus selected wells inside the K Reactor area and downgradient of the 116-K-2 trench were analyzed for trichloroethene. Trichloroethene was not detected at the wells near the 116-K-2 Trench. Wells associated with the KE Reactor area had detections of trichloroethene at concentrations below the DWS of 5.0 µg/L.

The highest concentrations were 9.2 and 9.0 µg/L in a May 2009 sample, but concentrations declined to 6.2 µg/L in October 2009. Wells on the west side of the hexavalent chromium plume and pump-and-treat system reported the next highest concentrations of trichloroethene (59 µg/L and 6.2 µg/L). Wells on the east side of the plume pump-and-treat system reported lower concentrations ranging from 1.0 µg/L to 4.1 µg/L. Upgradient wells reported trichloroethene concentrations from of 3.0 µg/L to 3.9 µg/L. This distribution suggests a plume source upgradient and, in part, west of the KW Reactor area.

Further information regarding the performance of the groundwater pump-and-treat systems can be found in the annual *Hanford Site Groundwater Monitoring and Performance Report for 2009*.

2.11.5.6 Protectiveness Statement

The final remedy at 100-KR-4 OU is expected to be protective of human health and the environment upon completion of the final remedy. The current interim actions ensure that exposure pathways that could result in unacceptable risks are being controlled.

2.12 100-N Area

2.12.1 Background

The N Reactor operated from 1963 until 1987. In 1991, the final decision to retire the N Reactor from service permanently was issued. The 100-NR-1 OU includes contaminant sources in the soil (including the contaminated shoreline site), while the 100-NR-2 Groundwater OU includes contamination present in the underlying groundwater.

2.12.2 Chronology

The following information summarizes the chronology of significant documents and events relevant to response actions in the 100-N Area.

100-N Area

9/23/1994	AR/PIR/ D196063443	Action Memorandum: N Springs Expedited Response Action
12/1998	AR/PIR/D199017702	Action Memorandum: 100 N Area Ancillary Facilities
9/29/1999	EPA/ROD/R10-99/112	Interim Action ROD: 100-NR-1 and OU 100-NR-2 OUs
1/18/2000	EPA/ROD/R10-00-120	Interim Action ROD: 100-NR-1 TSD Unit
5/2003	AR/PIR/D2020929	ESD: 100-NR-1 TSD Unit and 100-NR-1 and 100-NR-2 OUs Interim Action ROD
2/2005	AR/PIR/D7590428	Action Memorandum: 105-N Reactor Building and 100-N Heat Exchanger Building
9/2010	AR/PIR/0084198	Interim Action ROD Amendment: 100-NR-1 and 100-NR-2 OUs
3/2011	AR/PIR/0093940	ESD: 100-NR-1 and 100-NR-2 OUs Interim Action ROD

2.12.3 100-NR-1 Operable Unit

2.12.3.1 Background

This section describes the waste site remedial actions for the 100-NR-1 Source OU, which includes all of the 100-N Area (Figure 18).

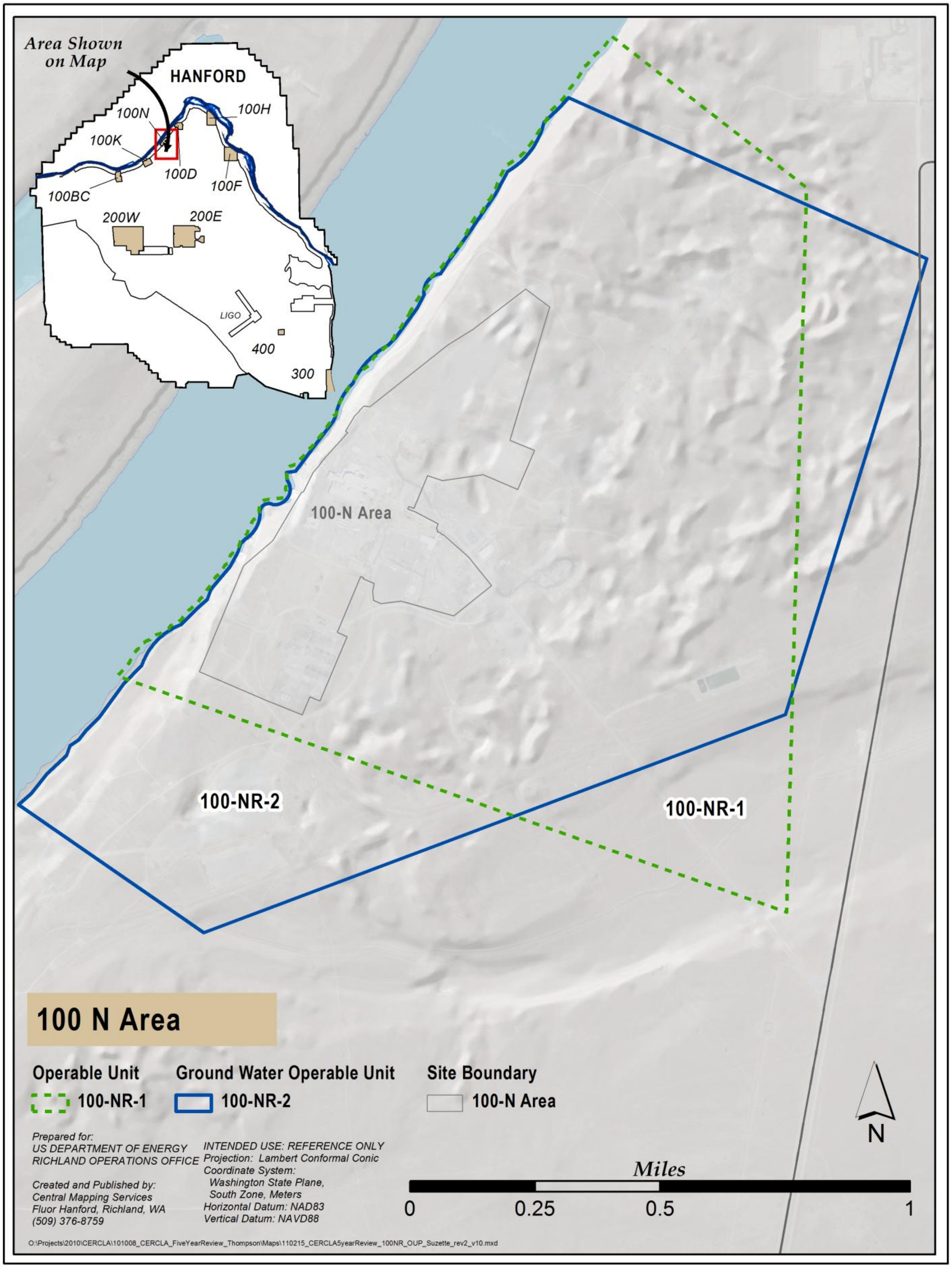
2.12.3.2 Chronology

In September 1999, the *Interim Remedial Action Record of Decision for 100-NR-1 and 100-NR-2 Operable Units* was issued. There are 81 waste sites in the 100-NR-1 Source OU identified as requiring interim remedial actions under this interim action ROD. For 58 of the sites, the remove, treat, and dispose remedy was selected (37 radioactive sites, six inorganic waste sites, six burn pits, and nine surface solid waste and miscellaneous source waste sites). Other actions for 22 petroleum sites include excavating and treating soil using ex situ bioremediation, disposing of the treated soil for the 20 near-surface petroleum sites, and in situ bioremediation for the two deep petroleum sites. The final site identified in the interim action ROD is the shoreline site, where the selected remedy was for implementation of institutional controls. The selected remedy for 100-NR-2 Groundwater OU was continuation of a pump-and-treat system for strontium-90, which was begun as a removal action in 1995, and the capture of free-floating petroleum within any monitoring wells. Since the 2006 five-year review, remediation of the 100-NR-1 TSD units was initiated and completed (EPA/ROD/R10-00-120); while remediation of the associated TSD piping work continues. In addition, remediation of the 100-NR-1 Source OU waste sites began, and the remediation work is continuing.

In January 2000, the *Interim Remedial Action Record of Decision for 100-NR 1 Operable Unit,* 116-N-1 (1301-N Liquid Waste Disposal Facility) and 116-N-3 (1325-N Liquid Waste Disposal Facility), integrated CERCLA and RCRA requirements and addressed remediation of radioactively and chemically contaminated soils, structures, and pipelines. The interim action ROD selected interim remedial actions for two RCRA TSD units and an associated unplanned release site within the 100-NR-1 OU. The 116-N-1 and 116-N-3 cribs, trenches, and associated pipelines comprise the two TSD units. The selected remedy called for removal of the units, associated contaminated piping, and unplanned release site, treatment as necessary, and disposal of contaminated materials in ERDF. Approximately 250,000 tons of material had been removed as of March 2010 from the 116-N-1 (1301-N Liquid Waste Disposal Facility) and 154,600 tons of material was removed from the 116-N-3 (1325-N Liquid Waste Disposal Facility).

In April 2003, the *Explanation of Significant Difference for 100-NR-1 Operable Unit Treatment, Storage, and Disposal Interim Action Record of Decision and 100-NR-1/100-NR-2 Operable Unit Interim Action Record of Decision*, documented significant differences associated with two RODs. The *Interim Remedial Action Record of Decision for 100-NR 1 Operable Unit* was issued in 2000 to consider the use of balancing factors to determine the extent of additional excavation where residual contamination exists below the 116-N-1 engineered structure at a depth greater than 15 feet (4.6 meters). Based on the balancing factors analysis and contaminant modeling, additional excavation at a depth greater than 15 feet (4.6 meters) was determined to be unnecessary if institutional controls were implemented and maintained to prevent application of irrigation water. The ESD also revised the annual institutional control requirements in the 100-NR-1 TSD ROD and the 100-NR-1/100-NR-2 ROD to change the reporting date from July 31 to September 30 to remain consistent with the reporting date established in the *Site-Wide Institutional Controls Plan for Hanford CERCLA Response Actions* (DOE/RL-2001-41).

Figure 18. 100-N Area



In September 2011, amendment to the *Interim Remedial Action Record of Decision for the 100-NR-1/NR-2 Operable Units* revised the selected interim remedial action for the Strontium-90 remedy in the 100-NR-2 Groundwater OU. This interim action ROD amendment alters the selected remedy specified in the 1999 interim action ROD as follows: (1) deploys the apatite sequestration technology for remediation of Strontium-90 in the 100-NR-2 Groundwater OU by extending the existing apatite permeable reactive barrier from 300 feet (90 meters) to approximately 2,500 feet (760 meters); (2) allows for deployment of the apatite sequestration technology elsewhere within the 100-NR-2 OU in accordance with an Ecology approved work plan; and (3) concurrent with or following construction of the extended apatite permeable reactive barrier, DOE will decommission the treatment components of the existing 100-NR-2 Groundwater OU pump-and-treat system. Performance monitoring will be conducted to confirm the effectiveness of the apatite permeable reactive barrier.

In March 2011, DOE submitted the *Explanation of Significant Differences for the 100-NR-1 and 100-NR-2 Operable Units Interim Remedial Action Record of Decision* to incorporate 45 additional waste sites in the decision to remove, treat, and dispose remedy.

2.12.3.3 Remedial Action

100-NR-1 Non-Treatment, Storage, and Disposal Unit Remedial Action Objectives

Remedial Action Objective 1	Protect potential human and ecological receptors under the rural-residential scenario from exposure by ingestion, external exposure, and inhalation to radioactive contaminants present in the upper 15 feet (4.6 meters) of soils, structures, and debris. The levels of reduction will be such that the total dose does not exceed EPA radionuclide soil cleanup guidance of 15 millirem/year above Hanford Site background for 1000 years following remediation.
Remedial Action Objective 2	Protect potential human and ecological receptors under the rural-residential exposure scenario from exposure by ingestion of nonradioactive contaminants present in surface and shallow subsurface soils and debris in the upper 15 feet (4.6 meters) of soil having concentrations exceeding the MTCA Method B levels (Method A for total petroleum hydrocarbon).
Remedial Action Objective 3	Protect the unconfined aquifer from adverse impacts by: (1) reducing concentrations of radioactive and nonradioactive contaminants present in all portions of the soil column that could migrate to the unconfined aquifer, or (2) reducing contaminant transport within the soil column. Contaminant levels will be reduced so concentrations reaching the unconfined aquifer do not exceed MCLs promulgated under the SDWA or the State of Washington's Drinking Water Standards, or MTCA Method B levels (Method A for total petroleum hydrocarbon), whichever is lower. The location and measurement of the point of compliance will be defined in the Remedial Design/Remedial Action Workplan. Monitoring for compliance will be performed at the defined point.
Remedial Action Objective 4	Protection of the Columbia River from adverse impacts so contaminants remaining in the soil after remediation do not result in an impact to groundwater and, therefore, the Columbia River that could exceed the ambient water quality criteria under the Clean Water Act for protection of fish. Since there are no ambient water quality criteria for radionuclides, MCLs will be used. Measurement of compliance will be at a near-shore well, in the downgradient plume. The location and measurement will be defined by EPA and Ecology.
Remedial Action Objective 5	Prevent destruction of significant cultural resources and sensitive wildlife habitat. Minimize the disruption of cultural resources and wildlife habitat in general and prevent adverse impacts to cultural resources and threatened or endangered species.

100-NR-1 Treatment, Storage, and Disposal Unit Remedial Action Objectives

Remedial Action Objective 1	Protect human and ecological receptors from exposure to radioactive contaminants in surface and subsurface soils, structures, and debris. Exposure routes include ingestion and inhalation, as well as external radiation exposure from radionuclides. Protection will be achieved by reducing concentrations of contaminants in the upper 15 feet (4.6 meters) of soil. Soils will also be removed to a depth of 5 feet (1.5 meters) below the engineered structures of the 116-N-1 and 116-N-3 cribs and trenches that contain plutonium-239/240. The levels of reduction will be such that the total dose does not exceed 15 millirem (mrem)/year above Hanford Site background for 1,000 years following remediation. The 1,000-year requirement ensures that the proposed standard accounts for decay of radionuclides to daughter products that are more highly radioactive.
Remedial Action Objective 2	Protect potential human and ecological receptors from exposure to nonradioactive contaminants present in the upper 15 feet (4.6 meters) of soil and debris. Exposure routes include ingestion, inhalation, or dermal exposure. Protection will be achieved by reducing concentrations of contaminants in the upper 15 feet (4.6 meters) of soil to the State of Washington MTCA Method B levels or alternates as allowed by MTCA.
Remedial Action Objective 3	Protect the unconfined groundwater system from adverse impacts by reducing concentrations of radioactive and nonradioactive chemical contaminants present the soil column that could migrate to the groundwater. Contaminant levels will be reduced so concentrations reaching the groundwater do not exceed the State of Washington MTCA Method B levels or MCLs.
Remedial Action Objective 4	Protection of the Columbia River from adverse impacts so that designated beneficial uses are maintained. Protect associated potential human and ecological receptors using and living in the river from exposure to radioactive and nonradioactive chemical contaminants. Protection will be achieved by reducing concentrations of, or limiting exposure pathways to, contaminants present in the soil column that could migrate to the groundwater and eventually to the river. Contaminant levels will be reduced so that concentrations reaching the river do not exceed MTCA Method B values, MCLs promulgated under the federal *Safe Drinking Water Act*, the State of Washington's Drinking Water Standards, ambient water quality criteria, or the State of Washington's *Surface Water Quality Standards* (including Cr6 standard of 10 ppb) Washington Administrative Code (WAC) 173-201A), whichever is most stringent.
Remedial Action Objective 5	Prevent destruction of significant cultural resources and sensitive wildlife habitat. Minimize the disruption of cultural resources and wildlife habitat in general and prevent adverse impacts to cultural resources and threatened or endangered species.

2.12.3.4 Progress Since 2006 Review

Modeling of vadose zone contamination beneath the 116-N-1 site indicated potential impacts to groundwater if the rural residential exposure scenario with 30 inches (76 centimeters) of annual irrigation was used. After a public comment period, an ESD was issued by the Tri-Parties to evaluate risk, assuming no irrigation at this site, and require an additional institutional control restricting irrigation. This institutional control will remain in place under the control of DOE for the duration of the 100-N Area interim remedial action. In addition, the institutional control will be maintained in accordance with the two 100-NR-1 RODs and Hanford Site institutional control plan. As specified in the ESD, additional institutional controls may be required as a part of the final remedy to ensure long-term viability. Backfill and re-vegetation of the 116-N-1 crib and trench were completed in FY07 and the site was 'interim closed out' (the interim remedial action for the other 100-NR-1 TSD unit [the 116-N-3 crib and trench] was completed during the time frame covered by the previous CERCLA five-year review. Unlike the 116-N-1 unit, the 116-N-3 crib and trench did not require any institutional control prohibiting irrigation at the waste site.)

A pilot scale system was installed in FY09 to assess in situ bioremediation at the largest waste site with deep petroleum contamination (UPR-100-N-17). Testing and initial operation of the bioremediation system began in 2010. The *Bioremediation Well Borehole Soil Sampling and Data Analysis Summary Report for the 100‑N Area Bioremediation Project* (UPR-100-N-17) (WCH-370), identified zones of total petroleum hydrocarbon contamination starting approximately 55 feet below ground surface and extending to the groundwater table in the unconfined aquifer. The report concluded that the lateral and upgradient boundaries of the total petroleum hydrocarbons diesel contamination zone are not fully defined. The

UPR-100-N-17: Bioventing Pilot Plant Performance Report (WCH-490), documents the results of a pilot study (conducted February 2010 through May 2011). The report indicates that bioventing provides a method for enhancing in-situ bioremediation of deep soils impacted with petroleum hydrocarbons.

Several waste sites in the 100-NR-1 OU are beneath or adjacent to buildings that are being demolished in accordance with a CERCLA removal action. Integration between the building removal activities and waste site remediation is necessary because waste site remediation cannot occur until impeding facilities are demolished. The remediation strategy for the 100-N Area involves remediation of waste sites on the outer boundary of the area and proceeding inward. Remediation began on approximately 70 of the 100-N Area waste sites in 2010, 22 waste sites have been excavated as of June 2011 (although not yet verified and closed). It is anticipated that remediation will be complete in 2012.

Between August 2007 and March 2009, an 'orphan sites' evaluation was conducted to identify any previously unidentified waste sites at the 100-N Area. The results of this evaluation are documented in the *100-N Area Orphan Sites Evaluation Report* (OSR-2006-0001). Based on this evaluation, 23 new waste sites were discovered that might require remediation. These sites are subjected to further review or characterization to determine the need for cleanup. Additionally, 31 groups of non-hazardous debris (e.g., wood waste, uncontaminated concrete, miscellaneous non-hazardous trash) were documented as potential material to be removed and disposed of as part of miscellaneous restoration activities.

Since the 2006 five-year review, the following waste sites have been remediated and are documented in Waste Site Cleanup Verification Packages and Remaining Waste Sites Verification Packages.

100-NR-1 Operable Unit

116-N -1 Liquid Waste Disposal Crib and Trench

2.12.3.5 Technical Assessments

The purpose of the five-year review is to determine whether the remedy at a site is, or upon completion will be, protective of human health and the environment. The following is the technical assessment response of the 100-NR-1 OU interim remedy concerning the technical assessment questions provided in the EPA guidance. The following also establishes a framework for organizing and evaluating data and ensuring that all relevant issues are considered when determining the protectiveness of the remedy.

Is the remedy functioning as intended by the decision documents?

The interim remedy has not been fully implemented at this time, and is still under construction. The 1999 *Interim Remedial Action Record of Decision 100-NR-1 and 100-NR-2 Operable Units* specifies the in-situ bioremediation remedy include installation of necessary injection wells and infrastructure to meet the remedial action objectives. The extent of contamination has not been fully characterized, and bioventing wells have been installed only to determine whether the remediation is viable. The DOE and Ecology are currently negotiating a final in-situ bioremediation plan.

Are the exposure assumptions, toxicity data, cleanup levels, and remedial action objectives used at the time of remedy selection still valid?

The exposure assumptions, toxicity data, cleanup levels, and the interim remedial action objectives used at the time of remedy selection are still valid for all OUs for purposes of implementing the interim action RODs. However, since issuance of the interim action ROD, soil cleanup levels (e.g., MTCA-based cleanup levels) have been modified. These modified levels will be considered during development of the final RODs.

Has any other information come to light that could call into question the protectiveness of the remedy?

No new information is known that could call into question the protectiveness of the remedy for these 100-NR-1 OU.

2.12.3.6 Protectiveness Statement

The final remedy at 100-NR-1 OU is expected to be protective of human health and the environment upon completion of the final remedy. The current interim actions ensure that exposure pathways that could result in unacceptable risks are being controlled.

2.12.4 100-NR-2 Groundwater Operable Unit

2.12.4.1 Background

This section describes the groundwater remedial actions for the 100-NR-2 Groundwater OU, which includes the groundwater beneath the 100-N Area. The following progress has been made in the 100-N Area within the 100-NR-2 Groundwater OU since the 2006 five-year review and includes system operations, operation, and maintenance information as applicable

2.12.4.2 Chronology

An interim action ROD was signed on September 30, 1999, for the 100-NR-1 and 100-NR-2 OUs (EPA/AMD/R10-00/122). The interim action ROD selected remedies for numerous source waste sites in the 100-NR-1 OU (except 116-N-1 and 116-N-3). The interim action ROD also addressed groundwater contaminants for the 100-NR-2 Groundwater OU, including petroleum hydrocarbons and strontium-90. This interim action ROD also addressed strontium-90 contamination present in the 100-NR-2 Groundwater OU. For the strontium-90 plume present in the 100-NR-2 Groundwater OU aquifer, the interim action ROD directed DOE to continue operation of an existing groundwater pump-and-treat system using an ion exchange resin to remove strontium-90 from groundwater. The interim action ROD also requires DOE to evaluate technologies for strontium-90 removal because it was recognized that pump-and-treat was unlikely to be an effective long-term aquifer treatment method. Performance monitoring conducted while the pump-and-treat system was in operation confirmed the system's limited effectiveness in removing strontium-90 from the aquifer. As a result, in March 2006, operation of the pump-and-treat system was placed in standby.

The DOE issued the *Proposed Plan for Amendment of 100-NR-1/NR-2 Interim Action Record of Decision* in June 2010. This proposed plan describes the rationale for amending the 1999 EPA/ROD/R10-99/112, *Interim Remedial Action Record of Decision for the 100-NR-1 and 100-NR-2 Operable Units, Hanford Site, Benton County, Washington*. The following changes to the interim action ROD were proposed:

- Construct a subsurface permeable reactive barrier to immobilize strontium-90 present in soil and groundwater, thus reducing its flux to the Columbia River through groundwater flow.
- Decommission the existing pump-and-treat system's treatment facility and conveyance piping.

As described in the evaluation of alternatives section of this proposed plan, five remedial action alternatives were evaluated with the overall goal of reducing the strontium-90 flux to the Columbia River.

The EPA issued the *Amended Record of Decision, Decision Summary and Responsiveness Summary* in September 2010, amending the 1999 *Interim Remedial Action Record of Decision for the 100-NR-1 and 100-NR-2 Operable Units* (EPA/ROD/R10-99/112 interim action ROD). This interim action ROD Amendment alters the selected remedy specified in the 1999 interim action ROD as follows:

- Deploys the apatite sequestration technology for remediation of strontium-90 in the 100-NR-2 Groundwater OU by extending the existing apatite permeable reactive barrier from 300 feet (90 meters) to approximately 2,500 feet (760 meters).
- Allows for deployment of the apatite sequestration technology elsewhere within the 100-NR-2 Groundwater OU in accordance with an Ecology approved work plan.
- Provides that concurrent with or following construction of the extended apatite permeable reactive barrier, DOE will decommission the treatment components of the existing 100-NR-2 Groundwater OU pump-and-treat system.

- Performance monitoring will be conducted to confirm the effectiveness of the apatite permeable reactive barrier. The apatite permeable reactive barrier will complement the existing interim remedial actions that are underway or have already been completed in the 100-NR-2 Groundwater OU. The existing interim actions include institutional controls to control land and groundwater use, free phase hydrocarbon removal, and groundwater monitoring.

2.12.4.3 Remedial Action

The principal contaminant of concern is strontium-90, which is currently the focus of most of the efforts at the OU. This work was conducted under the *Interim Remedial Action Record of Decision for the 100-NR-1 and 100-NR 2 Operable Units, Hanford Site, Benton County, Washington* (EPA/ROD/R10-99/112).

The final *Integrated 100 Area Remedial Investigation/Feasibility Study Work Plan, Addendum 5: 100-NR-1 and 100-NR-2 Operable Units* (DOE/RL-2008-46, Addendum 5) and the associated *Sampling and Analysis Plan for the 100-NR-1 and 100-NR-2 Operable Units Remedial Investigation/Feasibility Study* (DOE/RL-2009-42) for the 100-N Area were prepared and issued as Draft A for regulatory review in December 2009 and as Draft B for regulatory review in April 2010. To expedite the RI/FS characterization well drilling work and other remedial investigation activities, the sampling and analysis plan for 100-NR-2 OU (DOE/RL-2009-42, Rev. 0), was approved by DOE-RL, Ecology, and EPA on January 3, 2011. The associated RI/FS well locations for additional characterization boreholes and wells were staked in September 2010.

The RI/FS work plan was approved March 2011; there was no need to amend the sampling and analysis plan approved January 2011. The schedule for completing the work identified in these documents and submittal of the resultant RI/FS report and proposed plan is September 17, 2012.

DOE submitted in March 2011, the *Remedial Design/Remedial Action Work Plan for the 100-NR-2 Operable Unit*, DOE/RL-2001-27, Revision 1, Draft A. The document is currently under regulatory review. This RD/RA work plan describes the scope and schedule for testing and construction of the permeable reactive barrier to sequester strontium-90 in groundwater and vadose zone per the September 2010 ROD amendment.

100-NR-2 Operable Unit Remedial Action Objectives

Remedial Action Objective 1	Protect the Columbia River from adverse impacts from the 100-NR-2 groundwater so that designated beneficial uses of the Columbia River are maintained. Protect associated potential human and ecological receptors using the river from exposure to radioactive and nonradioactive contaminants present in the unconfined aquifer. Protection will be achieved by limiting exposure pathways, reducing, or removing contaminant sources, controlling groundwater movement, or reducing concentrations of contaminants in the unconfined aquifer.
Remedial Action Objective 2	Protect the unconfined aquifer by implementing remedial actions that reduce concentrations of radioactive and nonradioactive contaminants present in the unconfined aquifer.
Remedial Action Objective 3	Obtain information to evaluate technologies for strontium-90 removal and evaluate ecological receptor impacts from contaminated groundwater.
Remedial Action Objective 4	Prevent destruction of sensitive wildlife habitat. Minimize the disruption of cultural resources and wildlife habitat in general and prevent adverse impacts to cultural resources and threatened or endangered species.

2.12.4.4 Progress Since 2006 Review

Since the 2006 review, work continued on the human health and ecological risk assessment to evaluate post remediation conditions of source waste sites and current conditions in groundwater, the riparian zone, and the near shore of the Columbia River. DOE had previously prepared and received regulatory approval of a DOE/RL-2004-37, *Risk Assessment Work Plan for the 100 Area and 300 Area Component of the RCBRA*. DOE, with technical assistance from Hanford Natural Resource Trustee representatives, had gone through a data quality objective process and received regulatory approval of DOE/RL-2005-42, *100 Area and 300 Area Component of the RCBRA Sampling and Analysis Plan*. Using existing data gathered at the completion of waste site remediation prior to backfill, and supplemental data to be gathered under the sampling and analysis plan, a risk assessment report will be produced.

The risk assessment for the 100 Area and 300 Area component of the *River Corridor Baseline Risk Assessment Volume II Human Health Risk Assessment,* Draft A, was submitted in accordance with TPA Milestone M-16-72 (*Submit Draft 100 and 300 Areas Component Baseline Risk Assessment Report* by June 30, 2007). In November 2006, the 100 Area and 300 Area Component of the RCBRA Sampling and Analysis Plan (DOE/RL-2005-42, Revision 1) was issued. The Inter-Areas Shoreline Assessment sampling was completed and results are reflected in the December 2012 risk assessment report (Draft C *River Corridor Baseline Risk Assessment Volume II Human Health Risk Assessment*, DOE/RL-2007-21, Part 1 and DOE/RL-2007-21, Part 2).

The 100-NR-2 Groundwater OU pump-and-treat operations ceased in March 2006. Several ongoing treatability studies and remedial investigation activities were conducted during the review period. Based on the results of the treatability testing, the permeable reactive barrier test (active groundwater remediation) will be expanded via the *Amended Record of Decision 100-NR-1 and 100-NR-2 Operable Units*. The subsequent revision to the *Remedial Design/Remedial Action Work Plan for the 100-NR-2 Operable Unit*, (DOE/RL-2001-27) was developed and submitted as a draft to Ecology on March 29, 2011.

DOE agreed to construct and evaluate the effectiveness of a permeable reactive barrier for strontium-90, utilizing apatite sequestration technology as part of the RI/FS process, which is consistent with the requirement to evaluate alternative remedial technologies consistent with the 1999 Interim Action ROD for the 100-NR-1 and 100-NR-2 OUs, and the TPA Change Control Form M-16-06-01. Strontium-90 sequestration using this technology occurs by injecting a calcium-citrate-phosphate solution. The treatability test plan for permeable reactive barrier using apatite sequestration (*Strontium-90 Treatability Test Plan for 100-NR-2 Groundwater Operable Unit*, DOE/RL-2005-96) was implemented. A permeable reactive barrier was installed via low-concentration injections in FY 2007 and high-concentration injections in FY 2008 (*Interim Report: 100-NR-2 Apatite Treatability Test: Low-Concentration Calcium-Citrate-Phosphate Solution Injections for In Situ Strontium-90 Immobilization* (PNNL-17429). In December 2009, jet injection tests were performed in three plots along the 100-N Area shoreline, just upriver from the existing apatite permeable reactive barrier and test objectives were met (*Treatability Test Report for Field-Scale Apatite Jet Injection Demonstration for the 100-NR-2 Operable Unit*, SGW-47062 and *Hanford 100-N Area In Situ Apatite and Phosphate Emplacement by Groundwater and Jet Injection: Geochemical and Physical Core Analysis*, PNNL-19524). Infiltration gallery tests (using sodium bromide tracer) took place in the fall of 2010 at the test site located approximately five meters past the downriver end of the existing apatite permeable reactive barrier (*100-NR-2 Apatite Treatability Test: Fall 2010 Tracer Infiltration Test*, PNNL-20322). A phytoextraction test was performed at the 100-K Area from 2007 through 2009 using coyote willows (*100-N Area Strontium-90 Treatability Demonstration Project: Phytoextraction Along the 100-N Columbia River Riparian Zone – Field Treatability Study*, PNNL-19120). After injection of the solution, biodegradation of the citrate results in apatite (a calcium phosphate mineral) precipitation. Strontium-90 substitutes for calcium via cation exchange and eventually becomes part of the mineral matrix as apatite crystallization occurs (*Hanford 100-N Area Apatite Emplacement: Laboratory Results of Ca-Citrate-PO4 Solution Injection and Sr-90 Immobilization in 100-N Sediments*, PNNL-16891). The permeable reactive barrier at 100-N Area has been successfully designed to meet a goal of 90 percent reduction of strontium-90 concentrations at the river's edge. DOE has planned further testing of injection methods for optimization of the apatite permeable reactive barrier formation under the *Design Optimization Study for Apatite Permeable Reactive Barrier Extension for the 100-NR-2 Operable Unit* (DOE/RL-2010-29) and the Jet Injection Design Optimization Study (*Jet Injection Design Optimization Study for the 100-NR-2 Groundwater Operable Unit*, DOE/RL-2010-68).

DOE has obtained new ecological data for 100-N. The ecological data published in the *Aquatic and Riparian Receptor Impact Information for the 100-NR-2 Groundwater Operable Unit* (DOE/RL-2006-26, Rev. 1) is consistent with previously identified data and analyses that the pump-and-treat system, operating in that location for the last 10 years, has not appreciably reduced the strontium-90 concentrations in groundwater that upwells into the Columbia River. Any further ecological work at 100-N Area will be integrated into the overall 100 Area ecological risk studies that are currently being planned.

2.12.4.5 Technical Assessment

The purpose of the five-year review is to determine whether the remedy at a site is, or upon completion will be, protective of human health and the environment. The following is the technical assessment response of the 100-NR-2 Groundwater OU interim remedy concerning the technical assessment questions provided in the EPA guidance. The following also establishes a framework for organizing and evaluating data and ensuring that all relevant issues are considered when determining the protectiveness of the remedy.

Is the remedy functioning as intended by the decision documents?

The pump-and-treat remedy selected in the 1999 *Interim Remedial Action Record of Decision 100-NR-1 and 100-NR-2 Operable Units* has not functioned within the specified remedial action objectives; as a result, the ROD was amended. The 2010 *Interim Remedial Action Record of Decision for the 100-NR-1/NR-2 Operable Units of the Hanford 100-N Area* revised the selected interim remedial action for the Strontium‑90 remedy in the 100-NR-2 Groundwater OU. The results of the initial 300 feet permeable reactive barrier remedy selected in the 2010 ROD shows promise in meeting the remedial action objectives.

Are the exposure assumptions, toxicity data, cleanup levels, and remedial action objectives used at the time of remedy selection still valid?

Exposure assumptions, toxicity data, cleanup levels, and interim remedial action objectives used at the time of the interim remedy selection are still valid for this OU for purposes of implementing the interim action ROD. However, since the issuance of the interim action ROD, soil cleanup levels have been revised and will be considered during the development of the final ROD.

Has any other information come to light that could call into question the protectiveness of the remedy?

The following information has become known since the 2006 five-year review.

2.12.4.5.1 Strontium‑90

The current conceptual site model predicts that the majority of the strontium‑90 remaining in the unsaturated and saturated zones in the 100-N Area is present in the vadose zone above the aquifer. Far more strontium‑90 is contained within the unsaturated zone than in the groundwater. Strontium‑90 has a much greater affinity for sediment than for water (i.e., a high distribution coefficient), so its rate of transport in groundwater to the river is considerably slower than the actual groundwater flow rate.

Based on the existing inland groundwater monitoring network (which has not changed during the last three review periods), the size, and shape of the strontium‑90 plume in groundwater have varied little over the years. The plume has nearly the same areal extent and shape currently as was evidenced in 1996 (prior to startup of 100-N Area pump-and-treat operations). The plume extends from beneath 116-N-1 (1301-N Liquid Waste Disposal Facility) and 116-N-3 (1325-N Liquid Waste Disposal Facility) to the Columbia River at levels exceeding the DWS of 8 pCi/L. Concentrations exceeding 100 pCi/L are limited to approximately the upper 9.8 feet (3 meters) of the aquifer (*Hanford Site Groundwater Annual Report for Fiscal Year 2006*). Concentrations in several wells and aquifer tubes exceeded DOE's derived concentration guideline of 1,000 pCi/L.

The highest strontium‑90 concentrations along the Columbia River in soil and groundwater are found near the current apatite permeable reactive barrier and immediately downriver to the northeast. This area is the focus of increased monitoring and remediation activities. The barrier has had an effect on reducing the strontium‑90 concentration in its immediate vicinity. Concentrations in all of the wells and aquifer tubes have been reduced considerably from those reported in the *Hanford Site Groundwater Monitoring for Fiscal Year 2009*.

Strontium‑90 in monitoring wells near the former 116-N-1 (1301-N Liquid Waste Disposal Facility) and the former 116-N-3 (1325-N Liquid Waste Disposal Facility) show no obvious long-term decline in concentrations, but do vary significantly in relation to water levels within the wells. Water levels were significantly higher below the Liquid Waste Disposal Facilities in the 1980s and early 1990s, when discharges were still occurring.

As the water level decreased, strontium‑90 remained in the vadose zone above the water table. When the water table rises beneath the former Liquid Waste Disposal Facilities, strontium‑90 from the periodically re-wetted vadose zone is mobilized and the concentrations in groundwater increase. Levels have been consistent for the last few years, with the increase and decrease of strontium‑90 concentrations mirroring changes in the water table elevation. The overall trend for strontium‑90 shows a slight decrease in concentration; however, strontium‑90 concentrations have trended upwards downstream of 116-N-1 (DOE/RL-2010-11).

Strontium‑90 contamination in the 100-N Area is primarily adsorbed to sediments by ion exchange (99 percent absorbed and 1 percent in solution in the groundwater) in the upper portion of the unconfined aquifer and lower vadose zone (Figure 19). Although primarily adsorbed, strontium‑90 is still considered a high-mobility risk, because seasonal river stage increases and plumes of higher ionic strength water, relative to groundwater mobilize strontium‑90 (PNNL-16891).

Solution injections were made to the Hanford Formation and Ringold Formation over a period of three years (2006 through 2008). Several reports have been issued concerning this treatability test and a brief summary of each is presented in the Hanford Site annual groundwater monitoring reports. These reports indicate the progress of the apatite permeable reactive barrier in retarding the migration of strontium‑90 (DOE/RL-2010-01).

During Fall 2009 and Spring 2010, 171 wells were installed for the future extension of the existing apatite permeable reactive barrier. Well installations were both upriver and downriver of the barrier. The proposed apatite permeable reactive barrier extension will cover approximately 2,500 feet (762 meters) of length where the strontium‑90 plume intersects the Columbia River along the 100-N Area shoreline. After installation, the injection and barrier wells will be available for further injections of apatite-forming chemicals or other chemicals as determined by ongoing apatite permeable reactive barrier testing and allowed by the *100-NR-1/100-NR-2 Operable Unit Interim Action Record of Decision* amendment. The plans covered in the proposed barrier emplacement optimization plan, include injecting wells along an additional 600 feet (182.8 meters) of permeable reactive barrier, 300 feet (91.4 meters) upriver and downriver on both ends of the existing permeable reactive barrier. Jet injection permeable reactive barrier emplacement methodology, infiltration permeable reactive barrier emplacement methodology, and phytoextraction removal technology are being evaluated and tested as an integral part of the permeable reactive barrier. More information on these additional treatment technologies can be found in the *Hanford Site Annual Groundwater Monitoring Report for 2010* (DOE/RL-2010-11). Although the existing permeable reactive barrier has treated groundwater and the lower vadose zone, it has not treated the upper vadose zone. Gross beta data from wells 199-N-147, 199-N-122, NVP2-116.0, 199-N-146, 199-N-142, 199-N-164, 199-N-145, and 199-N-160 (*Hanford Site Groundwater Monitoring for Fiscal Year 2010*, DOE/RL-2011-11, Figures 6-12, 6-24, 6-25, and 6-26) indicate strontium‑90 concentrations downgradient to the permeable reactive barrier have either generally stabilized above the radiocarbon analysis of groundwater 8 pCi/L) or are trending upwards (well above the radiocarbon analysis of groundwater). These contamination trends (which generally began in 2009) indicate that the recently amended ROD remedial action goals will not be met without additional apatite barrier injections in the existing permeable reactive barrier. The *Jet Injection Design Optimization Study for 100-NR-2 Groundwater Operable Unit* (DOE/RL-2010-68, Revision 0), when implemented, will vertically extend the existing apatite permeable reactive barrier into the unsaturated vadose zone. In addition, the *100-NR-2 Groundwater Operable Unit Phytoextraction Treatability Test Plan* (DOE/RL-2010-70, Draft A), when implemented, will remove strontium‑90 occurring in the near-shore riparian zone.

2.12.4.5.2 Petroleum Hydrocarbons

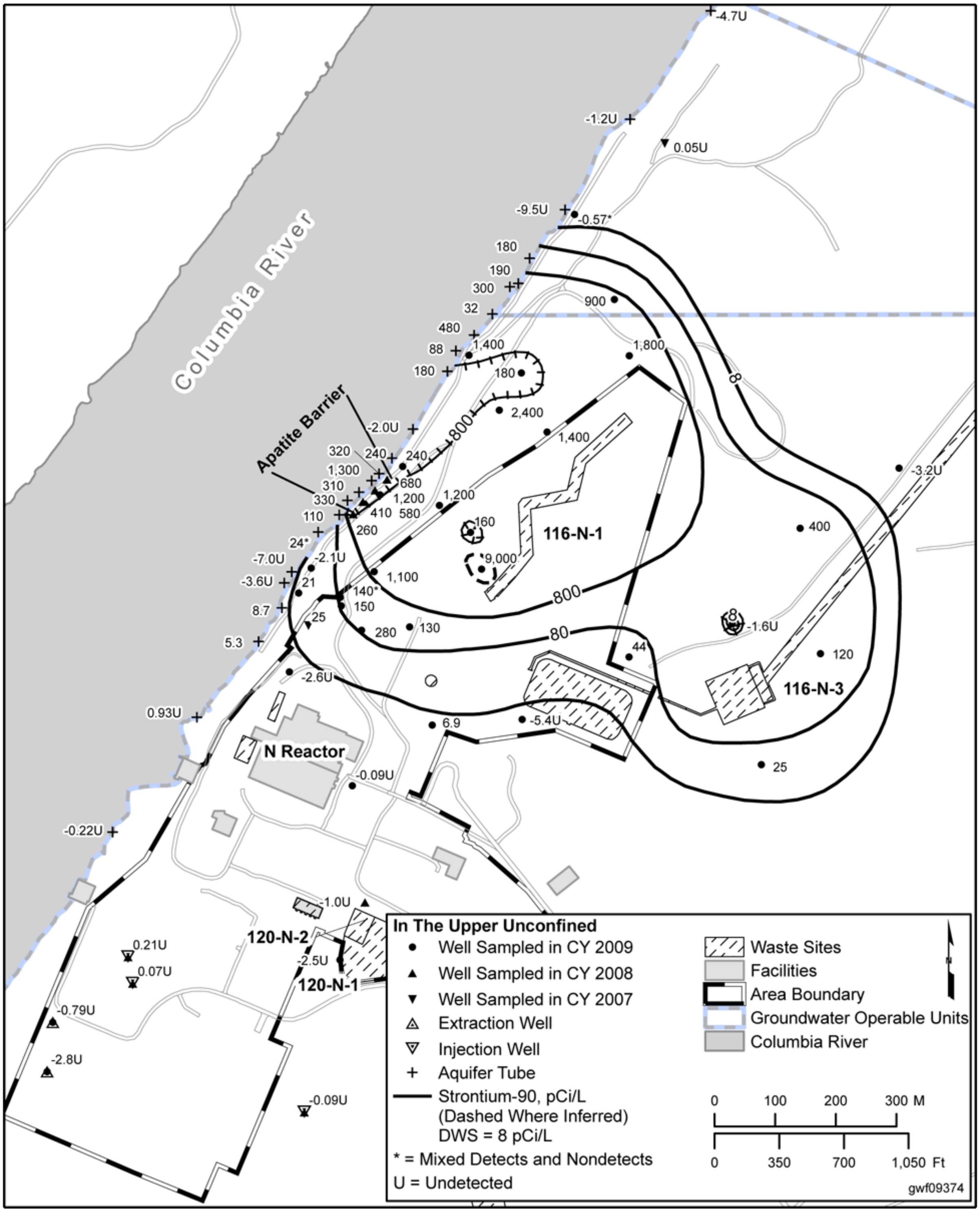
Petroleum hydrocarbon from a 1960s diesel fuel tank spill (UPR-100-N-17) continues to be detected in 100-N Area groundwater. This plume is confined to a relatively small region in the 100-N Area. DOE continued remedial actions to remove diesel free product from a well. Passive remediation involves the use of a polymer 'smart sponge' that selectively absorbs petroleum products from the surface of the water within the well. Every 2 months, two of the sponges are lowered into the water table at a well. The sponges are weighed prior to placement in the well and again after removal from the well. The weight difference between the two measurements is the amount of product, or diesel fuel contamination, removed from the well. This has been ongoing since 2003. Recently, one of the sponges broke in the well, but it has been successfully removed. A replacement well (199-N-183/C8185) has been staked for construction under the final RI/FS work plan. Well 199-N-18 is not planned to be decommissioned; it will continue to be used for free product removal. The replacement well will become the new monitoring well.

Low levels of hydrocarbon contamination have previously been observed in other wells (*Hanford Site Groundwater Monitoring for Fiscal Year 2002*) in the past. Recently, these wells did not have detectable levels of total petroleum hydrocarbon-diesel. Other wells near the plume also have not had detectable levels of total petroleum hydrocarbon-diesel. Aquifer tubes near the southern portion of the 100-N Area shoreline are also sampled for diesel-range petroleum hydrocarbon. In 2009, only two tubes had detections of total petroleum hydrocarbon-diesel, with values of 770 µg/L and 840 µg/L, respectively. An oil sheen was observed during the installation of the apatite barrier and upwelling sampling of groundwater.

2.12.4.6 Protectiveness Statement

A protectiveness determination of the remedy at 100-NR-2 Groundwater OU cannot be made at this time until further information is obtained. Further information will be obtained by completing the *Jet Injection Design Optimization Study for 100-NR-2 Groundwater Operable Unit* (DOE/RL-2010-68). With the completion of the optimization study and selection of the final remedy, a protectiveness determination will be made for 100-NR-2 Groundwater OU. It is expected that completion of the design optimization will take approximately two years to complete. Institutional controls required by the ROD for interim action prevent human exposure to contaminants.

Figure 19. 100-N Area Average Strontium-90 Concentrations, Upper Portion of Unconfined Aquifer



3 200 AREA

3.1 Background

The Hanford Site 200 Area NPL Site is comprised of the 200 East and West Areas, along with a smaller 200 North Area, all located in the Central Plateau portion of the Hanford Site. The Hanford Site 200 Area NPL Site covers approximately 75 square miles (194 km^2). The 200 East Area is located 17 miles (27 km) north-northwest of the city of Richland. The 200 West Area is located 6 miles (9.6 km) further west.

The Central Plateau was primarily used for waste management activities and reprocessing spent nuclear fuel to recover special nuclear materials for use in the national defense. Approximately 1,000 facilities, structures, and buildings, including the Plutonium Finishing Plant (PFP) and five large chemical processing facilities or 'canyon' facilities: T Plant, B Plant, U Plant, S Plant (REDOX Plant), and the Plutonium/Uranium Extraction (PUREX) Plant, were built to support processing of irradiated fuel from the plutonium production reactors and for treatment, storage, and disposal of waste. These processing activities generated large volumes of radioactive, hazardous, and mixed waste that were disposed to the soil column as liquid effluent, or went into the soil column as spills and leaks. The liquid effluents were transported to the disposal waste sites or tank farms via single-wall and double-wall pipelines. The processing activities also generated solid waste that was disposed in landfills. The intentional and inadvertent disposal of this waste created approximately 1,000 waste sites in the Hanford 200 Area.

Chemical processing of nuclear materials was terminated in the early 1990s, but waste management activities continue and are anticipated to continue into the future. Radioactive and mixed waste treatment and disposal are anticipated to continue for many years, at least until 2035 or beyond. The underground storage tank farms, buried solid waste, and the contaminated inactive soil areas and groundwater are the legacy of the old production mission and the primary focus of today's cleanup mission. Another key component of the 200 Areas is ERDF, which was built to provide safe disposal of waste generated because of ongoing cleanup activities across the Hanford Site.

A list of the CERCLA decision documents for the 200 Area Source and Groundwater OUs, as well as those associated with D&D of facilities, is provided in Section 3.2. The 200 Area was listed on the NPL on October 4, 1989. Remedial investigations began in the 200 Areas in 1992. These initial investigations pointed to the need for remedial action for a carbon tetrachloride plume located in the 200-ZP-1 Groundwater OU and 200-PW-1 Source OU (in 1992 known as 200-ZP-2), as well as an action for uranium and technetium contamination in the 200-UP-1 Groundwater OU. The 200 Area Groundwater OUs are depicted in Figure 20 and the 200 Area Source OUs are shown in Figure 21. Numerous sources of liquid waste discharges have existed in the 200 Areas since the inception of activities on the Hanford Site in 1945. Low-level waste was disposed of in open trenches and ponds that were later flushed with fresh water.

3.1.1 Land Use

In September 1999 DOE issued the *Record of Decision: Hanford Comprehensive Land-Use Plan Environmental Impact Statement (HCP EIS)*, the 1999 ROD (64 FR 61615; November 12, 1999) adopted a Comprehensive Land-Use Plan (CLUP) for the Hanford Site (*Final Hanford Comprehensive Land-Use Plan* Environmental *Impact Statement (HCP-EIS*), (DOE/EIS 0222-F). DOE has documented the future land use in the 1999 ROD to facilitate decision making and application of DOE institutional controls on the Hanford Site for at least the next 50 years.

The DOE amended the 1999 ROD, in the *Amended Record of Decision for the Hanford Comprehensive Land-Use Plan Environmental Impact Statement*, (73 FR 55824; September 2008), to clarify two points: that when considering land-use proposals, DOE will use regulatory processes in addition to the implementing procedures in the HCP-EIS Chapter 6 to ensure consistency with CLUP land-use designations, and that DOE will continue to apply the process under HCP-EIS Chapter 6 to modify or amend the CLUP, as needed. The CLUP will remain in effect as long as DOE retains legal control of some portion of the Hanford Site, which is expected to be longer than 50 years, as a 'living document', the CLUP is intended to be flexible enough to accommodate changes, both anticipated and unforeseen, in missions and conditions. The HCP-EIS recommends reassessment of the CLUP every five years through a Supplement Analysis process under the DOE *National Environmental Policy Act of 1969* Implementing Procedures (10 CFR 1021.314).

DOE has established a waste site surveillance and maintenance program and an environmental monitoring program that support DOE's ability to maintain protectiveness from current conditions through the remedial investigation phases and the completion of remedial actions. The 200 Area surveillance and maintenance operations include surveillances on the waste sites that are inspected as often as three times a year. The frequency depends on the specific waste site conditions related to erosion potential, vegetation uptake potential, and biotic intrusion potential.

The surveillance and maintenance program ensures a consistent process is in place to provide appropriate physical controls to prevent intrusion into hazardous areas and maintain waste sites in a stabilized condition that minimizes exposure to contamination. Physical controls such as postings, markers, barriers, and fencing are maintained via the surveillance and maintenance program to prevent potential exposure to contamination.

All source OUs are in different stages of progression toward completing the RI/FS process. Significant progress has been made toward completing the RI/FS process. Significant progress has been made toward the completion of these RI/FS processes over the last five years, with plans on issuing RODs during the next five years.

3.1.1.1 Inner Area

The Inner Area is defined as the final footprint area of the Hanford Site that will be dedicated to waste management and containment of residual contamination, which will remain under federal ownership and control for the future. This boundary is defined by waste disposal decisions already in place and anticipated future decisions that will result in the requirement for continued waste management and containment of residual contamination.

3.1.1.2 Outer Area

The Outer Area is defined as all areas of the Central Plateau beyond the boundary of the Inner Area. The Tri-Party agencies are planning to cleanup this portion of the site to a level comparable to that achieved for the River Corridor. Contaminated soil and debris will be removed to ERDF within the Inner Area for final disposal. Completion of the Outer Area cleanup will shrink the footprint of active cleanup to the final approximate 10 square miles (16 km^2) Inner Area.

3.1.1.3 Tank Farms

High radioactivity liquid effluents from the canyons were sent to the single and double shell underground tanks in the tank farms. Underground tanks in the Central Plateau include the 177 single-shell and double-shell tanks used to store high-activity waste generated during reprocessing operations. The tanks range in size from 55,000 gallons (208,198 liters) to approximately 1 million gallons (3.8 million liters).

These tanks received liquid waste from all of the processing facilities. Double shell tanks are active RCRA permitted TSD units, while single-shell tanks are in RCRA TSD units in varying stages of waste retrieval, and closure planning. In some cases, there have been leaks from single-shell tanks that are either known or suspected to commingle with soil contamination from liquid effluent disposal sites (e.g., cribs). The Tri-Party agencies are beginning to characterize that commingled contamination in an integrated manner (e.g., at the B-BX-BY Tank Farms and adjacent waste disposal sites). Closure and long-term disposition of these tanks is not discussed in this CERCLA five-year review.

3.1.1.4 Groundwater

The 200 Area Groundwater OUs are depicted in Figure 20. To support the groundwater remediation, four OUs have been established. Numerous sources of liquid waste discharges have existed in the 200 Areas since the inception of activities on the Hanford Site in 1945. Low-level waste was disposed of in open trenches and ponds that were later flushed with fresh water that saturated the vadose zone.

Figure 20. 200 Area Groundwater Operable Units

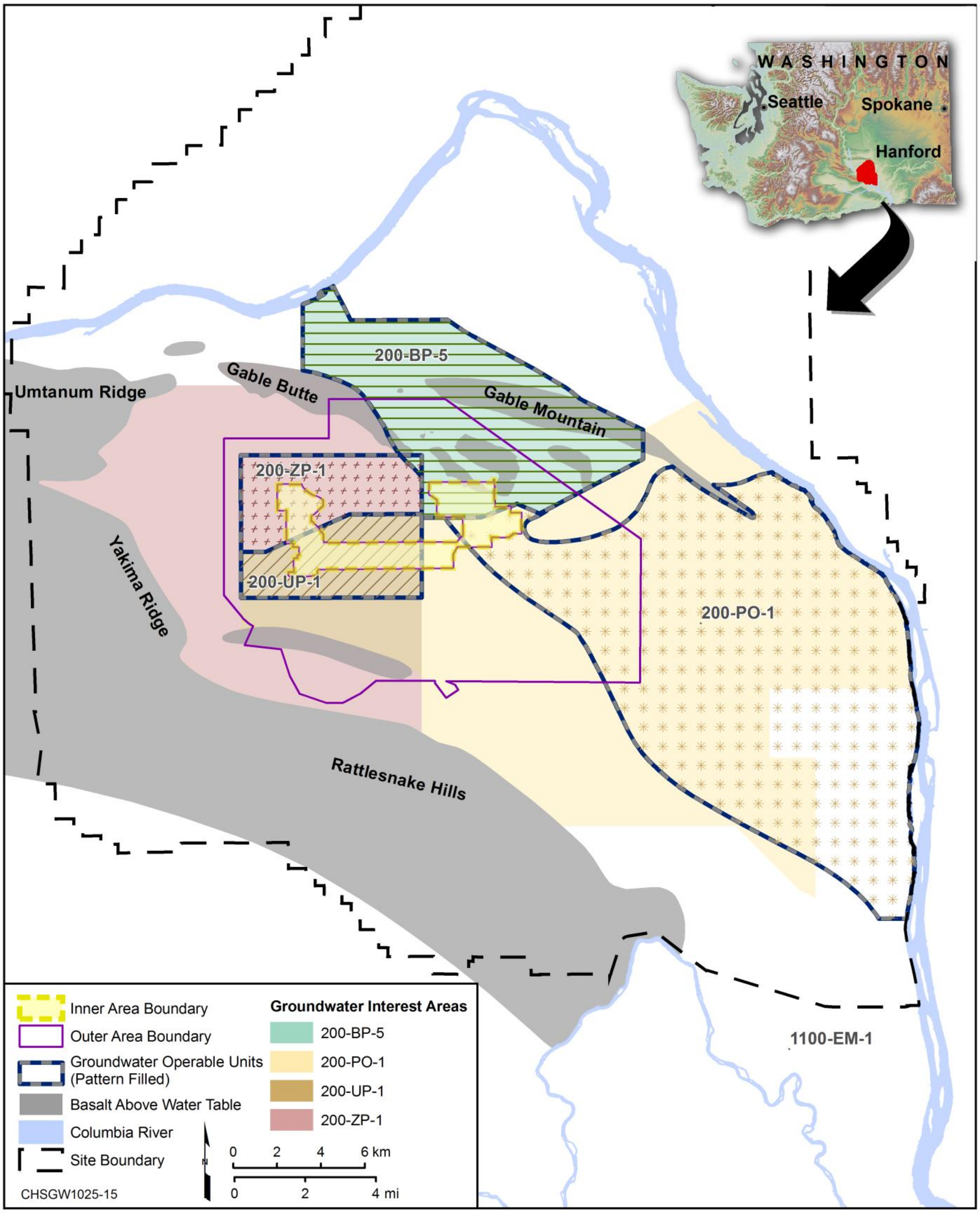
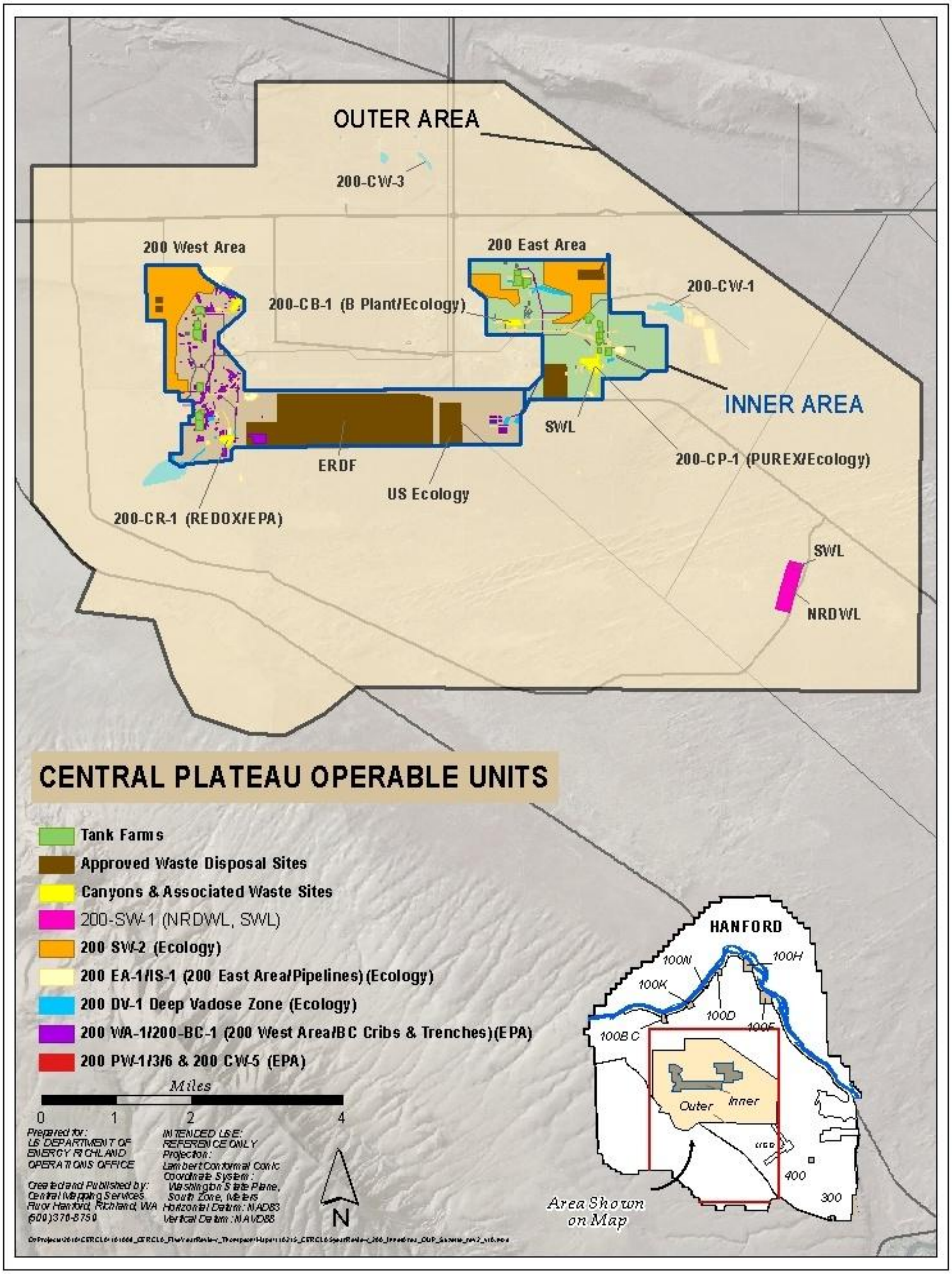


Figure 21. 200 Area Source Operable Units



3.2 Chronology

The following summarizes the chronology of decision documents and action memoranda relevant to CERCLA response actions in the 200 Area.

Environmental Restoration Disposal Facility (ERDF)

1/20/1995	EPA/ROD/R10-95/100	ROD: ERDF
7/30/1996	EPA/ESD/R10-96/145	ESD: ERDF
9/25/1997	EPA/AMD/R10-97/101	ROD Amendment: ERDF
3/25/1999	EPA/AMD/R10-99/038	ROD Amendment: ERDF
1/31/2002	EPA/AMD/R10-02/030	ROD Amendment: ERDF
5/24/2007	EPA/DOE/Ecology	ROD Amendment and ESD: ERDF
8/6/2009	09-AMRC-0179	ROD Amendment and ESD: ERDF (ERDF expansion, Supercells 9 & 10)

200-ZP-1 Groundwater Operable Unit

5/24/1995	EPA/ROD/R10-95/114	Interim Action ROD: 200-ZP-1 OU (pump-and-treat for carbon tetrachloride)
9/25/2008	DOE/EPA/Ecology	ROD: 200-ZP-1 OU (expanded pump-and-treat for all contaminants of concern

200-UP-1 Groundwater Operable Unit

2/11/1997	EPA/ROD/R10-97/048	Interim Action ROD: 200-UP-1 OU (pump-and-treat for uranium and technetium-99)
2/2009	09-AMCP-0082	ESD: Interim Action ROD 200-UP-1 Groundwater OU

Outer Area

7/15/1999	AR/PIR D199153689	Interim Action ROD: Hanford 100 Area and 200 Area (200-CW-3 OU)
5/2008	DOE/RL-2008-21	Action Memorandum: Non-Time Critical Removal Action for the Northern Part of the BC Controlled Area (UPR-200-E-83)
7/20/2009	DOE/RL-2009-48	Action Memorandum: Non Time Critical Removal Action for 11 Waste Sites in 200-MG-1 OU
8/2009	DOE/EPA/Ecology	ESD: 100 Area Remaining Sites Interim Action ROD (100-BC-1, 100-BC-2, 100-D-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)
3/2010	DOE/RL-2009-86	Action Memorandum: Non Time Critical Removal Action for 37 Waste Sites in 200-MG-1 OU

Approved Disposal Sites

1/1992	AR/PIR D196088487	Action Memorandum: 200 West Area Carbon Tetrachloride Plume

Canyons & Associated Waste Sites

3/24/1997	AR/PIR D197166461	Action Memorandum: Non Time Critical Removal Action at the 233-S Plutonium Concentration Facility
3/24/1997	AR/PIR D197166461	Removal Action: 233-S Plutonium Concentration Facility
5/2004	DOE/AR D6853085	Action Memorandum: 200 Area, Burial Ground 218-W-4C Waste Retrieval
6/2004	DOE/RL/2004-36	Action Memorandum: Non-Time Critical Removal Action 224-B Plutonium Concentration Facility
11/2004	DOE/RL-2004-67	Action Memorandum: Non-Time-Critical Removal Action for the U Plant Ancillary Facilities
11/5/2004	04-AMCP-0486	Action Memorandum: Non-Time Critical Removal Action for removal of the 232-Z Contaminated Waste Recovery Process Facility at PFP
12/21/2004	09-AMCP-0096	Action Memorandum: Non Time Critical Removal Action 232-Z Contaminated Waste Recovery Facility (Incinerator)

Canyons & Associated Waste Sites		
12/21/2004	05-AMCP-0096	Action Memorandum: Non-Time-Critical Removal Action 232-Z Contaminated Waste Recovery Process Facility (dismantlement to slab-on-grade
5/2005	05-AMCP-0242	Action Memorandum: Non-Time-Critical Removal Action Memorandum for PFP, Above-Grade Structures
6/15/2005	DOE/RL-2004-68	Action Memorandum: Non-Time-Critical Removal Action for the 224-T Plutonium Concentration Facility
9/30/2005	DOE/EPA/Ecology	ROD: 221-U Facility (Canyon Disposition Initiative)
General Building Decommissioning		
3/2010	DOE/RL-2010-22	Action Memorandum: General Hanford Site Decommissioning Activities

3.3 200 Area Source Operable Units

Since the 2006 five-year review, RI/FSs are being prepared for the 200 Area Source OUs, however no RODs have been issued. Removal actions have been implemented for some waste sites. The results of the removal actions will be consistent with the final remedies selected through the RI/FS and ROD processes.

3.3.1 Environmental Restoration Disposal Facility

3.3.1.1 Background

ERDF is a large, multi-cell CERCLA waste disposal facility located just southeast of the 200 West Area on the Central Plateau. ERDF was constructed using a double liner and a leachate collection system that meet RCRA Subtitle C minimum technological requirements. ERDF is used to dispose of hazardous and dangerous waste, low-level radioactive waste, as well as mixed waste that meets, or has been treated to meet, land disposal restrictions, and ERDF waste acceptance criteria.

3.3.1.2 Chronology

The Tri-Parties signed a CERCLA ROD (EPA/AMD/R10-99/038) in January 1995 authorizing the construction of ERDF to provide waste disposal capacity for cleanup of contaminated areas on the Hanford Site. The ERDF ROD provides the overall plan for construction of the facility and disposal of remediation waste from the Hanford Site.

A subsequent ESD to the ERDF ROD was issued (EPA/ESD/R10-96/145) in July 1996. The ESD allows for the disposal of investigation-derived waste; D&D waste; waste from RCRA past-practice OUs and closures; and non-RCRA waste from inactive TSD units. The ESD also authorized the conditional use of ERDF leachate for dust suppression and waste compaction.

The following ROD amendments have been issued for ERDF.

- October 1997: The first amendment was issued (EPA/AMD/R10-97/101) to authorize expansion of the facility by constructing two new disposal cells and to allow for limited waste treatment at ERDF.
- March 1999: The second amendment (EPA/AMD/R10-99/038) was issued authorizing the delisting of ERDF leachate. Delisting ERDF leachate was done to allow for implementation of more cost-effective and appropriate leachate handling techniques. The basis for the delisting was leachate analytical results that showed no significant level of contaminants to be present.
- January 31, 2002: The third amendment (EPA/AMD/R10-02/030) was signed authorizing the second ERDF expansion to disposal cells 5 through 8, and allowed the staging of remediation waste at ERDF while awaiting treatment.

3.3.1.3 Remedial Actions

Since the 2006 five-year review, the following activities have taken place.

- May 2007: The fourth amendment (EPA 2007) authorized disposal of certain Hanford Site waste in storage and created a 'plug-in' approach of Hanford-only generated waste in storage for ERDF disposal

- July 2009: The fifth amendment (09-AMRC-0179) authorized super cells 9 and 10, including modification of the cell design to allow a single 'super cell' to be used in place of the double cell side-by-side configuration described in the initial ROD. In addition, the amendment authorized the addition of future ERDF cells upon EPA approval through the issuance of a fact sheet by DOE, rather than using the ROD amendment process required by the original ERDF ROD.

Since beginning operation on July 1, 1996, more than 10.2 million tons (9.25 million metric tons) of remediation waste has been disposed of at ERDF. Approximately 12.6 million gallons (47.7 million liters) of ERDF leachate have been treated or recycled, and approximately 82.45 tons (74.8 metric tons) of waste has been treated at ERDF prior to disposal. The two initial disposal cells reached their operational capacity in August 2000 and an interim cover was installed. In 2009, the initial interim cover was extended 500 feet (152.4 meters) to the east. Six additional disposal cells have been constructed, all of which have been placed into operation.

3.3.2 200-PW-1, 200-PW-3, 200-PW-6, and 200-CW-5 Operable Units

A ROD has not been issued for 200-PW-1, 200-PW-3, 200-PW-6, and 200-CW-5 OUs. The 200-PW-1 OU, 200-PW-3, and 200-PW-6 OUs are the Plutonium/Organic-Rich Process Condensate/Process Waste Group OUs (Figure 22), and remain a high priority for completion of the RI/FS process because of the large scale carbon tetrachloride contamination primarily associated with the 200-PW-1/6 and 200-CW-5 OUs on the Central Plateau and radionuclides such as plutonium in the soil.

The vadose zone underlying the carbon tetrachloride area consists of approximately 216.5 feet (66 meters) of relatively permeable sand and gravel. This region is interrupted from 125 to 148 feet (38 to 45 meters) by a less permeable interval composed of 23 feet (7 meters) of silt and sand. Because it constitutes a relatively low-flow zone, this less permeable interval effectively divides the vadose zone into two distinct zones: an upper zone from the ground surface to the top of the less permeable layer and a lower zone from the bottom of the less permeable layer to the water table.

3.3.2.1 Background

Carbon tetrachloride contained in aqueous and organic liquid waste generated during plutonium-processing operations at PFP (formerly called Z Plant) was discharged primarily to three subsurface infiltration facilities. The recovery of uranium and plutonium by the extraction plutonium-processing operation was discontinued in April 1962 and was replaced in May 1964 by the Plutonium Reclamation Facility. A total of 1,256,633 to 2,028,250 pounds (570,000 to 920,000 kilograms) of carbon tetrachloride is estimated to have been discharged to the soil column between 1955 and 1973.

3.3.2.2 Chronology

Since the 2006 five-year review, work has progressed on finishing the RI/FS process.

3.3.2.3 Remedial Action

There have not been any remedial actions implemented since the 2006 five-year review.

3.3.2.4 Progress Since 2006 Review

A final proposed plan was prepared is being prepared for issuance to the public during FY12.

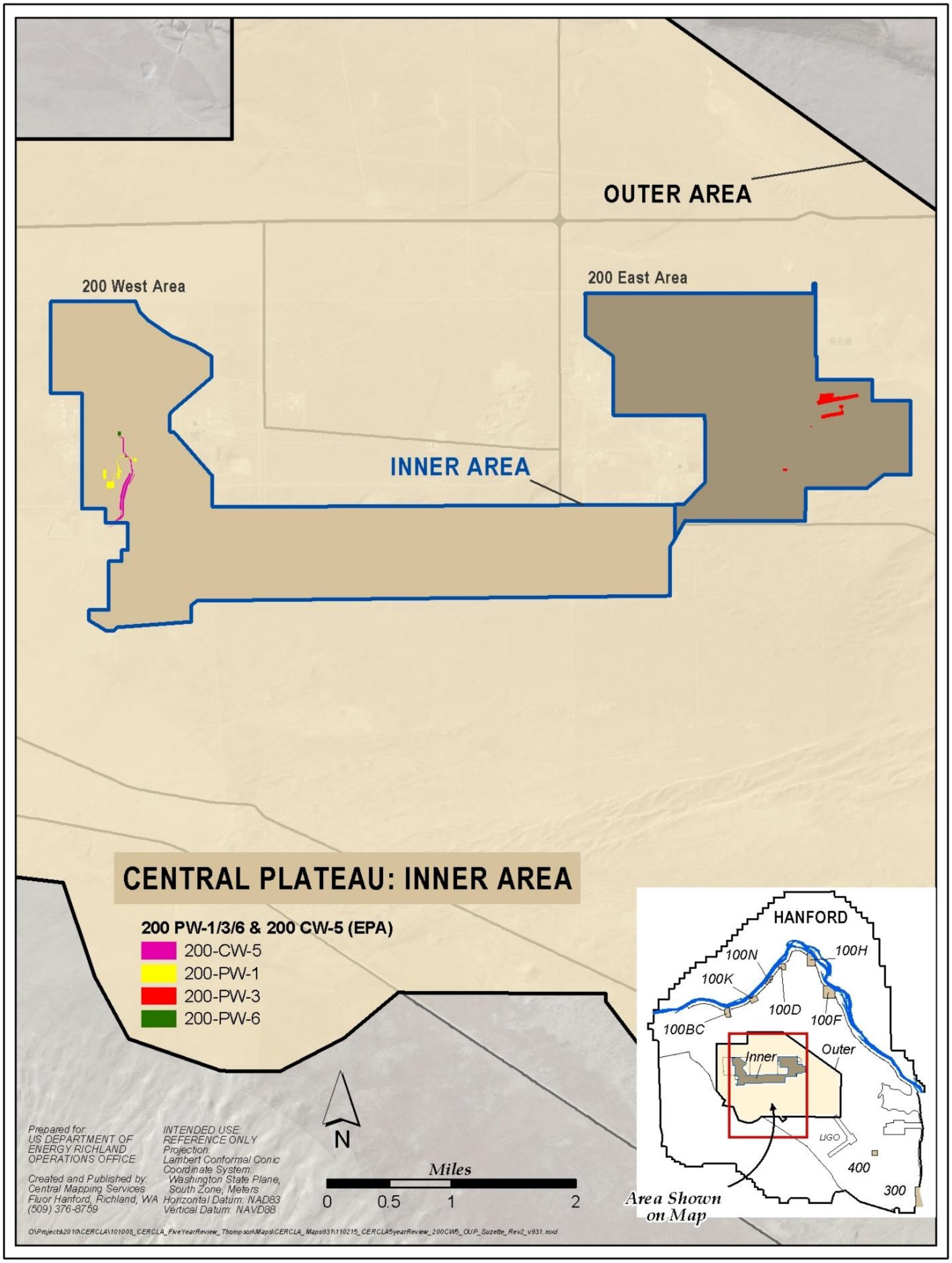
3.3.2.5 Technical Assessment

A technical assessment has not been performed since the final remedial actions for the 200-PW-1 Source OU, 200-PW-3, 200-PW-6, and 200-CW-5 OUs have been implemented.

3.3.2.6 Protectiveness Statement

A protectiveness determination of the remedy at 200-PW-1 OU cannot be made at this time until further information is obtained. Further information will be obtained by completing the RI/FS process and selecting a final remedy. It is expected that these actions will be completed by 2024, at which time a protectiveness determination will be made. The 200-PW-1 OU has a vapor extraction system to remove carbon tetrachloride from the soil. This system has proven to be effective and will continue operation, with improvements.

Figure 22. 200-PW-1, 200-PW-3, 200-PW-6, and 200-CW-5 Operable Units



3.3.3 200-WA-1 and 200-BC-1 (200 West Inner Area)

3.3.3.1 Background

The 200-WA-1 OU consists of the waste sites in the 200 West Inner Area not already assigned to other geographic OUs. 200-BC-1 OU consists of the cribs and trenches in the 200-B/C Area. The 200 West Inner Area (200-WA-1 and 200-BC-1) is shown in Figure 23.

3.3.3.2 Chronology

Since the 2006 five-year review, efforts have been ongoing to finish the RI/FS process.

3.3.3.3 Remedial Action

Efforts have been ongoing to prepare the final 200-BC-1/200-WA-1 RI/FS work plan and associated sampling and analysis plan by December 31, 2011, followed by the RI/FS Report and a proposed plan by June 30, 2013.

3.3.3.4 Progress Since 2006 Review

Since the 2006 five-year review, efforts have been focused on preparing a final RI/FS work plan to finish any investigations needed to support the baseline risk assessment and remedial alternative development.

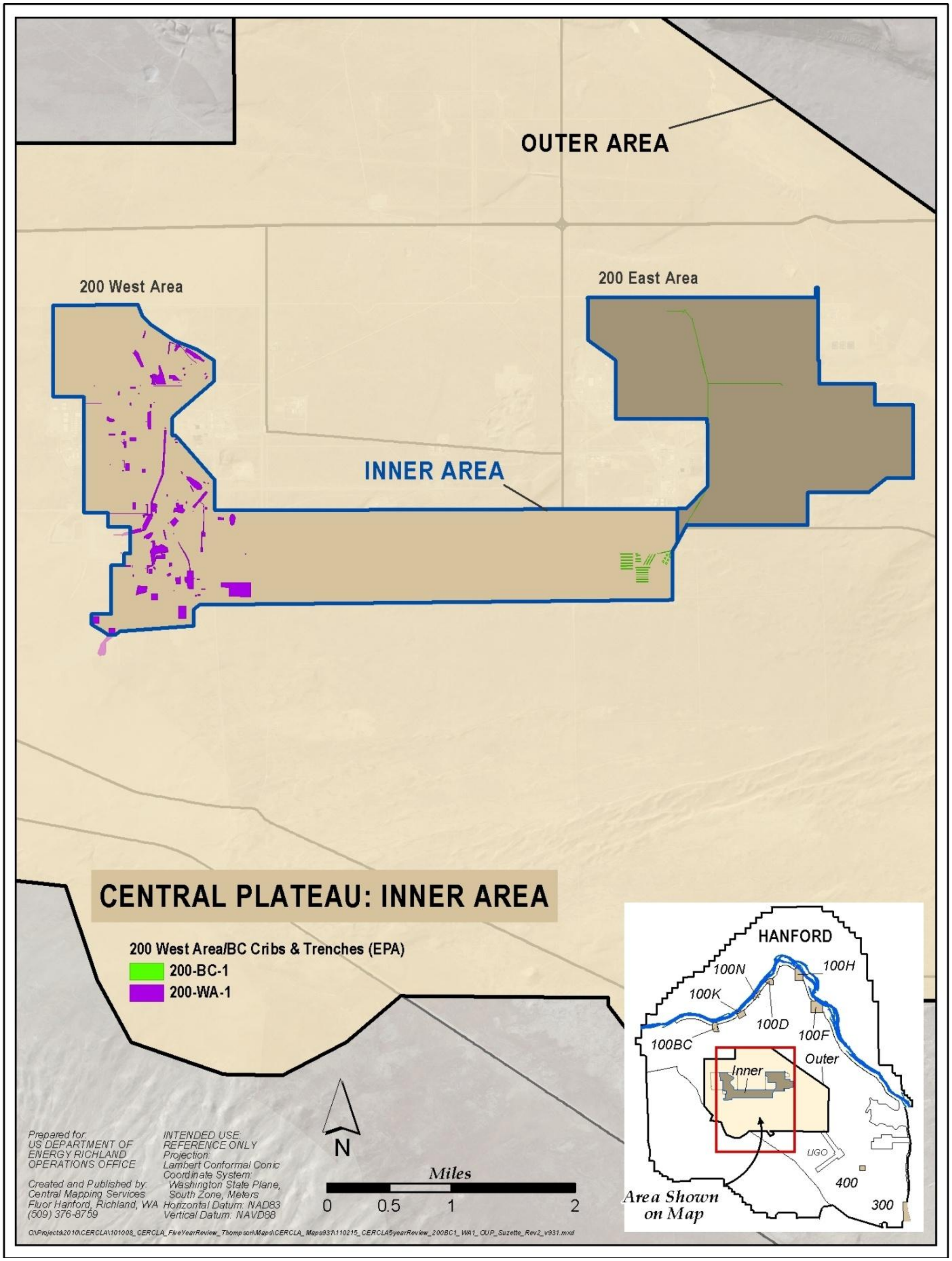
3.3.3.5 Technical Assessment

A technical assessment has not been performed because a ROD has not been issued for the 200 West Inner Area (200-WA-1 and 200-BC-1).

3.3.3.6 Protectiveness Statement

A protectiveness determination for the 200 West Inner Area (200-WA-1 and 200-BC-1) cannot be made at this time until further information is obtained. Further information will be obtained by completing the RI/FS process and selection of the final remedy. It is expected that these actions will be completed by 2024, at which time a protectiveness determination will be made. Some removal actions have been initiated or completed, and it is expected that the results of the removal actions will be consistent with the final remedies selected through the RI/FS and ROD processes.

Figure 23. 200 West Inner Area (200-WA-1 and 200-BC-1)add 200-IS-1 and 200-SW-2



3.3.4 200-EA-1 and 200-IS-1 (200 East Inner Area)

The 200 East Inner Area (200-EA-1 and 200-IS-1) is shown in Figure 24.

3.3.4.1 Background

The 200-EA-1 OU consists of the waste sites in the inner area not already assigned to other geographic OUs. The 200-IS-1 OU consists of the pipeline and associated components in both the 200 East and West Areas.

3.3.4.2 Chronology

Since the 2006 five-year review, efforts have been ongoing to prepare a final RI/FS work plan.

3.3.4.3 Remedial Actions

Efforts have been ongoing to map all the past-practice pipelines and components in the 200 East and West Areas. Information was gathered on the physical characteristics of the pipelines and their operational history. Known unplanned releases are being assigned to individual pipelines.

3.3.4.4 Progress Since 2006 Review

No physical remedial action has taken place since the 2006 five-year review.

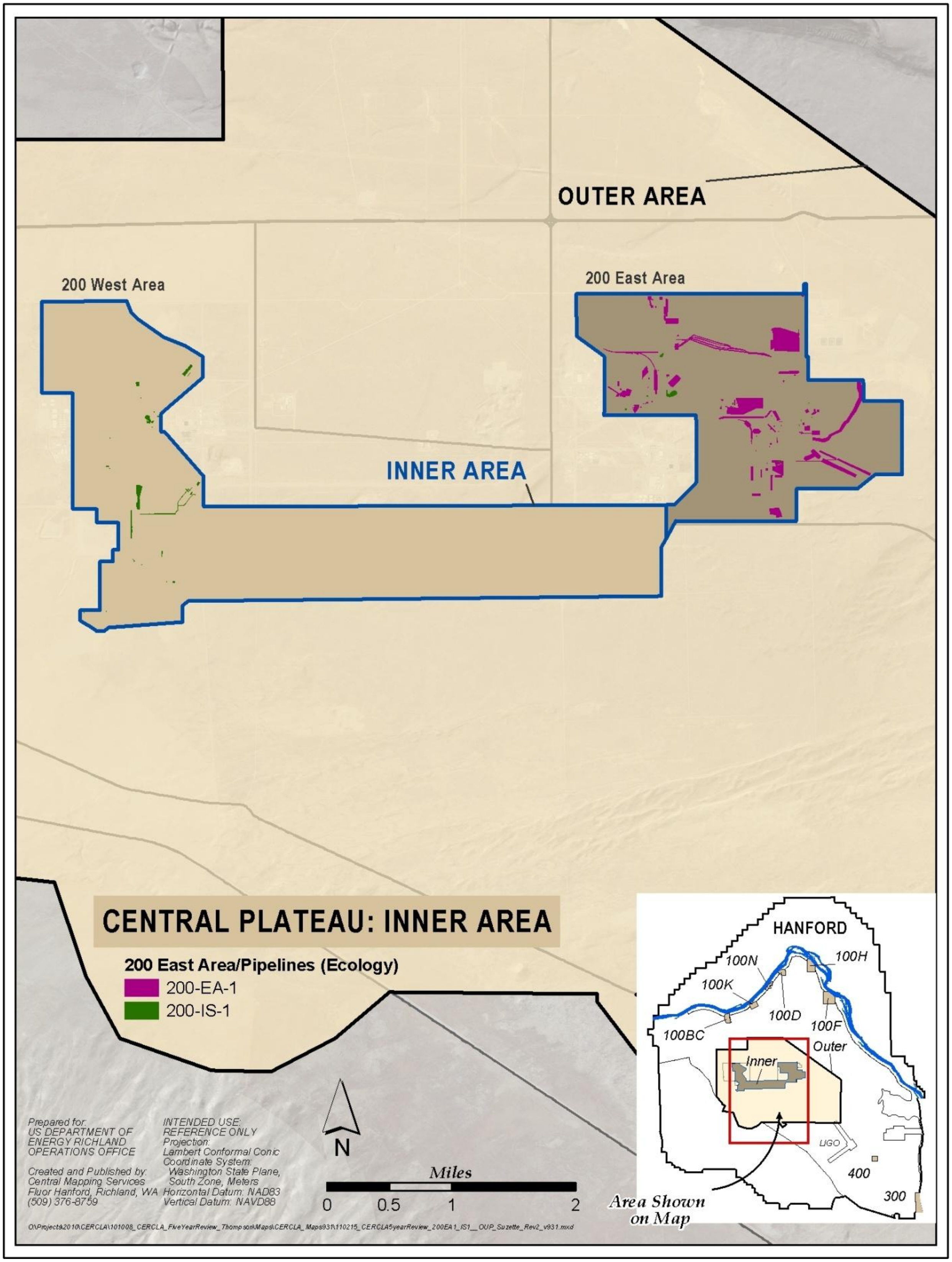
3.3.4.5 Technical Assessment

A technical assessment has not been performed because a ROD has not been issued for the 200 East Inner Area (200-EA-1 and 200-IS-1).

3.3.4.6 Protectiveness Statement

A protectiveness determination for the interim remedy at the 200 East Inner Area (200-EA-1 and 200-IS-1 OUs) cannot be made at this time until further information is obtained. Further information will be obtained by completing the RI/FS process and selection of the final remedy..

Figure 24. 200 East Inner Area (200-EA-1 and 200-IS-1)



3.3.5 200-CU-1, 200-CB-1, 200-CP-1, and 200-CR-1 (Canyons and Associated Waste Sites)

The canyons and associated waste sites are shown in Figure 25. As part of the Central Plateau OU restructuring, geographic OUs were created with canyons and waste sites in the vicinity. In addition, the Canyon Disposal Initiative program is being implemented by DOE to carry out the D&D of the large chemical separation plants on the Hanford Site. The Canyon Disposal Initiative resulted from a 1996 Agreement in Principle among the Tri-Party agencies is to evaluate disposition paths for the canyon buildings using CERCLA processes and to explore the potential for using the canyon buildings as disposal sites for Hanford cleanup waste, rather than demolishing structures and sending the resulting waste and debris to another disposal facility.

3.3.5.1 Background

The Central Plateau contains five large defense production facilities, referred to as canyons, which were originally designed for fuel reprocessing operations: T Plant, B Plant, U Plant, REDOX Plant, and PUREX Plant. The canyon buildings range from approximately 800 feet (244 meters) long to over 1,000 feet (305 meters) long and are constructed of thick reinforced concrete. Approximately half of each structure was constructed below grade level for shielding purposes. The below grade portion of the structure is divided into cells that contain a variety of equipment and piping used for reprocessing operations. Thick concrete cover blocks protect the cells and form the surface of the canyon deck.

Primary waste streams from canyon facilities included process waste, decontamination wastewater, and aqueous process waste that were discharged to tanks, cribs, and trenches. The nonradioactive, low-volume chemical sewer waste was generally sent to ponds and ditches. Very low-volume radioactive waste streams were sent to the French drains.

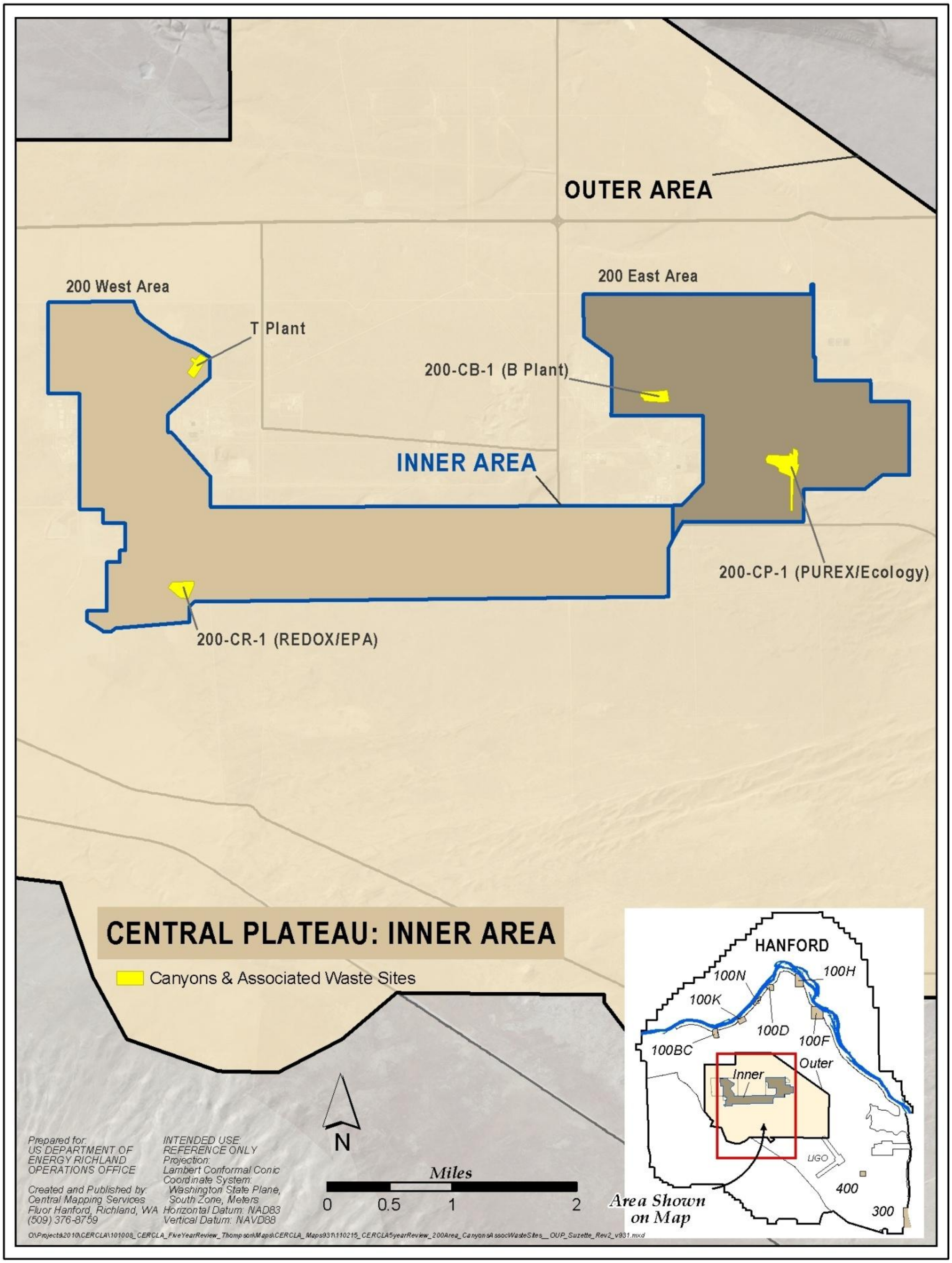
3.3.5.2 U Plant Remedial Action (200-CU-1 Operable Unit)

The 221-U Facility is the first canyon building to be dealt with under the Canyon Disposal Initiative. The process to disposition this facility is viewed as a pilot project to assist in the disposition of the remaining four canyon buildings, as well as providing lessons learned for similar facilities at the Idaho National Laboratory and Savannah River. A ROD was signed in September 2005 establishing the selected remedial action as partial demolition of the building followed by installation of an earthen cap.

The *Remedial Design/Remedial Action Work Plan for the 221-U Facility,* DOE/RL-2006-21 was issued in December 2008. Supplemental remedial design reports are currently being developed to support implementation of the final remedy. The following items have been completed since the 2006 five-year review:

- Cell loading and deck clearing of U Canyon: Completed on July 16, 2010
- U Ancillary above ground tanks 211-U/UA: Demolished and sent to ERDF on July 25, 2009
- U Ancillary process facility 203-UX: Demolished and sent to ERDF on June 25, 2010
- U Ancillary process facilities 224-U/UA: Demolished on August 19, 2010
- Institutional controls have been in place since remedial activities have commenced (December 1, 2008) and have been effective to prevent exposure to contamination by unauthorized personnel or the public.

Figure 25. 200-CB-1, 200-CP-1, and 200-CR-1 Operable Units (Canyons and Associated Waste Sites)



- Removal of roof and wall sections of the 221-U Facility down to the deck level and placement on or near the deck.
- Construction of an engineered barrier over the remnants of the canyon building (with the possible inclusion of inert rubble from the demolition of ancillary facilities as fill material).
- Planting of semiarid-adapted vegetation on the barrier to enhance the evapotranspirative design of the barrier.
- Institutional controls to ensure that the remedy is protected and changes in land use do not occur that could result in unacceptable exposures to residual contamination.
- Post-closure care, including barrier inspection and maintenance.
- Ongoing barrier performance and groundwater monitoring to ensure effectiveness of the remedial action and to support five-year remedy reviews.
- Reasonably anticipated future land use for the 200 Area is industrial, and the 221-U Facility remedy will result in protection of human health and the environment based on the exposure assumptions contained in the 200 Area industrial use scenario.

The RI/FS work plan for the 221-U Canyon was issued in 2007. Subsequently, individual remedial designs to implement each phase of the work plan are being prepared and issued for approval. Final remedial actions are scheduled to take place in 2011.

3.3.5.2.1 Progress Since 2006 Review

Since the 2006 five-year review, a strategy change on how to organize OUs in the 200 Area NPL Site has been implemented. One of the major changes reorganized each major canyon facility, associated structures, and waste sites in the vicinity into geographic OUs. Work will continue to issue final remedial designs for the 221-U Plant remedy.

3.3.5.2.2 Technical Assessment

The purpose of the five-year review is to determine whether the remedy at a site is, or upon completion will be, protective of human health and the environment. The following is the technical assessment response of the 221-U Plant final remedy concerning the technical assessment questions provided in the EPA guidance. The following also establishes a framework for organizing and evaluating data and ensuring that all relevant issues are considered when determining the protectiveness of the remedy.

Is the remedy functioning as intended by the decision documents?

Construction has not been completed for the final remedy; therefore, no decision can be made to determine if the remedy is functioning as intended. However, as the final remedial designs are completed and approved, there is no indication that the remedy will not function within the specified remedial action objectives.

Are the exposure assumptions, toxicity data, cleanup levels, and remedial action objectives used at the time of remedy selection still valid?

The exposure assumptions, toxicity data, cleanup levels, and interim remedial action objectives used at the time of remedy selection are still valid for this canyon remedy.

Has any other information come to light that could call into question the protectiveness of the remedy?

No additional information has come into light since the 2006 five-year review that calls into question the protectiveness of the final remedy, once constructed.

3.3.5.2.3 Protectiveness Statement

A protectiveness determination for the interim remedy at 200-CB-1, 200-CP-1, and 200-CR-1 OUs (Canyons and Associated Waste Sites) cannot be made at this time until further information is obtained. Further information will be obtained by completing the RI/FS process and selection of the final remedy. B Plant (200-CB-1 Operable Unit)

The B Plant, one of the original fuels-separation facilities, was constructed between August 1943 and February 1945; and operated until 1952. B Plant used the bismuth phosphate process to separate plutonium from irradiated fuel. In 1968, B Plant was converted to a waste-fractionization plant as part of a program to solidify high-level waste. B Plant also played a role in removing strontium-90 and cesium-137 from PUREX Plant acid waste and high-level supernatant liquids, as well as sludges from self-boiling liquid waste to manufacture sealed source capsules containing cesium-137 and strontium-90. The capsules are currently stored underwater in the Waste Encapsulation and Storage Facility adjacent to B Plant.

3.3.5.2.4 T Plant

The T Plant complex (including 221-T Canyon Building and 224-T Building) was built in 1944 and operated as one of the first nuclear material separation facilities at the Hanford Site until 1956. This facility used a bismuth phosphate separation process.

The 221-T Canyon Building was used for a series of testing programs from 1964 to 1990. Current operations in the 221-T Canyon Building include radioactive decontamination and reclamation, as well as decommissioning of process equipment. In addition, T Plant will receive sludge from the cleanout of the K Basins for storage. Currently there are no plans to begin a remedial action process while the complex is still in operation.

Plutonium scrap in liquid and solid forms was stored in the 224-T Building beginning in the early 1970s. Scrap was removed from the 224-T Building in 1985 when it was designated as the Transuranic Waste Storage and Assay Facility. The Transuranic Waste Storage and Assay Facility was used for nondestructive assay and nondestructive examination of newly generated, contact-handled transuranic solid waste packages destined to be shipped to the Waste Isolation Pilot Plant. Use of the 224-T Building for this activity ceased in 1997, and in 2005, *Action Memorandum for the Non-Time-Critical Removal Action for the 224-T Plutonium Concentration Facility* (DOE/RL-2004-68) documented the removal action to demolish and dispose of the building (DOE/RL-2004-68).

3.3.5.2.5 REDOX Plant (200-CR-1 Operable Unit)

The REDOX Plant (also known as S Plant) located in the 200 West Area, was built in the late 1940s, and operated between 1952 and 1967. In the REDOX process, hexone was used as a diluting agent to extract plutonium and uranium from acidic, fission-product-rich solutions in which the fuel rods had been dissolved. The REDOX Plant consisted of the main 202-S REDOX Canyon Building, the 222-S Laboratory, 233-S Concentration Facility, and a series of support buildings and waste handling and storage facilities. The 233-S Concentration Facility was the first plutonium processing facility that was demolished to slab on-grade. The decontamination and demolition of the facility was accomplished through a CERCLA removal action from October 2003 through June 2004. The materials were shipped to ERDF with the exception of the transuranic materials, which have been packaged and are awaiting shipment to the Waste Isolation Pilot Plant. The below grade structure portion of 233-S Concentration Facility will be addressed through the REDOX canyon remedial action. The 222-S Laboratory continues to support the 200 Areas for process control and environmental sample analysis.

3.3.5.2.6 PUREX Plant (200-CP-1 Operable Unit)

The PUREX Plant, constructed in 1956, is located in the southeast portion of the 200 East Area. The PUREX Plant was used for the recovery of uranium and plutonium from irradiated reactor fuel. Liquid processes were used to separate the plutonium and uranium. The PUREX Plant consists of the 202-A Building and support structures. The 202-A Building consists of three main structural components: a thick-walled, concrete canyon containing remotely operated process equipment (in cells mostly below grade); the pipe and operating, sample, and storage galleries; and an annex that included offices, process control rooms, laboratories, and building services.

3.3.5.2.7 Plutonium Finishing Plant

The PFP structures and soil will go through D&D or remediation in phases. The first phase will be decontamination and dismantlement of the above grade structures to slab-on-grade. An engineering evaluation and cost analysis (EE/CA) was prepared that resulted in an *Action Memorandum, Plutonium Finishing Plant Above-Grade Structures Non-Time Critical Removal Action* (05-AMCP-0242), signed by DOE and Ecology in May 2005. The action memorandum authorized the D&D of the above grade structures to slab-on-grade. Future work will consist of remediation of any residual contamination once the structures have been removed. The following is the progress since the 2006 review.

- November 2009: All containerized special nuclear material was shipped out of PFP, and Protected Area controls were eliminated.
- February 2010: PFP Vault Complex and selected ancillary structures were readied for demolition.

3.3.6 200-CW-1, 200-CW-3, and 200-OA-1 Operable Units (Outer Area)

The 200-CW-1, 200-CW-3, and 200-OA-1 Operable Units (Outer Area) is shown in Figure 26.

3.3.6.1 Background

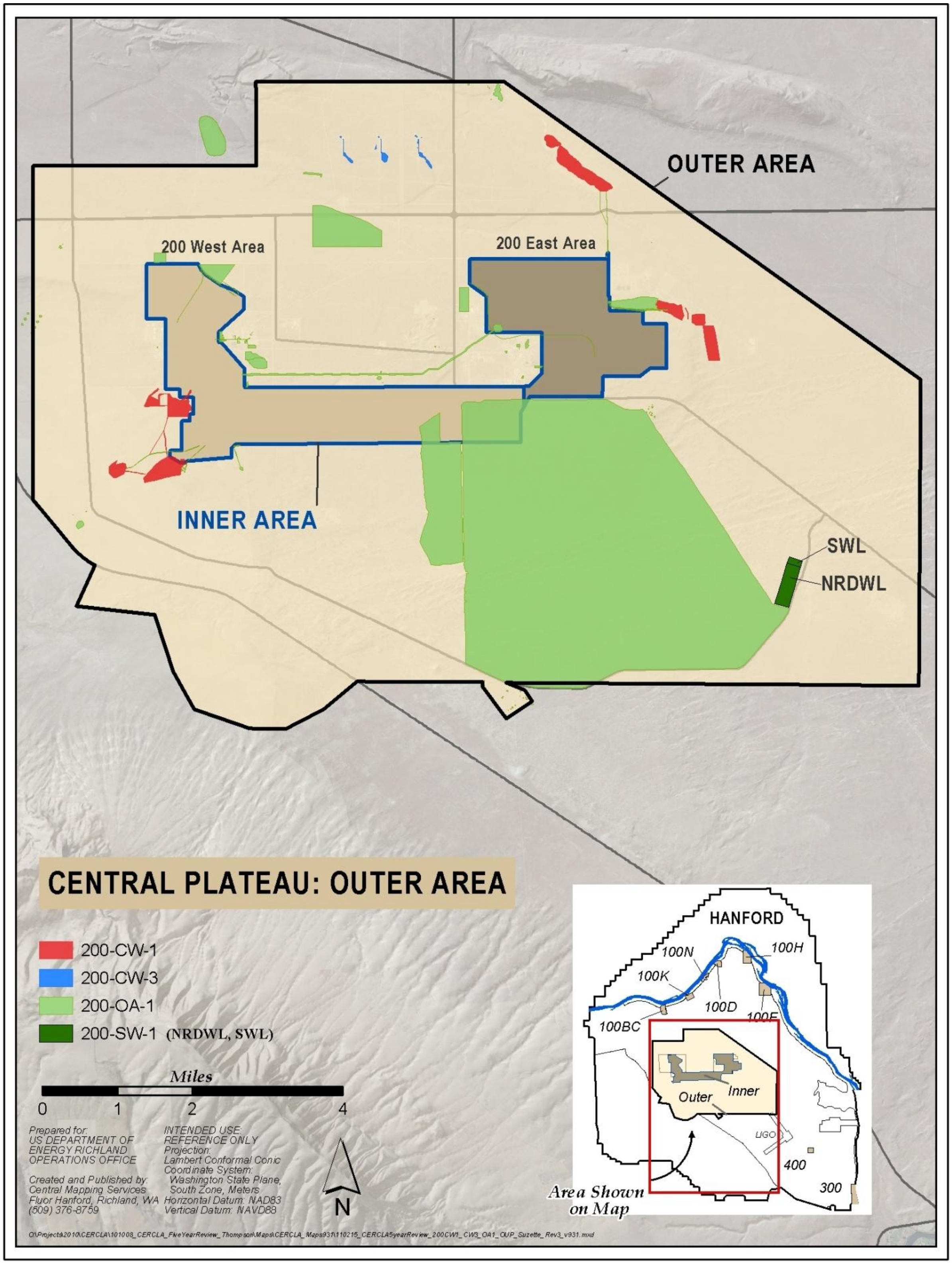
The waste sites in the Outer Area include trenches, cribs, pits, ditches, and other areas of shallow contamination generally less than 15 feet (4.6 meters) deep. They also include sites where chemical and radioactive contaminants were released during material transfers (i.e., unplanned release sites). Some sites were produced by airborne dissemination of radioactive particles, or dispersal through plant or animal fecal material.

3.3.6.2 Chronology

Outer Area (200-CW-1, 200-CW-3, and 200-OA-1 Operable Units)

7/15/1999	AR/PIR D199153689	Interim Action ROD: Hanford 100 Area and 200 Area (200-CW-3 OU)
5/2008	DOE/RL-2008-21	Action Memorandum: Non-Time Critical Removal Action for the Northern Part of the BC Controlled Area (UPR-200-E-83)
7/20/2009	DOE/RL-2009-48	Action Memorandum: Non-Time Critical Removal Action for the 11 Waste Sites in the 200-MG-1 OU
8/2009	DOE/EPA/Ecology	ESD: 100 Area Remaining Sites Interim Action ROD (100-BC-1, 100-BC-2, 100-D-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)
3/2010	DOE/RL-2009-86	Action Memorandum: Non Time Critical Removal Action for 37 Waste Sites in 200-MG-1 OU

Figure 26. 200-CW-1, 200-CW-3, and 200-OA-1 Operable Units (Outer Area)



3.3.6.3 Remedial Action

Only one source OU in the Central Plateau, 200-CW-3, has had an interim action ROD issued. Because the waste sites located in 200-CW-3 OU contained similar contaminants and were constructed in the same manner as the 100 Area sites, they were included in the *Interim Action ROD for the 100 And 200 Area Remaining Sites* (EPA/ROD/R10-99/039).

In July 1999, the *Interim Action Record of Decision for the 100-BC-1, 100-BC-2, 100-DR-1, 100-DR-2, 100-FR-1, 100-FR-2, 100-HR-1, 100-HR-2, 100-KR-1, 100-KR-2, 100-IU-2, 100-IU-6, and 200-CW-3 Operable Units* (EPA/ROD/R10-99/039) was issued. Because the waste sites located in 200-CW-3 OU contained similar contaminants and were constructed in the same manner as the 100 Area sites, they were included in the interim action ROD. The selected remedy in the Remaining Sites ROD consists of removal, treatment, and disposal of contaminated materials, followed by waste site backfilling and re-vegetation. These components of the remedy can be summarized as follows:

- Excavate contaminated soil, structures, and associated debris above cleanup standards in accordance with the Remaining Sites ROD. The Remaining Sites ROD requires removal of contamination but does allow for some amount of contamination to be left at depths greater than 15 feet (4.6 meters) based on a site-specific determination.
- Treatment of waste, as required, to meet ERDF waste disposal requirements.
- Disposal of contaminated materials at ERDF.
- Backfill of excavated areas with clean material and re-vegetation of the excavated area.

Two RD/RA work plans were issued, one for four waste sites (*Remedial Design Remedial Action Work Plan for Select 200 North Area Waste Sites 216-N-2 216-N-3 216-N-5 and 216-N-7 IN 200-CW-3 OU* (DOE/RL-2006-69, Draft B, February 2007)), and one for the remaining 12 waste sites (*Remedial Design/Remedial Action Work Plan for 200 North Area Waste Sites Located in the 200-CW-3 OU*, (DOE/RL-2007-55, October 2008)). Waste site remediation was completed in 2009 and interim cleanup levels were achieved.

200-CW-3 Operable Unit Waste Site Remediation

200-N-3	216-N-3	216-N-5	2607-N	2607-R	600-286-PL	UPR-200-N-1
216-N-1	216-N-4	216-N-7	2607-P	600-285-PL	600-287-PL	UPR-200-N-2
216-N-2						

The *Explanation of Significant Differences for the 100 Area Remaining Sites Interim Remedial Action Record of Decision* was issued in August 2009. The ESD was required because remediation was necessary to protect human health and the environment for 200-CW-3 OU. The Remaining Sites ROD did not provide for the use of the 'plug-in' approach for the 200-CW-3 OU, even though 200-CW-3 waste sites are included in the Remaining Sites ROD. Since the remaining Sites ROD was issued, additional 200-CW-3 sites have been identified that are similar to the waste sites in the Remaining Sites ROD in terms of contaminants, contaminated media, and contaminated waste material. Therefore, the Remaining Sites ROD is being revised to allow sites in the 200-CW-3 OU to be added as plug-in and candidate sites in accordance with ROD requirements.

The waste sites where an interim action has taken place will be added to the appropriate final remedial action documents to ensure that these interim actions are compatible with the final actions. Listed below are the waste sites that have had interim actions implemented.

3.3.6.3.1 Removal Action

The B/C Controlled Area waste site is part of the Outer Area, 200-OA-1 OU (UPR-200-E-83), and is the largest waste site on the Hanford Site. The contamination in the B/C Controlled Area (UPR-200-E-83) was the result of animal intrusion and wind dispersion from the B/C Cribs and Trenches. The B/C Cribs and Trenches are separate waste sites (not included in the Outer Area) and are part of the 200-BC-1 OU. A final remedial decision for the 200-OA-1 OU has not been made; however, CERCLA radioactive hazardous substances in the northern part of the B/C Controlled Area present a potential threat to human health and the environment to the extent that a removal action was warranted before a final remedial decision. An *Action Memorandum for the Non-Time Critical Removal Action for the Northern Part of the B/C Controlled Area (UPR-200-E-83)* (DOE/RL-2008-21) was issued in May 2008. Remediation activities that have been completed since the issuance of the removal action work plan include field excavation of 140 acres, with a cumulative total of approximately 483,000 tons (439,530 metric tons) of contaminated soil disposed of at ERDF. Additional soil removal is planned in the future. This waste site will be included in the 200-OA-1 OU ROD for final cleanup decisions to be applied to this waste site.

The 200-MG-1 OU waste sites include trenches, cribs, pits, ditches, and other areas of shallow contamination (generally less than 15 feet [4.6 meters] deep). They also include sites where chemical and radioactive contaminants were released during material transfers (i.e., unplanned release sites). Some sites were produced by airborne dissemination of radioactive particles, or dispersal through plant or animal fecal material. An EE/CA for the 200-MG-1 OU Waste Sites (DOE/RL-2008-44) was prepared that evaluated removal action alternatives and was issued to the public for review and comment. An *Action Memorandum for Non-Time-Critical Removal Action for 11 Waste Sites in 200-MG-1 Operable Unit* (DOE/RL-2009-48) was issued in July 2009, which documents the approval of the preferred removal action of a combination of confirmatory sampling and no further action or remove, treat, and dispose depending on waste site conditions. The waste sites where an interim action has taken place will be added to the appropriate final remedial action documents to ensure that these interim actions are compatible with the final remedial actions. Since the issuance of the removal action work plan, 16 waste sites have been cleaned-up. All of these waste sites will be included in the 200-OA-1 OU ROD for final cleanup decisions to be applied to these waste sites.

3.3.6.4 Progress Since 2006 Review

Removal actions have been implemented for 29 waste sites in the Outer Area as of September 2010. The information from these removal actions will support the issuance of a final RI/FS work plan. This work plan includes the investigation activities to support the remedial action alternative evaluations.

3.3.6.5 Technical Assessment

The purpose of the five-year review is to determine whether the remedy at a site is, or upon completion will be, protective of human health and the environment. The following is the technical assessment response of the 200-CW-3 OU interim remedy concerning the technical assessment questions provided in the EPA guidance. The following also establishes a framework for organizing and evaluating data and ensuring that all relevant issues are considered when determining the protectiveness of the remedy.

Is the remedy functioning as intended by the decision documents?

The interim remedy is functioning within the specified remedial action objectives. The remove, treat, and dispose action has proven to be functioning at a depth of 15 feet (4.6 meters) for the direct exposure pathway, and has also been demonstrated to be protective of groundwater and the river throughout the soil column based on modeling scenarios developed for use in implementing the interim action RODs. Verification sampling after completion of excavation has indicated that the soil contamination has been removed and has been sent to ERDF for disposal. The final ROD will address additional exposure scenarios and additional models for evaluating contaminant migration pathways.

Are the exposure assumptions, toxicity data, cleanup levels, and remedial action objectives used at the time of remedy selection still valid?

The exposure assumptions, toxicity data, cleanup levels, and the interim remedial action objectives used at the time of remedy selection are still valid for all OUs.

Has any other information come to light that could call into question the protectiveness of the remedy?

No new information has come to light that could call into question the protectiveness of the remedy for these OUs.

A technical assessment has not been performed because a ROD has not been issued for 200-CW-1 and 200-OA-1 Operable Units (Outer Area).

3.3.6.6 Protectiveness Statement

A protectiveness determination of the remedy at 200-CW-1, 200-CW-3, and 200-OA-1 Operable Units (Outer Area) cannot be made at this time until further information is obtained. Further information will be obtained by completing a risk assessment.

3.3.6.7 Removal Actions

The following removal actions have been performed within the 200 Area NPL Site:

March 1997. *The Removal Action at the 233-S Plutonium Concentration Facility, United States Department of Energy (USDOE) Hanford Site, Benton County, Washington*. This decision document represents D&D as the selected removal action alternative of the 233-5 Plutonium Concentration Facility.

June 2004. *Action Memorandum for the Non-Time Critical Removal Action for the 224-B Plutonium Concentration Facility*. This memorandum represents D&D as the selected removal action alternative of the 224-B Facility.

May 1994. *Action Memoranda for the 200 Area, Burial Ground 218-W-4C Waste Retrieval*. This action memorandum documents the approval of a time-critical removal action. The contents of landfill 218-W-4C are being retrieved in accordance with a settlement agreement between DOE, EPA, and Ecology. 218-W-4C are being retrieved in accordance with a settlement agreement between DOE, EPA, and Ecology.

November 2004. *Action Memorandum for the Non-Time Critical Removal Action for Removal of the 232-Z Contaminated Waste Recovery Process Facility at Plutonium Finishing Plant*. This memorandum is for removal and disposal of the 232-Z Contaminated Waste Recovery Process Facility from PFP.

December 2004. *Action Memorandum for the 200 West Area, Plutonium Finishing Plant, 232-Z Contaminated Waste recovery Facility, Hanford Site, Washington*. This memorandum documents the approval of the removal action to D&D the 232-Z Contaminated Waste Recovery Facility (Incinerator).

May 2005. *Action Memorandum for the Non-Time-Critical Removal Action Memorandum for Plutonium Finishing Plant, Above-Grade Structures*.

June 2005. *Action Memorandum for the Non-Time-Critical Removal Action for the 224-T Plutonium Concentration Facility*. The removal action for the 224-T Facility is D&D to grade, excluding building foundation and underlying soils and structures.

3.3.6.8 General Building Decommissioning

An EE/CA for *General Hanford Site Decommissioning Activities* (DOE/RL-2010-14) was issued to perform decommissioning of Hanford excess industrial buildings, structures, and cleanup of miscellaneous debris. The evaluation assists DOE-RL in identifying the most effective means to decommission excess buildings and structures for which the specific missions have been completed. The evaluation also assists DOE-RL in cleanup of miscellaneous debris (e.g., solid waste) identified during the cleanup process. The scope of the EE/CA encompasses excess industrial buildings and structures that were never used for radiological or chemical processing and debris; however, these buildings, structures, and debris may be potentially contaminated with hazardous substances because of their proximity to Hanford Site contamination and based on the building and debris components and contents (e.g., asbestos, paints, and coatings). *Action Memorandum for General Hanford Site Decommissioning Activities* (DOE/RL-2010-22) was issued in March 2010 to document the selected alternative to perform decommissioning of Hanford excess industrial buildings and structures and cleanup of miscellaneous debris.

3.3.6.9 Investigative Derived Waste Purgewater Management

Presently, groundwater is withdrawn from Hanford Site wells for (1) developing newly constructed groundwater monitoring wells, (2) purging existing wells prior to sample collection, (3) aquifer testing, (4) periodic cleaning and renovating existing monitoring wells, and (5) abandoning existing wells. The withdrawn groundwater is called 'purgewater'. The removal action consisted of re-lining an existing storage unit, building additional units, and operating the units solely for purgewater consolidation and management. These units are referred to herein as the Modular Storage Units. Eventual demolition of the Modular Storage Units is also included in DOE/RL-2009-39. Prior to demolition of the Modular Storage Units, a removal action work plan will be developed for implementation of that action.

3.3.6.10 212-N, 212-P, and 212-R Facilities

The 212-N, 212-P, and 212-R Facilities have been demolished and the rubble was disposed of in ERDF. The *Action Memorandum for the Non-Time Critical Removal Action for the 212-N, 212-P, and 212-R Facilities, Addendum 1* (DOE/RL-2008-80-ADD 1) documents the approval of the proposed CERCLA non-time-critical removal action for the 212-N, 212-P, and 212-R structures located north of the 200 East and 200 West Areas of the Hanford Site. The 212-N, 212-P, and 212-R structures were former facilities built to provide storage of irradiated fuel before processing at 200 East and West Areas fuel reprocessing facilities. This removal action minimizes the potential for a release of hazardous substances from the 212-N, 212-P, and 212-R structures that could adversely impact human health and the environment. The removal action also contributes to the efficient performance of any anticipated long-term remedial actions, such as subsurface soil remediation conducted under the *Interim Action Record of Decision for the 100-BC-1, 100-BC-2, 100-D-1, 100-DR-2, 100-FR-1, 100-FR -2, 100-HR-1, 100-HR-2, 100-KR-1, 100-KR –2,100-IU-2, 100-IU-6, and 200-CW-3 OUs* (EPA/ROD/R10-99/039 referred to as the Remaining Sites ROD). The comments received during the public comment period that ended January 14, 2009, supported implementation of this action on the *212-N, -P, and -R Facilities Engineering Evaluation/Cost Analysis* (DOE/RL-2008-07), which was prepared to evaluate removal action alternatives for the 212-N, 212-P, and 212-R Facilities.

3.3.6.11 U Plant Ancillary Facilities

An *Action Memorandum for the Non-Time-Critical Removal of Action for the U Plant Ancillary Facilities* (DOE/RL-2004-67) was signed in November 2004. Work on 10 of the 17 U Plant Ancillary Facilities has been completed.

3.3.6.12 Plutonium Finishing Plant

3.3.6.13 224-T Plutonium Concentration Facility

DOE signed the *Action Memorandum for the Non-Time-Critical Removal Action for the 224-T Plutonium Concentration Facility* (DOE/RL-2004-68) in June 2005. The closure plan for the RCRA treatment, storage, and disposal of 224-T Transuranic Waste Storage and Assay Facility was completed, and the Part A Form was marked closed on November 11, 2008. Work for the 224-T Plutonium Concentration Facility is on hold until December 31, 2025, when the draft removal action work plan is scheduled to be submitted.

3.3.6.14 224-B Plutonium Concentration Facility

An *Action Memorandum for the Non-Time-Critical Removal Action for the 224-B Plutonium Concentration Facility* (DOE/RL/2004-36) was approved in June 2004. The cleanup of the laydown yard associated with the facility was completed; however, the remaining work for the 224-B Plutonium Concentration Facility is on hold until December 31, 2025, when the draft removal action work plan is scheduled to be submitted.

3.4 200 Area Groundwater Operable Units

3.4.1 200-ZP-1 Groundwater Operable Unit

The 200-ZP-1 Groundwater OU is shown in Figure 27.

3.4.1.1 Background

The 200-ZP-1 Groundwater OU encompasses the northern and central portions of the 200 West Area and adjacent areas to the north and east. The 200-ZP-1 Groundwater OU activities focus on monitoring and remediation of groundwater contaminant plumes beneath the northern and central portions of the 200 West Area and 600 Area (adjacent to the 200 West Area). Groundwater monitoring continued under the *Sampling and Analysis Plan for the 200-ZP-1 Groundwater Monitoring Well Network* (DOE/RL-2002-17). Groundwater is monitored to assess the performance of the interim action pump-and-treat system for carbon tetrachloride, and technetium, to track other contaminant plumes, and to support four RCRA TSD unit groundwater monitoring requirements, and the State-Approved Land Disposal Site. In addition, data from facility-specific monitoring is integrated into the CERCLA groundwater investigations. Radionuclide monitoring from facilities is performed in accordance with the AEA.

3.4.1.2 Chronology

The CERCLA cleanup process for the 200-ZP-1 Groundwater OU is described in a series of regulatory documents, including the following:

- May 1995: *Interim Action Record of Decision for the 200-ZP-1 Groundwater Operable Unit* (EPA/ROD/R10-95/114)
- FY04-FY05: *Remedial Investigation/Feasibility Study Work Plan for the 200-ZP-1 Groundwater Operable Unit* (DOE/RL-2003-55) was implemented.
- October 2006: *Remedial Investigation Report for 200-ZP-1 Groundwater Operable Unit* (DOE/RL-2006-24, Draft A) was published.
- July 2008: *Feasibility Study Report for 200-ZP-1 Groundwater Operable Unit* (DOE/RL-2007-28) and *Proposed Plan for Remediation of 200-ZP-1 Groundwater Operable Unit* (DOE/RL-2007-33) were completed.
- September 2008: The final selected remedy for the 200-ZP-1 Groundwater OU was completed, in the *Declaration of the Record of Decision Hanford 200 Area 200-ZP-1 Superfund Site Benton County, Washington*.
- March 2009: The plan and schedule for implementing all of the tasks for the design, installation, and operation of the 200 West Area pump-and-treat system, as set forth *in the 200-ZP-1 Record of Decision (*DOE/RL-2008-78), was issued (*200 West Area 200-ZP-1 Pump-and-Treat Remedial Design/Remedial Action Work Plan* (DOE/RL-2008-78).
- October 2010: The *200-West Area Groundwater Pump and Treat Remedial Design Report* (DOE/RL-2010-13) was issued.

3.4.1.3 Remedial Actions

The selected remedy for the 200-ZP-1 Groundwater OU combines pump-and-treat, monitored natural attenuation, flow path control, and institutional controls. Since 1994, DOE has operated the 200-ZP-1 Groundwater OU pump-and-treat system located near the middle of the 200 West Area (Figure 28), which removes carbon tetrachloride as the primary contaminant of concern, with chloroform, and trichloroethene, and other contaminants of concern. The system is limiting movement of the shallow, high-concentration portion of the plume; however, the system does not address contamination deeper in the aquifer and at the periphery of the plume. In 2009, under a ROD for final remediation (*Declaration of the Record of Decision Hanford 200 Area 200-ZP-1 Superfund Site Benton County, Washington*), DOE began construction of the 200 West Area Groundwater Treatment Facility to address the full plume. The *200-UP-1 and 200-ZP-1 Operable Units Pump-and-Treat System Annual Report for Fiscal Year 2008* (DOE/RL-2008-77) provides a detailed status of the interim remediation from previous years.

From 1994 to date, the system has removed 26,400 pounds (12,000 kilograms) of carbon tetrachloride from the groundwater. Carbon tetrachloride and other constituents are removed from the waste stream at an interim treatment facility in the 200 West Area selected in the 2008 ROD. In addition to the pump-and-treat system, natural attenuation processes will be used to reduce concentrations to below the cleanup levels. Natural attenuation processes that will be relied on as part of this component include abiotic degradation, dispersion, sorption, and, for tritium, natural radioactive decay. Monitoring will be employed in accordance with the approved RD/RA documents to evaluate the effectiveness of the pump-and-treat system and natural attenuation processes.

200-ZP-1 Operable Unit Remedial Action Objectives

Removal Action Objective 1	Return the 200-ZP-1 OU groundwater to beneficial use (restore groundwater to achieve domestic drinking water levels) by achieving the specified cleanup levels. This objective is to be achieved within the entire 200-ZP-1 OU groundwater plumes. The estimated timeframe to achieve cleanup levels is within 150 years.
Removal Action Objective 2	Apply institutional controls to prevent the use of groundwater until the cleanup levels have been achieved. Within the entire OU groundwater plumes, institutional controls must be maintained and enforced until the specified cleanup levels are achieved, which is estimated to be within 150 years.
Removal Action Objective 3	Protect the Columbia River and its ecological resources from degradation and unacceptable impact caused by contaminants originating from the 200-ZP-1 OU. This final objective is applicable to the entire 200-ZP-1 OU groundwater plume. Protection of the Columbia River from impacts caused by 200-ZP-1 OU contaminants must last until the cleanup levels are achieved, which is estimated to be within 150 years.

3.4.1.4 Progress Since 2006 Review

Since the 2006 five-year review period, the *Record of Decision Hanford 200 Area 200-ZP-1 Superfund Site* was issued in September 2008. This decision document presents the selected remedy for the 200-ZP-1 Groundwater OU. Additional CERCLA accomplishments included DOE's publication of the *200 West Area 200-ZP-1 Pump-and-Treat Remedial Design/Remedial Action Work Plan* (DOE/RL-2008-78) and the *200 West Area Groundwater Pump-and-Treat Remedial Design Report* (DOE/RL-2010-13), which detail the plan and schedule for implementing all tasks for design, installation, and operation of the final remedy. Several documents were also issued related to pump-and-treat operations. The primary contaminant of concern is carbon tetrachloride. Other contaminants include tritium, nitrate, hexavalent chromium, total chromium, iodine-129, technetium-99, and trichloroethene as documented in the final ROD.

The September 2008, *Record of Decision Hanford 200 Area 200-ZP-1 Superfund Site*, and the 200-UP-1 and *200-ZP-1 OUs Pump-and-Treat System Annual Report* for FY08 (DOE/RL-2008-77) provide a detailed status of the interim remediation from previous years. Interim remedial measures are implemented through operation of 14 extraction wells and five injection wells to capture the high-concentration (greater than 2,000 µg/L) region of the plume.

Figure 27. 200-ZP-1 Groundwater Operable Unit

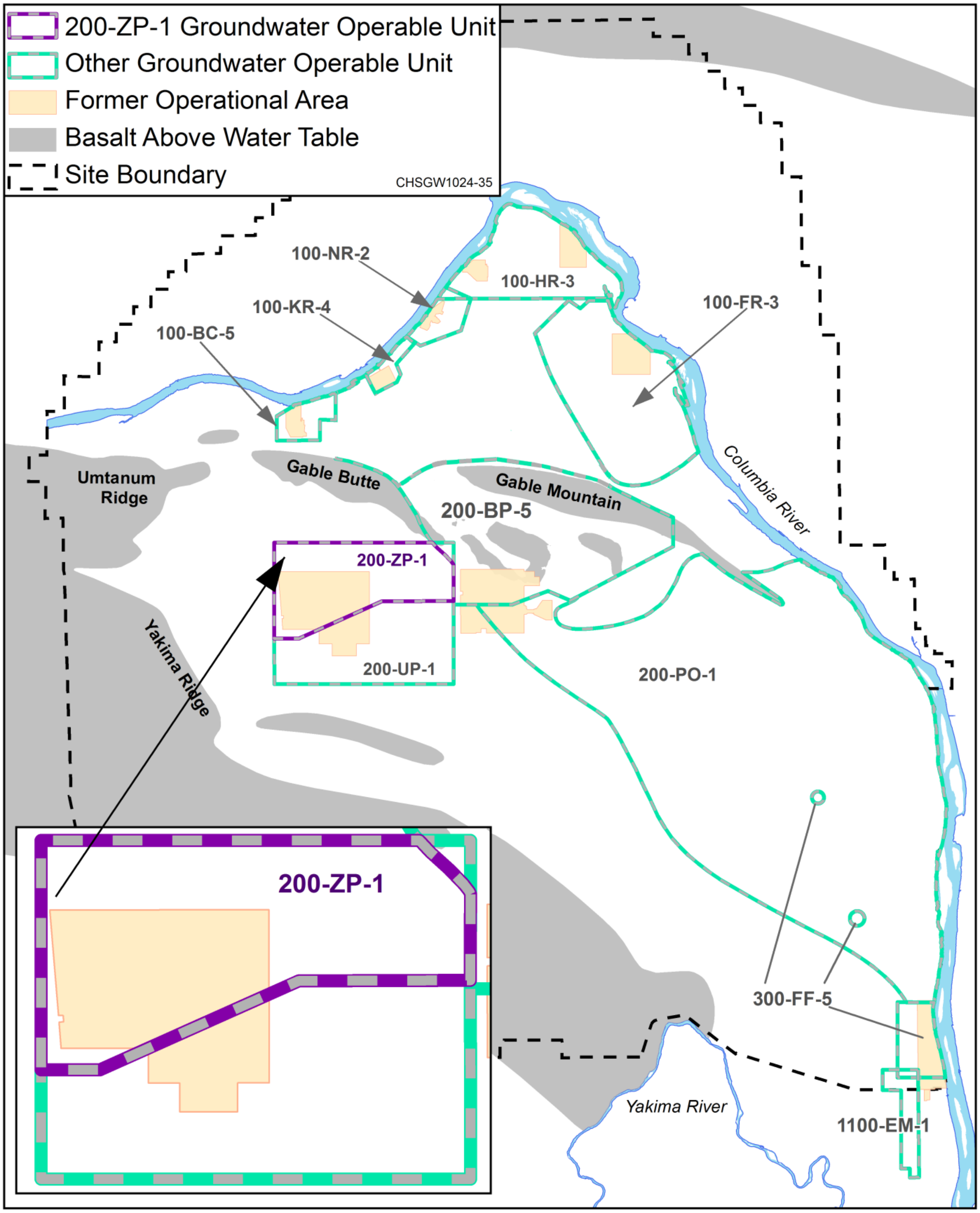
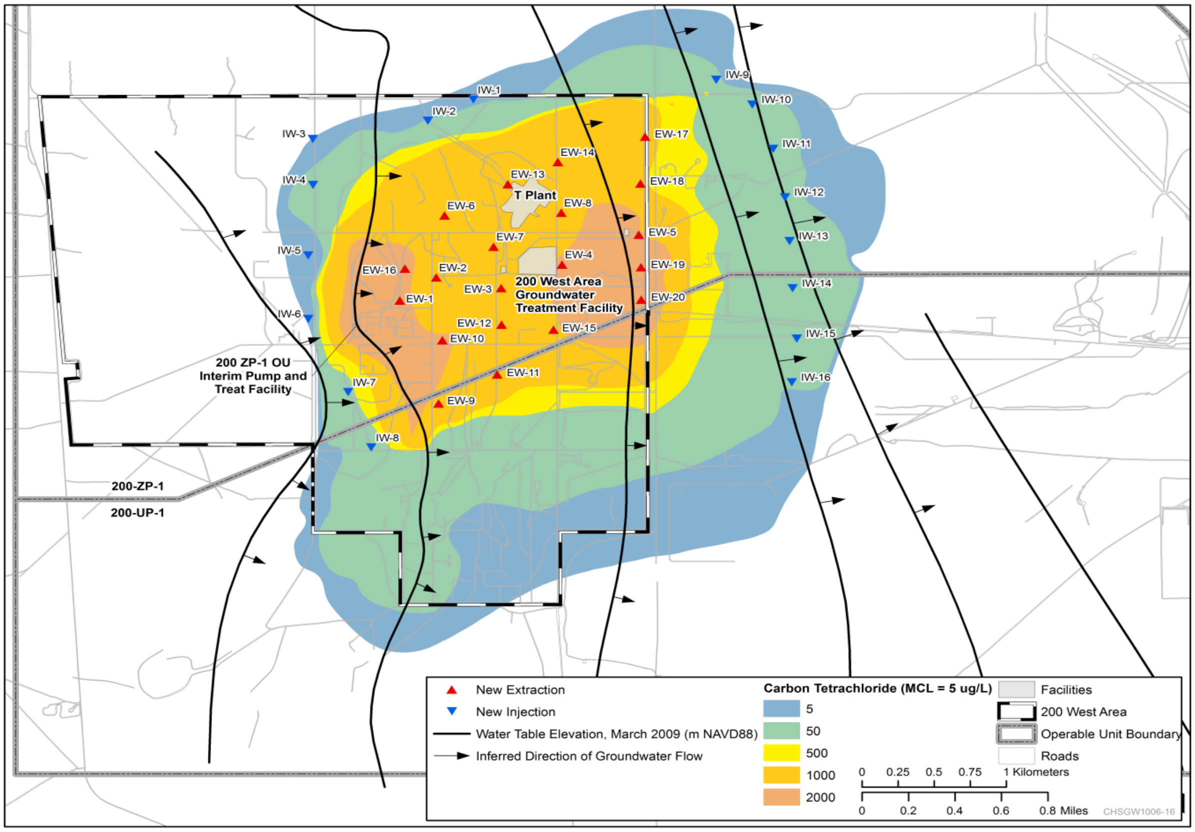


Figure 28. 200-ZP-1 Interim Pump-and-Treat Facility



3.4.1.5 Technical Assessment

The purpose of the five-year review is to determine whether the remedy at a site is, or upon completion will be, protective of human health and the environment. The following is the technical assessment response of the 200-ZP-1 OU interim and final remedy concerning the technical assessment questions provided in the EPA guidance. The following also establishes a framework for organizing and evaluating data and ensuring that all relevant issues are considered when determining the protectiveness of the remedy.

Is the remedy functioning as intended by the decision documents?

The interim remedy is functioning within the specified remedial action objectives. The pump-and-treat systems are continuing to remove carbon tetrachloride from the groundwater.

Are the exposure assumptions, toxicity data, cleanup levels, and remedial action objectives used at the time of remedy selection still valid?

The exposure assumptions, toxicity data, cleanup levels, and the interim remedial action objectives used at the time of remedy selection are still valid for the OUs.

Has any other information come to light that could call into question the protectiveness of the remedy?

The following information has become known since the 2006 five-year review that supports the final remedy implementation.

3.4.1.5.1 Carbon Tetrachloride

Carbon tetrachloride is the principal contaminant of concern for the 200-ZP-1 Groundwater OU and is found at levels greater than the DWS (5 µg/L) in the groundwater under most of the 200 West Area (Figures 29 and 30). The main sources of carbon tetrachloride are three of the 216-Z cribs and trenches that received waste from PFP. Interim remediation of this plume began in 1994. The capture and cleanup requirements to remediate this area are described in the *Declaration of the Interim Record of Decision for the 200-ZP-1 OU*, (EPA/ROD/R10-95/114). The target capture zone for interim remediation was the area with concentrations greater than 2,000 µg/L at the 216-Z cribs and trenches.

The carbon tetrachloride plume extent is depicted in Figure 31. The 2,000 µg/L contour is located west of WMA TX-TY. Fourteen extraction wells, within and adjacent to this area, are staggered in a north-to-south configuration and operate to remove contaminated groundwater for subsequent treatment at the 200-ZP-1 Interim Treatment Facility (Figure 28). After treatment, the remediated water is injected at five wells oriented north to south, west of Low-Level Waste Management Area (LLWMA)-4.

The outermost plume contour at the DWS (5 µg/L) extends beyond the boundaries of the 200 West Area to the north, south, and east. The main plume orientation indicates migration predominantly northeast to east. Carbon tetrachloride levels at a well along the eastern boundary of the 200 West Area showed an increasing trend since the 2006 five-year review that peaked in CY09. Two new wells were drilled along the eastern boundary of the 200 West Area during CY09 and were sampled at discrete intervals in the saturated zone. Each well yielded samples with elevated carbon tetrachloride at levels greater than 1,000 µg/L.

During FY09, 10 wells in the 200-ZP-1 performance-monitoring network exceeded the remedial action objective of 2,000 µg/L; seven of these were extraction wells. The highest recorded concentration was 3,900 µg/L, followed by another monitoring well with a concentration of 3,200 µg/L. A well outside of the northeastern corner of the 200 West Area has shown a continuing increase in carbon tetrachloride, above the DWS in FY02 and currently over 80 µg/L. Each of the 14 extraction wells had lower reported maximum concentrations for FY09 than in FY08.

Depth-discrete sampling is performed at the 200-ZP-1 Groundwater OU for all new groundwater wells. During CY09, nine new extraction wells were drilled to support future operations of the 200 West Area Groundwater Treatment Facility. The wells are staggered from west of WMA TX-TY to the eastern boundary of the 200 West Area. The westernmost wells are located in the highest concentration portion of the carbon tetrachloride plume. Vertically collected, discrete samples indicated that concentrations were above the DWS from the groundwater table to the bottom of the aquifer.

3.4.1.5.2 Chromium

Chromium contamination is found at levels above the DWS (100 µg/L) in groundwater near WMA T and WMA TX-TY (Figure 32). This hexavalent form of chromium is soluble and mobile in water. For the groundwater plume analysis, total chromium is used to characterize concentrations and plume extent. Chromium is found beneath the single-shell tank farms at the 200-ZP-1 Groundwater OU. Concentrations greater than 100 µg/L are found beneath WMA T.

The maximum concentration reported south of WMA T was 552 µg/L. The chromium plume direction is oriented toward the northeast and is present in a compact group of wells. A total of nine performance monitoring wells exceeded the DWS for chromium during FY09, and eight of these wells were adjacent to WMA T. The chromium-contaminated wells in the northeastern corner of WMA T are within the capture zone for the 241-T pump-and-treat system. The northern set of wells at WMA T also has chromium concentrations two to three times lower than wells directly south; it is uncertain whether this is a result of capture during pump-and-treat or proximity to the source. Overall, the chromium plume has remained stable.

Figure 29. 200-ZP-1 Groundwater Operable Unit Comparison of the Shallow Carbon Tetrachloride Plume, Top of the Unconfined Aquifer

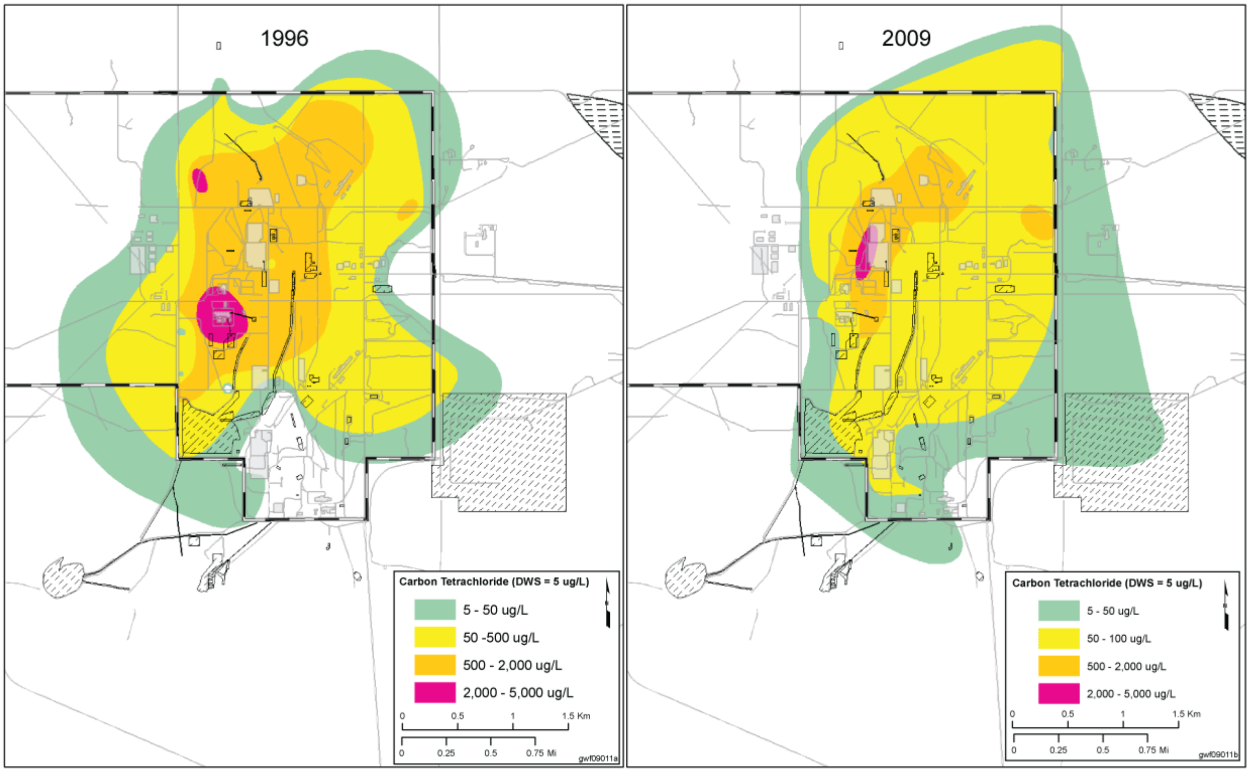


Figure 30. 200-ZP-1 Upper Portion of Unconfined Aquifer Average Carbon Tetrachloride Concentration

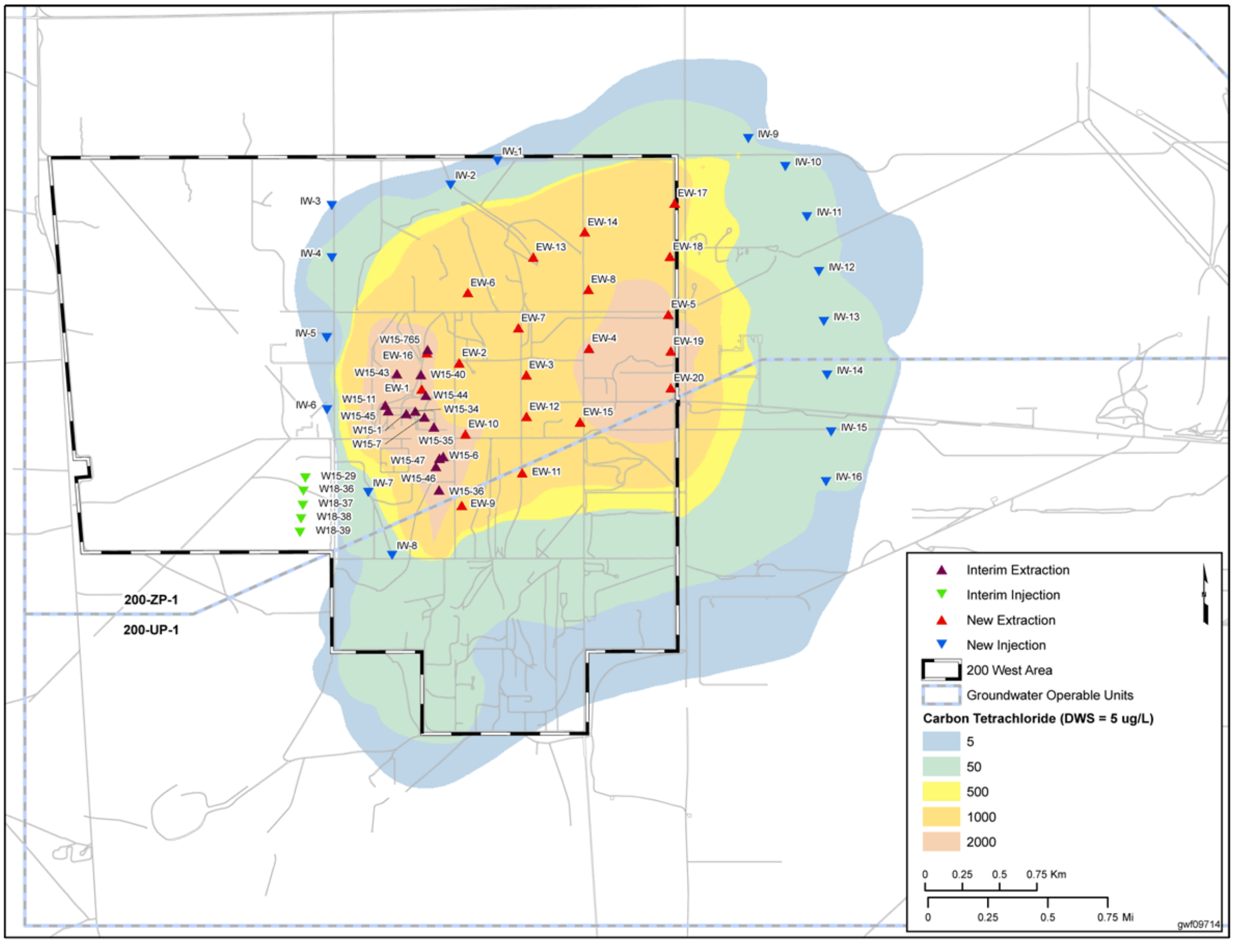
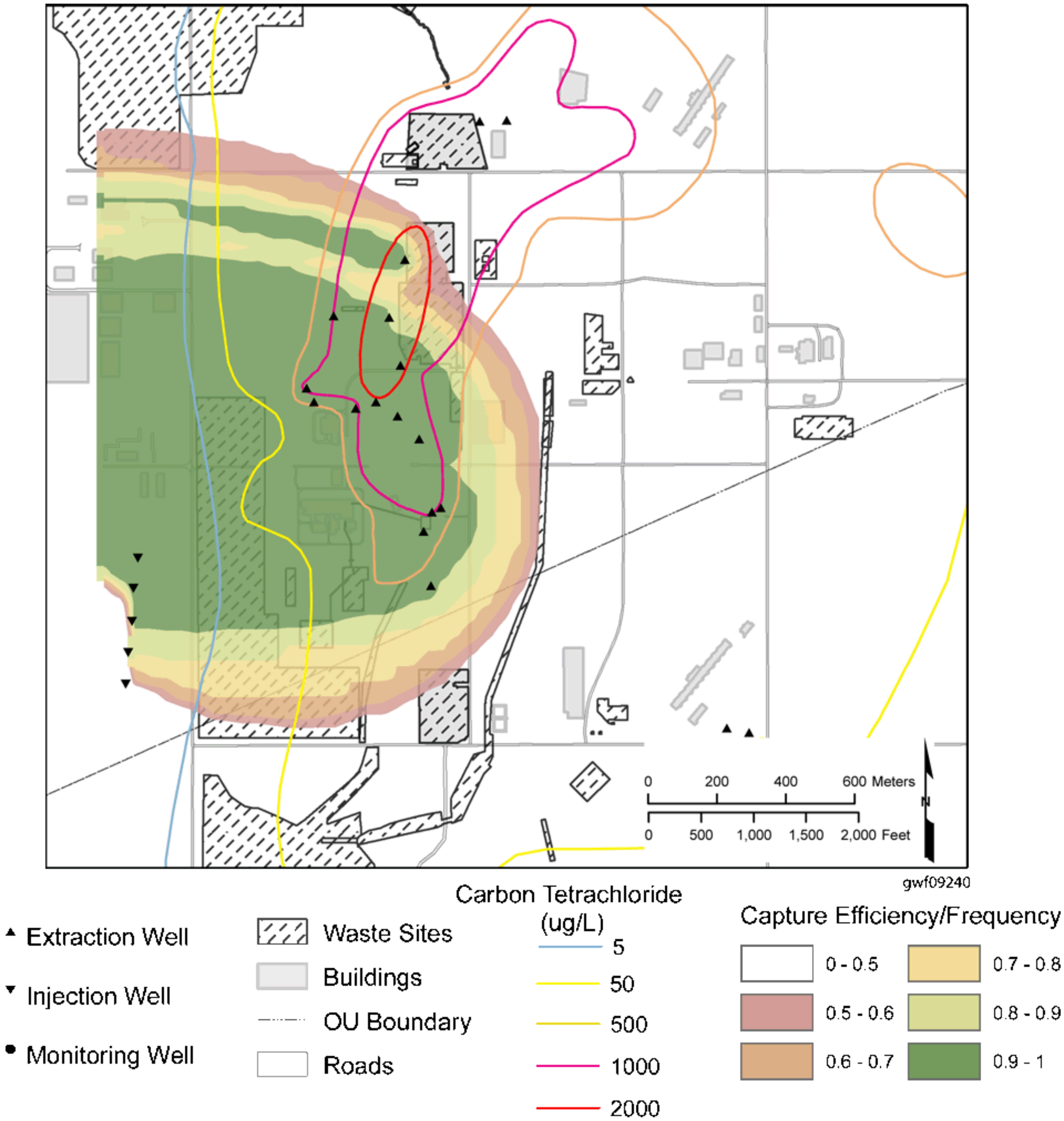


Figure 31. 200-ZP-1 Approximate Extent of Capture



3.4.1.5.3 Trichloroethene

Trichloroethene is detected at levels above the DWS (5 µg/L) in the 200-ZP-1 OU groundwater interest area (Table 6). The main trichloroethene plume (Figure 33) extends north and northeast from the 216-Z cribs and trenches, particularly the 216-Z-9 Trench. There are three discrete plumes: (1) beneath WMA TX-TY, co-located with the high-concentration portion of the carbon tetrachloride plume; (2) beneath WMA T; and (3) directly east of WMA T. Each of these plumes is downgradient, along the centerline of the carbon tetrachloride plume. Wells in all three locations show a slight increase in concentration. Trichloroethene exceeded the DWS in 22 performance monitoring wells, including nine extractions wells (seven adjacent of WMA TX-TY), and the two wells east of WMA T. The maximum reported concentration during 2009 was 50 µg/L.

The plumes for both WMA TX-TY and WMA T are within the capture zone for their respective pump-and-treat systems. The plume east of WMA T is downgradient and outside of the capture zone for the current extraction wells on the west side of WMA T.

3.4.1.5.4 Nitrate

Nitrate concentrations were above the DWS (45 mg/L, as nitrate) beneath much of the 200-ZP-1 OU groundwater interest area (Figure 34). Multiple sources of nitrate likely exist in this area, including the cribs near WMA T and the 216-Z cribs and trenches. Two discrete, high-concentration plumes (greater than 450 mg/L) are discernible in the 200-ZP-1 Groundwater OU: (1) a plume located beneath WMA T, and (2) a plume near the 216-Z Cribs and Trenches. The 45 mg/L contour extends from the 216-Z Cribs and Trenches at the southwest to beyond the 200 West Area boundary to the northeast. The northern high-concentration plume is located, in part, within the capture zone for the 241-T Tank Farm pump-and-treat wells. The central path of the nitrate plume bisects both sets of pump-and-treat wells for the 200-ZP-1 Groundwater OU. The highest concentration since the 2006 five-year review period is 2,550 mg/L south of WMA T. Overall, the nitrate plume has remained stable.

3.4.1.5.5 Tritium

Tritium contamination at levels greater than the DWS (20,000 pCi/L) in the 200-ZP-1 OU groundwater interest area is restricted mainly to a plume extending northeast from waste disposal facilities adjacent to WMA T and WMA TX-TY. These waste management areas have multiple tritium plumes in the groundwater. In addition, tritium from permitted discharges at the State-Approved Land Disposal Site is found in the groundwater. The maximum tritium concentration in a well was 77,000 pCi/L.

Only five performance monitoring wells in the 200-ZP-1 Groundwater OU exceeded the DWS since the 2006 five-year review. In general, the tritium plume at the State-Approved Land Disposal Site remained stable, with the exception of the discharge campaign from K Basins in 2008. The 20,000 pCi/L contour from the single-shell tank farms may have receded slightly, although the general lack of monitoring wells at the northern boundary to define the plume extent makes this determination problematic. Some fluctuation occurred in wells, with some wells increasing from 2009 and others decreasing. This plume has also remained stable relative to the last part of this five-year review.

Figure 32. 200-ZP-1 Average Filtered Chromium Concentration near Waste Management Areas T and TX-TY, Upper Portion of Aquifer

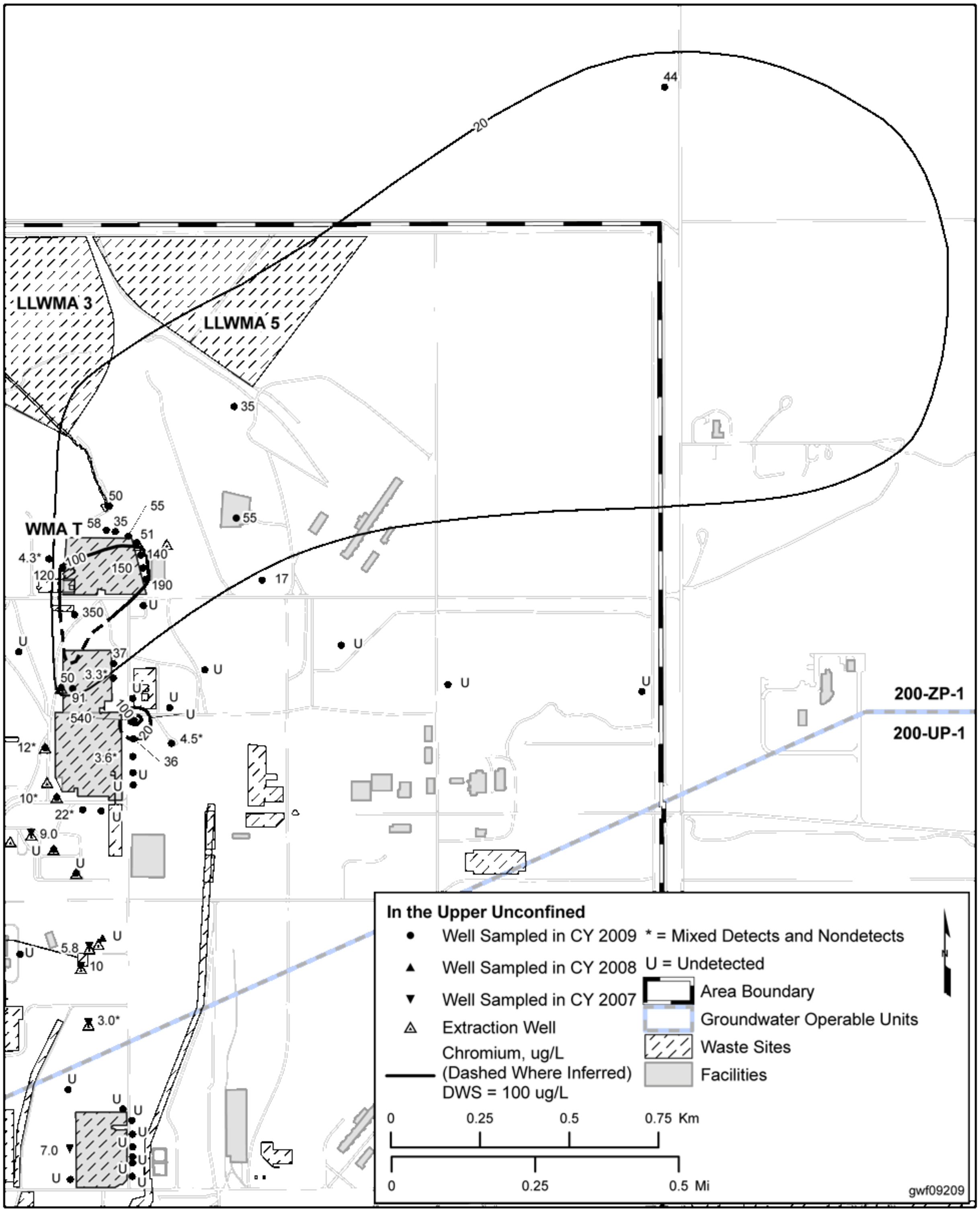
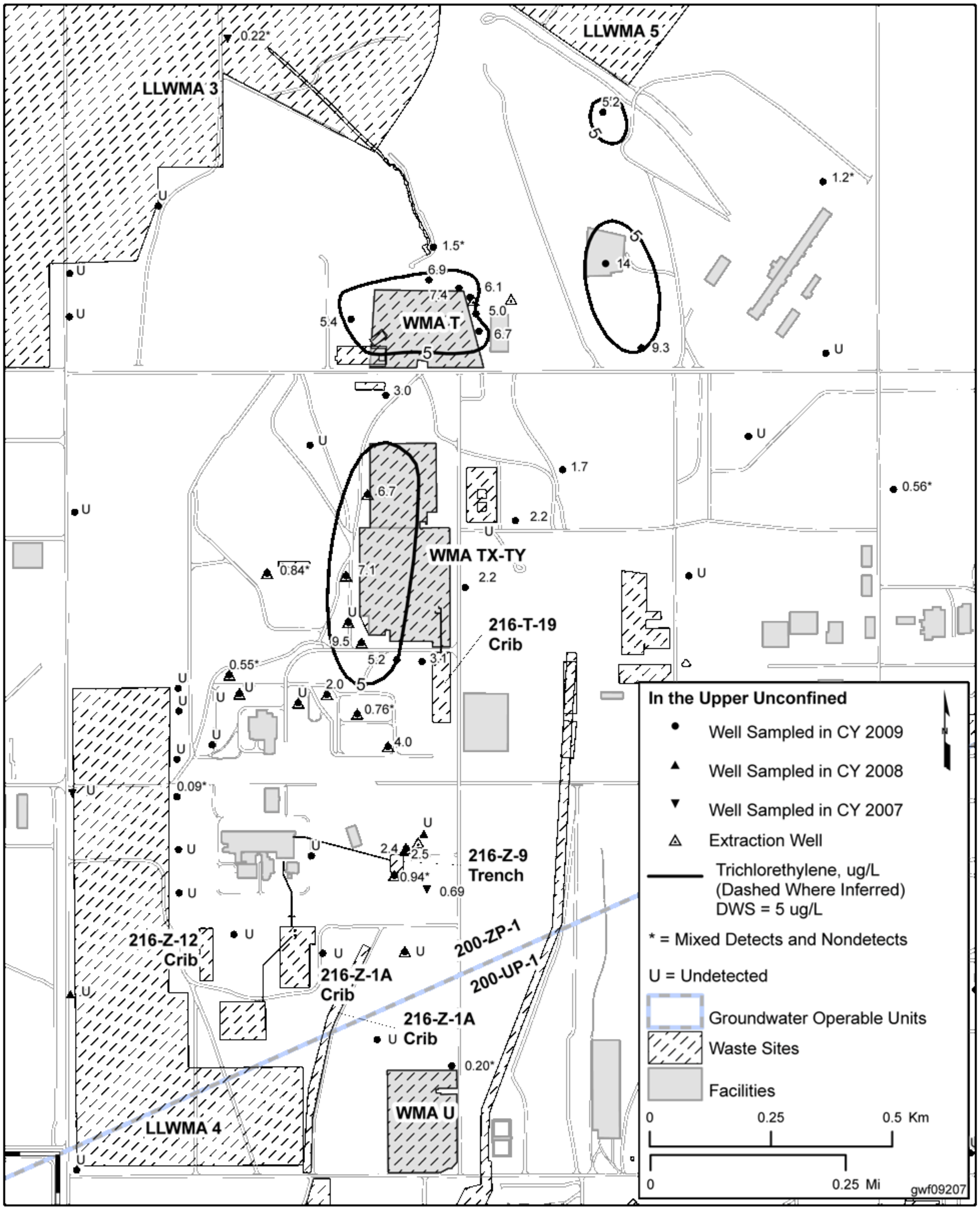


Figure 33. 200-ZP-1 Upper Portion of Unconfined Aquifer Average Trichloroethene Concentration



3.4.1.5.6 Iodine-129

Iodine-129 is found in the 200-ZP-1 OU groundwater interest area beneath WMA TX-TY. Determining the extent of iodine-129 contamination is difficult because the detection limit is often near or above the 1.0 pCi/L DWS. Ten performance monitoring wells exceeded the DWS for iodine-129 during FY09. The maximum concentration reported was 4.5 pCi/L northeast of WMA T. The maximum concentrations reported at the 241-T pump-and-treat wells ranged from 1.94 pCi/L to 1.86 pCi/L. In general, the iodine-129 plume did not change from the previous years.

3.4.1.5.7 Technetium-99

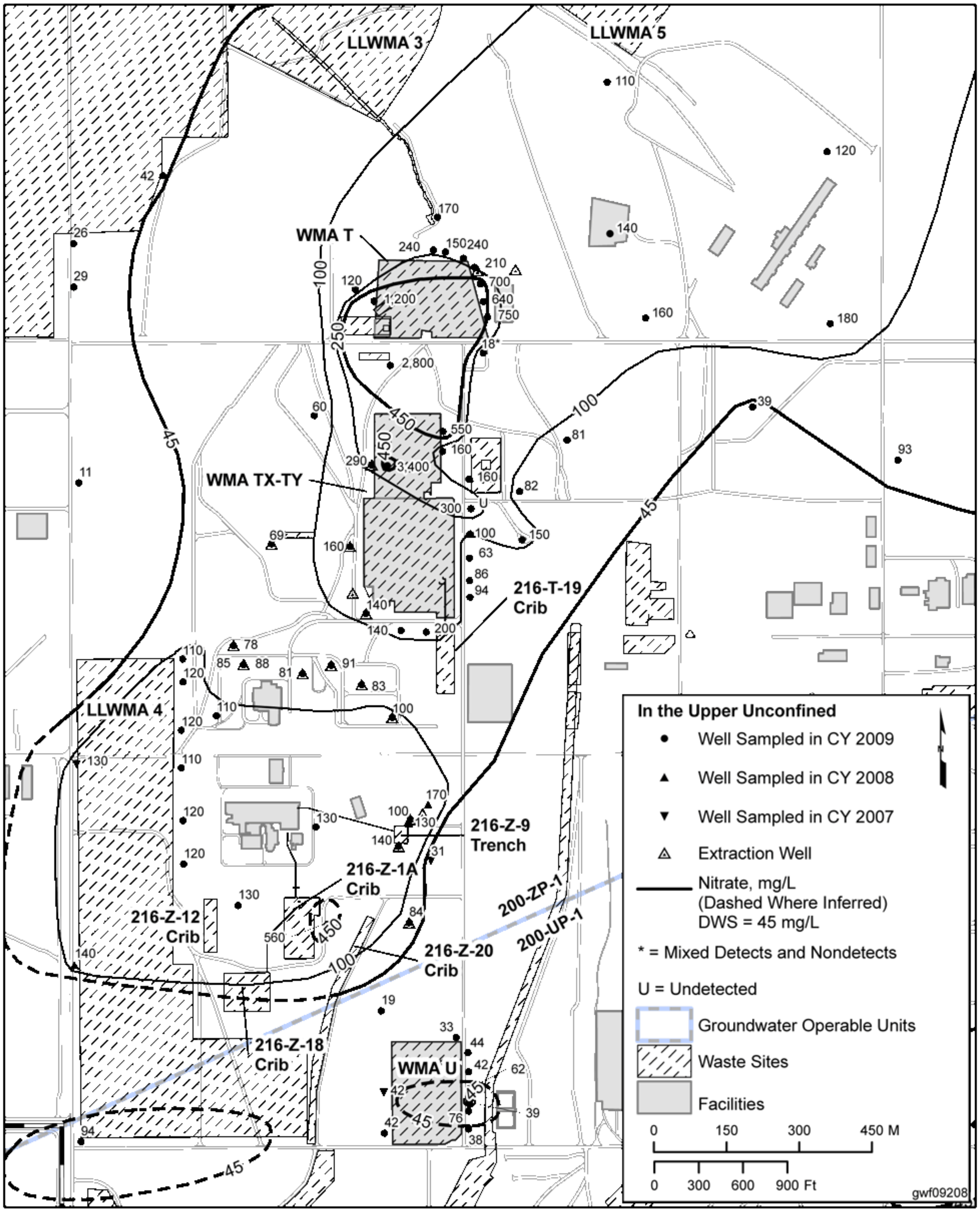
Technetium-99 within the 200-ZP-1 OU groundwater interest area is found at levels significantly above the DWS (900 pCi/L) on the eastern (downgradient) side of WMA T and is centered on two areas near WMA TX-TY. .

The purpose of the 241-T pump-and-treat wells is to capture technetium-99 migrating to groundwater beneath WMA T. The maximum technetium-99 concentrations recorded for CY09 at the two extraction wells ranged from 8,600 pCi/L to 6,400 pCi. The plume centered on WMA T is migrating to the northeast. The maximum concentration for the plume is 9,800 pCi/L at one performance monitoring well, which was the only well exceeding the remedial action objective within the OU. The plume centered on the northern portion of WMA TX-TY is elongated toward the southeast, with the maximum concentration of 4,000 pCi/L. The southern plume under WMA TX-TY is slightly elongated to the east, with the maximum concentration of 3,400 pCi/L. The technetium-99 concentrations at wells in all three plumes have fluctuated, but remained relatively stable.

3.4.1.6 Protectiveness Statement

A protectiveness determination of the final remedy at 200-ZP-1 Groundwater OU cannot be made at this time until further information is obtained. Further information will be obtained when the final pump-and-treat remedy is constructed and operational. It is expected that the pump-and-treat final remedial action will operate for 25 years with continued monitored natural attenuation taking place over 125 years for all contaminants of concern to meet cleanup levels. The two RODs for interim action that address groundwater contaminants, two interim action pump-and-treat systems, and a vapor extraction system will continue operations until the final remedy has been constructed and is operational.

Figure 34. 200-ZP-1 Upper Portion of the Unconfined Aquifer Average Nitrate Concentration



3.4.2 200-UP-1 Groundwater Operable Unit

The 200-UP-1 OU is shown in Figure 35.

3.4.2.1 Background

The 200-UP-1 OU is one of the two Groundwater OUs located in the 200 West Area. The primary contaminants in the 200-UP-1 Groundwater OU addressed by the interim action ROD are uranium and technetium-99. The selected remedy consisted of pumping the highest concentration zone of the contaminated groundwater plume at the 200-UP-1 Groundwater OU followed by treatment using the existing 200 Area Effluent Treatment Facility (state permitted dangerous waste management unit). The effluent from the 200 Area Effluent Treatment Facility was then discharged to a state permitted wastewater discharge facility. The selected remedy reduced contaminant mass within the plume and minimize migration of uranium and technetium-99 from the 200 West Area. The 200-UP-1 (U Plant) pump-and-treat system, located in the area of U Plant continued operations during the five-year review period, until the system was shutdown in the spring of 2011, once the remedial action objectives within the capture zone were satisfied.

3.4.2.2 Chronology

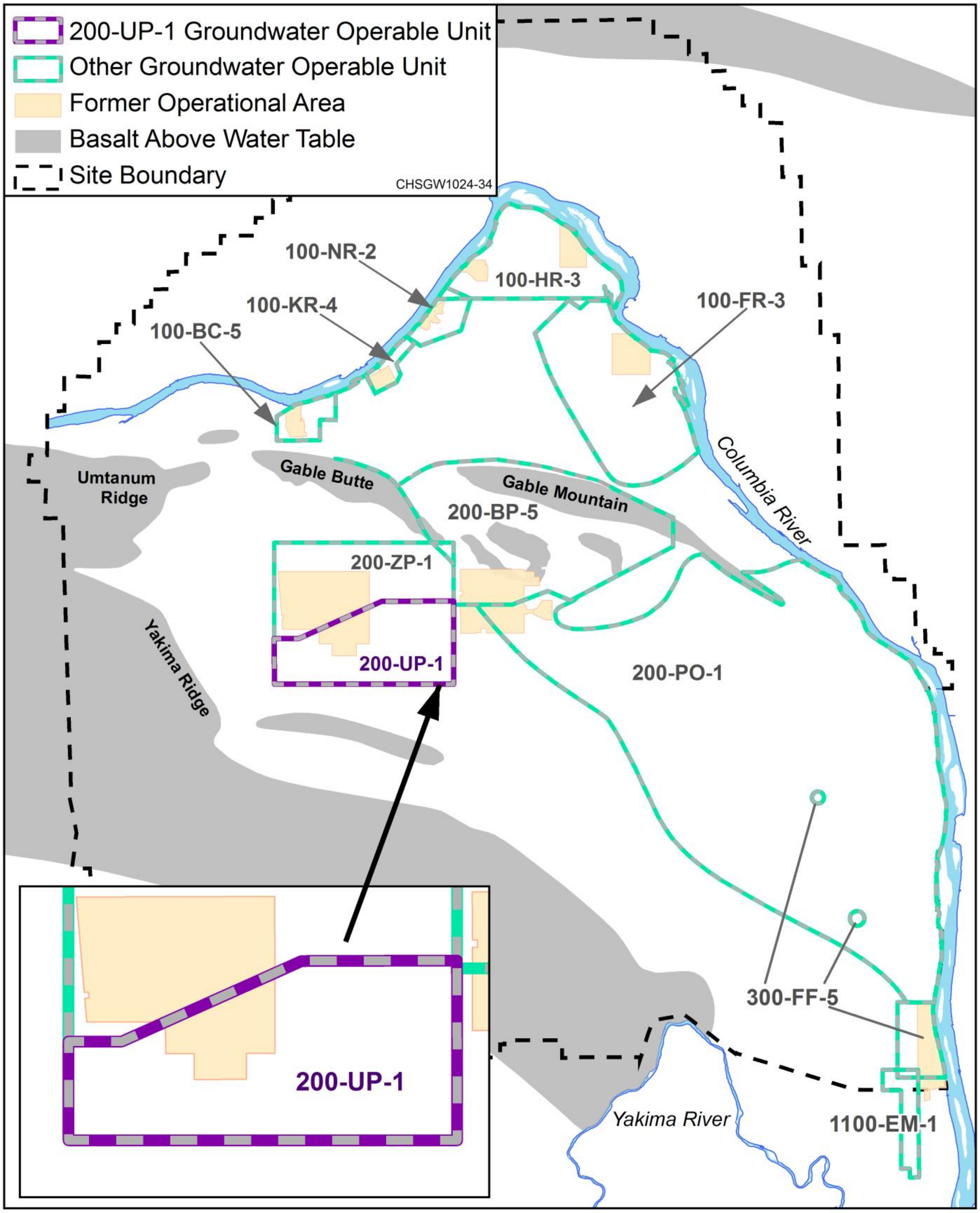
On February 11, 1997, the *Record of Decision Hanford 200 Area, Interim Remedial Action for the U.S. DOE Hanford 200-UP-1 Operable Unit, 200 Area* (EPA/ROD/R10-97/048) was issued for the 200-UP-1 OU pump-and-treat system. The selected remedy consisted of the following:

- Reduce contamination in the area of highest concentrations of uranium and technetium-99 to below 480 µg/L for uranium and 9,000 pCi/L for technetium-99.
- Reduce potential adverse human health risks through reduction of contaminant mass.
- Prevent further movement of these contaminants from the highest concentration area.
- Provide information that will lead to development and implementation of a final remedy that will be protective of human health and the environment.

In February 2009, the *Explanation of Significant Differences for the Interim Action Record of Decision for the 200-UP-1 Groundwater Operable Unit* was issued. The interim action ROD required uranium to be treated to the MTCA cleanup value of 48 ppb. Since the issuance of the interim action ROD, a national primary drinking water MCL of 30 µg/L (parts per billion) was established for uranium. The Tri-Parties have agreed that for this action the national primary drinking water regulation will be added as an ARAR for treatment of extracted groundwater. The ESD modifications are as follows:

- The remedial action objective for uranium was reduced to 300 µg/L.
- The requirement was updated to extract groundwater from existing or new extraction wells in accordance with an approved RD/RA work plan until the concentration of uranium and technetium-99 are less than or equal to their respective remedial action objectives for four consecutive quarters.
- A requirement was added to a sample well at WMA S-SX for technetium-99 quarterly, and to purge a minimum of 1,000 gallons (3,785 liters) of water during each sample event until the technetium-99 concentration is less than or equal to 9,000 pCi/L for four consecutive quarters.
- Institutional controls were revised.
- The cost estimate for the remedial action was revised.

Figure 35. 200-UP-1 Operable Unit



3.4.2.3 Remedial Action

The selected remedy consists of pumping the highest concentration zone of the contaminated groundwater plume in the area of U Plant and treatment using the existing 200 Area Effluent Treatment Facility. The selected remedy goal was to reduce contaminant mass within the plume and minimize migration of uranium and technetium-99 from the 200 West Area. The 200-UP-1 (U Plant) pump-and-treat system, continued operations during the five-year review period, until the system was shutdown in the spring of 2011, once the remedial action objectives in the capture zone to remove and treat these two contaminants of concern, in addition to the specific co-contaminants of nitrate and carbon tetrachloride was completed. Throughout the five-year review period, technetium-99 concentrations were below the remedial action objective of 9,000 pCi/L in the area of U Plant. Uranium concentrations were above the remedial action objective of 300 µg/L at a few wells within the baseline plume area (i.e., the area originally targeted for remediation), during much of the five-year review period, but concentrations were below the remedial action objective in all wells within the capture zone at the end of the five-year review period. Concentrations were above the remedial action objective at a well upgradient from the baseline plume area near the source (216-U-1 and 216-U-2 Cribs).

The monitoring for the 200-UP-1 OU is subdivided to (1) characterize and track all contaminants of concern or potential concern in the OU; and (2) evaluate the performance of a pump-and-treat system that removes technetium-99, uranium, carbon tetrachloride, and nitrate from groundwater near U Plant.

The *200-UP-1 Groundwater Remedial Design/Remedial Action Work Plan* (DOE/RL-97-36, Revision 3) was approved by DOE-RL and Ecology on February 4, 2010. The work was plan revised and signed by DOE, and Ecology on February 24, 2009 to implement the modifications identified in the ESD.

200-UP-1 Operable Unit Remedial Action Objectives

Remedial Action Objective 1	Reducing contamination in the area of highest concentrations of uranium and technetium-99 to below 10 times the cleanup level under the MTCA, and 10 times the MCL for technetium-99.
Remedial Action Objective 2	Reducing potential adverse human health risks through reduction of contaminant mass.
Remedial Action Objective 3	Preventing further movement of these contaminants from the highest concentration area.
Remedial Action Objective 4	Providing information that will lead to development and implementation of a final remedy that will be protective of human health and the environment.

3.4.2.4 Progress Since 2006 Review

During CY09, DOE continued groundwater monitoring under the *Remedial Investigation/Feasibility Study Work Plan for the 200-UP-1 Groundwater Operable Unit* (DOE/RL-92 -76). Accomplishments related to CERCLA actions since the 2006 five-year review included issuing an ESD and modified interim action ROD to address changes in the uranium remedial action goal, to add extended purging as an interim action for the removal of technetium-99 and to update other provisions of the 200-UP-1 OU pump-and-treat system.

3.4.2.5 Technical Assessment

The purpose of the five-year review is to determine whether the remedy at a site is, or upon completion will be, protective of human health and the environment. The following is the technical assessment response of the 200-UP-1 OU interim remedy concerning the technical assessment questions provided in the EPA guidance. The following also establishes a framework for organizing and evaluating data and ensuring that all relevant issues are considered when determining the protectiveness of the remedy.

Is the remedy functioning as intended by the decision documents?

The interim remedy is functioning within the specified remedial action objectives. The pump-and-treat system has remediated the uranium and technetium-99 in the groundwater as intended.

Are the exposure assumptions, toxicity data, cleanup levels, and remedial action objectives used at the time of remedy selection still valid?

The exposure assumptions, toxicity data, cleanup levels, and interim remedial action objectives used at the time of remedy selection are still valid for the OUs.

Has any other information come to light that could call into question the protectiveness of the remedy?

The following information has come into light since the 2006 five-year review that will assist in the development of a final remedy.

3.4.2.5.1 Technetium‑99

Technetium‑99 concentrations were below the 9,000 pCi/L remedial action objective for all of the pump-and-treat system monitoring wells in the area of U Plant (Figure 36). Technetium‑99 concentrations occur above the DWS of 900 pCi/L in three regions of the 200‑UP‑1 OU: (1) downgradient from the 216-U-1/2 cribs near U Plant, (2) at WMA S-SX, and (3) at WMA-U. A technetium‑99 plume originates from the 216-U-1/2 cribs (Figure 37), which were active in the 1950s and 1960s. The plume extends approximately 1 to 1.2 miles (1.5 to 2 km) east into the 600 Area, but the plume is mostly at levels below the DWS.

When wastewater was disposed at the nearby 216-U-16 crib in the mid-1980s, it migrated north along a caliche layer and mobilized the technetium‑99 and uranium in the soil column beneath the 216-U-1/2 cribs, which added contaminant mass to the groundwater plume (*Remedial Investigation/Feasibility Study Work Plan for the 200-UP-1 Groundwater OU* (DOE/RL-92-76). This plume is separated into two parts: one downgradient from the 216-U-1/2 Cribs, and one east of the 200 West Area boundary. This separation was caused by capture of the high-concentration portion of this plume by the 200-UP-1 interim remedial action pump-and-treat system, while the lower concentration portion that was not captured continued to migrate to the east. Historically, the highest measured technetium‑99 concentration in the 216-U-1/2 cribs plume was 41,000 pCi/L (west of the 216-U-17 crib) in October 1989.

The pump-and-treat system operated in the central portion of the 216‑U‑1/2 cribs plume from 1995 until a rebound study began in early 2005. Groundwater extraction resumed in April 2007 following the rebound study. The pump-and-treat system has been successful in reducing technetium‑99 concentrations in the aquifer. Throughout the five-year review period, technetium‑99 concentrations were below the 9,000 pCi/L remedial action objective in both extraction wells (299-W19-36 and 299-W19-43) and in all of the compliance wells. Technetium‑99 concentrations exceeded the DWS in both extraction wells but were below the DWS at all of the compliance wells. In November 2008, the maximum concentration measured during the five-year review period at the pump-and-treat system was 8,000 pCi/L in extraction well 299-W19-36.

At WMA S-SX, a technetium‑99 plume originates from the southwestern corner of the WMA and another plume originates from the northern portion (Figure 38). The highest technetium‑99 concentrations within the OU occur in this southern plume. In June 2009, concentrations in this well exhibited a generally increasing trend, peaking at 75,000 pCi/L. The southern plume from WMA-S-SX represents a growing contamination issue because the plume is increasing in areal extent and concentrations are increasing in many of the downgradient wells. During 2009, at far downgradient wells, the technetium‑99 concentration increased to 9,200 pCi/L, exceeding 10 times the DWS.

The northern plume at WMA S-SX originates from the S Tank Farm. Concentrations began increasing in this plume during FY07 and continued to increase during the five-year review period. Technetium‑99 concentrations were not detectable in upgradient wells during the latter part of the five-year review period, confirming the S Tank Farm as the source. The recent concentration increases in the northern plume indicate that it too is a growing contamination issue. Future remediation of both the northern and southern plumes from WMA S-SX is being addressed by the 200-UP-1 OU CERCLA activities. Technetium‑99 concentrations in the downgradient wells at WMA U are elevated compared to concentrations in the upgradient well. This indicates that the U Tank Farm is a source of technetium‑99 contamination (*Groundwater Quality Assessment for Waste Management Area U: First Determination*, PNNL‑13282); however, concentrations are very low compared to WMA S-SX. The DWS was exceeded in four wells during FY09, with peak concentrations occurring in July 2009 of between 1,200 pCi/L and 2,200 pCi/L at 299-W19-47.

3.4.2.5.2 Uranium

Within the 200-UP-1 OU, uranium primarily occurs in a plume downgradient from the 216-U-1/2 cribs (Figure 39) and is associated with the technetium-99 plume. The plume extends a total of approximately 1 mile (1.5 km) to the east at levels above the 30 µg/L DWS. Uranium interacts with soil particles and is not as mobile in the aquifer as technetium-99. The uranium originated from the 216-U-1/2 cribs, which were active in the 1950s and 1960s. As with technetium-99, additional mass was added to the groundwater plume when effluent disposed at the nearby 216-U-16 crib in the mid-1980s migrated north along a caliche layer in the vadose zone mobilizing the technetium-99 and uranium in the soil column beneath the 216-U-1/2 cribs (DOE/RL-92-76).

The uranium plume map shown in Figure 39 depicts the average conditions during FY09, showing a 300 µg/L contour within the pump-and treat area. However, by the end of the five-year review period, all uranium sample results were below the current remedial action objective of 300 µg/L at all wells that have not gone dry within the remedial action target area (i.e., baseline plume area).

3.4.2.5.3 Tritium

Disposal facilities associated with the REDOX Plant are the primary sources of tritium in the 200-UP-1 OU. The REDOX Plant operated from 1952 until 1967, although effluent releases continued to occur after that time. A large tritium plume from the REDOX Plant cribs originates from the southern portion of the 200 West Area and extends approximately 5 km (3.1 miles) toward the east and northeast at levels above the 20,000 pCi/L DWS. Two high-concentration areas occur within this region: a large plume extending to the east and northeast from the 200 West Area, and a smaller plume extending approximately 188 miles (550 meters) to the east-southeast from the 216-S-25 Crib (Figure 40).

3.4.2.5.4 Iodine-129

Iodine-129 plumes in the 200-UP-1 OU originate from both the U Plant and REDOX Plant disposal facilities (Figure 41). One plume originates from the 216-U-1/2 cribs and a second plume originates from the southern portion of the 200 West Area. At the current level of monitoring detail, these plumes merge downgradient and become indistinguishable. This combined plume (as defined by the 1 pCi/L contour) extends to the east a total distance of approximately 2 miles (3.5 km). Sample results near the REDOX Plant cribs are above the DWS (1 pCi/L).

The highest concentrations of iodine-129 within the OU, greater than 10 times the DWS, occur in a region extending approximately 1.2 miles (2 km) east into the 600 Area from the southeastern 200 West Area (Figure 41). The most recent sampling was in March 2008 and the iodine-129 result was 37 pCi/L. Concentrations are generally declining or stable within the larger plume (as delineated by the 1 pCi/L contour) and dispersion is slowly reducing the areal extent of the plume above the DWS. Radiological decay is not a factor in the declining areal extent because iodine-129 has a long half-life (15.7 million years).

Figure 36. 200-UP-1 Groundwater Interest Area Facilities and Groundwater Monitoring Wells

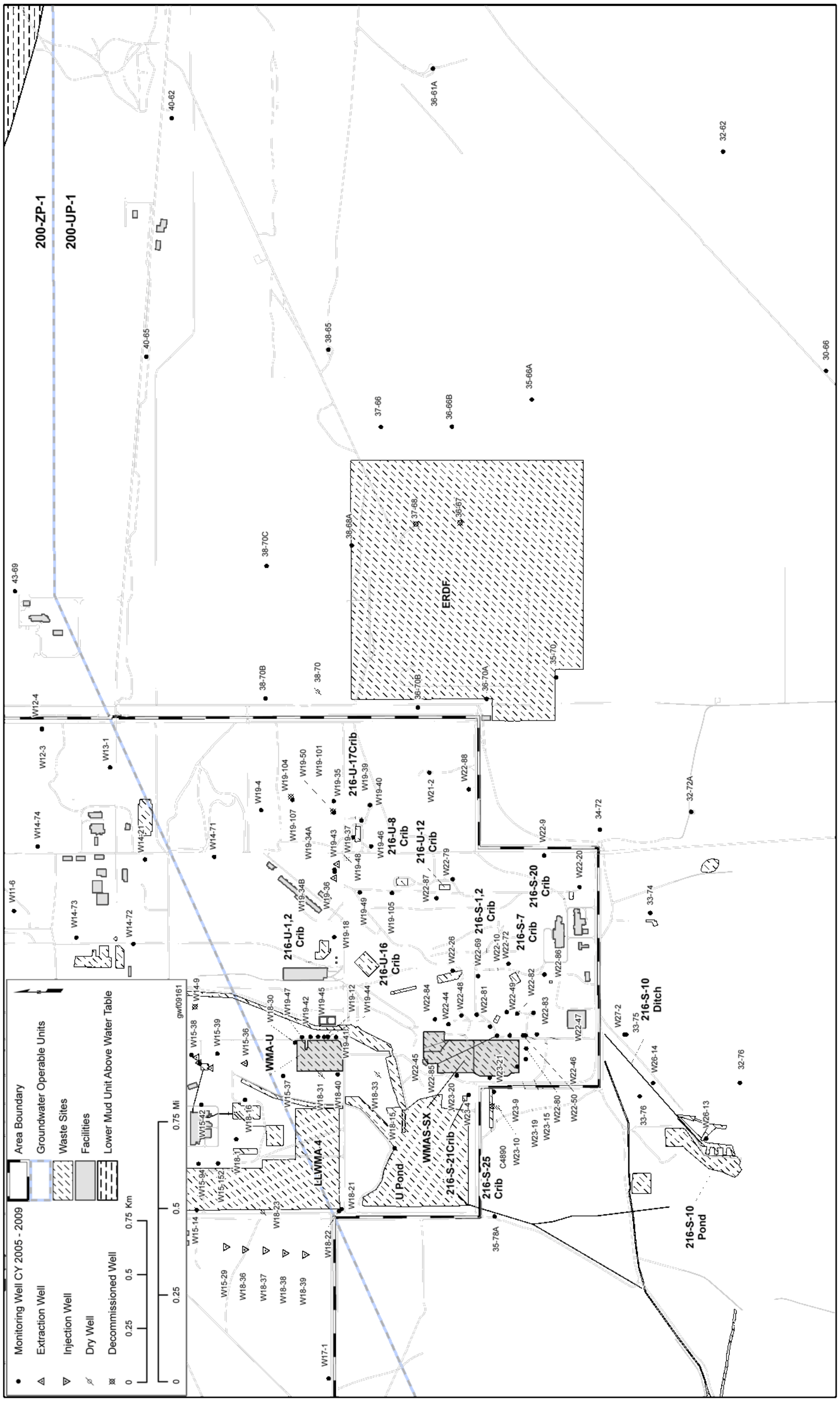


Figure 37. 200-UP-1 Groundwater Interest Area, Upper Portion of Unconfined Aquifer Average Technetium-99 Concentrations

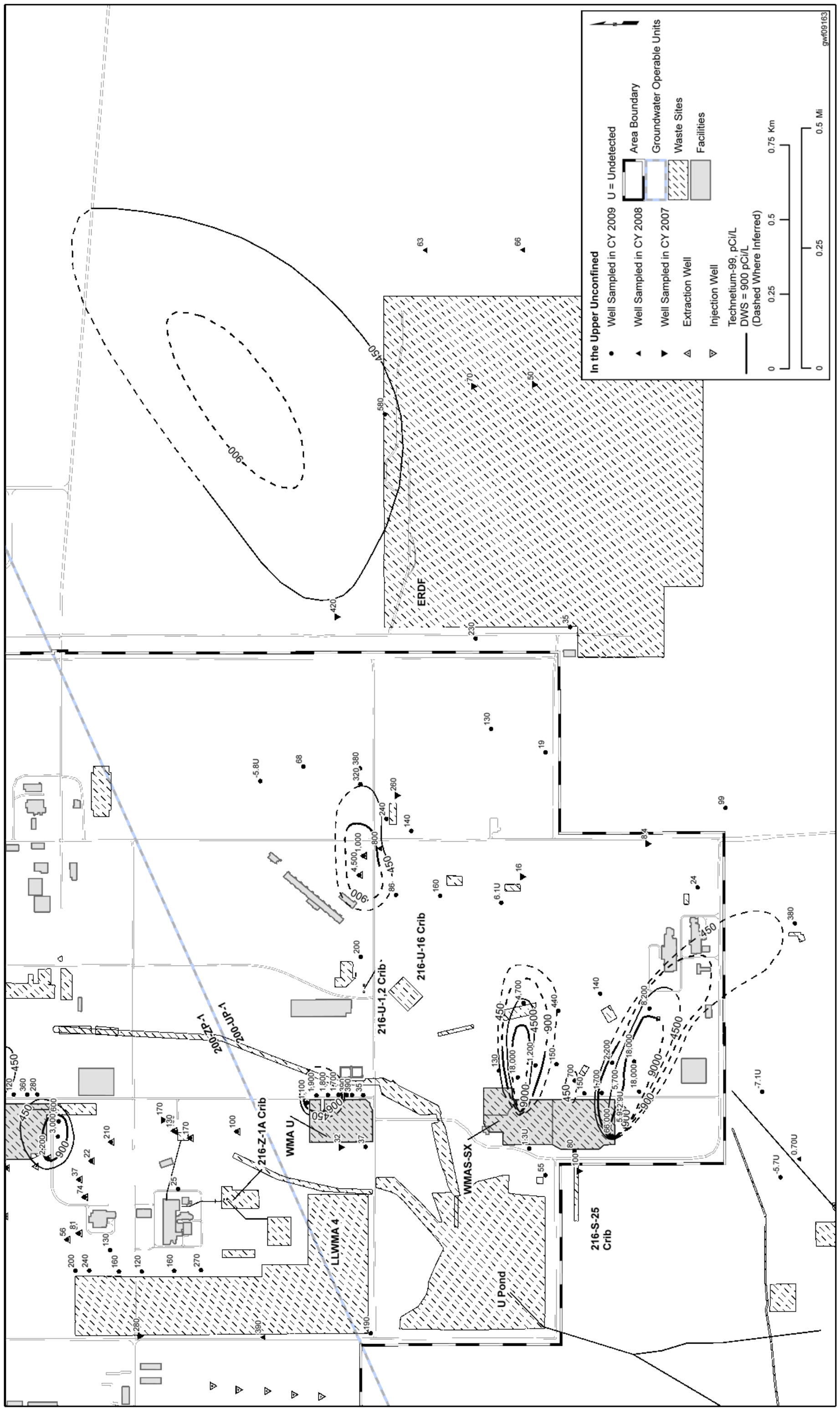


Figure 38. 200-UP-1 Chromium and Technetium-99 Concentrations Well 299-W23-19, Southern Portion of Waste Management Area S-SX

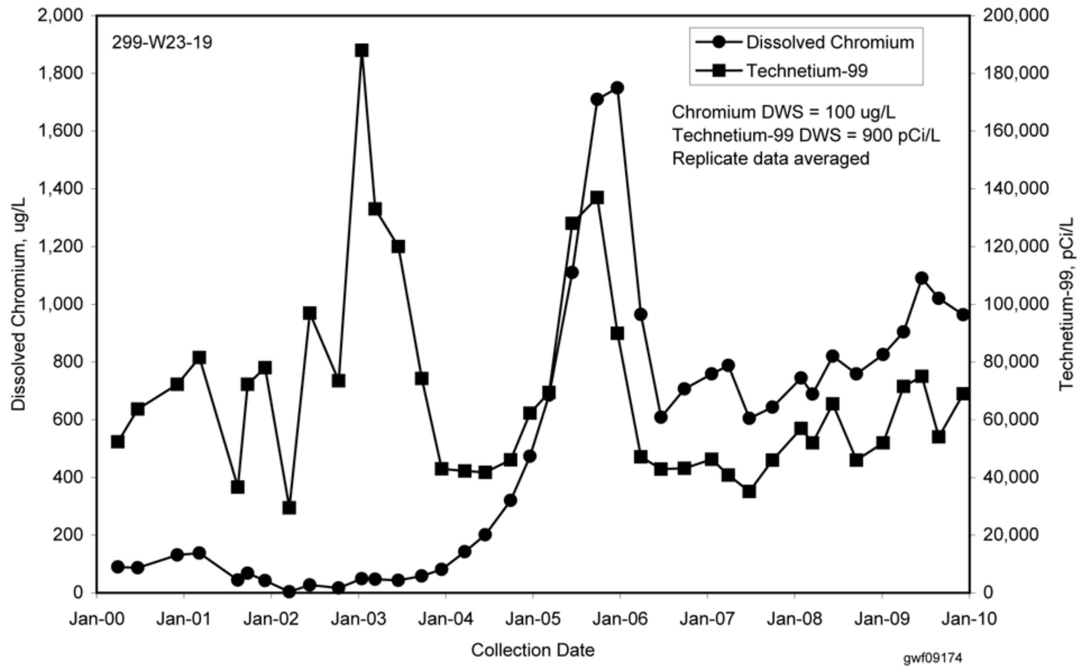
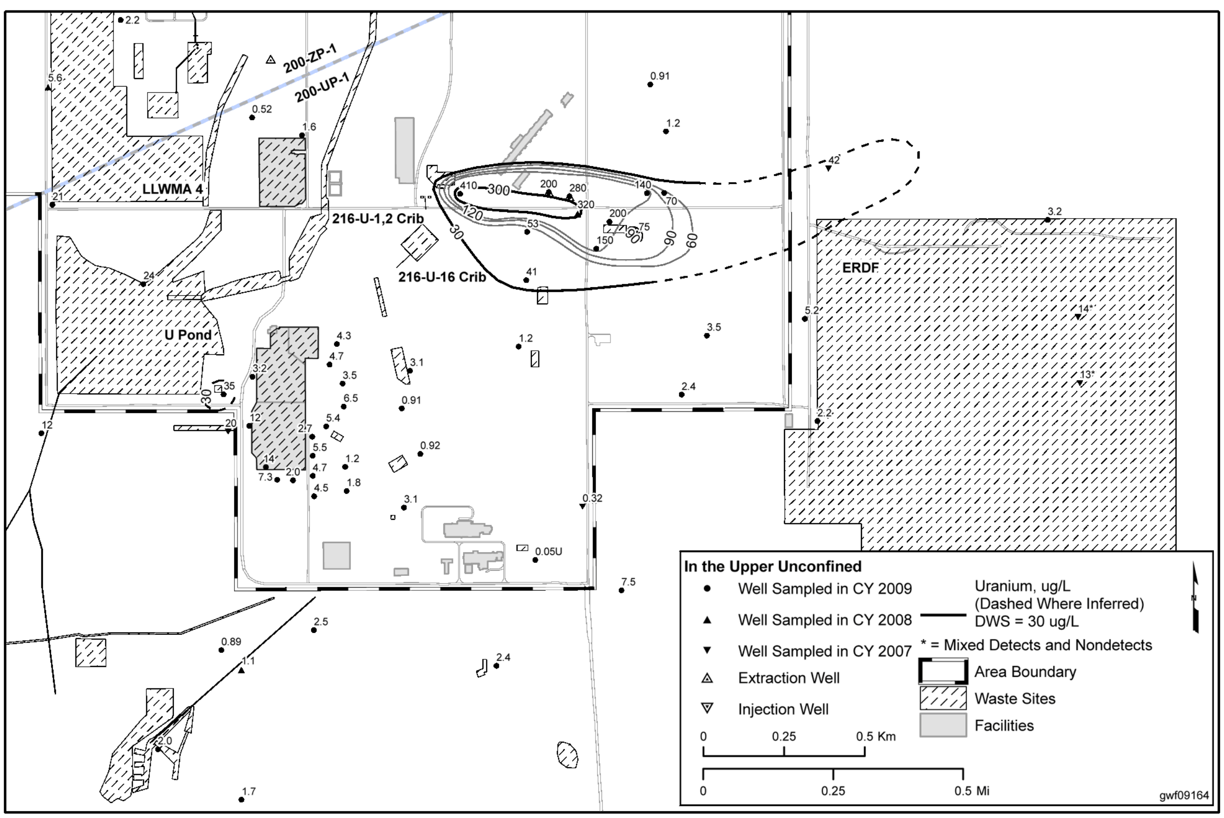


Figure 39. 200-UP-1 Groundwater Interest Area, Upper Portion of Unconfined Aquifer Average Uranium Concentrations



3.4.2.5.5 Nitrate

Nitrate plumes in the 200-UP-1 OU are thought to have originated from both the U Plant and REDOX Plant disposal facilities and are widespread throughout the area. Potential sources of nitrate from U Plant include the 216-U-1/2, 216-U-8, and 216-U-12 cribs. The nitrate plumes from these and other sources merge downgradient into a single large plume, which extends to the east and northeast a total distance of approximately 2.5 miles (4 km) (Figure 42). Nitrate sources from the REDOX Plant disposal facilities may also have contributed to this plume. Concentrations throughout the large plume outside the 200 West Area are stable or declining, with a few exceptions.

Nitrate concentrations are highest in the two extraction wells within the U Plant pump-and-treat area. Nitrate concentrations decreased during the five-year review period, from 1,080 mg/L to 668 mg/L. Concentrations fluctuate in this well in response to pumping outages, and the pump was not operational during most of the spring and summer of 2008 (*200-UP-1 and 200-ZP-1 OUs Pump-and-Treat System Annual Report for Fiscal Year 2008*, DOE/RL-2008-77). The concentration declines are likely the result of reduced contaminant mass in the aquifer combined with the growth of the capture zone. As the capture zone grows in response to pumping, water with a lower nitrate concentration (quite possibly from beneath the plume) may be drawing into the extraction well and diluting the water of higher nitrate concentration. The maximum nitrate concentration values are higher than concentrations measured historically at the 216-U-1/2 cribs in the 1970s and 1980s (approximately 100 to 300 mg/L). Thus, it appears that nitrate may have a local source near the pump-and-treat area.

Sample results in the eastern high-concentration area ranged from approximately 130,000 to 1 million pCi/L. Concentrations are generally declining at eight wells, are relatively stable in two wells, and are increasing in one well within the 20,000 pCi/L contour. The plume has localized high-concentration areas, which may account for increasing trends as these areas pass wells. However, the plume exhibits declining concentrations overall, and the areal extent has changed slightly in recent years, indicating natural attenuation by dispersion and radiological decay.

The occurrence of nitrate above the DWS deep in the unconfined aquifer does not appear to be widespread. The nitrate distribution depicted in Figure 42 represents the nitrate concentrations in the upper portion of the unconfined aquifer because most of the wells are screened across the water table. Of the wells actively sampled within the OU, eight are screened deeper in the aquifer; five of these wells are located within the mapped nitrate plume. Nitrate is found at levels above the DWS in only one of the deeper wells. The concentration in this well was 151 mg/L in November 2009 and the trend is slightly declining. Further downgradient to the east, nitrate may occur relatively deep in the unconfined aquifer due to hydrodynamic dispersion.

3.4.2.5.6 Chromium

High concentrations of dissolved chromium are found in two regions of the 200-UP-1 OU: WMA S-SX and in the 600 Area (east and southeast of the 200 West Area) (Figure 38). During the five-year review period, samples from five wells at WMA S-SX exceeded the 100 μg/L DWS. The highest concentrations where dissolved chromium exhibited a generally increasing trend (average of 949 μg/L in filtered samples), this well is near the source of a chromium, technetium-99, and nitrate plume originating from the SX Tank Farm.

A second plume occurs in the northern portion of WMA S-SX, downgradient from the S Tank Farm. At a near field downgradient well, dissolved chromium has continued to trend generally upward since October 2006. During the five-year review period, the maximum concentration for a filtered sample was 668 μg/L in March 2009. The other mobile tank waste constituents (technetium-99 and nitrate) have also increased substantially in this well. In general, chromium concentrations are increasing at WMA S-SX and the areal extent of both the northern and southern plumes is growing.

Figure 40. 200-UP-1 Groundwater Interest Area, Upper Portion of Unconfined Aquifer Average Tritium Concentrations

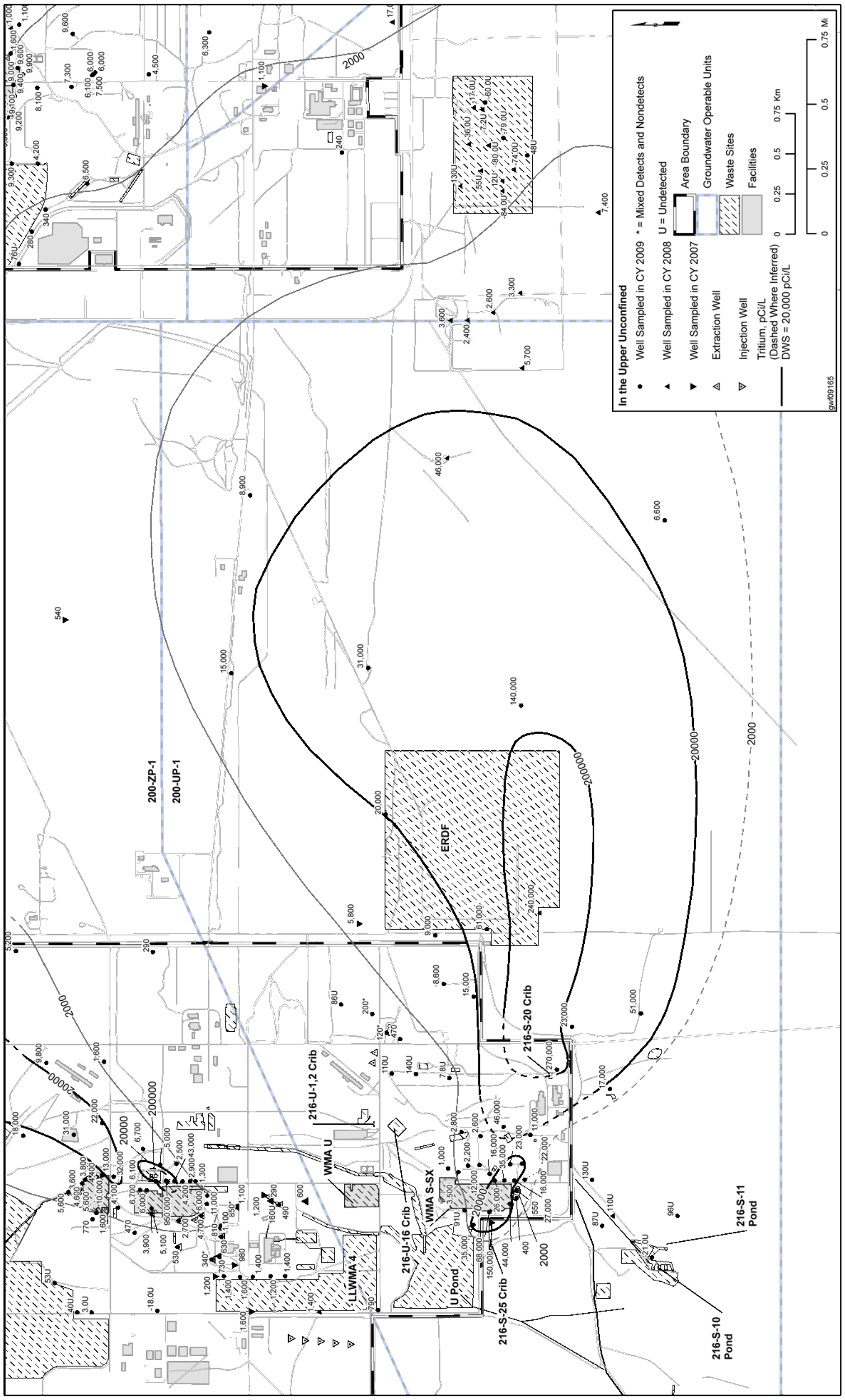


Figure 41. 200-UP-1 Groundwater Interest Area, Upper Portion of Unconfined Aquifer Average Iodine-129 Concentrations

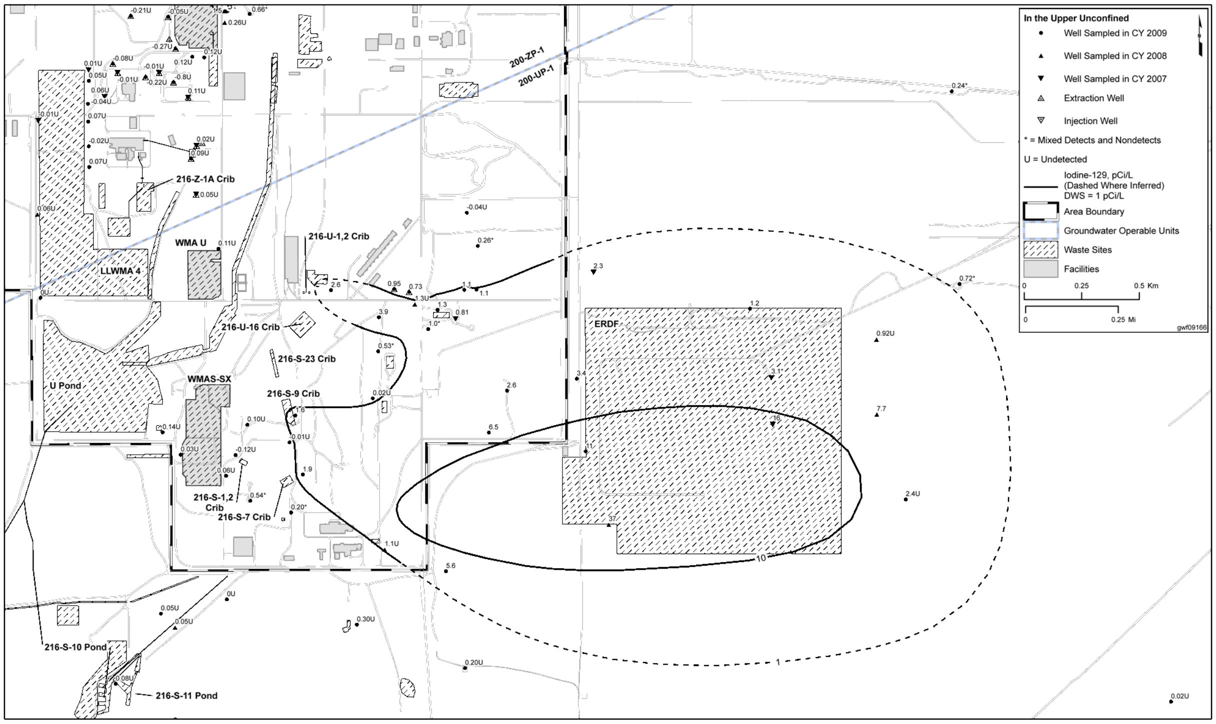
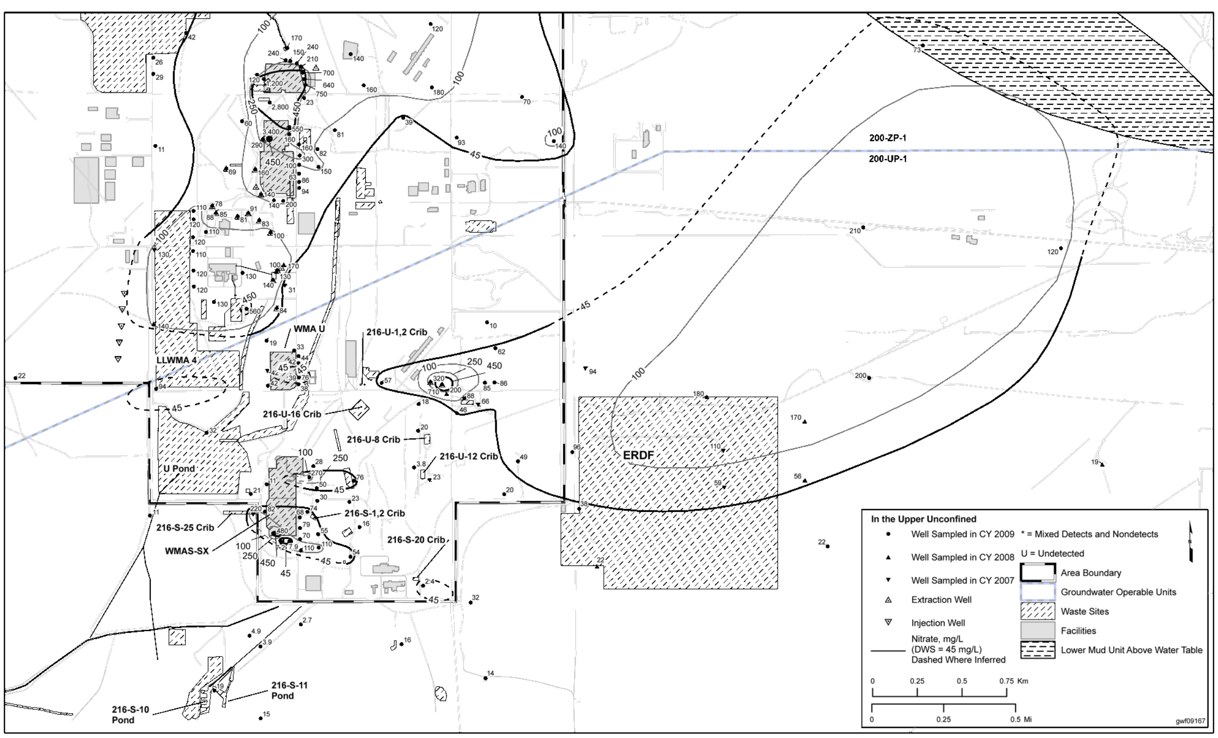


Figure 42. 200-UP-1 Groundwater Interest Area, Upper Portion of Unconfined Aquifer Average Nitrate Concentrations



3.4.2.5.7 Carbon Tetrachloride

Carbon tetrachloride occurs above the DWS (5 µg/L) in wells within the 200-UP-1 OU and the maximum concentration in 23 wells during the five-year review period exceeded 10 times the DWS. The highest concentrations occur within and near the 200 West Area, with concentrations decreasing toward the east. At the water table, the plume is widespread in the southern portion of the 200 West Area and extends approximately 0.62 mile (1 km) east into the 600 Area. The plume originated from waste disposal sites associated with PFP in the 200-ZP-1 Groundwater OU. Concentration trends vary, with different wells exhibiting increasing trends, stable trends, or declining trends, and no clear spatial pattern is evident among the wells with increasing or decreasing trends.

Depth-discrete sampling during well drilling in the eastern portion of the plume has shown that concentrations generally increase with depth in the unconfined aquifer. The highest carbon tetrachloride concentration measured during the five-year review period was 1,300 µg/L at a distance of 135 to 148 feet (41 to 45 meters) below the water table, just above the Ringold lower mud unit.

Carbon tetrachloride concentrations at all wells exceeded the 5 µg/L DWS within the 200-UP-1 pump-and-treat system. The maximum concentration within the baseline plume area was 400 µg/L in an extraction well in December 2008. Given the size of the carbon tetrachloride plume and the relatively low pumping rates, groundwater extraction is not having any noticeable effect on carbon tetrachloride concentrations in this area.

Chloroform is a degradation product of carbon tetrachloride and tends to occur in the same wells with carbon tetrachloride. Thus, some natural degradation of carbon tetrachloride may be occurring, although chloroform was likely introduced to the aquifer from the 2607-Z Tile Field as well. During the five-year review period, 158 chloroform analyses were performed on samples from 52 wells within the 200-UP-1 groundwater interest area; none of the samples exceeded the DWS (80 µg/L for total trihalomethanes) were observed. The maximum concentration measured was 18 µg/L in a well located north of the WMA U Tank Farm. Depth-discrete sampling during new well installation has indicated that concentrations tend to increase with depth, similar to carbon tetrachloride.

Sampling of well 299-W-22-20 near the 216-S-20 Crib, in August 2009, revealed the presence of 1,4-dioxane at 39 µg/L. This was a decline from the previous sample result of 120 µg/L in August 2006. Between 2002 and FY09, this constituent was detected during four sample events with concentrations ranging from 39 to 160 µg/L. This well has gone dry, so no further samples will be collected.

A new well (699-34-72) was installed in FY08 approximately 755 feet (230 meters) east-southeast of well that went dry. There were no detections of 1,4-dioxane in this well during the five-year review period, but sampling for this constituent will continue in future years.

Trichloroethene is found in the 200-UP-1 OU above the DWS (5 µg/L) near the pump-and-treat system. Depth-discrete sampling results during well drilling have shown that concentrations tend to increase with depth. During the five-year review period, 158 trichloroethene analyses were performed on samples from 52 wells within the interest area, and the DWS was exceeded only in two wells. Both of these wells are screened deep within the unconfined aquifer, just above the Ringold lower mud unit. None of the wells monitoring the upper portion of the aquifer exceeded the DWS. The maximum concentration measured was 9.4 µg/L in well 299-W14-71. The areal extent of trichloroethene does not coincide with the distribution of carbon tetrachloride, which suggests a localized source in the U Plant area.

3.4.2.5.8 Strontium-90

Strontium-90 in groundwater occurs in only one location (well 299-W-22-10) within the OU downgradient from the 216-S-1/2 Cribs. Well 299-W-22-10 was last sampled in FY06 with a result of 27 pCi/L, which was above the DWS (8 pCi/L). The 216-S-1/2 Cribs received highly acidic waste from the REDOX Plant between 1952 and 1956. In 1955, the waste is believed to have corroded the casing of a nearby well (located approximately 82 feet (25 meters)south-southeast of the 216-S-1/2 Cribs), which allowed the effluent to bypass the soil column and flow down the well directly into groundwater. Strontium-90 may have reached the groundwater at this location through this postulated pathway.

3.4.2.6 Protectiveness Statement

The final remedy at 200-UP-1 OU is expected to be protective of human health and the environment upon completion of the final remedy. The current interim actions ensure that exposure pathways that could result in unacceptable risks are being controlled. The interim remedial action addresses both chemicals and radionuclides.

3.4.3 200-BP-5 Groundwater Operable Unit

The 200-BP-5 Groundwater OU is shown in Figure 43.

3.4.3.1 Background

Groundwater in the northern part of the 200 East Area and the 600 Area north of 200 East constitutes the 200-BP-5 OU.

3.4.3.2 Chronology

There is no ROD for 200-BP-5 OU. The CERCLA monitoring requirements for the 200-BP-5 OU are defined in the *Groundwater Sampling and Analysis Plan for the 200-BP-5 OU*, which was revised in late FY04 to integrate AEA monitoring and make minor modifications in the monitoring network. The CERCLA monitoring data are used to define the groundwater contaminant plume extent and movement and includes sampling of significant waste source plumes originating from the 216-B-5 injection well site, BY cribs, and Gable Mountain Pond. A remedial investigation is being conducted to identify the appropriate remedial actions to address the contaminant plumes in the 200-BP-5 OU.

3.4.3.3 Remedial Action

The remedial investigation activities are defined in *Remedial Investigation/Feasibility Study Work Plan for the 200-BP-5 Groundwater OU* (DOE/RL-2007-18, Rev. 1) in FY09 at the request of EPA. The following discussion includes the activities completed and the results, as required by DOE/RL-2007-18 and DOE/RL-2001-49.

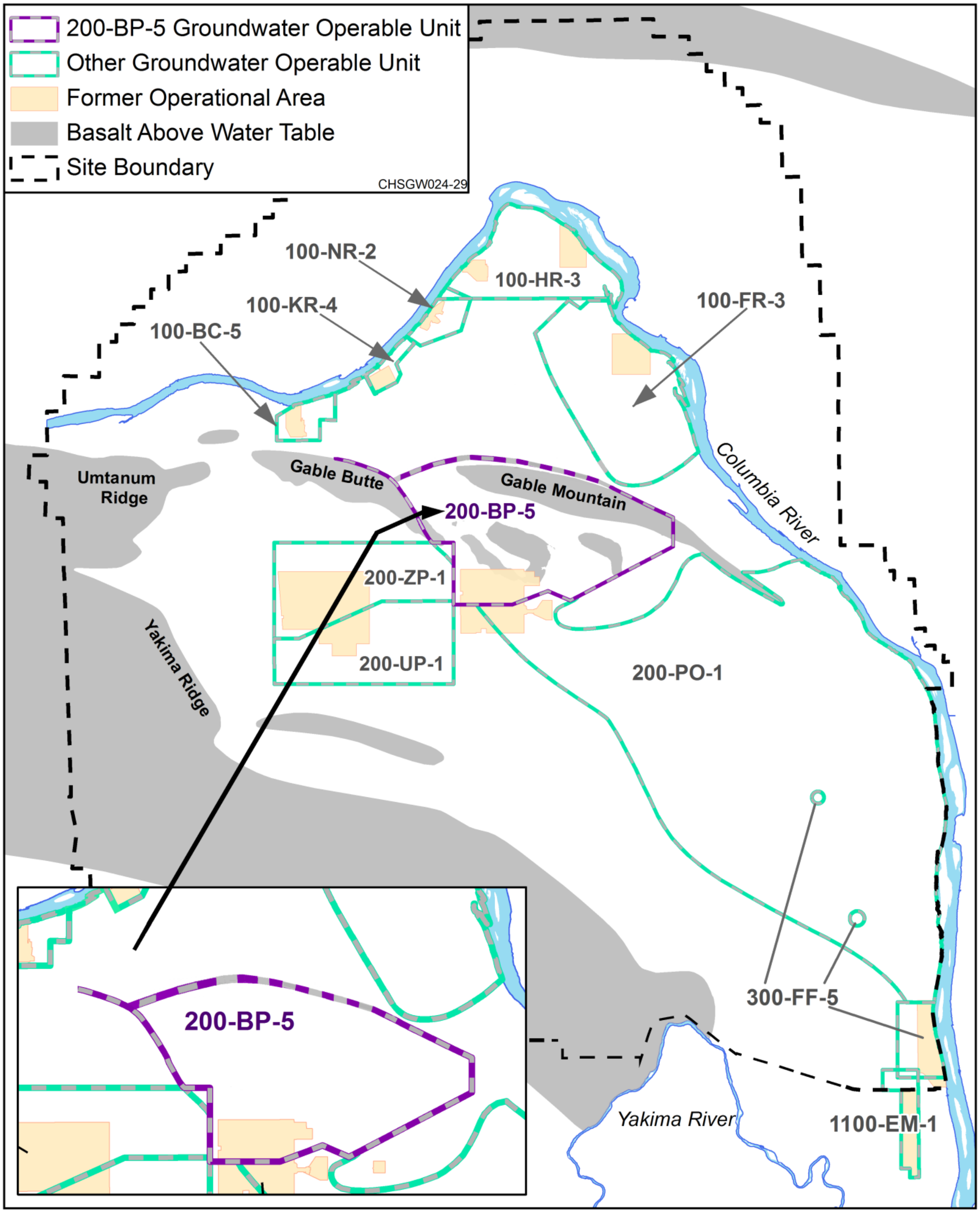
Analyses for the eight remedial investigation wells were completed and compiled during the five-year review period. Chemical analyses for four of the remedial investigation wells were published in FY09. The results are provided in the following documents.

- PNNL-SA-18578, Analytical Data Report for Sediment Samples Collected from BP-5 OU C Well
- PNNL-SA-62124, Analytical Data Report for Grab Samples Collected from BP-5 OU N Well
- PNNL-SA-62656, Analytical Data Report for Grab Samples Collected from OU BP-5 B Well

These investigations provided valuable information for the conceptual transport model and development of the baseline risk assessment. The investigations may also yield information useful to future refinement of the flow and transport modeling to support a composite site analysis. Details of the results of activities described in this section will be published in the RI/FS reports.

The CERCLA groundwater monitoring in FY09 included sampling at the existing network monitoring wells in the 200-BP-5 OU, in accordance with DOE/RL-2001-49. Triennial sampling is performed for wells that have shown stable trends for several years, which generally includes wells that are distal to the source areas with few identified contaminants and low levels of contamination or that are supplemented by RCRA sampling requirements. Quarterly to semiannual sampling is completed for new wells and existing wells in areas where contaminant concentrations are changing, as identified in the 200-BP-5 data quality objectives summary report.

Figure 43. 200-BP-5 Operable Unit



The information derived from this routine sampling, in addition to samples from the new remedial investigation wells, has provided evidence for the source of the uranium plume and the flow direction (Figure 44). In addition, the data generated from beneath the BY Cribs have provided clarity regarding the contaminant suite associated with the BY Cribs. The three new remedial investigation wells north of the 200 East Area have clarified transport pathways across the buried basalt anticline ridge.

Overall contaminant concentration and activity increases were primarily associated with WMA B-BX-BY, WMA C, the BY Cribs, and possibly other past-practice liquid effluent waste sites near WMA B-BX-BY. Although new peak concentrations were reported in some of these areas, the extent of contaminant migration is minimal due to the low hydraulic gradient, the flow reversal observed throughout the northwest portion of the 200 East Area, or the low mobility of the contaminant.

3.4.3.4 Progress Since 2006 Review

During monitoring of the local and regional contaminant plumes in the 200-BP-5 OU during the past year, much of the OU experienced a groundwater gradient reversal. The gradient at the beginning of the five-year review period was to the south because of high Columbia River stages in the spring of 2008 (*Hanford Site Groundwater Monitoring for Fiscal Year 2008*). The gradient reversal to the north was not confirmed until July 2009. Although the groundwater gradient reversal in the northern portion of the 200 East Area was confirmed, areas southeast of this location (along the southern portion of the 200-BP-5 OU) were flat with an undetermined local gradient direction. Flow direction and flow rates for most of the OU were not determined during the five-year review period because of this occurrence.

No significant changes in distribution of the 10-contaminant plumes within the 200-BP-5 OU were observed during the five-year review period. Although the contaminant distribution has not shown significant change from FY09, some incremental degradation of water quality was observed locally near selected sites.

One example is the significant increases in sulfate and nitrate along the southern side of WMA C during the five-year review period. These increases lead to initiation of a groundwater assessment monitoring action at WMA C, and initial assessment samples were collected in December 2009. Another action associated with the *Interim Status Groundwater Quality Assessment Plan for the Single Shell Tank Waste Management Area* is the installation of two additional wells.

Nitrate was observed with historic high concentrations with wells associated with the northern portion of the BY Cribs. Well 299-E-33-7 had a high concentration of 1,690 mg/L, the highest concentration reported in 50 years. Other associated contaminants (e.g., cyanide, sulfate, technetium-99, and tritium) that were reported suggest contaminant contributions from the vadose zone are continuing to infiltrate into the groundwater from the source (Figure 45). A data quality objectives process was initiated in October 2009 to begin planning for a treatability test for evaluating the practicality of performing groundwater extraction to remediate contaminant plumes in this area.

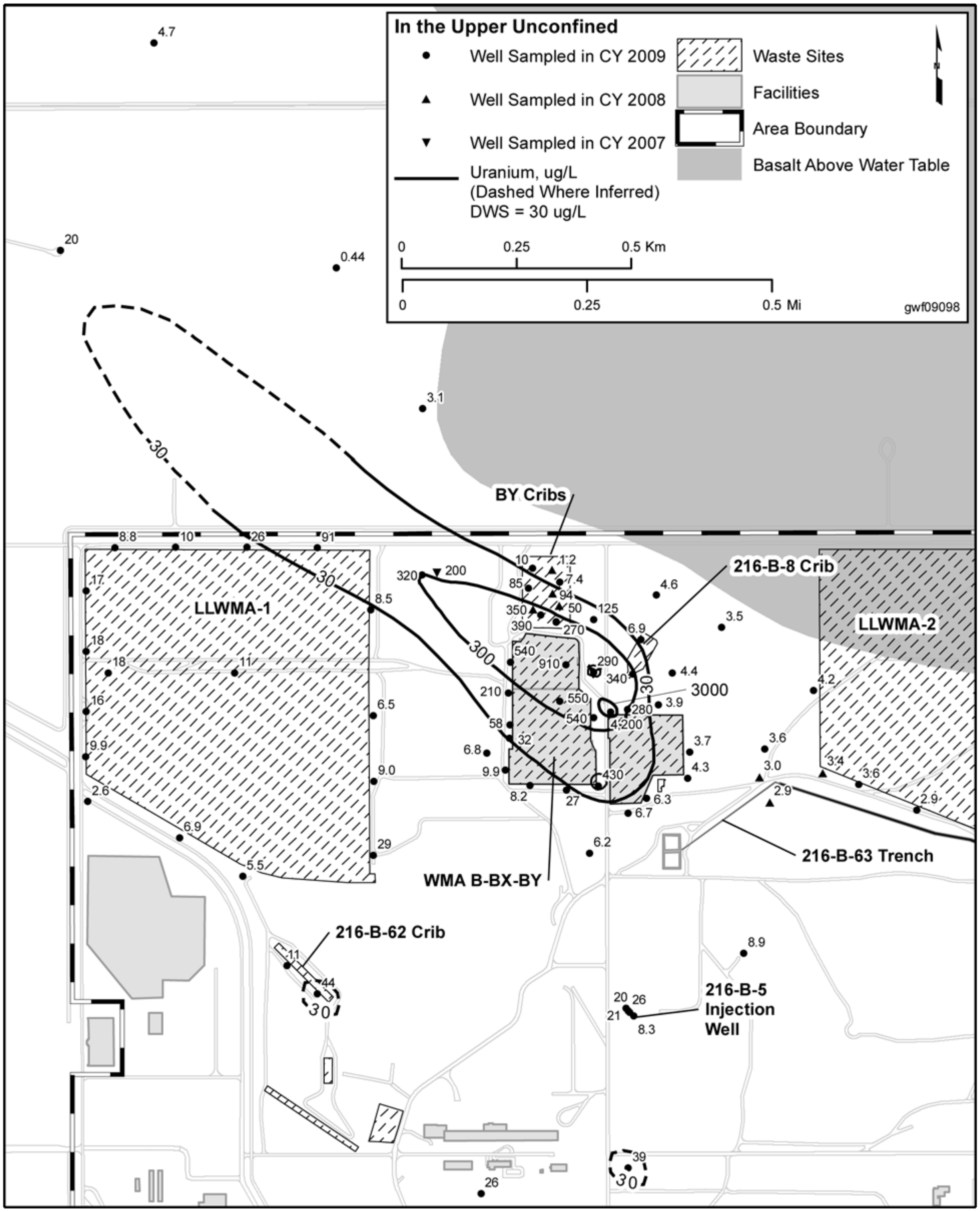
Finally, cesium-137, strontium-90, and tritium plumes have seen marked decreases in concentration due to decay over the past few years. Cesium-137 near the 216-B-5 injection well is approximately 65 percent of the average concentration observed in the 1980s. The strontium-90 concentration beneath the Gable Mountain Pond has steadily decreased from 1,320 pCi/L to 522 pCi/L over the past 12 years. The tritium concentration near the Columbia River and the Gable Gap area has also decreased below the DWS.

3.4.3.5 Technical Assessment

A technical assessment was not performed since a ROD has not been issued for the 200-BP-5 Groundwater OU. The following factors have the potential to influence cleanup decisions that will be identified through the RI/FS process.

- Source units that have not been remediated; removal of contamination from waste sites is expected to have the long-term effect of reducing the amount of contamination that migrates to groundwater. The RI/FS activities for these source OUs will address remediation of these waste sites (Figure 46).

Figure 44. 200-BP-5 Average Groundwater Uranium Concentrations



- The greatest increases in contaminant concentrations have occurred near waste source areas. In order to address the increasing contamination, a data quality objectives process is underway to support RI/FS characterization activities for the 200-BP-5 OU.
- The number of monitoring wells in the 200-BP-5 OU is limited, especially near BY Cribs and B-BX-BY Tank Farms (Figure 47). New monitoring wells are proposed as part of the data quality objectives process and the RI/FS work plan will identify the number, locations, and characterization requirements of new wells.
- Uncertainty in the extent and mobility of vadose zone contamination. Vadose zone contamination under the tank farms, cribs, and trenches will continue to be characterized and evaluated to reduce uncertainty and make cleanup decisions as progress continues under the RI/FS process.

3.4.3.5.1 Nitrate

The highest nitrate concentrations in the 200-BP-5 OU continue to be reported from the wells associated with the BY cribs. A concentration of 1,700 mg/L, in December 2009, was the highest concentration from this well in 50 years and the highest concentration reported in the OU since the 2006 five-year review. The nitrate plume extends to the northwest, beyond the 200 East Area (Figure 48).

3.4.3.5.2 Tritium

Tritium above the 20,000 pCi/L DWS is limited to three wells around the BY Cribs (Figure 49). The northwest portion of the BY Cribs has had the highest quarterly tritium activity (91,000 pCi/L) for well 299-E33-7, which was expected; because of the tritium inventory received by the overlying 216-B-50 Crib, and previous groundwater results from this well. The average annual value is 48,000 pCi/L. The significant fluctuations reported throughout FY09 indicate infiltration and groundwater movement. Overall, the plume extent above the DWS is shrinking. Activities from the wells in the northern portion of the 200-BP-5 OU near the Columbia River have decreased below the DWS.

3.4.3.5.3 Iodine-129

Iodine-129 contamination is present throughout the west portion of the 200-BP-5 OU. Like the tritium plume, the iodine-129 plume extends to the northwest toward the gap between Gable Mountain and Gable Butte. The distribution of iodine-129 has not changed significantly between 1996 and 2004, but the levels of iodine-129 have decreased slightly in several wells. A band of elevated iodine-129 concentrations (approximately 5 pCi/L) exists in WMA B-BX-BY. The highest reported value in this vicinity was 7 pCi/L reported in well 299-E33-16 on May 1, 2000. (Figure 50, Average Groundwater Iodine-129 Concentrations in the 200 East Area and the 600 Area within the 200-BP-5 OU, FY09).

3.4.3.5.4 Cobalt-60 and Cyanide

Cyanide is found in more than one well at levels above the DWS (200 µg/L), and cobalt-60 is found in one well at levels above the DWS (100 pCi/L) (Figure 51). The maximum cyanide concentration in the 200-BP-5 OU since 1996, a value of 1,730 µg/L, was located beneath the BY Cribs. Although the concentration was the highest, it was reported early in FY09 and subsequent results have since declined. Cyanide contamination has increased in some wells and may be related to past discharges of ferrocyanide waste to the BY Cribs.

In FY09, cobalt-60 groundwater values did not exceed the DWS. The decrease below the DWS is due to decreased infiltration, radiological decay, and natural attenuation.

Figure 45. 200-BP-5 Average Groundwater Technetium-99 Concentrations

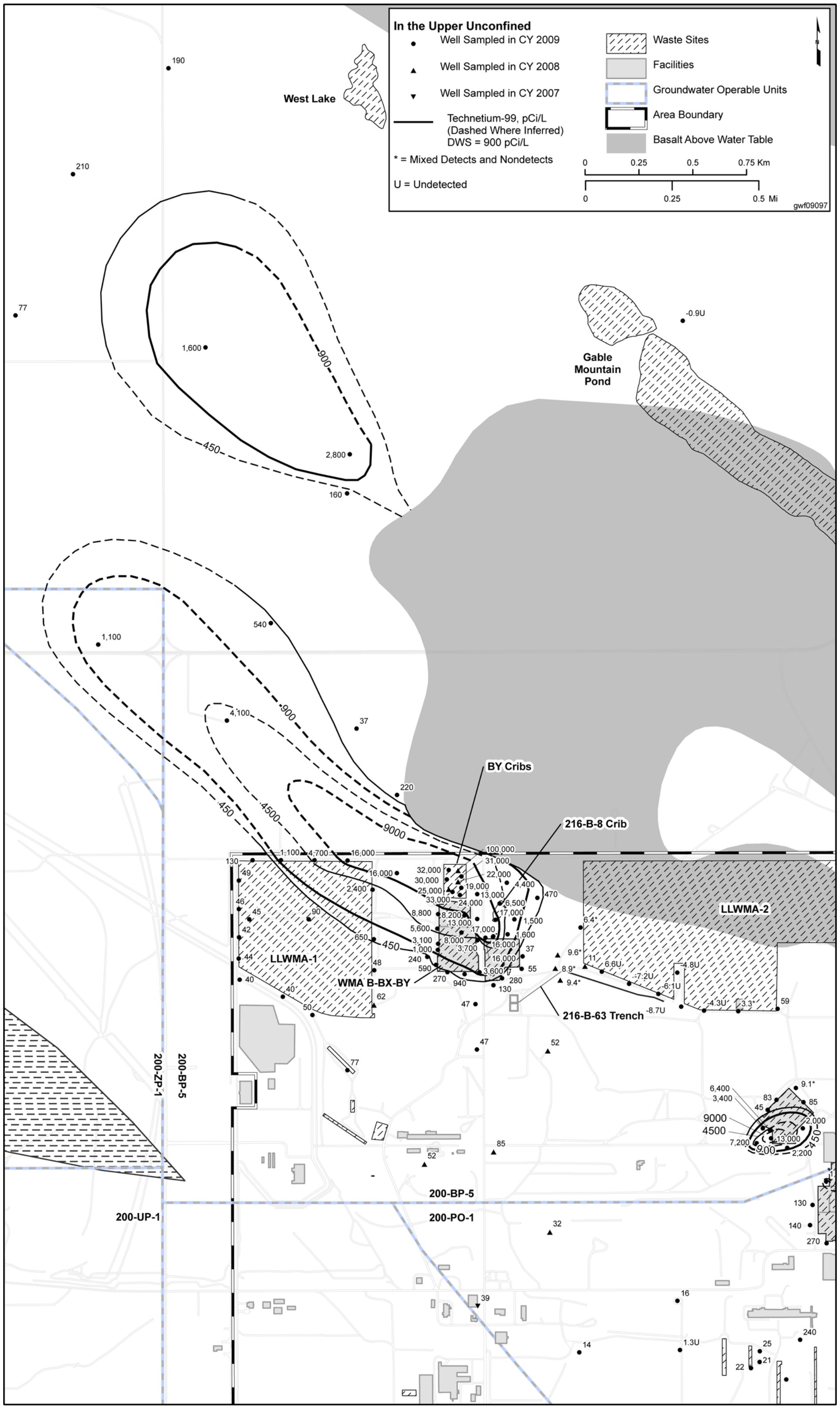


Figure 46. 200-BP-5 Groundwater Monitoring Wells and Selected Waste Sites

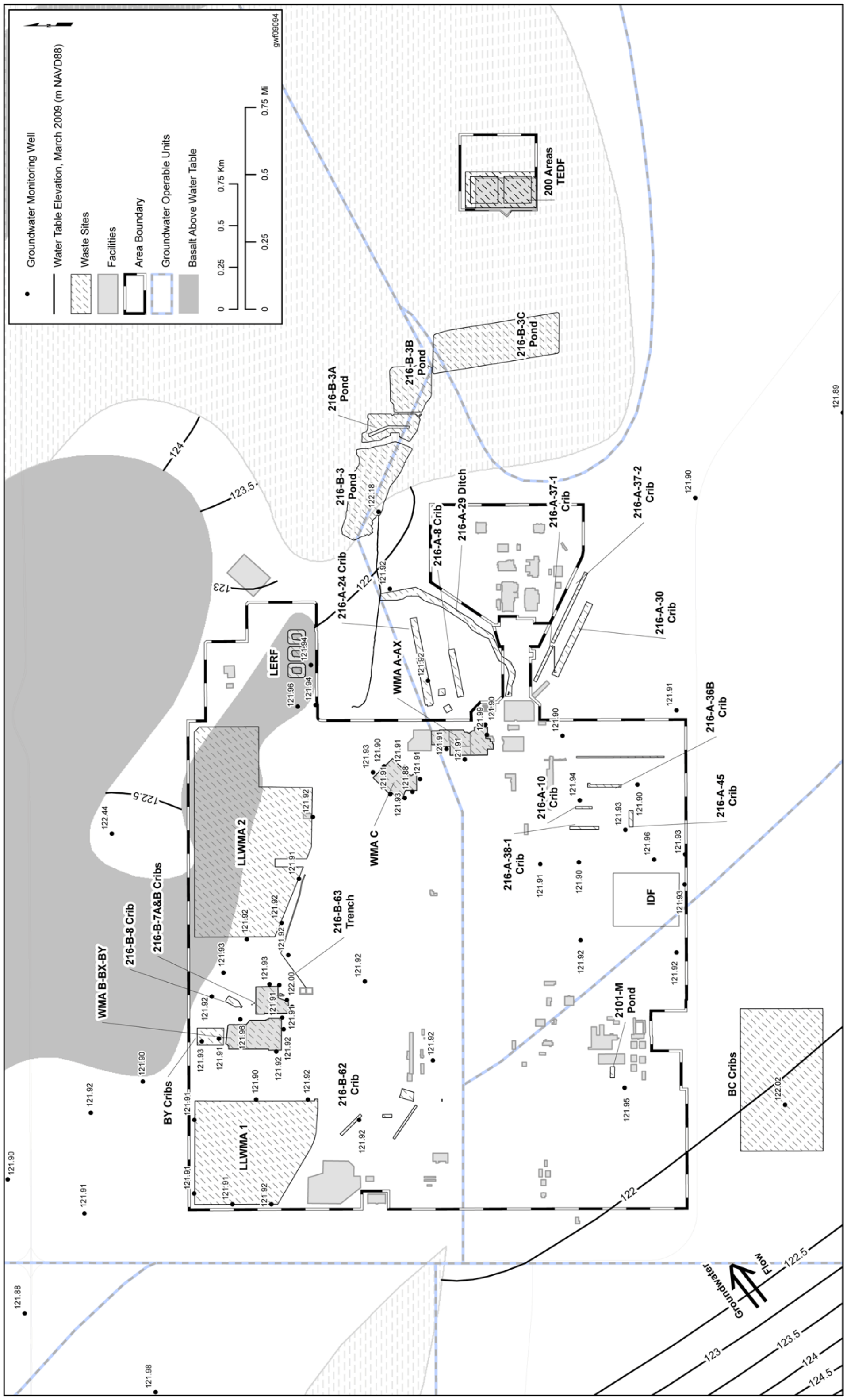
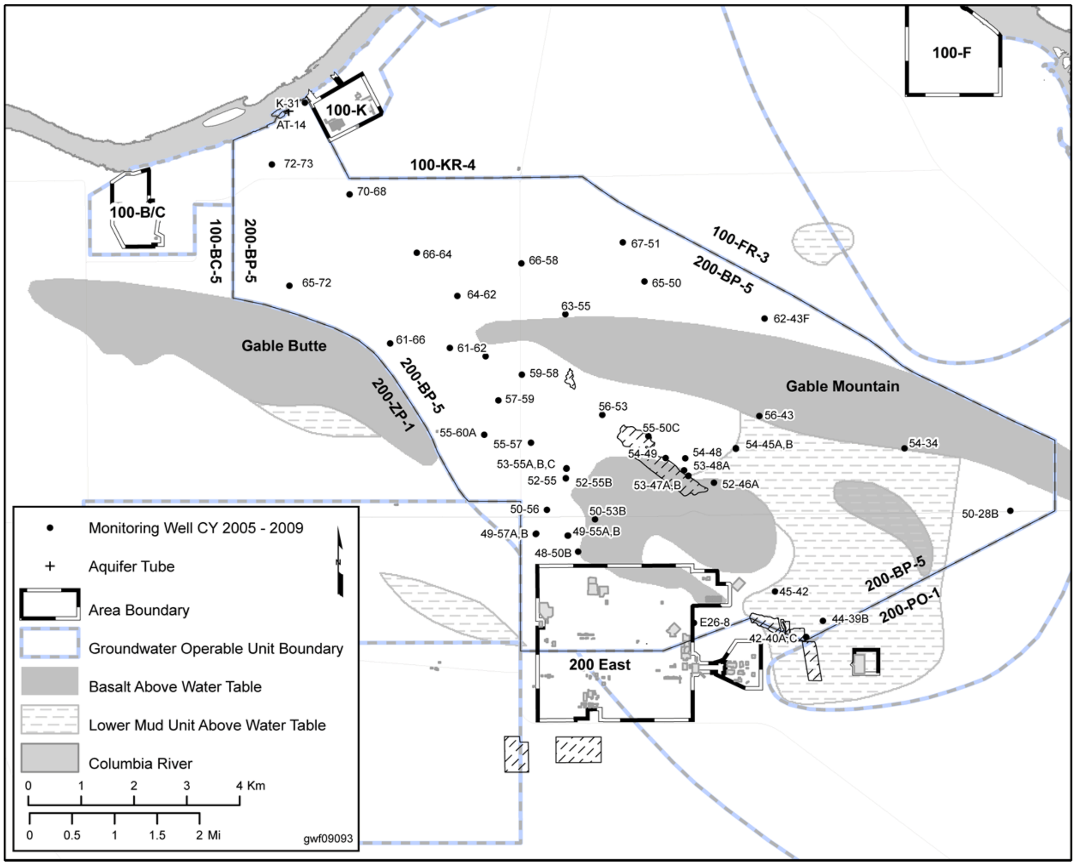


Figure 47. 200-BP-5 Facilities and Groundwater Monitoring Wells



3.4.3.5.5 Cesium-137 and Strontium‑90

Cesium‑137 and strontium‑90 have relatively low mobility and are generally found near their source (Figure 52). Only three wells (near the 216-B-5 injection well) had detectable cesium‑137 within the 200-BP-5 OU, with activities ranging from 36 to 2,430 pCi/L. Well 299-E28-23, located approximately one meter from the 216-B-5 injection well, had the highest activity at 2,430 pCi/L. Although the reported activity is above the 200 pCi/L DWS, the activity is less than the DOE‑derived concentration guide of 3,000 pCi/L. The current activity is approximately 65 percent of the average activities in the 1980s. Based on historical comparisons, this plume appears to be decaying without much movement, as modeled and concluded in the *200-BP-5 Operable Unit Treatability Test Report* (DOE/RL-95-59).

Eleven of the 39 wells sampled were reported with strontium‑90 levels above detection. Nine of the wells reported strontium‑90 concentrations above the 8 pCi/L DWS. Five of the wells with strontium‑90 levels above the DWS are located near the 216-B-5 injection well, and the other four wells are located near Gable Mountain Pond. The highest strontium‑90 activity (4,900 pCi/L) for this reporting period was approximately one meter from the 216-B-5 injection well, which is also the only well above the DOE-derived concentration guide of 1,000 pCi/L. The highest strontium‑90 activity reported near Gable Mountain Pond was in well 699-53-47A, located beneath the southeastern portion of the pond, at 522 pCi/L. The concentration from this well has steadily decreased over the last 12 years from 1,320 pCi/L.

Figure 48. 200-BP-5 Average Groundwater Nitrate Concentrations

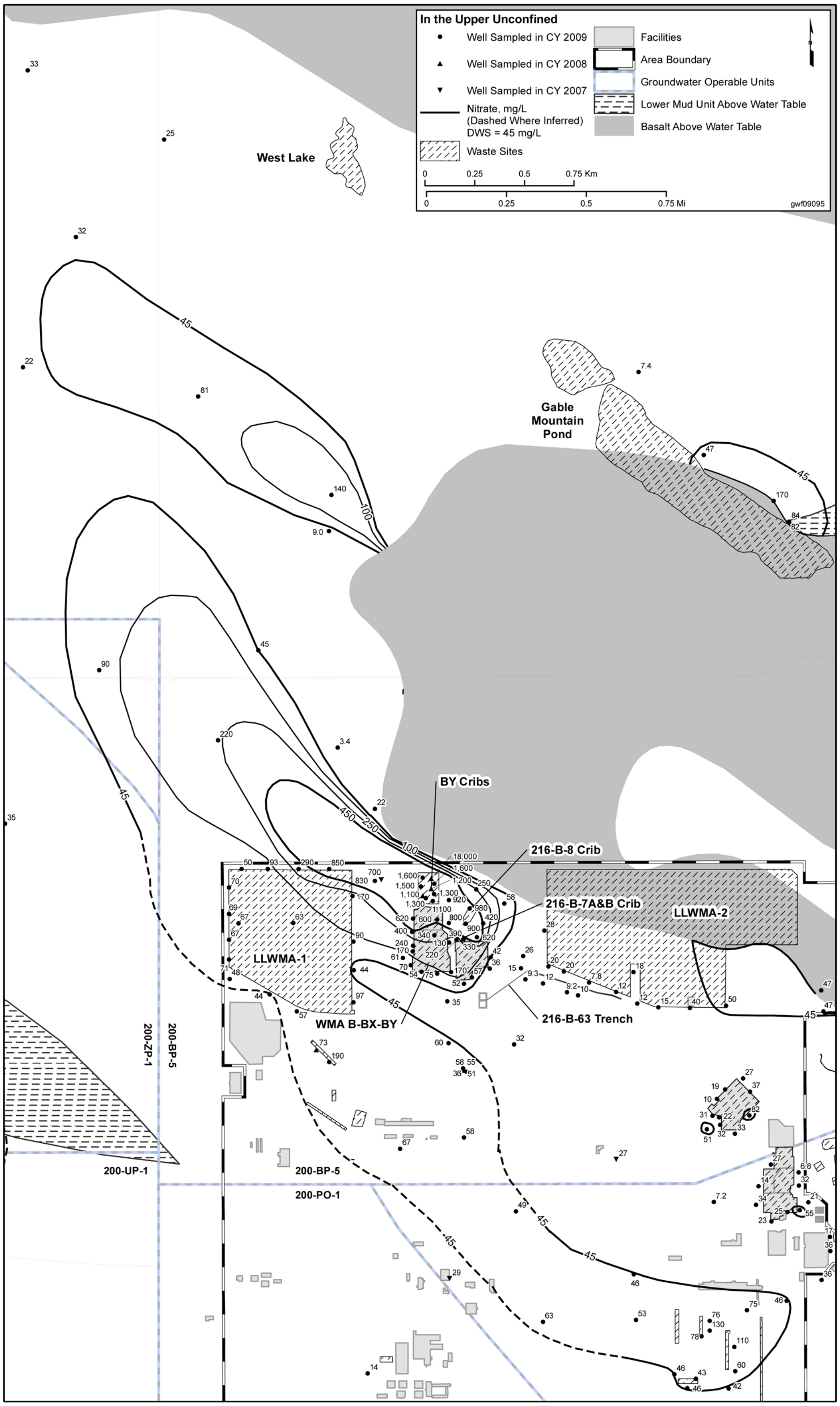


Figure 49. 200-BP-5 Average Groundwater Tritium Concentrations

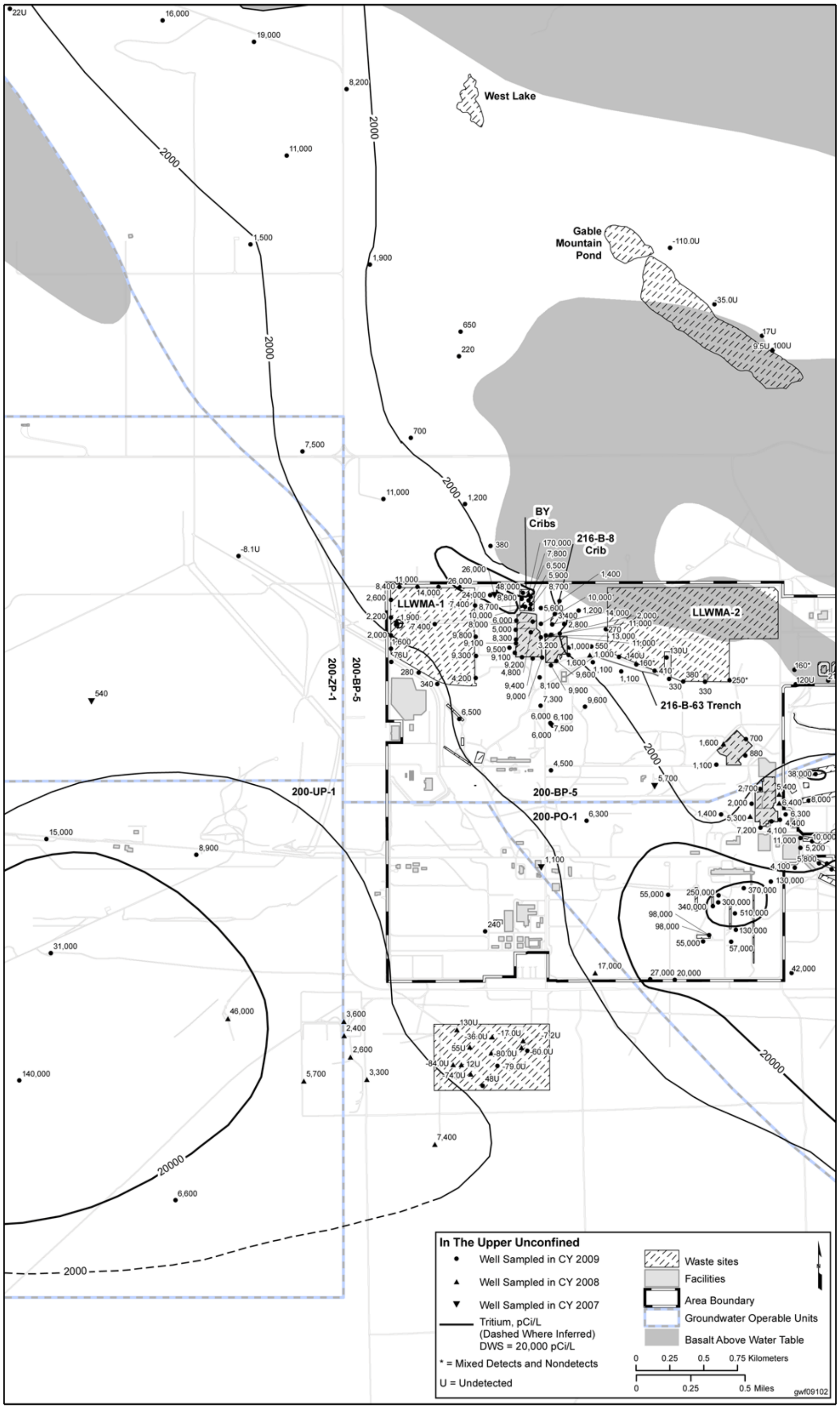
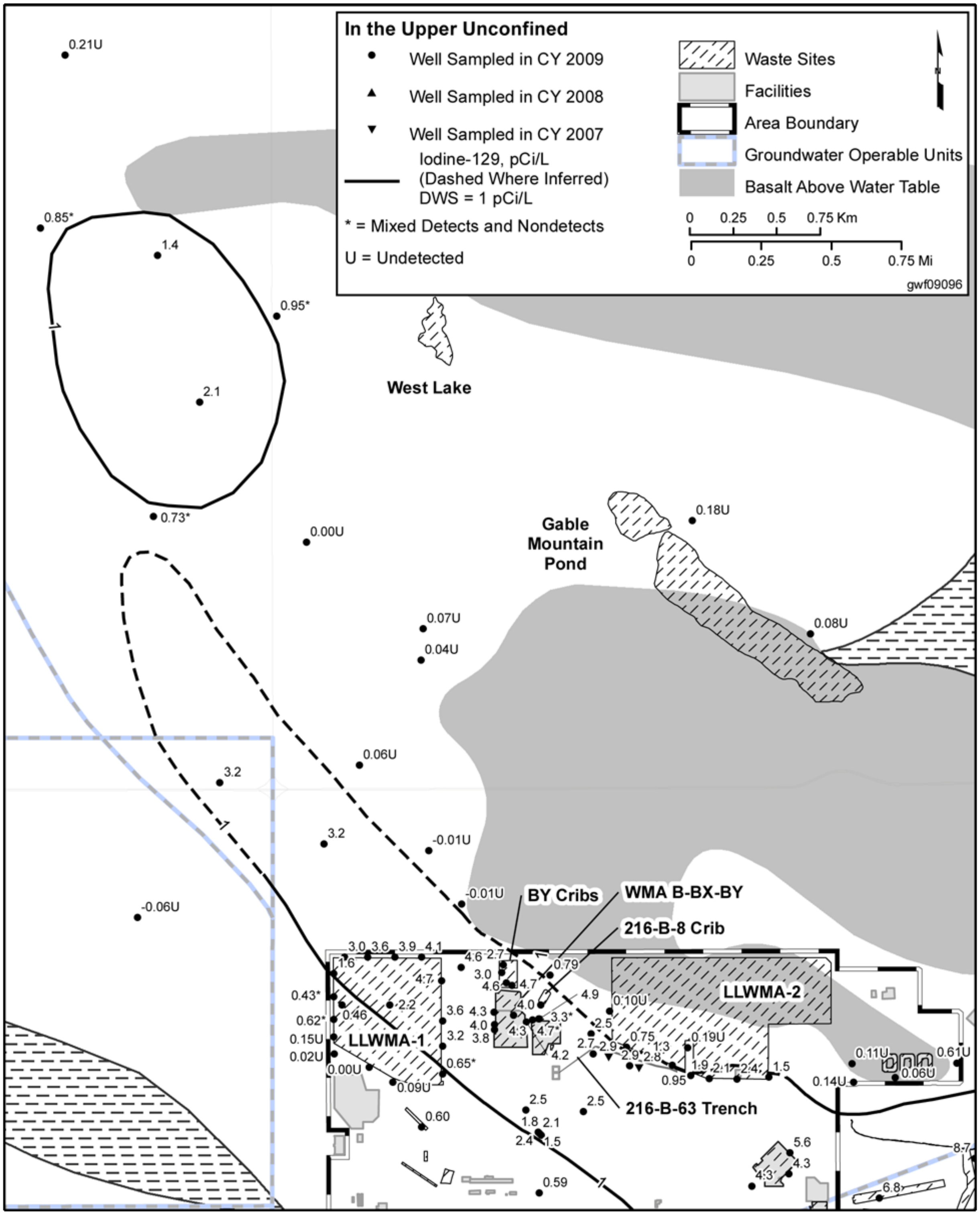


Figure 50. 200-BP-5 Average Groundwater Iodine-129 Concentrations



3.4.3.5.6 Plutonium-239 and -240

Plutonium-239 and plutonium-240 have been detected during past years in samples taken from several wells near the 216-B-5 injection well. Plutonium is relatively immobile and, therefore, is found only near the source, which was the injection well. The highest reported plutonium concentration since CY96 was 81.68 pCi/L for an unfiltered sample collected in June 1996. More recently, the highest plutonium concentrations have been a filtered value of 5.27 pCi/L and an unfiltered value of 66.2 pCi/L in a sample from June 2004. The lower concentration in the filtered versus unfiltered samples suggests that a portion of the plutonium is associated with particulates. The concentration of plutonium has not exhibited a change in trend in recent years. Wells sampled at the 216-B-5 injection well site have indicated plutonium levels were below the DOE derived concentration guide in recent years.

3.4.3.6 Protectiveness Statement

A protectiveness determination of the remedy at 200-BP-5 Groundwater OU cannot be made at this time until further information is obtained by completing the RI/FS process. Once the RI/FS is completed, a proposed plan will be issued to the public for review and comment.

Figure 51. 200-BP-5 Average Groundwater Cyanide Concentrations

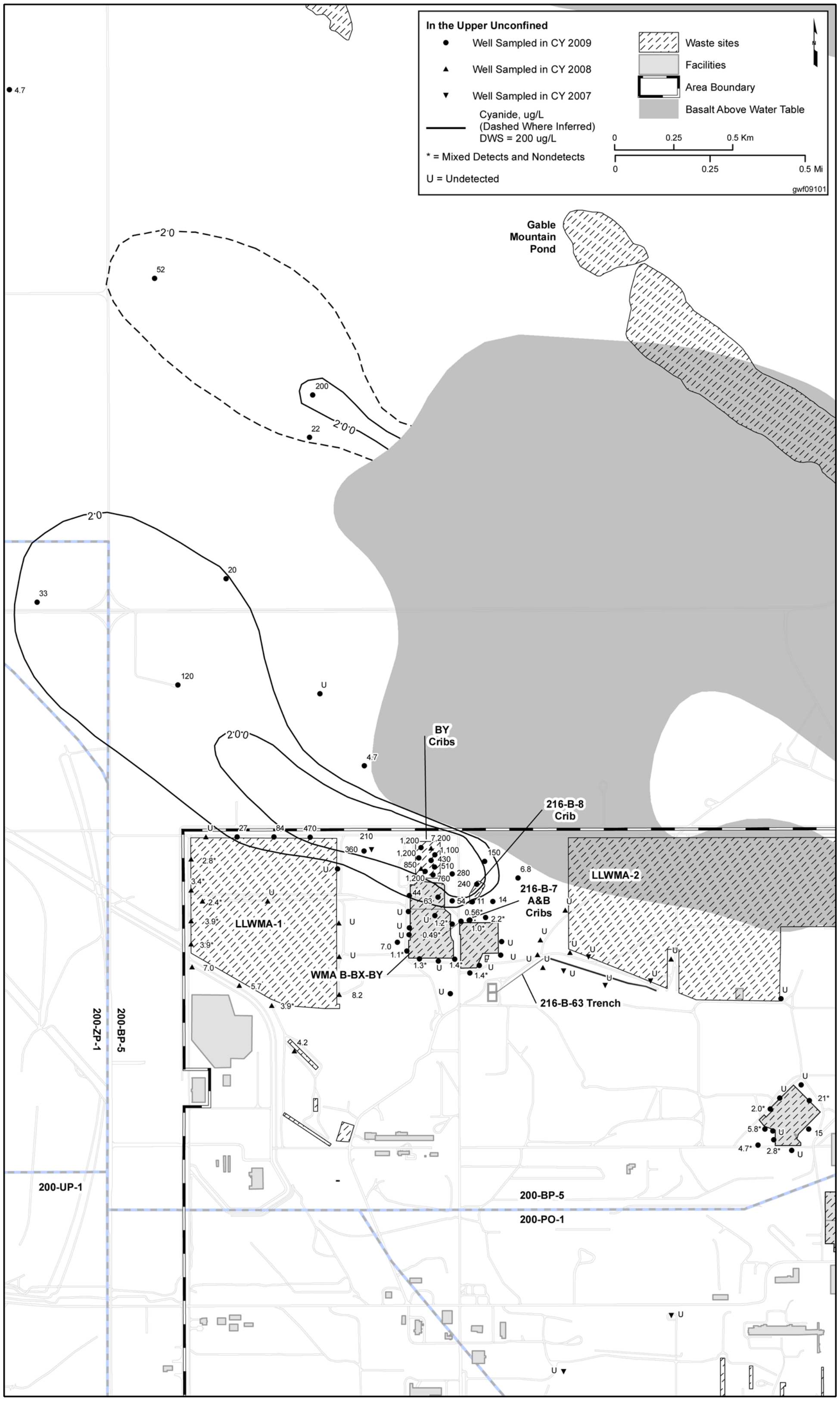
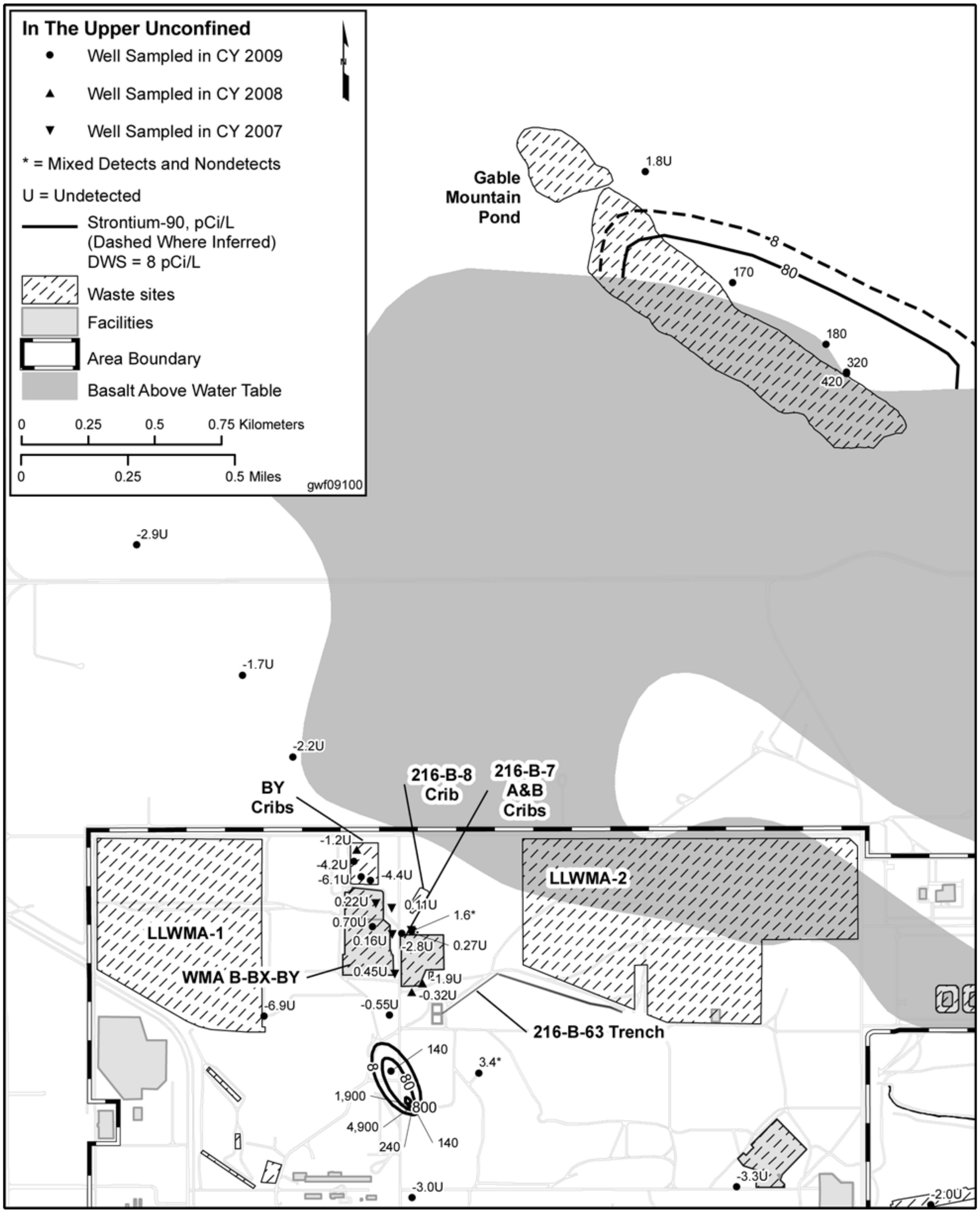


Figure 52. 200-BP-5 Fiscal Year Average Groundwater Strontium‑90 Concentrations



3.4.4 200-PO-1 Groundwater Operable Unit

200-PO-1 Groundwater OU is shown in Figure 53.

3.4.4.1 Background

The 200-PO-1 OU encompasses the southern portion of the 200 East Area and a large region to the east and southeast where groundwater is contaminated with tritium and iodine-129. Concentrations of tritium continued to decline as the groundwater plume attenuates naturally due to radioactive decay and dispersion. Nitrate covers a large area with levels elevated above background but mostly below the DWS. Other contaminants include strontium-90, technetium-99, and uranium, but these contaminants are limited to smaller areas.

3.4.4.2 Chronology

A final ROD has not been issued; however, work is proceeding on finalizing an RI/FS work plan.

3.4.4.3 Remedial Action

There is no active groundwater remediation in the 200-PO-1 OU. The immediate goal for the 200-PO-1 OU is to monitor the contaminants of concern (and potential concern) under the RI/FS process until final cleanup decisions are made. The 200-PO-1 OU fieldwork for the characterization phase of an RI/FS was completed in FY10. In addition to the routine groundwater monitoring within the OU, wells were sampled for site characterization, a baseline risk assessment was completed, geophysical surveys were conducted, advanced techniques were used for borehole logging, and the *Remedial Investigation Report for the 200-PO-1 Groundwater Operable Unit* (DOE/RL-2009-85, Draft A) was provided to the regulators for review in June 2010 with the baseline risk assessment.

Groundwater monitoring at the 200-PO-1 OU supports the RI/FS process under the direction of a work plan and two sampling and analysis plans (one for routine groundwater sampling and a second for characterization to supplement routine groundwater monitoring). Work began on a draft remedial investigation report in FY09 following completion of fieldwork. The work plan and the sampling and analysis plans are summarized below.

Sampling and Analysis Plan for the 200-PO-1 Groundwater OU (DOE/RL-2003-04) was approved in August 2005, to provide groundwater data necessary to track the extent and concentration of contaminant plumes. This sampling and analysis plan (referred to as *Routine Sampling and Analysis Plan*) provides the basis for routine monitoring and analyses of 200-PO-1 OU contaminants of concern for CERCLA and AEA. In CY08, the lists of the wells monitored and groundwater constituents analyzed in groundwater samples were updated to provide additional wells and analytes. The locations of monitoring wells that were sampled to satisfy requirements of the *Routine Monitory Sampling and Analysis Plan* are shown in Figure 54 (near field wells) and Figure 55 (far-field wells).

Remedial Investigation/Feasibility Study Work Plan for the 200-PO-1 Groundwater OU (DOE/RL-2007-31), Rev. 0), was issued in FY08 to define further the conditions within the 200-PO-1 OU. Data acquisition was designed to complement the routine monitoring sampling and analysis plan and to provide new information regarding groundwater flow direction and rates, preferential pathways for contaminant migration, and contaminant mass transport. Appendix A of the work plan includes a remedial investigation sampling and analysis plan (referred to as characterization sampling and analysis plan) that directed: (1) sampling of additional wells to supplement the routine monitoring sampling and analysis plan, (2) opportunistic sampling of vadose zone boreholes when they reached groundwater, (3) sampling wells planned for decommissioning, and (4) sampling of 11 new aquifer tubes.

Figure 53. 200-PO-1 Operable Unit

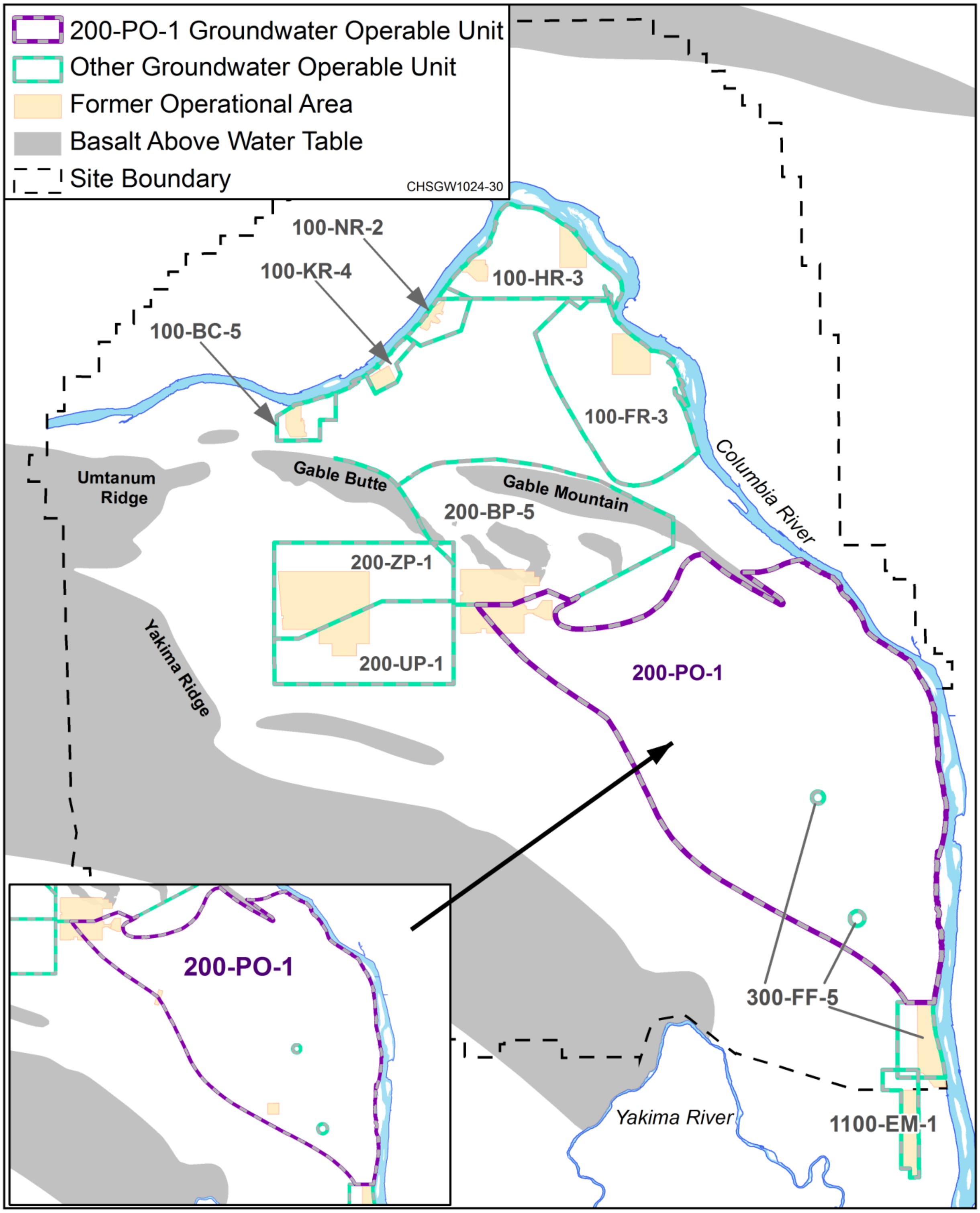


Figure 54. 200-PO-1 Facilities and Wells, Near-Field

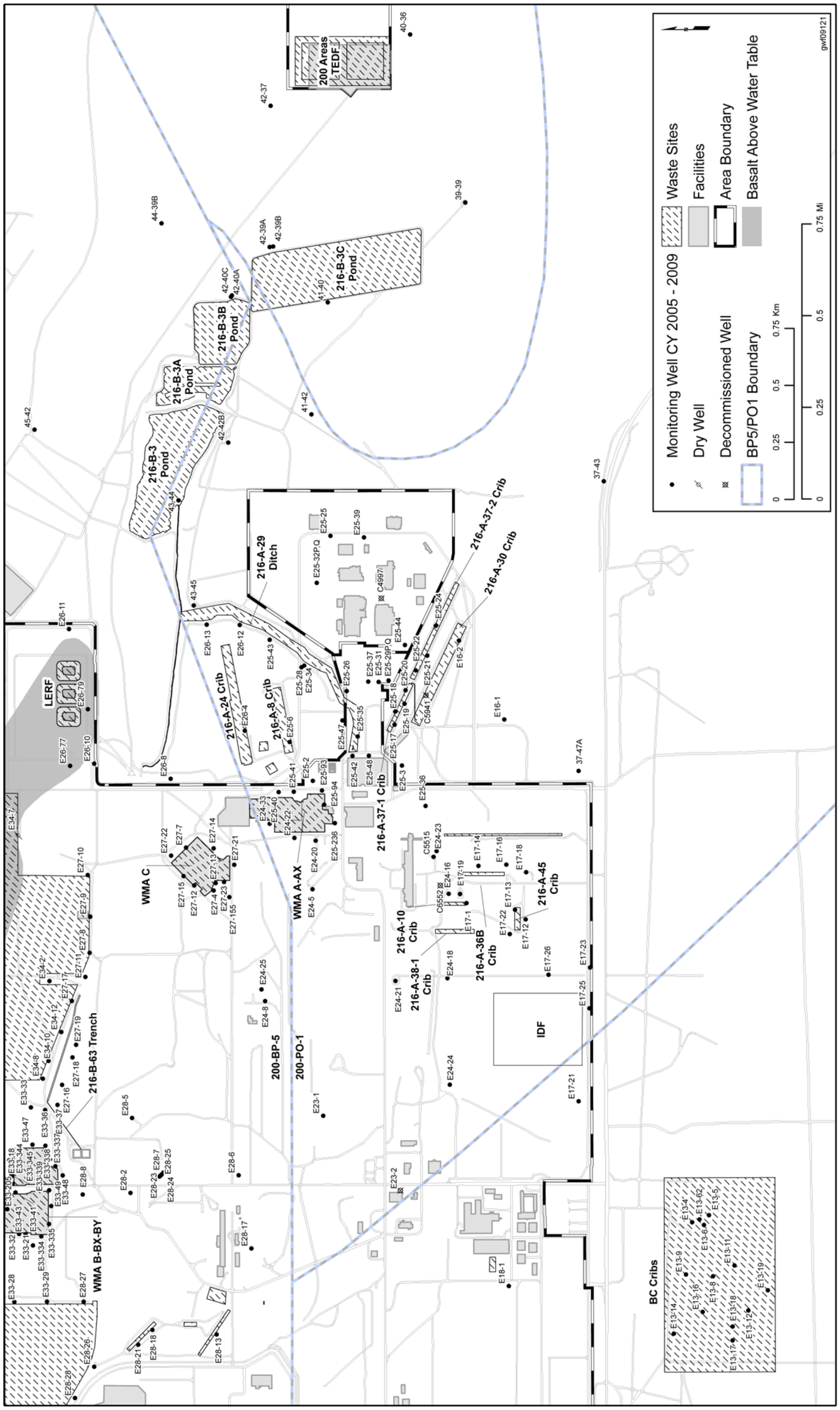
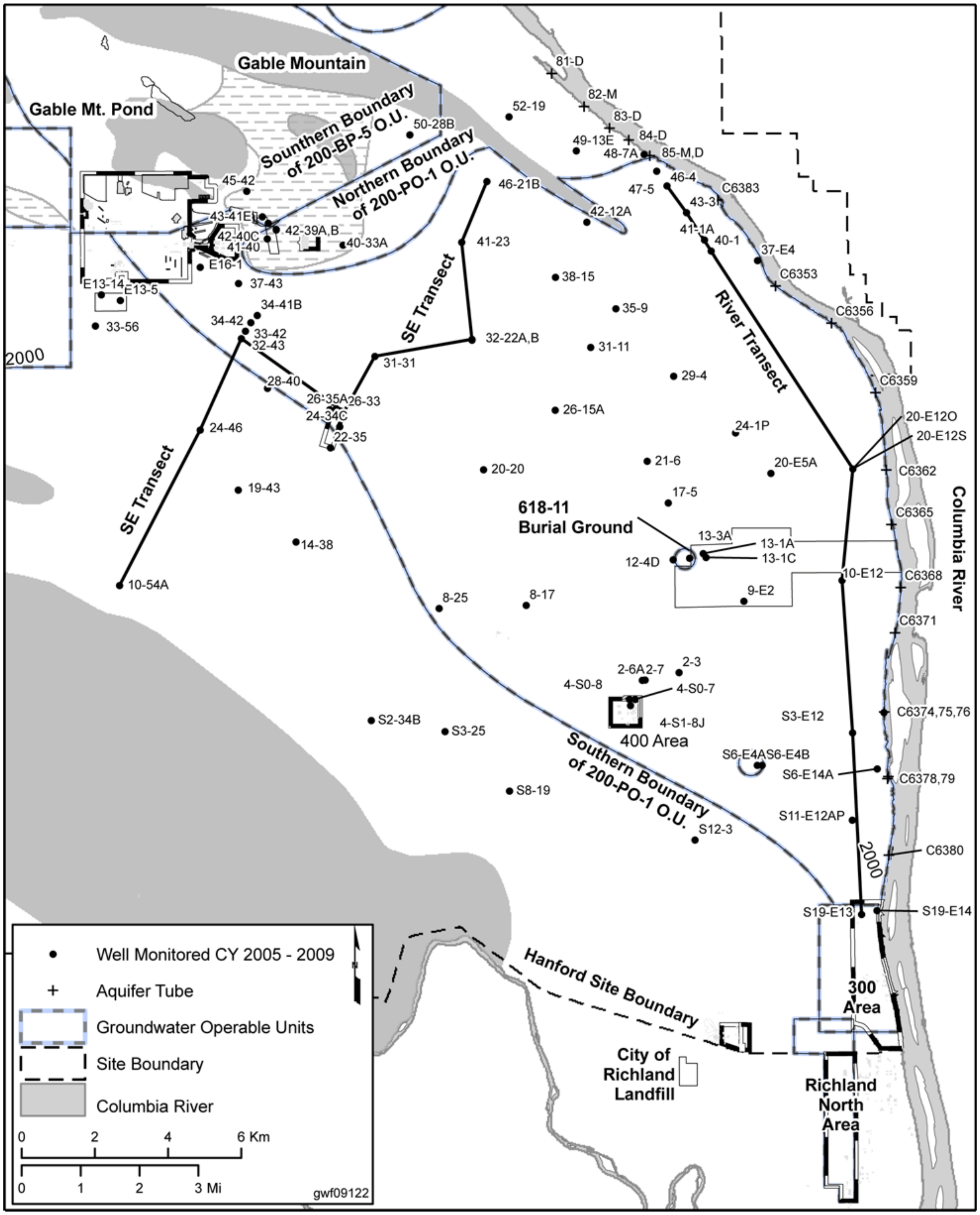


Figure 55. 200-PO-1 Far-Field Wells, and Transects



3.4.4.4 Progress Since 2006 Review

The primary CERCLA accomplishments for the five-year review period included the following:

- Completed of the RI/FS field investigation requirements (including groundwater sampling).
- Conducted of a baseline risk assessment.
- Prepared of the *draft Remedial Investigation Report for the 200-PO-1 Groundwater OU,* DOE/RL-2009-85, Draft A.

The focus of 200-PO-1 OU CERCLA groundwater monitoring during the five-year review period was to continue monitoring the wells in the *Sampling and Analysis Plan for the 200-PO-1 Groundwater Operable Unit* (DOE/RL-2003-04), as well as complete the *Remedial Investigation/Feasibility Study Work Plan for the 200-PO-1 Groundwater Operable Unit* (DOE/RL-2007-31). The results from these groundwater monitoring efforts were provided for the baseline risk assessment (along with historical groundwater and geologic data) to determine a refined physical model and to identify exposure pathways, exposed populations, and ecological exposure. Contaminants of concern listed in the RI/FS work plan include nitrate, iodine-129, strontium-90, technetium-99, tritium, and uranium. Results of the baseline risk assessment will be in the completed remedial investigation report.

Groundwater monitoring results continue to show that tritium, iodine-129, and nitrate are the major plumes that extend from the 200 East Area into the remainder of the 200-PO-1 OU, and also that smaller, more isolated plumes (including strontium-90, technetium-99, and uranium) are located near the PUREX cribs and technetium-99 at WMA A-AX. All of these groundwater contaminants continue to exceed their respective MCLs. Other detected contaminants that are deemed significant to the baseline risk assessment are volatile organic compounds (trichloroethene, tetrachloroethene, 1,1dichloroethene, and carbon tetrachloroethene) that exceeded WAC 173-340-720 limits at the Solid Waste Landfill, Nonradioactive Dangerous Waste Landfill, and PUREX cribs (trichloroethene only at the PUREX cribs). Two contaminants of concern (tritium and nitrate) exceed their respective MCLs at the Columbia River.

3.4.4.5 Technical Assessment

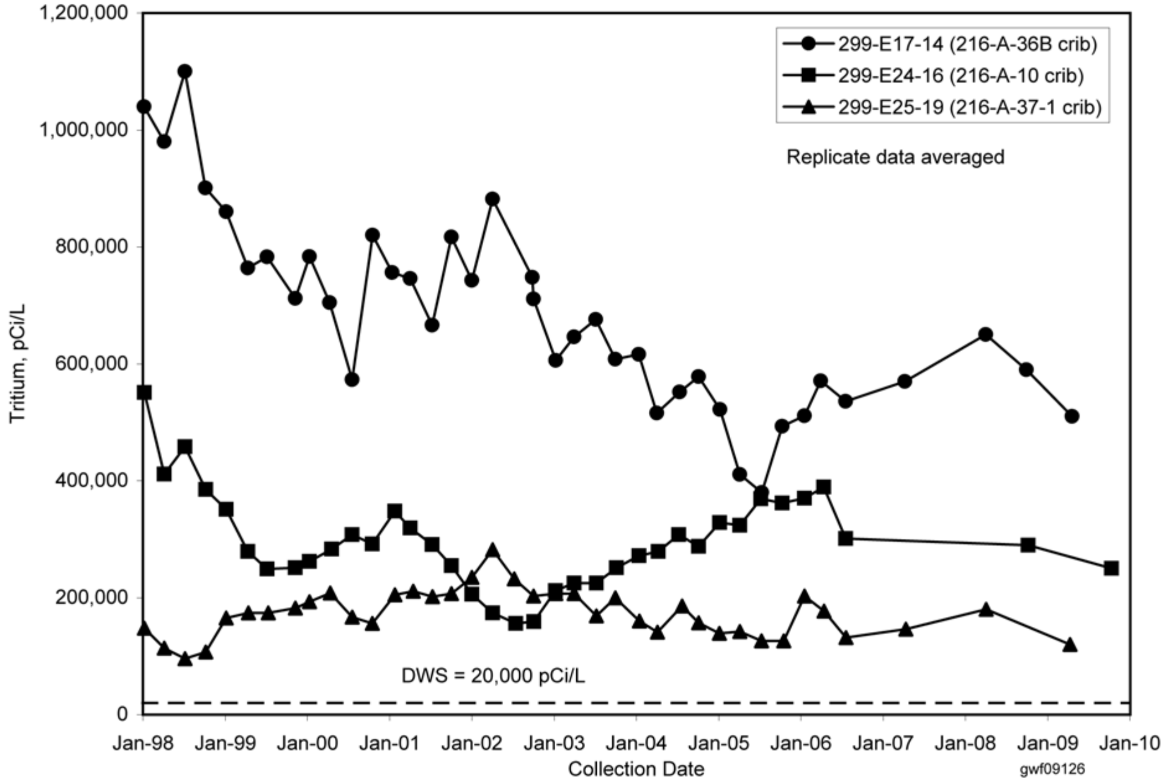
A technical assessment has not been performed since a ROD has not been issued for 200-PO-1 Groundwater OU. However, the following sections describe the major contaminants of concern with the 200-PO-1 OU, which include tritium, iodine-129, nitrate, strontium-90, technetium-99, and uranium. Other contaminants of potential concern are also discussed. The cribs, ponds, and ditches surrounding the PUREX Plant are responsible for most of the groundwater contamination in the 200-PO-1 OU. The plumes that are present primarily contain those species associated with process condensates, including tritium, iodine-129, and nitrate. Some strontium-90 and technetium-99 are also associated with PUREX waste disposal, although technetium-99 is not found above the 900 pCi/L MCL in contaminant plumes from PUREX cribs. Technetium-99 exceeds the MCL near WMA A-AX.

3.4.4.5.1 Tritium

The principal source for the large tritium plume extending from the southeastern portion of the 200 East Area to the Columbia River is near the PUREX cribs (Figure 56). The highest concentrations of tritium (20,000 pCi/L MCL) in this plume remain near these cribs. The highest reported level of tritium during the five-year review period was 510,000 pCi/L for a sample collected in April 2009 near the 216-A-36B crib.

Wells in the near-field area (Figure 57) generally have higher tritium concentrations than wells in the far-field area (Figure 58) because the near-field wells are closer to the source of the tritium. Many of the wells near the PUREX cribs have shown increasing trends over the past 10 years but showed steady to decreasing trends in 2009. The reason for the more recent decrease in tritium concentration near the PUREX cribs is not known, but may be due to changing groundwater flow directions after cessation of wastewater discharges at B Pond. Determining a precise groundwater flow direction near the PUREX cribs is difficult due to the extremely flat water table.

Figure 56. 200-PO-1, PUREX Cribs (RCRA) Wells Tritium Concentrations



Concentrations of tritium generally continue to decline in the far-field area as the plume attenuates naturally due to radioactive decay, advection, and dispersion. Some wells in the northeastern portion of the 200-PO-1 OU have tritium concentrations above 80,000 pCi/L (Figure 57), resulting from an early period of discharge to the PUREX cribs *(Hanford Site Groundwater Monitoring for Fiscal Year 1995)*.

Tritium concentrations in the aquifer tubes are similar to, or lower in concentration than, nearby groundwater monitoring wells. The highest concentration of tritium in aquifer tube C6353 during the five-year review period had an average concentration of 35,500 pCi/L. This area is located southeast of the Hanford Town Site, which corresponds to the highest concentrations of the tritium plume along the Columbia River. Similarly, two water samples taken from shallow sediments in the Columbia River in December 2009 also had elevated tritium concentrations.

Deeper 200-PO-1 OU wells screened, or casings perforated, in the middle or lower portions of the unconfined aquifer had tritium results ranging from non-detect to slightly higher than the 20,000 pCi/L MCL. Tritium was detected in seven of the eight wells sampled in this depth zone, but only one sample exceeded the 20,000 pCi/L MCL. The detection concentrations ranged from 27,000 pCi/L at a well south of B pond to 2,200 pCi/L at a 400 Area water supply well. Other wells in this depth zone where tritium was detected included a 400 Area process pond well, a 216-A-29 ditch well, two other 400 Area water supply wells, a well near the 216-A-37-1 crib, and a 216-B-3 pond well.

Tritium was not detected in the three wells located around the Treated Effluent Disposal Facility, located east of the 200 East Area. Tritium was also not detected in five of six wells monitoring basalt-confined aquifers. This occurrence is consistent with the decreasing heads with depth and the downward groundwater flow caused by extensive B pond wastewater discharges.

Figure 57. 200-PO-1 Tritium Plume, Near-Field

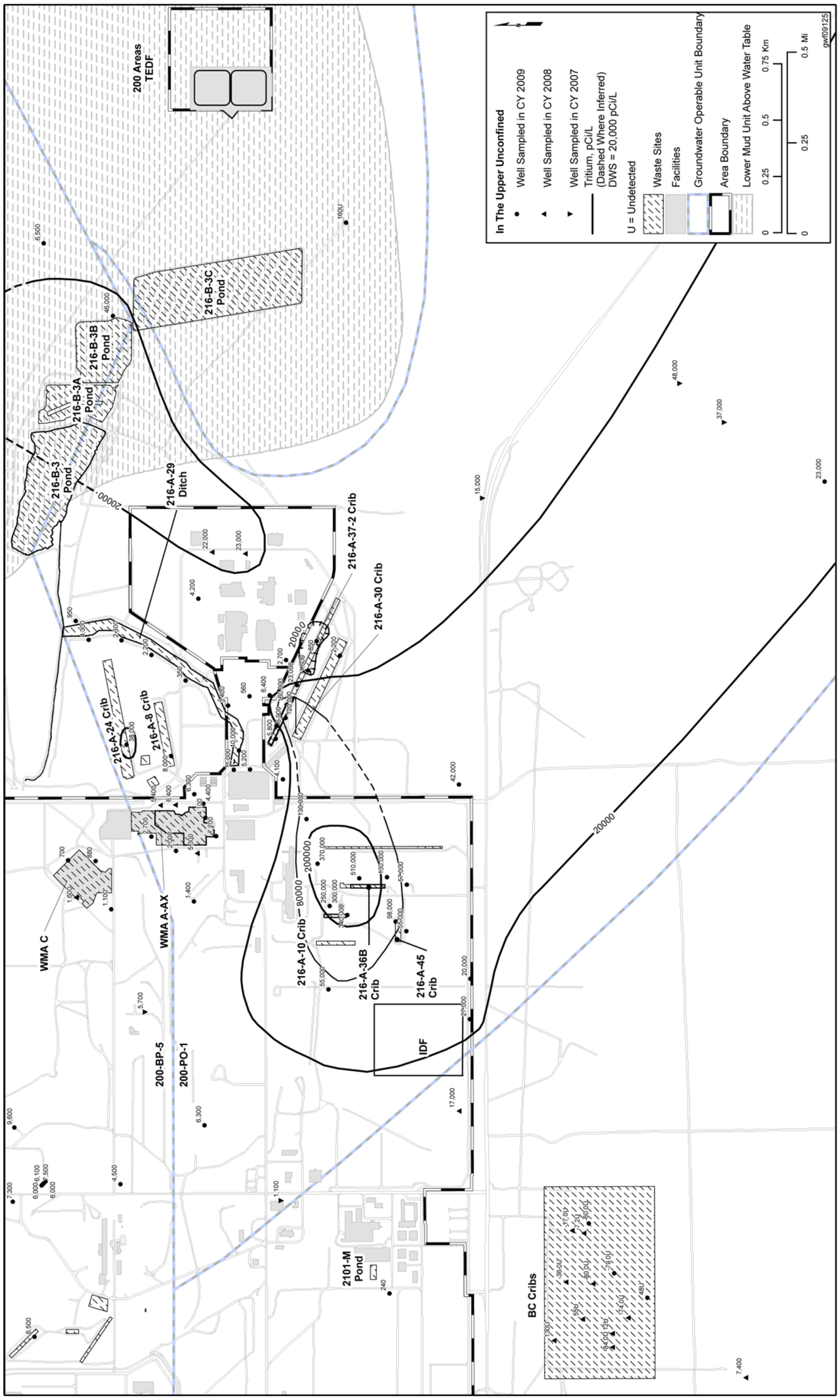
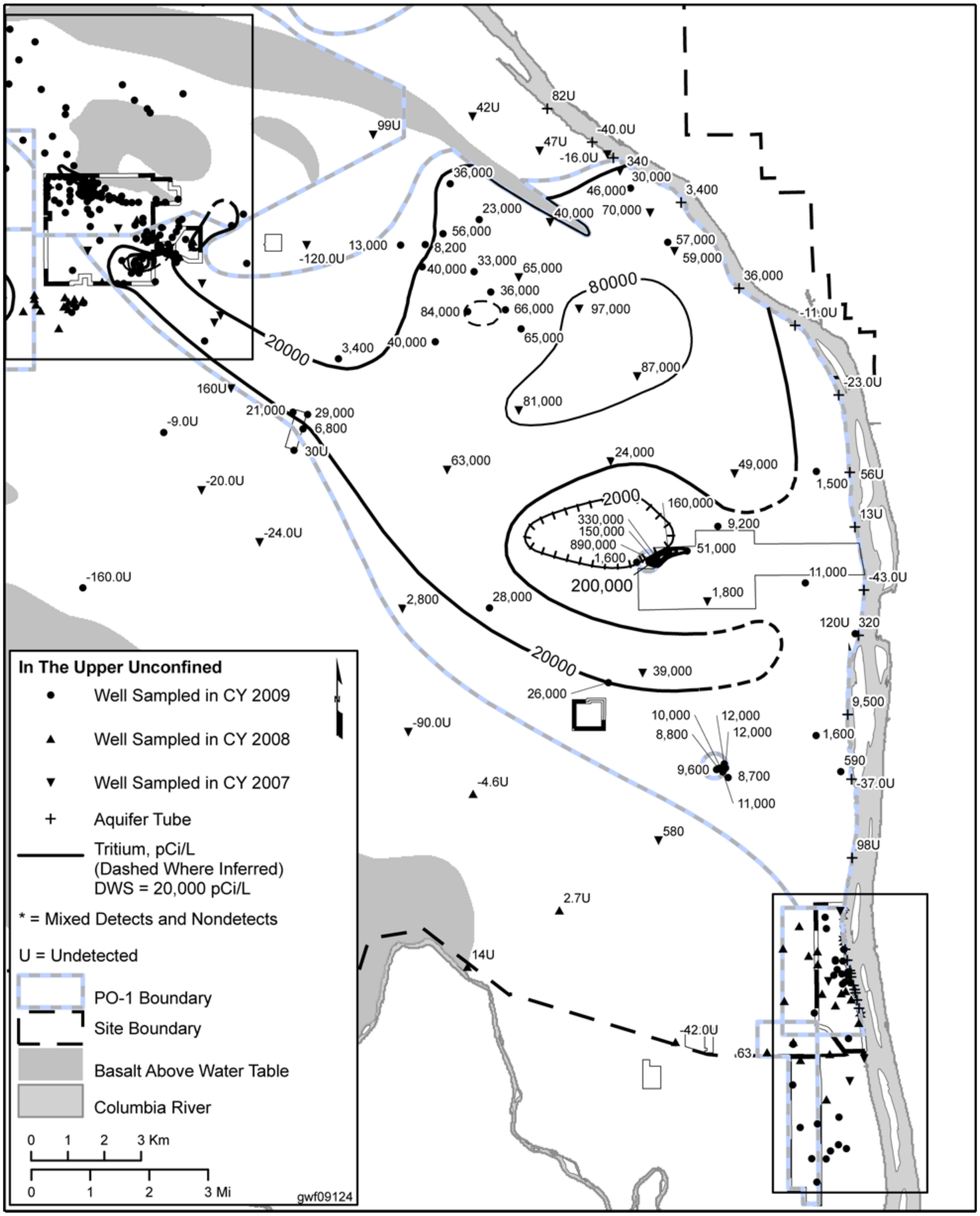


Figure 58. 200-PO-1 Far-Field Wells Tritium Plume



3.4.4.5.2 Iodine-129

The iodine-129 plume (Figure 59) extends southeast into the 600 Area from the 200 East Area and appears to coincide with the northern portions of the tritium plume. During the five-year review period, the highest concentrations of iodine-129 in the plume were near the sources in the 200 East Area and B pond area. The concentrations in this near-field area ranged from non-detect to 9.7 pCi/L at a well near the 216-A-36B crib. Although the trend may be decreasing, sources in the 200 East Area continues to contribute iodine-129 to the large plume, as attested by the persistence of the plume across the northern portions of the 200-PO-1 OU.

Iodine-129 has a half-life of 15.7 million years and a low distribution coefficient (average of 0.2 mL/g and ranging from 0 to 2, depending on aquifer conditions) (PNNL-11800, Addendum 1, Addendum to Composite Analysis of Low-Level Waste Disposal in the 200 Area Plateau of the Hanford Site; PNNL-14702, *Vadose Zone Hydrogeology Data Package for the 2004 Composite Analysis*). With a low retardation factor, the iodine-129 will be expected to disperse more quickly if the plume were not continually replenished. Iodine-129 was generally not detected in deeper wells or in aquifer tubes along the river. Iodine-129 was not detected in any of the 200-PO-1 aquifer tubes during the five-year review period.

3.4.4.5.3 Nitrate

The extent of the nitrate plume (Figure 60) is similar to the tritium plume; however, the portion of the extensive plume that exceeds the MCL (45 mg/L) is relatively small when comparing overall size. Nitrate at levels above the MCL north of the 400 Area and at the Energy Northwest complex (within the area impacted by the PUREX cribs) can be attributed to wastewater disposal activities in those areas. During the five-year review period, the highest nitrate concentration in the 200-PO-1 OU was at wells near the PUREX cribs. The nitrate plume, with sources in the 200 East Area, appears to have dispersed slightly over previous years, except near the PUREX cribs (*Hanford Site Groundwater Monitoring for Fiscal Year 2005*; *Hanford Site Groundwater Monitoring for Fiscal Year 2007*) and WMA A-AX. Another nitrate plume with offsite sources exists near the 300 Area. Nitrate concentrations from samples collected from aquifer tubes during the five-year review period range from very low levels (groundwater diluted with river water) up to 32.8 mg/L located southeast of the Hanford Town Site. The aquifer tube results are generally similar to or lower than concentrations in nearby wells.

Many of the wells near the PUREX cribs in the southeastern portion of the 200 East Area have had increasing nitrate concentrations in recent years. Increasing nitrate concentrations were also observed at WMA A-AX. The cause of the increase in nitrate concentrations at many of the wells in the southeastern portion of the 200 East Area is unknown but may be the result of shifting groundwater flow directions related to cessation of wastewater discharges at B pond or continued seepage from the vadose zone near the PUREX cribs and WMA A-AX.

3.4.4.5.4 Strontium-90

A localized area of strontium-90 (a beta emitter) contamination exists at the PUREX cribs. There was one well with strontium-90 concentrations above the 8 pCi/L MCL during the five-year review period 11 pCi/L. Strontium-90 was not detected at other wells near the PUREX cribs during the five-year review period. Strontium-90 was not detected in any of the wells screened (or perforated) in the middle to lower portions of the unconfined aquifer; below the Ringold lower mud unit or basalt-confined aquifers.

Figure 59. 200-PO-1 Iodine-129 Plume

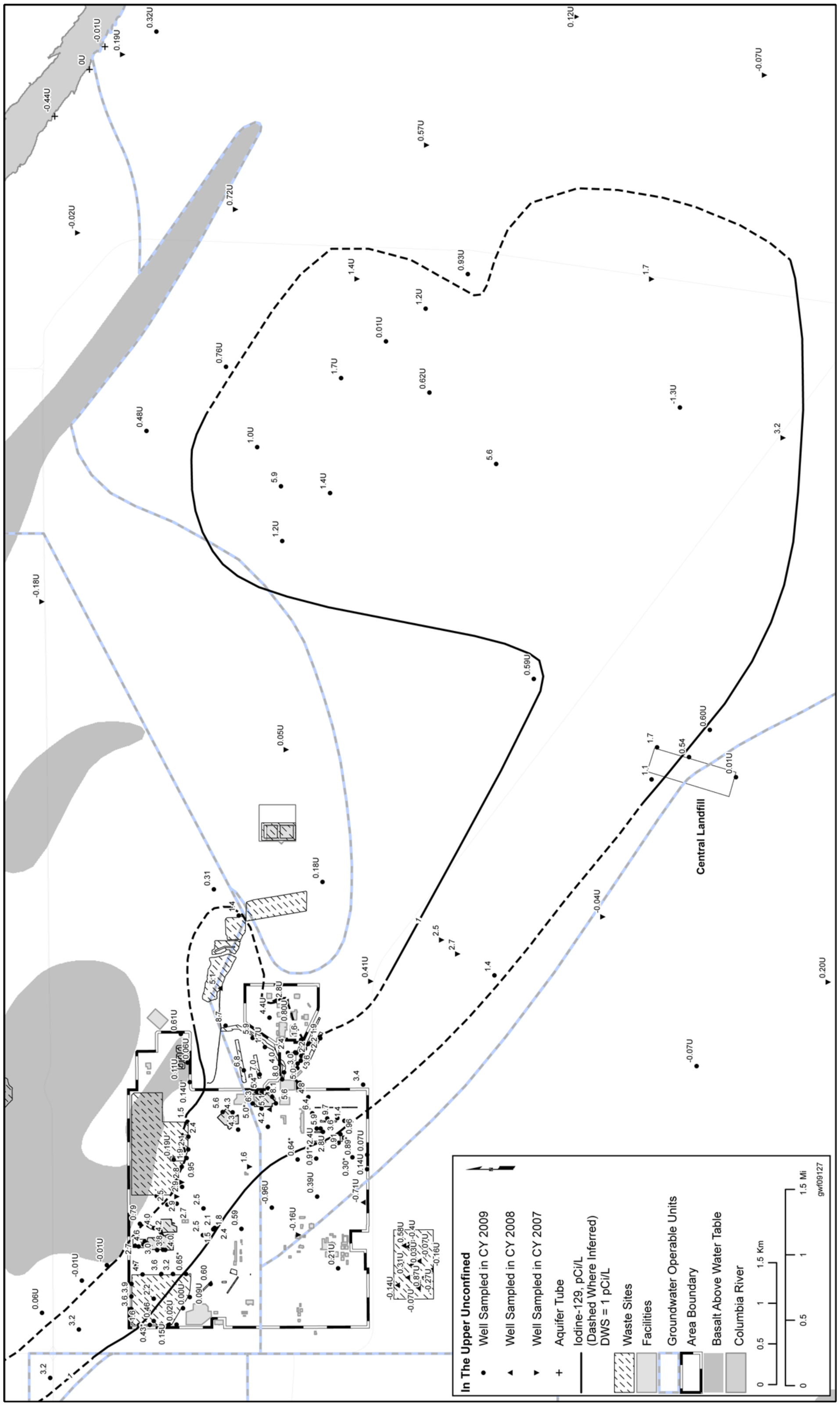
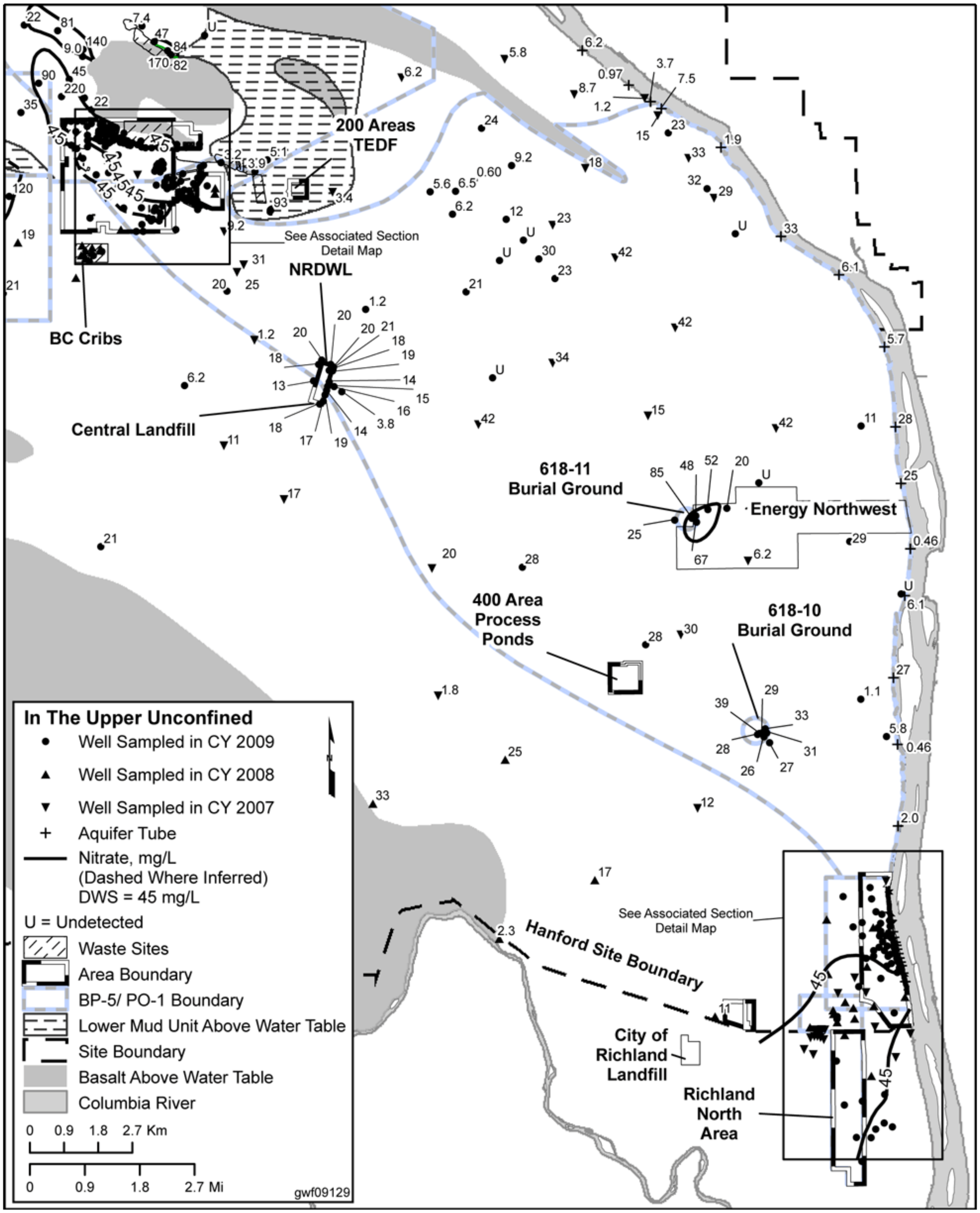


Figure 60. 200-PO-1 Nitrate Plume, Far-Field



3.4.4.5.5 Technetium-99

Technetium-99 (a beta emitter) continues to be detected at WMA A-AX at levels well above the 900 pCi/L MCL. Technetium-99 is above the MCL at the WMA A-AX upgradient well with results ranging from 800 to 1,100 pCi/L. Technetium-99 was also detected near the PUREX cribs (up to 250 pCi/L) and at well 699-26-33 (average of 308 pCi/L) near the Nonradioactive Dangerous Waste Landfill. Concentrations were detected at other locations, including the aquifer tubes, within the 200-PO-1 OU but not at concentrations above 100 pCi/L. Technetium-99 was not detected in the deeper wells.

3.4.4.5.6 Uranium

In recent years, uranium concentrations have been increasing in wells near the PUREX cribs (Figure 61). The Hanford Site background concentration at the 95th percentile is 14.4 µg/L (*Hanford Site Background: Part 3, Groundwater Background*, DOE/RL-96-61). The trend has been increasing since CY05, and the concentration has reached the 30 µg/L MCL. In the two other nearby wells, concentrations are higher, with the highest concentration at 92 µg/L.

At the 618-10 and 618-11 landfills, uranium concentrations have reached or slightly exceed the 14.4 µg/L background concentration; however, these are sites of known uranium concentration in the 300-FF-5 OU. Elsewhere, including in the aquifer tubes and deeper wells, uranium concentrations are within the background range.

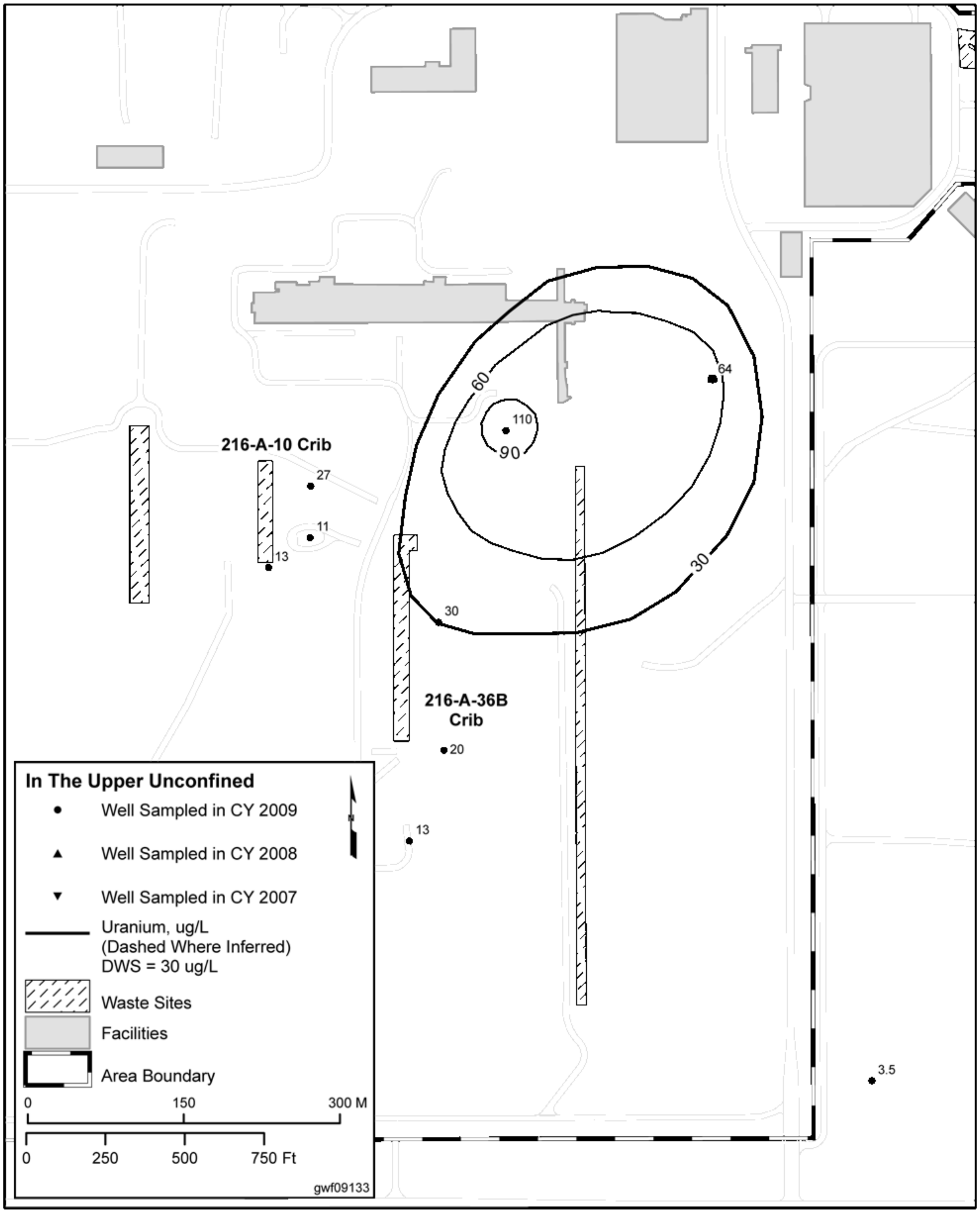
Vanadium concentrations ranged from the method detection limit of 12 µg/L to 45.7 µg/L for a filtered sample collected at a well located at the southeast end of the 216-A-30 crib. The trend for vanadium has increased slightly at this well since 2006. Vanadium is detected in wells throughout the 200-PO-1 OU. The 95th percentile background level for vanadium is approximately 19 µg/L. Vanadium does not have an MCL.

Groundwater monitoring is routinely conducted at three wells in the BC cribs and trenches. The results from these wells show that the contaminants of potential concern (i.e., chromium, cobalt-60, cyanide, and uranium), as well as the 200-PO-1 OU major contaminants of concern, were either not detected or were similar to background (upgradient) concentrations in the BC cribs and trenches.

3.4.4.6 Protectiveness Statement

A protectiveness determination of the remedy at 200-PO-1 Groundwater OU cannot be made at this time until further information is obtained by completing the RI/FS process. Once the RI/FS is completed, a proposed plan will be issued to the public for review and comment.

Figure 61. 200-PO-1, Local Uranium Plume near the PUREX Cribs



4 300 AREA

4.1 Background

The 300 Area is located along the Columbia River north of the Richland, Washington, city limits in the southeast portion of the Hanford Site (Figure 62). In 1998, the EPA placed the 300 Area, which includes three OUs on the NPL. The 300 Area includes a 0.52 square miles (1.35 km^2) industrial complex area that was used for uranium fuel fabrication and research and development activities for the Hanford Site; an unlined liquid disposal area north of the industrial complex area; and burial grounds, landfills, and miscellaneous disposal sites associated with operations in the industrial complex. The 300-FF-1 and 300-FF-2 OUs address contaminated soil, debris, and landfills associated with 300 Area operations, and the 300-FF-5 OU covers the contaminated groundwater under the 300-FF-1 and 300-FF-2 OUs.

Use of the 300 Area began in 1943. The 300 Area facilities were primarily associated with reactor fuel fabrication and research and development activities for the Hanford Site. During the period of operation (most operations ended before or during the 1990s), fuel fabrication and laboratory facilities disposal practices, spills, and other unplanned releases resulted in contamination of the facilities, surface, underlying soil column, and groundwater. Waste from 300 Area operations was also purposefully disposed of in unlined landfills and burial grounds and discharged to unlined surface ponds and trenches. Figure 62 depicts the 300 Area OUs. The primary contaminant in many of the waste sites is uranium from the fuel fabrication process. However, additional contaminants such as plutonium, beryllium, metals, and petroleum, are expected throughout the landfills, either because of materials being used in the fuel fabrication process, or because of laboratory and development activities that historically took place in the 300 Area facilities. Chlorinated organics' associated with fuel fabrication or laboratory activities were also identified as contaminants in the 300 Area.

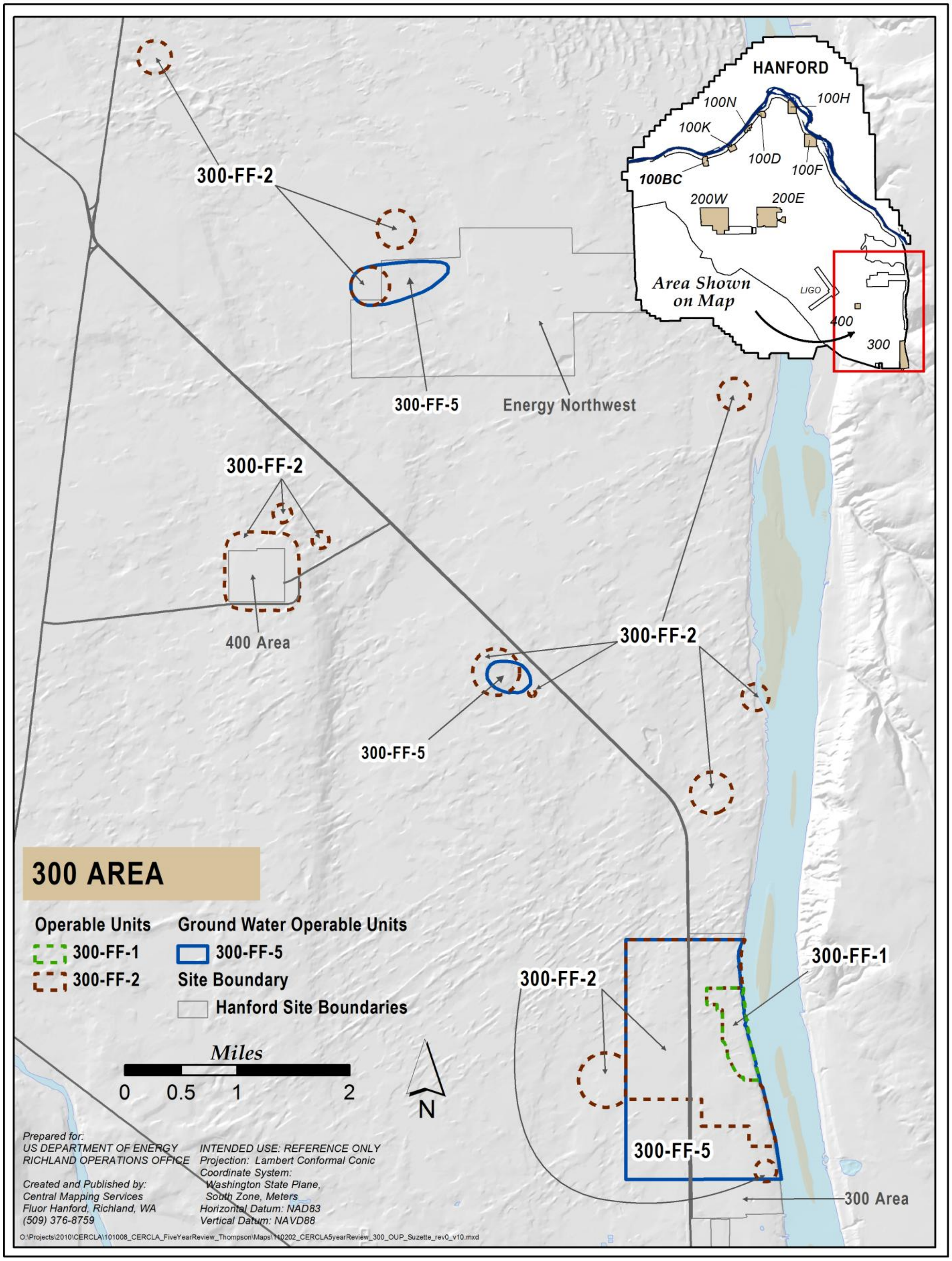
The primary cleanup actions involve the removal of contaminated soil and debris; treating the material, as appropriate, to reduce the toxicity, mobility, or volume of waste; disposing of the material in an appropriate long-term waste management facility; backfill, re-vegetation, and where appropriate, establishment of institutional controls. Majority of the waste from the 300 Area cleanup has been disposed of at ERDF in the 200 West Area of the Hanford Site.

The 300-FF-1 remedial actions selected in the 300-FF-1 ROD (EPA/ROD/R10-96/143) were completed and a remedial action report issued documenting completion.

The 300-FF-2 cleanup activities are still in progress at 300-FF-2 waste sites, as well as demolition of surplus facilities in the 300 Area. Since the issuance of the ROD (EPA/ROD/R10-01/119) and *Explanation of Significant Differences for the 300-FF-2 Operable Unit Record of Decision* in 2004, ongoing cleanup efforts in the 300 Area have identified 14 additional waste sites which fit the profile for the remove, treat, and dispose remedy selected in the ROD. These waste sites were added in 2009, *Explanation of Significant Differences for the 300-FF-2 Operable Unit Interim Action Record of Decision*. Two additional waste sites have been identified which meet the profile in the ROD as candidate sites for characterization sampling; the new sites were added to the ROD.

The 300-FF-5 OU includes groundwater contamination originating from waste sites identified in the 300-FF-1 and 300-FF-2 OUs. Groundwater contamination originating from waste sites in the 200 Area NPL migrating beneath the 300 Area NPL Site are not included in the 300-FF-5 OU. The remediation approach identified in the existing interim action ROD for contaminated groundwater in the 300 Area is to monitor the groundwater to ensure that contamination levels are attenuating through natural processes in a reasonable time. The CERCLA five-year review performed in 2006 identified that natural attenuation was not effective in meeting groundwater remediation goals in an acceptable period. A RI/FS is underway to assess and recommend alternative remediation approaches.

Figure 62. 300 Area Operable Units



The 300-FF-5 OU ROD was expanded through an ESD (EPA/ESD/R10-00/524) to include all groundwater contamination beneath the soil waste sites and landfills. The current decision for contaminated groundwater in the 300 Area is to monitor the groundwater to ensure that contamination levels are attenuating through natural processes in a reasonable period, which was estimated to be 3 to 10 years based on modeling performed at the time of the ROD.

4.2 Chronology

The following summarizes the chronology of decision documents and action memoranda relevant to CERCLA response actions in the 300 Area.

300-FF-1 Operable Unit

7/17/1996	EPA/ROD/R10-96/143	ROD: 300-FF-1 and 300-FF-5 Interim Action ROD – removal, treatment, monitoring
1/12/2000	EPA/ESD/R10-00/505	ESD: ROD for 300-FF-1 OU Site-Specific Variance from Land Disposal Restrictions Treatment Standard for Lead

300-FF-2 Operable Unit

4/4/2001	EPA/ROD/R10-01/119	ROD: 300-FF-2 OU Interim Actions – removal, treatment, monitoring
5/2004	DOE/AR 0061318	ESD: 300-FF-2 OU ROD – soil cleanup level
8/2009	AR/PIR 0096132	ESD: 300-FF-2 OU Interim Action ROD

300-FF-5 OU Operable Unit

6/15/2000	EPA/ESD/R10-00/524	ESD: 300-FF-5 OU ROD – Expansion of 300-FF-5 scope, increased monitoring and new operation and maintenance plan

General Decommissioning

7/13/1991	91-ERB-039	Expedited Response Action: 618-9 Burial Ground (remove and dispose of drums containing uranium-contaminated hexone)
7/15/1991	AR/PIR D196069898	Action Memorandum: 316-5 Process Trenches (Expedited Response Action to remove soil from the 300 Area Process Trenches)
7/8/1992	AR/PIR D196102556	Approval to Proceed on Expedited Response Action at the 618-11 Burial Grounds
2/15/2000	DOE 00-ORL-030	Action Memorandum: 331-A Virology Laboratory Building, (demolition, removal, and disposal of building)
1/2005	AR/PIR D7135498	Action Memorandum: 300 Area Facilities #1 Action Memo
5/2006	AR/PIR DA02553852	Action Memorandum: 300 Area Facilities #2 Action Memo
11/30/2006	07-AMRC-0046	Action Memorandum: 300 Area Facilities #3 Action Memo
4/2010	DOE/RL-2010-22	Action Memorandum: General Hanford Site Decommissioning Activities

4.3 Crosscutting Issues and Actions from the 2006 Five-Year Review

Below are the crosscutting issues identified in the 2006 five-year review and response actions taken to resolve the issues for the 300 Area OUs.

100 and 300 Area Crosscutting Issues	Actions Taken/Actions Proposed
Issue 1. Additional risk assessment information is needed to evaluate the interim actions prescribed within the RODs and to develop final cleanup decisions.	
Action 1.1. Submit *Draft A of the River Corridor Baseline Risk Assessment Report*.	Draft A of the Risk Assessment Report for the 100 Area and 300 Area Component of the River Corridor, Draft A was submitted in June 2007, to meet TPA Milestone M-16-72. Draft C of the River Corridor Baseline Risk Assessment Volume II Human Health Risk Assessment, was issued in December 2010 (DOE/RL-2007-21, Part 1 and DOE/RL-2007-21, Part 2). This completed Action 1-1 from the 2006 five-year review.

100 and 300 Area Crosscutting Issues	Actions Taken/Actions Proposed
Action 1.2. Submit draft sampling and analysis plan for Inter-Areas Shoreline Assessment.	Draft A of the sampling and analysis plan for Inter-Areas Shoreline Assessment was submitted in 2006. This completed Action 1-2. The Inter-Areas Shoreline Assessment sampling was completed in accordance with the plan and results will be reflected in Draft B of the risk assessment report.
Issue 2. A strategy to obtain the final RODs and integrate the waste sites, deep vadose zone, and groundwater has not been developed and agreed upon with the regulator agencies.	
Action 2.1. Submit Draft A of the River Corridor Strategy for Achieving Final Cleanup Decision in the River Corridor. The document will identify issues for integration and provide alternatives for future milestone discussions between the Tri-Parties for a final ROD in the River Corridor.	The Tri-Parties met in 2009 and agreed upon a strategy on how to obtain final decision for 100 and 300 Area OUs by providing integrated RI/FS documents for surface, vadose zone, and groundwater for geographic areas in the 100 and 300 Areas. DOE/RL-2008-46, which integrated the 100 Area RI/FS Work Plan, contains this integrated strategy. Subsequent addendums will evaluated the data needs for geographic areas in the 100 and 300 Areas, and if necessary, propose a sampling and analysis plan to gather the necessary data.

4.4 300-FF-1 Operable Unit

4.4.1 Background

The 300-FF-1 OU covers an area of approximately 117 acres (47.4 hectares) and contains many of the current and past 300 Area liquid waste disposal units. The 300-FF-1 OU is bounded on the east side by the Columbia River and on the north, south, and west sides by the 300-FF-2 OU. The 300-FF-1 OU includes the major 300 Area liquid and process waste disposal sites, the 618-4 burial ground, and three small landfills. The liquid and process waste disposal sites were unlined trenches and ponds that received discharges of millions of gallons of contaminated wastewater. These liquid and process waste disposal sites are suspected to be the primary source of uranium contamination in the groundwater beneath the 300 Area. The remedial action objectives from the selected remedy in the 1996 ROD are provided in Section 4.4.3.

4.4.2 Chronology

In July 1996, the 300-FF-1 OU ROD (EPA/ROD/R10-96/143) was issued. The selected remedy in the ROD was removal of contaminated soil and debris, treatment as necessary, and disposal of the waste in ERDF. Institutional controls were required as part of the remedy because the cleanup will leave waste in place and not allow for unrestricted use.

In January 2000, EPA issued an ESD to the ROD (EPA/ESD/R10-00/505) for 300-FF-1 to grant a site-specific treatability variance for a small quantity of soil and debris (1,210 cubic yards [925 cubic meters]) in one 300-FF-1 waste site (Landfill 1D) so that it could be removed from the 300 Area and disposed of in ERDF. The ESD resulted in a reduction in cleanup cost and complexity, while maintaining protection for human health and the environment.

4.4.3 Remedial Actions

Remedial actions at the 300-FF-1 OU began in CY97 and were complete by CY04. The selected remedy and remedial action objectives established in the 300-FF-1 ROD (EPA/ROD/R10-96/143) have been met. Three 300-FF-2 waste sites were also remediated in conjunction with 300-FF-1, including 300-10, 300-45, and 618-5 burial ground. An evaluation of the *300-FF-1 Operable Unit Remedial Action Report* (DOE/RL-2004-74) was performed which documents completion and outlines the submittal of cleanup verification packages submitted.

300-FF-1 Operable Unit Remedial Action Objectives

Remedial Action Objective 1	Protect human and ecological receptors from exposure to contaminants in soil and debris by exposure, inhalation, or ingestion of radionuclides, metals, or organics. This remedial action objective will be achieved through compliance with the MTCA (Model Toxics Control Act) cleanup values for organic and inorganic chemical constituents in soil to support industrial land use (WAC 173-340-745), and the draft EPA and draft Nuclear Regulatory Commission proposed protection of human health standards of 15 millirem/year in soils above background for radionuclides.
Remedial Action Objective 2	Protect human and ecological receptors from exposure to contaminants in the groundwater and control the sources of groundwater contamination in 300-FF-1 to minimize future impacts to groundwater resources. This remedial action objective will be achieved by attaining MCLs and non-zero MCLGs promulgated under the SDWA implementing regulations (40 CFR 141). The specific location and measurements of the compliance monitoring will be documented in an operations and maintenance plan for the 300-FF-5 OU, which will be approved by EPA. In addition, the contaminants remaining in the soil after remediation will not result in further degradation of groundwater quality.
Remedial Action Objective 3	Protect the Columbia River such that contaminants in the groundwater or remaining in the soil after remediation do not result in an impact to the Columbia River that could exceed the Washington State Surface Water Quality Standards (WAC 173-201A). The protection of the river will be achieved by preventing further degradation of groundwater quality in the uranium plume such that receptors that may be affected at the groundwater discharge point to the Columbia River are not subject to any additional incremental adverse risks. The specific location and measurements of the compliance monitoring will be documented in an operations and maintenance plan for the 300-FF-5 OU, which will be approved by EPA.

4.4.4 Progress Since 2006 Review

For the source (soil) sites in the 300-FF-1 OU, cleanup under a final ROD (EPA/ROD/R10-96/143) was completed prior to 2006, for all of the contaminants of concern. No additional remediation work associated with the 300-FF-1 OU was undertaken during this review period.

4.4.5 Technical Assessment

The purpose of the five-year review is to determine whether the remedy at a site is, or upon completion will be, protective of human health and the environment. The following is the technical assessment response of the 300-FF-1 remedy concerning the technical assessment questions provided in the EPA guidance. The following also establishes a framework for organizing and evaluating data and ensuring that all relevant issues are considered when determining the protectiveness of the remedy.

Is the remedy functioning as intended by the decision document?

The interim remedy is functioning as planned.

Are the exposure assumptions, toxicity data, cleanup levels, and remedial action objectives used at the time of remedy selection still valid?

The exposure assumptions, toxicity data, cleanup levels, and remedial action objectives used at the time of remedy selection are still valid for all OUs.

When considering whether the exposure assumptions, toxicity data, cleanup levels, and remedial action objectives are still valid, the review focused on the risk parameters on which the original remedy decision was based, as well as changes to target populations, exposure pathways, site characteristics, land use, and ARARs.

Has any other information come to light that could call into question the protectiveness of the remedy?

No new information is known that could call into question the protectiveness of the remedy.

When considering whether any other information came to light that could call into question the protectiveness of the remedy, the review focused on whether ecological risks had been adequately evaluated and addressed or whether new ecological risk information had become available.

4.4.6 Protectiveness Statements

The remedy at 300-FF-1 OU was selected under a ROD, and is protective of human health and the environment, because cleanup standards were met and are within the acceptable risk range. However, the *River Corridor Baseline Risk Assessment* will re-evaluate this OU again, and final decisions will be made for source sites adjacent to the 300-FF-1 OU (i.e., waste sites in the 300-FF-2 OU) to ensure long-term protectiveness.

4.5 300-FF-2 Operable Unit

4.5.1 Background

The original 300-FF-2 OU contained 56 waste sites. Forty waste sites were located beneath facilities and/or covered areas inside the 300 Area industrial complex fences. Seven waste sites were outside the industrial complex fences, seven general content burial grounds were in the vicinity of the 300 Area (one was beneath a building in the complex area); and two burial grounds containing transuranic-contaminated material are north of the 300 Area fenced complex. Fourteen waste sites were identified and added to the 300-FF-2 OU with the *Explanation of Significant Differences for the 300-FF-2 Operable Unit Interim Action Record of Decision* (AR/PIR 0096132, August 2009). This ESD also identified two candidate sites for characterization and potential inclusion for 'plug in' to the 300-FF-2 OU selected remedy.

4.5.2 Chronology

The 300-FF-2 ROD (EPA/ROD/R10-01/119) was issued in April 2001. The selected remedy requires removal of contaminated soil, structures, and associated debris; treatment if necessary to meet the waste acceptance criteria of the acceptable disposal facility; and disposal in ERDF, the Waste Isolation Pilot Plant, or other disposal facilities approved by EPA. The 300-FF-2 OU ROD remedial action objectives are provided in Section 4.2.

The *Explanation of Significant Differences for the 300-FF-2 Operable Unit Record of Decision* was issued in May 2004 to revise the soil cleanup standard for uranium concentrations in contaminated soil and to modify the soil cleanup levels for eight specific waste sites in the 300-FF-2 OU from industrial to unrestricted use. The original ROD (EPA/ROD/R10-01/119) required an engineering study to define more accurately the leachability and mobility of uranium in 300 Area soil. Because of the study, the soil cleanup level for uranium (industrial) changed from 350 pCi/g to 267 pCi/g.

The *Explanation of Significant Differences for the 300-FF-2 Operable Unit Interim Action Record of Decision* was issued in August 2009. This document added fourteen new 300 Area Complex waste sites that were identified in the 300-FF-2 OU to the remove, treat, and dispose remedy selected in the 300-FF-2 ROD. The ESD also added two additional sites for potential 'plug-in' to the remove, treat, and dispose remedy if characterization sampling shows that the sites require remediation. Finally, the ESD established a new public notification process for adding newly discovered waste sites to the remove, treat, and dispose remedy. Under this process, remediation may proceed on such sites as long as the cumulative cost associated with the work does not exceed 50 percent of the total estimate provided in the ROD. An annual fact sheet will document the addition of waste sites plugged-in to the remove, treat, and dispose remedy under this approach.

4.5.3 Remedial Actions

Remedial actions in the 300-FF-2 OU waste sites are ongoing. Eight remotely located waste sites are using cleanup standards that will allow for unrestricted use, and the remaining waste sites are being remediated to industrial use cleanup standards. Work in burial grounds at the 300-FF-2 OU has been progressing and presents additional challenges. Waste segregation and sorting operations are necessary to discover unknown waste and waste requiring treatment prior to disposal. Waste staging areas are located adjacent to the burial grounds to allow a sufficient area to further segregate and sort material. Treatment of waste may be necessary and the location of the treatment operations may be performed at the 300 Area, ERDF, or offsite. Since waste piles require sorting and segregation, the potential for spreading contamination is high in the event of high winds. The existing air-monitoring plan identifies the necessary controls to minimize fugitive dust.

300-FF-2 Operable Unit Remedial Action Objectives

Remedial Action Objective 1	Prevent or reduce risk to human health, ecological receptors, and natural resources associated with exposure to waste or soil contaminated above ARARs or risk-based criteria. For radionuclides, this remedial action objective means prevention or reduction of risks from exposure to waste or contaminated soil that exceed the CERCLA cumulative excess cancer risk range of 10-4 to 10-6[a]. For chemicals, this item means prevention or reduction of risk from direct contact with waste or contaminated soil that exceed the MTCA cumulative excess cancer risk goal of 10-5 and/or a hazard index of 1[b].
Remedial Action Objective 2	Prevent migration of contaminants through the soil column to groundwater and the Columbia River such that concentrations reaching groundwater and the river do not exceed MCLs and non-zero MCLG goals under: • Federal SDWA implementing regulations (40 CFR 141) and/or Washington State DWS (WAC 246-290) • Ambient water quality criteria for protection of freshwater aquatic organisms under the federal Clean Water Act implementing regulations (40 CFR 131) and/or Washington State surface water quality standards (WAC 173-201A) • MTCA groundwater cleanup standards (WAC 173-340-720).
Remedial Action Objective 3	Prevent or reduce occupational health risks to workers performing remedial action.
Remedial Action Objective 4	Minimize the general disruption of cultural resources and wildlife habitat, and prevent adverse impacts to cultural resources and threatened or endangered species.
Remedial Action Objective 5	Ensure that appropriate institutional controls and monitoring requirements are in place to protect future users at a remediated site.

[a] The Tri-Parties have chosen 15 millirem/year above background over a period of 1,000 years after final remediation for a maximally exposed individual to address this remedial action objective. Meeting this objective will also be protective of ecological receptors based on criteria specifying that dose rates shall not exceed 0.1 radionuclide/day for terrestrial organisms and 1.0 radionuclide/day for aquatic organisms and terrestrial plants.

[b] Direct contact values may have to be adjusted further to be protective of terrestrial plants and animals depending on the location of the individual waste site and the nature of the surrounding habitat.

Note: For most radionuclides, MCLs correspond to a cumulative dose of 4 millirem per year.

Excavation of the 316-4 waste site began in CY04 with excavation continuing into early CY05. Uranium is the primary contaminant. The uranium concentrations increase with depth. Further excavation appears to be necessary. Excavating deeper will require benching; based on the location of the 618-10 burial ground, benching and maintaining safe slopes will infringe on the 618-10 burial ground boundary. Further excavation at 316-4 has been postponed until remediation of the 618-10 burial ground. The site was backfilled in August 2005 for safety reasons.

Three waste sites in the 300-FF-2 OU were remediated as part of the 300-FF-1 cleanup actions. These sites were 300-10, 300-45, and 618-5 burial ground. Cleanup activities were complete by CY04. Cleanup actions on other 300-FF-2 waste sites have been ongoing since CY04. In CY08, remediation work began inside the 300 Area fence. As of CY10, remediation activities are being conducted across of the 300 Area.

4.5.4 Progress Since 2006 Review

The 300-FF-2 OU (300 Area source [soil] sites) cleanup has occurred, is ongoing, or will occur.

Since the 2006 five-year review, the following waste sites have been remediated and are documented in Waste Site Cleanup Verification Packages and Remaining Waste Sites Verification Packages.

300-FF-2 Operable Unit

300-8 aluminum shavings area	600-243 petroleum contaminated soil
300-18 surface contaminated area	600-259 special waste form lysimeter
300-109 333 building stormwater runoff	600-259-1 lysimeter
300-110 333 building stormwater runoff	600-290:1 pad/loading dock near 618-13
300-275 potential landfill on river edge	600-47 dumping area
333 east side hazardous waste storage area	618-1 burial ground
333 lay down hazardous waste storage area	618-1:1 east side heat treat salt storage area
303-M SA uranium oxide facility storage area	618-1:2 limestone neutralization pit
303-M uranium oxide facility	618-2 burial ground
300 vitrification test site	618-7 burial ground
UPR-300-13 acid neutralization tank leak	618-8 burial ground
UPR-300-14 acid leak at the 334 tank farm	618-13 burial ground
UPR-300-46 contamination north of 333 building	

4.5.5 Technical Assessment

The purpose of the five-year review is to determine whether the remedy at a site is, or upon completion will be, protective of human health and the environment. The following is the technical assessment response of the 300-FF-2 OU remedy concerning the technical assessment questions provided in the EPA guidance. The following also establishes a framework for organizing and evaluating data and ensuring that all relevant issues are considered when determining the protectiveness of the remedy.

Is the remedy functioning as intended by the decision document?

The remedy is functioning as intended by the decision document to the extent the actions are completed.

Are the exposure assumptions, toxicity data, cleanup levels, and remedial action objectives used at the time of remedy selection still valid?

The exposure assumptions, toxicity data, cleanup levels, and remedial action objectives used at the time of remedy selection are still valid.

When considering whether the exposure assumptions, toxicity data, cleanup levels, and remedial action objectives are still valid, the review focused on all risk parameters on which the original remedy decision was based, as well as changes to target populations, exposure pathways, site characteristics, land use, and ARARs were reviewed.

Has any other information come to light that could call into question the protectiveness of the remedy?

No new information is known that could call into question the protectiveness of the remedy.

When considering whether any other information came to light that could call into question the protectiveness of the remedy, the review focused on whether ecological risks had been adequately evaluated and addressed or whether new ecological risk information had become available.

4.5.6 Protectiveness Statement

The final remedy at 300-FF-2 OU is expected to be protective of human health and the environment upon completion of the final remedy. The current interim actions ensure that exposure pathways that could result in unacceptable risks are being controlled.

4.6 300-FF-5 Operable Unit

The 300-FF-5 OU includes groundwater beneath 300-FF-1 and 300-FF-2. The 300-FF-5 OU is currently regulated under the *Declaration of the Record of Decision for the 300-FF-1 and 300-FF-5 Operable Units* for interim remedial action, which requires groundwater monitoring and institutional controls for groundwater use.

4.6.1 Background

The 300-FF-5 OU is defined as groundwater contaminated by releases from source waste sites in the 300-FF-1 and 300-FF-2 OUs. The releases affect an area that is approximately 36,000 acres (14,569 hectares).

4.6.2 Chronology

In late 1980, the RI/FS process under CERCLA for the 300-FF-5 OU began with work planning (*Remedial Investigation/Feasibility Study Work Plan for 300-FF-5 Operable Unit*, DOE/RL-89-14). Several RI/FS reports were issued due to process phasing. The Phase I remedial investigation report was published in July 1993 and January 1994, *Phase I Remedial Investigation Report for the 300-FF-5 Operable Unit* (DOE/RL-93-21, Vol. 1, DOE/RL-93-21, Volume 2, 1 of 2, DOE/RL-93-21, Volume 2, 2 of 2). In January 1994, the *Phase I and II Feasibility Study Report for the 300-FF-5 Operable Unit* (DOE/RL-93-22) was issued. A combined RI/FS report was published for the OU in May 1995 (DOE/RL-94-85). This initial RI/FS activity subsequently led to the 300-FF-1 and 300-FF-5 OUs ROD for selected final remedial and interim actions (EPA/ROD/R10-96/143). Part of the reason for an interim action was the continuing nature of remedial actions for the 300-FF-1 and 300-FF-2 OUs, which contain the waste sites that could potentially have an impact on the groundwater.

In July 1996, the *300-FF-1 and 300-FF-5 Operable Units Record of Decision* (EPA/ROD/R10-96/143) was signed. At that time, the geographic area for the 300-FF-5 OU included the groundwater affected by releases from 300-FF-1 sources. The contaminants of concern identified in the ROD were uranium, trichloroethene, and 1,2-dichloroethene. The selected interim action remedy for groundwater contamination is monitored natural attenuation and institutional controls. The geographic extent of the OU was subsequently expanded in June 2000 to include groundwater potentially impacted by waste sites in two outlying areas north of the 300 Area (EPA/ESD/R10-00/524). The outlying areas include the 618-11 burial ground, the 618-10 burial ground, and the former 316-4 crib waste sites.

The interim remedy, as stated in EPA/ROD/R10-96/143, is interim remedial action that involves imposing restrictions on the use of the groundwater until health-based criteria are met for uranium, trichloroethene, and 1,2-Dichloroethene. This is an interim action because there are other constituents (e.g., tritium), which are migrating into 300-FF-5 OU that have not yet been fully addressed and because a portion of 300-FF-5 OU is overlaid by uncharacterized waste sites in 300-FF-2 OU. A final remedial action decision for 300-FF-5 will be made after these issues have been addressed. The selected interim remedy includes:

- Continued monitoring of groundwater that is contaminated above health-based levels to ensure that concentrations continue to decrease.
- Institutional controls to ensure that groundwater use is restricted to prevent unacceptable exposures to groundwater contamination.

Since the 2006 five-year review, the following TPA milestones were developed for 300-FF-5 OU:

- Milestone M-015-00D: DOE shall complete the RI/FS process through the submittal of a proposed plan for all 100 and 300 Area OUs (December 31, 2012).
- Milestone M- 015-71: Submit an RI/FS work plan for the 300-FF- 2 and 300‑FF-5 OUs for groundwater and soil (completed October 31, 2009).
- Milestone M-015-72-T01: Submit an RI/FS report and proposed plan for the 300-FF-2 and 300-FF-5 OUs for groundwater and soil (December 31, 2011).

- Milestone M-016-110-T05: DOE shall have a remedy in place designed to meet the federal DWS for uranium throughout the groundwater plume in the 300-FF-5 OU unless otherwise specified in a CERCLA decision document (December 31, 2015).

In July 1996 the 300-FF-1 and 300-FF-5, OU ROD was signed (EPA/ROD/R10-96/143). At that time, the geographic area for the 300-FF-5 OU included the groundwater affected by releases from 300-FF-1 sources. The contaminants of concern identified in the ROD were uranium, trichloroethene, and 1,2-dichloroethene. The selected interim action for groundwater contamination called for the monitoring of the expected attenuation of the uranium and institutional controls.

The interim remedial action objectives defined in the ROD (EPA/ROD/R10-96/143) are to protect human and ecological receptors from exposure to contaminants in the groundwater and protect the Columbia River such that contaminants in the groundwater do not result in an impact to the Columbia River that could exceed the *Water Quality Standards for Surface Waters of the state of Washington* (WAC 173-201A). The remedial action objectives for groundwater remediation remain as 'restoration of the aquifer'.

The selected interim remedy was for the monitoring of the expected attenuation of uranium with institutional controls on the use of the groundwater to prevent human exposure. The ROD required continued groundwater monitoring to verify modeled predictions of contaminant attenuation and to evaluate the need for active remedial measures. Institutional controls were required to prevent groundwater use while contaminant plumes were still present at concentrations above the DWS. The uranium plume has not attenuated at the rate expected when the ROD (EPA/ROD/R10-96/143) was issued (projected to be 3 to 10 years based on modeling performed at the time of the ROD). Therefore, DOE has initiated additional characterization activities and is evaluating more aggressive treatment alternatives to address the uranium plume. In the interim, the institutional controls on the use of groundwater prevent human consumption. The original operations and maintenance plan was revised per an action item from the first five-year review (DOE/RL-95-73).

The decision to rely on natural process to cause a decrease in the level of contamination in groundwater along with continued monitoring while source remedial actions progressed was partially predicated on the presumption that concentrations of the contaminants of potential concern in groundwater will continue to decrease at rates suggested by monitoring data and modeling results obtained during the initial remedial investigation (DOE/RL-94-85). An additional presumption was that contaminated groundwater will not pose an unacceptable risk to human health and the environment under the land use expected to prevail during the near future, i.e., while source remedial actions were underway and the land remained under federal control.

Contaminants in Hanford Site groundwater are transported to the Columbia River via groundwater discharge upward through the river bottom and, to a lesser extent, via riverbank springs during periods of low river flow. Characterizing this transport is an element of the *Remedial Investigation Work Plan for Hanford Site Releases to the Columbia River* (DOE/RL-2008-11), which continues during FY11. Routine monitoring of media (water, sediment, and biota) at shoreline exposure locations and in the Columbia River is conducted under DOE's Public Safety and Resource Protection Program. Results of monitoring conducted are published annually in the *Hanford Site Near-Facility Environmental Monitoring Data Report* (CY09, PNNL-19455). The Washington State Department of Health conducts co-sampling with the Public Safety and Resource Protection Program activities as part of their oversight role. A detailed ecological risk assessment of the Columbia River Corridor is in progress and should reach conclusions about potential effects (DOE/RL-2004-37).

In June 2000, an ESD (EPA/ESD/R10-00/524) to the 300-FF-5 OU ROD was developed by EPA. The ESD expanded the scope of the 300-FF-5 OU ROD to include groundwater beneath all 300-FF-2 OU waste sites and burial grounds (the original 300-FF-5 OU boundary was expanded as defined in the 1996 ROD [EPA/ROD/R10-96/143]). This includes the groundwater beneath the outlying 300-FF-2 OU source sites and burial grounds, including the following: 618-10 burial ground and adjacent 316-4 cribs; 618-11 burial ground; the 600-63 source waste site; and the 600-259 source waste site. In addition, the groundwater beneath any newly discovered waste sites that are plugged into the 300-FF-2 OU ROD in the future will be included in the scope of the 300-FF-5 OU ROD (EPA/ESD/R10-00/524). Contaminants of concern identified in the ESD were tritium at the 618-11 burial ground and uranium and tributyl phosphate at the 316-4 cribs. The selected remedies and remedial action objectives for groundwater contained in the original ROD were not changed with the addition of the two new sub regions. The ESD also required an update to the operations and maintenance for 300-FF-5 OU to ensure that adequate groundwater monitoring requirements and institutional controls were in place for groundwater beneath 300-FF-1 and 300-FF-2 OUs waste sites. The ESD (EPA/ESD/R10-00/524) did not make any fundamental changes to the 1996 remedy selection decision.

4.6.3 Remedial Action

Interim remedial actions in the 300-FF-5 OU waste sites are ongoing and include monitoring for the natural attenuation of uranium and maintaining institutional controls.

300-FF-5 Operable Unit Interim Remedial Action Objectives

Remedial Action Objective 2	Protect human and ecological receptors from exposure to contaminants in the groundwater and control the sources of groundwater contamination in 300-FF-1 to minimize future impacts to groundwater resources. This remedial action objectives will be achieved by attaining MCLs and non-zero MCLGs promulgated under the SDWA. These values are given in Table 10. The specific location and measurements of the compliance monitoring will be documented in an operation and maintenance plan for 300-FF-5, which will be approved by EPA. In addition, the contaminants remaining in the soil after remediation will not result in further degradation of groundwater.
Remedial Action Objective 3	Protect the Columbia River such that contaminants in the groundwater or remaining in the soil after remediation do not result in an impact to the Columbia River that could exceed the Washington State Surface Water Quality Standards. The protection of the river will be achieved by preventing further degradation of groundwater quality in the uranium plume such that receptors that may be affected at the groundwater discharge point to the Columbia River are not subject to any additional incremental adverse risks. The specific location and measurements of the compliance monitoring will be documented in an operation and maintenance plan for 300-FF-5, which will be approved by EPA.

4.6.4 Progress Since 2006 Review

Since the 2006 five-year review, the 300-FF-5 OU is in the later stages of the final RI/FS process.

4.6.4.1 Final Remedial Investigation/Feasibility Study

A major CERCLA accomplishment for the 300-FF-5 OU was the approval of the *300 Area Decision Unit Remedial Investigation/Feasibility Study Work Plan* (DOE/RL-2009-30) in April 2010. Other CERCLA accomplishments during the five-year review period included treatability testing and research on uranium contamination in the vadose zone and groundwater.

Current activities are directed at assembling information to support decisions for final remedial actions involving groundwater (*300 Area Decision Unit Remedial Investigation/Feasibility Study Work Plan*, DOE/RL-2009-30. The principal contaminant of concern in the 300 Area is uranium, although additional waste contaminants also exceed regulatory standards for groundwater in the 300 Area.

While the final RI/FS process continues, groundwater is monitored under an operation and maintenance plan, which describes the strategy for monitoring and characterization activities during the period of interim remedial action (DOE/RL-95-73). The *300-FF-5 Operable Unit Sampling and Analysis Plan* (DOE/RL-2002-11) implements the groundwater monitoring requirements. The period of interim action is governed by the *Declaration of the Record of Decision for the 300-FF-1 and 300-FF-5 Operable Units*, which was prepared in FY96 and expanded geographically in FY00 to include the two outlying sub regions (*EPA Superfund Explanation of Significant Differences: Hanford 300-Area [USDOE]*). Remedial actions during the interim period involve continued monitoring of groundwater and institutional controls to restrict the use of groundwater. These activities are deemed appropriate while other actions are underway to remediate waste disposal sites, unplanned release sites, and former 300 Area facilities.

Significant activities contributing to the RI/FS are underway in the 300 Area, including drilling characterization and monitoring wells at 16 locations, with the primary objective of characterizing the contamination remaining in the vadose zone and unconfined aquifer. Three characterization boreholes are also planned. Scope and schedule for these activities are described in *300 Area Remedial Investigation/Feasibility Study Sampling and Analysis Plan for the 300-FF-1, 300-FF-2 and 300-FF-3 Operable Units*, DOE/RL-2009-45. Field-testing is in progress using potential technologies to remediate uranium contamination in the subsurface. Groundwater monitoring via wells and river shoreline aquifer tubes is providing data used to evaluate the nature and extent of contamination, contaminant concentration trends, and associated risk. The DOE Office of Science also supports detailed research on the mobility characteristics of uranium beneath the 300 Area, as well as on the groundwater pathway leading to discharge into the Columbia River. Completion of the RI/FS process and submittal of a proposed plan for final remedial action have a TPA milestone due date of December 31, 2012.

4.6.4.2 Treatability Tests

Treatability Tests for Uranium Contamination in the Subsurface. Bench-scale testing using polyphosphate solutions to immobilize uranium in the subsurface began in FY06 under the DOE Environmental Management Program, and is documented in *Conceptual Hydrogeologic Model for the IFRC Well Field, 300 Area, Hanford Site* (PNNL-19340). The remedial action objective is to reduce uranium concentrations in groundwater.

A field test involving injection of polyphosphate into the aquifer at a site near the south end of the former 300 Area Process Trenches was performed following a successful bench-scale testing. While the chemical reactions worked well in the laboratory, application in the field proved more challenging (*Challenges Associated with Apatite Remediation of Uranium in the 300 Area Aquifer*, (PNNL-17480) because of heterogeneous sediment and geochemical conditions. A final report on the aquifer injection test is presented in *300 Area Uranium Stabilization through Polyphosphate Injection: Final Report* (PNNL-18529). Additional treatability testing, using polyphosphate solutions, was conducted during FY09 and continued into FY10 at a second test site with the focus on immobilizing uranium in the vadose zone (*300-FF-5 Groundwater Operable Unit Infiltration Test Sampling and Analysis Plan*, DOE/RL-2009-16).

Other DOE-Office of Science projects include geophysical investigations of the aquifer beneath the 300 Area and the connection of the aquifer to the river channel. This investigation uses a variety of near-surface geophysical methods to characterize preferential pathways for groundwater movement and discharge to the river channel. One of the methods uses fiber optic cables on the riverbed to record temperatures at 3.3 feet (1 meter) increments along the length of the approximately 0.6 mile (1 km) long cable. The results and interpretations are presented in *Use of Electrical Imaging and Distributed Temperature Sensing Methods to Characterize Surface-Water/Groundwater Exchange Regulating Uranium Transport at the Hanford 300 Area, Washington*.

Integrated Field-Scale Research Challenge Program. DOE-SC is supporting field research involving the mobility of uranium under a program referred to as Integrated Field-Scale Research Challenge. The Hanford Site 300 Area is one of three DOE sites where field and laboratory research activities are being performed. A highly instrumented, three-dimensional array of sensors is installed in the vadose zone and upper portion of the aquifer beneath a portion of the former South Process Pond liquid waste disposal site. A closely associated project uses a variety of near-surface geophysical methods to characterize preferential pathways for groundwater movement and discharge to the Columbia River channel. The project is in its third year; the results were published in 2010.

The interim remedial action groundwater monitoring required under the 1996 ROD is implemented via a sampling and analysis plan, which has been modified several times since its initial version. The current plan is *300-FF-5 Operable Unit Sampling and Analysis Plan* (DOE/RL-2001-11). Monitoring is conducted via wells and aquifer tubes at the shoreline, with principal events occurring semiannually, although more frequent sampling occurs where conditions change rapidly and/or major excavation activities are underway. Most monitoring wells have screens positioned to include the zone occupied by the water table; several wells are screened in the lower portion of the unconfined aquifer, and several wells are screened in the uppermost confined aquifer. During the period covered by this report, most wells and aquifer tubes were sampled as planned, with some exceptions because of maintenance issues and scheduling compromises. The monitoring objectives, as presented in *Operation and Maintenance Plan for the 300-FF-5 Operable Unit* (DOE/RL-95-73), were essentially met. The list of wells used for the monitoring and analyses conducted on groundwater samples is presented in Appendix A.

In 2004, the RI/FS activities were renewed for RI/FSs at the 300-FF-5 OU. Additional efforts included updating computer simulations of groundwater flow and uranium transport, conducting a limited field investigation of uranium (involving multiple characterization boreholes), updating the human health and ecological risk assessment, and assessing potential remedial action technologies for the 300 Area uranium plume. TPA Milestone M-016-68 was developed in early FY05 for some of this work and resulted in the issuance of the following two documents by March 31, 2005.

- DOE/RL-2005-41, *Work Plan for Phase III Feasibility Study, 300-FF-5 Operable Unit.*
- PNNL-15127, Contaminants of Potential Concern in the 300-FF-5 Operable Unit: Expanded Annual Groundwater Report for Fiscal Year 2004.

Many of the renewed activities were essentially complete by 2008, and are described in the following documents:

- DOE/RL-2008-36, Remediation Strategy for Uranium in Groundwater at the Hanford Site 300 Area, 300-FF-5 Operable Unit.
- PNNL-16435, Limited Field Investigation Report for Uranium Contamination in the 300-FF-5 Operable Unit at the 300 Area, Hanford Site, Washington.
- PNNL-16454, *Current Conditions Risk Assessment for the 300-FF-5 Groundwater Operable Unit.*
- PNNL-16761, *Evaluation and Screening of Remedial Technologies for Uranium at the 300-FF-5 Operable Unit, Hanford Site, Washington*.
- PNNL-17708, *Three-Dimensional Groundwater Models of the 300 Area at the Hanford Site, Washington.*
- In September 2008, a new planning effort was launched for the RI/FS activities that will lead to a proposed plan for final remedial actions for the 300 Area NPL OUs (i.e., 300-FF-2 OU, and 300-FF-5 OU; remedial actions are considered complete for the 300-FF-1 OU). The *300 Area Remedial Investigation/Feasibility Study Work Plan for the 300-FF-1, 300-FF-2, and 300-FF-5 Operable Units* (DOE/RL-2009-30) was prepared to describe activities that complement those already planned under source OU work plans and the groundwater OU operations and maintenance plan. The proposed activities will fill the data needs identified for selecting remedial action alternatives.

4.6.5 Technical Assessment

The purpose of the five-year review is to determine whether the remedy at a site is, or upon completion will be, protective of human health and the environment. The following is the technical assessment response of the 300-FF-5 Groundwater OU interim remedy concerning the technical assessment questions provided in the EPA guidance. The following also establishes a framework for organizing and evaluating data and ensuring that all relevant issues are considered when determining the protectiveness of the remedy.

Is the remedy functioning as intended by the decision document?

The remedy is not functioning as intended by the decision document. Concentrations of uranium in groundwater have not decreased to levels predicted by the initial remedial investigation. Institutional controls have functioned as planned to prevent human exposure to the groundwater.

Are the exposure assumptions, toxicity data, cleanup levels, and remedial action objectives used at the time of remedy selection still valid?

The exposure assumptions, toxicity data, cleanup levels, and remedial action objectives used at the time of remedy selection are still valid.

Has any other information come to light that could call into question the protectiveness of the remedy?

New information has become known that calls into question the protectiveness of the remedy. For 300-FF-5 Groundwater OU, monitoring results under the selected interim remedy have shown that the attenuation of the uranium contaminant in the groundwater is not performing as predicted. However, institutional controls are in place to prevent human consumption of the groundwater. Follow up actions are necessary to determine long-term protectiveness because remedial action objectives are not expected to be met. See the information below for further details.

300 Area Groundwater Contamination. The exposure assumptions for contaminants of potential concern beneath the 300 Area are those identified in the 1996 ROD, since land use has not changed, and not anticipated to change, as long as the 300 Area remains under federal government control. The assumption that the primary exposure pathways for groundwater are groundwater withdrawal to support human activities, and exposure of contaminated groundwater along the river shoreline, remains valid.

For uranium, the primary contaminant of concern at the 300 Area, the EPA MCL for drinking water supplies remains 30 μg/L. Risk to human health is driven by chemical toxicity, not radiological dose (radiological dose comes in to play at concentrations higher than the standard for chemical toxicity). For ecological risk, there has been some new research conducted regarding toxicity to aquatic organisms but no new standards have evolved. Figure 63 depicts the uranium plume in groundwater beneath the 300 Area in December 2009.

For the uranium plume at the 300 Area, a computer simulation made during the initial remedial investigation indicated that groundwater concentrations were likely to decrease to the proposed DWS (20 μg/L) within 3 to 10 years of 1993. This decrease has not occurred. The reasons for concentration trends during this period are now better understood than at the time of the first five-year and second five-year reviews in 2001 and 2006, respectively.

The better understanding of uranium contamination in groundwater has not led to a revised remedial action. Therefore, institutional controls are required while DOE completes additional field investigations and source remedial actions prior to selection of the final remedial actions. DOE currently controls the 300 Area and use of the groundwater. The existing institutional controls on groundwater are expected to remain protective until the final remedy is selected.

The prediction that uranium concentrations will decrease to a proposed DWS of 20 μg/L within 3 to 10 years of 1993 was based on key assumptions of no future increases in groundwater concentrations (because of source removal actions) and no negligible re-supply of uranium to the groundwater plume. If there had been no re-supply since the early 1990s, concentrations should have fallen to less than the concentration standard because of uranium mass removal by discharge of contaminated groundwater into the river and withdrawal of contaminated groundwater at a water supply well. The current conceptual model for the plume suggests that these assumptions are not completely valid and that uranium is being re-supplied to groundwater by several mechanisms. The following aspects of the conceptual model are extracted from *Uranium Contamination in the Subsurface Beneath the 300 Area* and *Uranium Contamination in the 300 Area: Emergent Data and their Impact on the Source Term Conceptual Model*.

First, evidence suggests the slow release of uranium from the lower vadose zone beneath some past practice disposal sites, i.e., at depths in the vadose zone greater than the remedial action excavation depths. This is revealed by higher groundwater concentrations at these sites. Because of the interaction between liquid waste containing uranium and vadose zone sediment, some uranium remains bound to the sediment and available for subsequent remobilization by infiltrating moisture and/or unusually high water table conditions.

Second, uranium has likely been widely distributed beneath the 300 Area by historical high water table events. During the early operations period (1940s, 1950s, and 1960s), high river stage conditions (e.g., the 1948 flood) created a hydraulic gradient that caused groundwater plumes to move inland from their normal positions under more typical gradients and river stages. In addition, the water table was elevated well above typical levels by these high river conditions, thus pushing contaminated groundwater upward into the lower vadose zone. Currently, uranium-bearing moisture and sediment in the lowermost portion of the vadose zone (i.e., throughout the vertical range of the water table) continues to release uranium to groundwater during periodic high water table events.

Third, aquifer sediment beneath the 300 Area is heterogeneous in texture and its ability to transmit water. Lenses of low-transmissivity sediment may have been saturated with the relatively more contaminated groundwater that existed during the operations period and those lenses are now slowly releasing that contamination to the relatively less contaminated groundwater in the surrounding highly transmissive sediment. Though no direct evidence is yet available to demonstrate this process, work planned and underway for the additional field investigation will likely reveal new information on this potential source for re-supplying the plume.

Finally, excavations at liquid waste disposal sites during the 1990s removed some protective surface cover and shortened the distance between the exposed surface and the water table, thus somewhat enhancing conditions for vadose zone uranium to migrate downward, potentially reaching groundwater. In addition, some application of water was necessary during the excavation operations to minimize contaminated airborne dust. The increased infiltration of moisture beyond the amount from natural precipitation may have remobilized uranium and carried it down to the aquifer.

618-11 Burial Ground Groundwater Contamination. The high concentration tritium plume created by releases from materials in the 618-11 burial ground has not changed appreciably in areal extent since its discovery in 2000 (Figure 64). The highest concentrations, which are in groundwater adjacent to the eastern side of the burial ground, have dropped significantly from peak values of approximately 8 million pCi/L observed in 2000, to their current level of approximately 1.8 million pCi/L (June 2005). Concentration trends at other wells that monitor the plume suggest a slow downgradient migration from the burial ground. Based on computer simulation of future plume behavior, the tritium plume is not expected to create an exposure risk at the Columbia River (PNNL-15293).

618-10 Burial Ground, and 316-4 Crib Groundwater Contamination. Concentrations for contaminants of potential concern in groundwater beneath these two waste sites have remained consistent with expectations, as described in the limited field investigation report for the 300-FF-2 OU and re-iterated in the ESD to the ROD. Groundwater contamination associated with the 316-4 waste site has remained constant or has declined during the past five years. Although no direct evidence has surfaced indicating impacts on groundwater because of releases from the 618-10 Burial Ground, there is some suspicion that localized release of uranium may have occurred. The evidence is based on uranium isotope ratios, which suggest that some of the uranium in groundwater is from more recent waste (e.g., those in the burial ground, than those disposed earlier to the 316-4 cribs). There is currently no removal of groundwater from this sub-region and no foreseeable need for near-future extraction of groundwater. Although a groundwater plume may have been created by releases to the 316-4 cribs during the 1950s, there is no data available to map the extent and current position. The most likely contaminants within a potential plume are uranium and possibly volatile organic compounds, such as tributyl phosphate, a solvent commonly used in the 300 Area. Analysis of uranium and other vadose zone contaminants is currently in progress. The remedial action objectives, as stated in the interim action ROD, remain appropriate for the 300 Area sub-region. There is no current or anticipated use of groundwater near these waste sites, nor are there any known locations for potential exposure of humans and biota.

300 Area Process Trenches Groundwater Contamination. This former liquid waste disposal site was the last site in the 300 Area to receive uranium-bearing effluent, with uranium discharges ending in 1985 and all discharges ending in December 1994. The site, which has been remediated, is regulated under RCRA and is monitored in accordance with post closure corrective action requirements (WAC 173-303-645), in conjunction with CERCLA and AEA. Uranium currently exceeds the DWS in wells downgradient from the waste site. Cis-1,2-dichloroethene concentrations exceed the DWS at downgradient well 399-1-16B, which is completed near the bottom of the unconfined aquifer. Most results for trichloroethene and tetrachloroethene were below detection limits during the five-year review period, with the exception of two detections of trichloroethene in samples from well 399-1-16B, but at concentrations near the detection limit.

Figure 63. 300 Area Uranium Plume in Groundwater

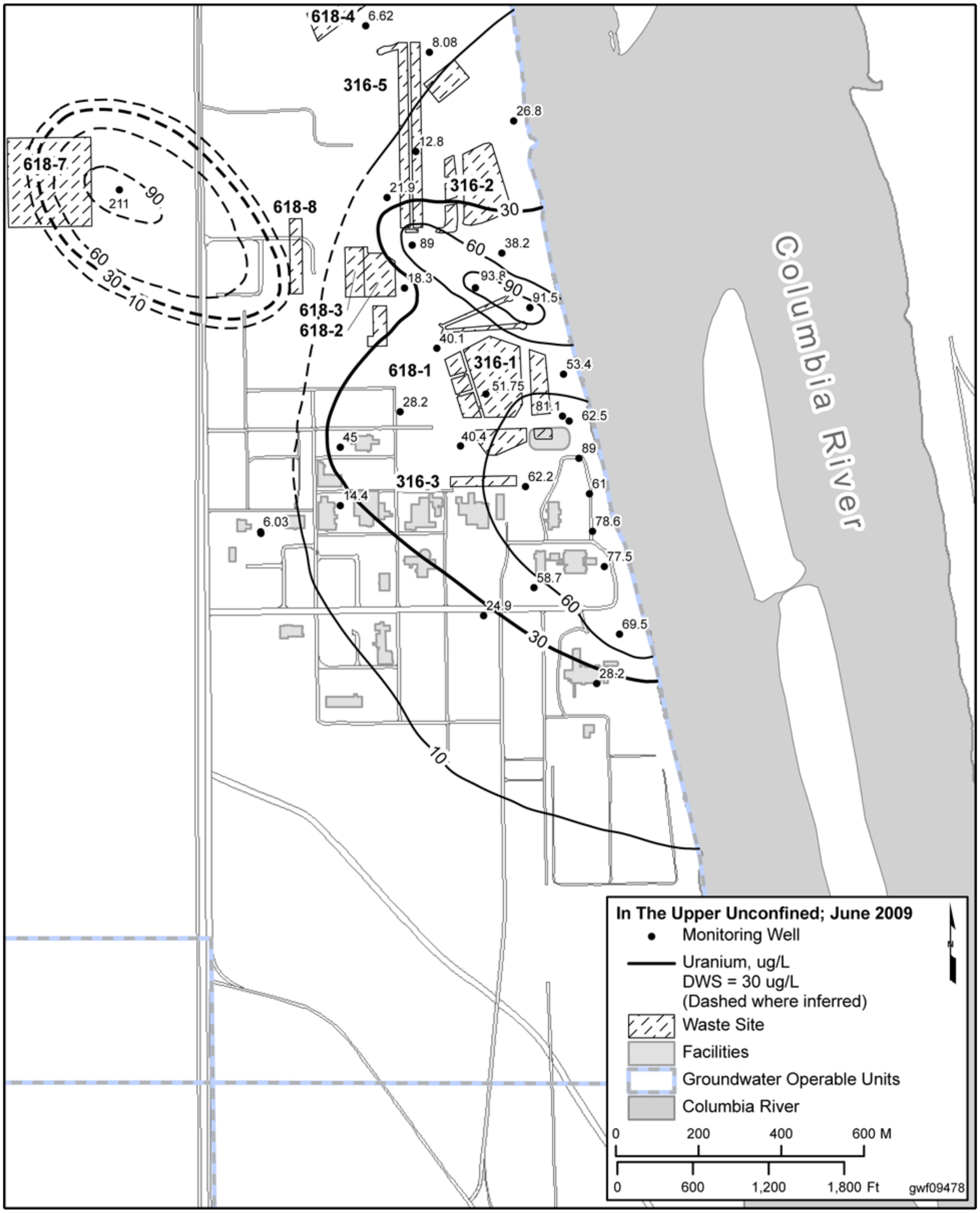
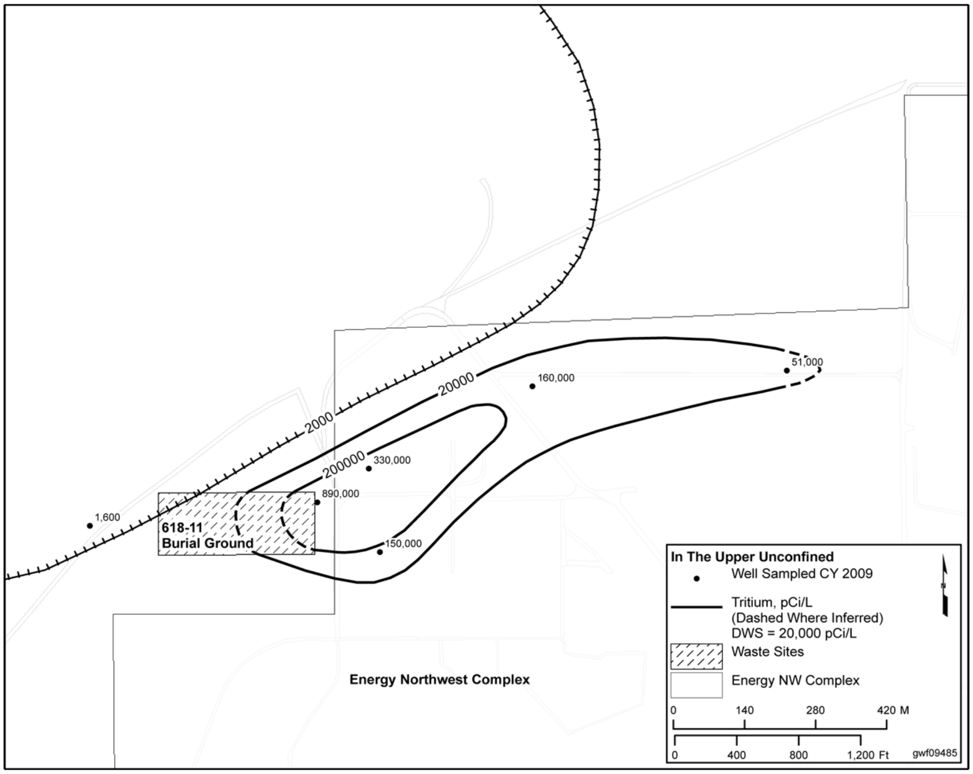


Figure 64. 618-11 Burial Ground Tritium Plume in Groundwater



4.6.6 Protectiveness Statement

The remedy at 300-FF-5 Groundwater OU is not protective because the interim remedy selected of monitoring the expected attenuation of the uranium are not predicted to meet the groundwater cleanup standards. As a result, the remedial actions and remedial action objectives for the final remedy are being evaluated. Further information will be obtained by completing the *River Corridor Baseline Risk Assessment*. It is expected that these actions will be completed by 2016, at which time a protectiveness determination will be made. In April 2010, the *300 Area Remedial Investigation/Feasibility Study Sampling and Analysis Plan for the 300-FF-1, 300-FF-2 and 300-FF-3 Operable Units*, DOE/RL-2009-45 was issued.

4.7 300 Area Facilities

For completeness, the following CERCLA removal actions that have been implemented for facilities and building in the 300 Areal NPL are discussed.

4.7.1 Removal Actions

In July 1991, *Action Memorandum Approval: 316-5 Process Trenches* was issued. The 300 Area process trenches received wastewater from operations in the 300 Area. In 1991, an expedited response action was performed to reduce the migration of radioactive and inorganic (heavy metals) contaminants to groundwater. The most contaminated soil was near the surface of the process trenches. This contamination was excavated and staged in spoils piles. Excavation sample results taken after the expedited response action indicate that the response action successfully reduced contamination in all areas of the trenches except the spoils area. The spoils pile and the remainder of the process trenches were later cleaned up as part of the 300-FF-1 OU remedial action.

In July 1991, *Expedited Response Action for the 618-9 Burial Ground* (91-ERB-039) was approved for removal of hexone drums to mitigate the threat to public health and the environment caused by contaminant migration from the drums to the soil column, and potentially the underlying groundwater. Approximately 700 gallons (3,183 liters) of methyl isobutyl ketone (also known as hexone) and 900 gallons (4,092 liters) of kerosene solvent were removed from 120 drums that had been buried at the west end of the 618-9 burial ground. Additional materials (e.g., empty waste drums, construction debris, and soil) were also removed from the remainder of the burial ground. The cleanup actions at the 618-9 burial ground allow for unrestricted use and unlimited exposure of the site.

The 331-A Virology Laboratory Building was a small T-shaped one-story concrete block building that rested on a concrete slab foundation with an almost flat wood-frame roof in the 300 Area, which was decontaminated and decommissioned in February through March 2000. The facility began operations in 1972 for the purpose of animal, bacterial, and viral research on the effects of exposure to radiation. The building contained laboratories, including a former pen area for laboratory animals. Due to radioactive contamination, the building could not be demolished and disposed of in an off-site landfill; therefore, D&D was performed under CERCLA. The floor slab and any contaminated belowground structures or soil associated with the building will be assessed and removed as part of the 300-FF-2 OU. On February 15, 2000, DOE authorized, with EPA concurrence, the D&D of the 331-A Virology Laboratory in *Action Memorandum Hanford 300 Area National Priorities List*. The removal action removed the aboveground structure (i.e., walls and roof). The floor slab and any contaminated belowground structures or soil associated with the building will be assessed and removed as part of the 300-FF-2 OU.

In January 2005, Action Memorandum #1 for 300 Area Facilities was issued for the 300 Area and authorized the demolition of buildings, vaults, structures, and pipelines in the north quarter of the 300 Area. Work immediately began on the demolition of the 313 facility upon issuance of this action memorandum. Disposition activities in the 314 Building and other buildings on top of the 618-1 burial ground will continue. Since the 2006 five-year review, physical removal of the facilities associated with *Action Memorandum #1 for 300 Area Facilities* has been completed.

In May 2006, *Action Memorandum #2 for the 300 Area Facilities* was issued and authorized the deactivation, decontamination, decommissioning, and demolition of the 324 and 327 buildings and the associated facilities. The action included building contents above ground structures, on-grade floor slabs and the below grade foundations and piping. Since the 2006 five-year review, the 327 Building above grade structure has been demolished, with below grade demolition ongoing. In October 2010, a significant past release of radiological materials was discovered beneath the 324 Building that has been assigned waste site number 300-296. Further deactivation of the 324 Building has been placed on hold pending additional characterization of waste site number 300-296.

In November 2006, *Action Memorandum #3 for the 300 Area Facilities* was issued and authorized the deactivation, decontamination, decommissioning, and demolition for up to 110 buildings and facilities in the central and southern portion of the 300 Area. The action included building and sub-surface structures (e.g. foundations, above ground utilities, fencing, piping, and ducting).

In March 2010, the *Engineering Evaluation/Cost Analysis for General Hanford Site Decommissioning Activities*, DOE/RL-2010-14, was issued to document the selected alternative to perform D&D of Hanford excess industrial buildings and structures and cleanup of miscellaneous debris. The action memorandum includes the 100 Area and 300 Area sites. The evaluation assists DOE-RL in identifying the most effective means to decommission excess buildings and structures for which the specific missions have been completed. The evaluation also assists DOE-RL in the cleanup of miscellaneous debris (e.g., solid waste) identified during the cleanup process. The scope of the EE/CA encompasses excess industrial buildings and structures that were never used for radiological or chemical processing and debris. However, these buildings, structures, and debris may be potentially contaminated with hazardous substances because of their proximity to Hanford Site contamination and based on the building and debris components and contents (e.g., asbestos, paints, and coatings). The 337B Building was demolished under the authority of the general Hanford Site decommissioning action memorandum. It is anticipated that additional buildings in the 300 Area will be demolished under the authority of this decision document when they become surplus facilities.

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