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11-AMCP-0024

NOV 23 2010

Mr. D. A. Faulk, Program Manager
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Hanford Project Office
U.S. Environmental Protection Agency
309 Bradley Boulevard, Suite 115
Richland, Washington 99352

Dear Mr. Faulk:

200 WEST AREA GROUNDWATER PUMP-AND-TREAT REMEDIAL DESIGN REPORT, DOE/RL-2010-13, REVISION 1

This letter transmits the approved 200 West Area Groundwater Pump-and-Treat Remedial Design Report (RDR), DOE/RL-2010-13, Revision 1. The RDR was signed by the U.S. Department of Energy Richland Operations Office and the U.S. Environmental Protection Agency (EPA) on November 2, 2010, and November 1, 2010, respectively.

The Draft A version of the RDR was submitted to on August 4, 2010, satisfying Hanford Federal Facility Agreement and Consent Order Milestone M-016-124. Comments from EPA were received on September 3, 2010. Comments have been addressed and incorporated, as applicable, in the final version of the report. Responses to EPA's comments are attached.

If you have any questions, please contact me, or your staff may contact Briant Charboneau, of my staff, on (509) 373-6137.

Sincerely,

FOR

Richard A. Holten, Acting Assistant Manager
for the Central Plateau

AMCP:ACT

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DOE/RL-2010-13
Revision 1

200 West Area Groundwater Pump-and-Treat Remedial Design Report

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

U.S. DEPARTMENT OF ENERGY

Richland Operations Office

P.O. Box 550
Richland, Washington 99352

Approved for Public Release;
Further Dissemination Unlimited

DOE/RL-2010-13
Revision 1

200 West Area Groundwater Pump-and-Treat Remedial Design Report

Date Published
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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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Concurrence Page

Title: *200 West Area Groundwater Pump-and-Treat Remedial Design Report*

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Signature 11-2-10 Date

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Executive Summary

This remedial design report (RDR) outlines the remedial design of the 200 West Area groundwater pump-and-treat system. The 200 West Area pump-and-treat system is a major component of the remedial action selected for cleanup of the 200-ZP-1 Groundwater Operable Unit (OU), located in the Hanford Site's Central Plateau.

The remedy selected in the *Record of Decision Hanford 200 Area 200-ZP-1 Superfund Site Benton County, Washington* (EPA et al., 2008) (hereafter referred to as the Record of Decision [ROD]) combines the installation of a groundwater pump-and-treat system, monitored natural attenuation, flow-path control, and institutional controls. These remedy components combine to meet the objective of achieving established groundwater cleanup levels for all contaminants of concern (COCs) in the 200-ZP-1 OU within 125 years. The COCs identified for the 200-ZP-1 OU are carbon tetrachloride, total chromium (trivalent and hexavalent), nitrate, trichloroethylene, iodine-129, technetium-99, and tritium.

The ROD also requires that a large fraction of the mass of contaminants (i.e., 95 percent of the dissolved mass of COCs) be removed within the first 25 years. This mass removal will primarily be accomplished by operation of the 200 West Area groundwater pump-and-treat system, which is designed to capture and treat contaminated groundwater to reduce the mass of COCs throughout the 200-ZP-1 OU. Treated water will be reinjected into the aquifer to attain flow-path control.

This RDR addresses the design of the 200 West Area groundwater pump-and-treat system to ensure that these objectives are met. This RDR outlines the basis of design of the major components of the 200 West Area groundwater pump-and-treat system and provides a summary of the anticipated construction cost and schedule.

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Terms

ASIL	acceptable source impact level
ATP	acceptance testing procedure
BOD	biochemical oxygen demand
CERCLA	*Comprehensive Environmental Response, Compensation, and Liability Act of 1980*
CHPRC	CH2M HILL Plateau Remediation Company
COC	contaminant of concern
CPVC	chlorinated polyvinyl chloride
DOE	U.S. Department of Energy
EPA	U.S. Environmental Protection Agency
ERDF	Environmental Restoration Disposal Facility
EW	extraction well
FBR	fluidized bed reactor
FRP	fiber-reinforced plastic
FY	fiscal year
GAC	granular activated carbon
HDPE	high-density polyethylene
IC	institutional control
IW	injection well
IX	ion exchange
LLWMA	low-level waste management area
MCL	maximum contaminant level
MNA	monitored natural attenuation
MTCA	Model Toxics Control Act
NA	not applicable
NTU	nephelometric turbidity units
O&M	operations and maintenance
OTP	operational testing procedure
OU	operable unit

PE	polyethylene
PVC	polyvinyl chloride
QA	quality assurance
QC	quality control
RAO	remedial action objective
RCRA	*Resource Conservation and Recovery Act of 1976*
RDR	remedial design report
RD/RAWP	remedial design/remedial action work plan
RL	U.S. Department of Energy, Richland Operations Office
ROD	Record of Decision
SCADA	supervisory control and data acquisition
TBD	to be determined
TCE	trichloroethylene
TOC	total organic carbon
TDS	total dissolved solids
TSS	total suspended solids
Tri-Party Agreement	*Hanford Federal Facility Agreement and Consent Order*
VOC	volatile organic compound
WMA	waste management area

1 Introduction

The 200 West Area groundwater pump-and-treat system is a major component of the remedial action selected in the *Record of Decision Hanford 200 Area 200-ZP-1 Superfund Site Benton County, Washington* (hereafter referred to as the Record of Decision [ROD]) (EPA et al., 2008). This remedial design report (RDR) provides a summary of the 200 West Area groundwater pump-and-treat system design.

This RDR for the 200-ZP-1 Operable Unit (OU) presents the selected design supporting the remedial alternative as established in the ROD. The selected remedy in the ROD combines pump-and-treat, monitored natural attenuation (MNA), flow-path control, and institutional controls (ICs). This remedial alternative will address groundwater with contaminant of concern (COC) concentrations that pose a potential human health risk and will meet the remedial action objectives (RAOs) identified in the ROD. The RAOs are presented in Section 2.1.

Figure 1-1 shows the location of the 200-ZP-1 OU within the Hanford Site's 200 West Area. The 200 West Area contains waste management facilities and former irradiated fuel reprocessing facilities. The major waste streams that contributed to groundwater and soil contamination were associated with the plutonium concentration and recovery operations at the Plutonium Finishing Plant facilities and the plutonium-separation operations at the T Plant facilities, both in the 200 West Area. The liquid waste disposal to the trenches near these facilities resulted in several groundwater contaminant plumes, as well as contamination in the trench soil. More detailed information describing the Hanford Site, the 200 West Area, and the 200-ZP-1 OU is provided in the U.S. Department of Energy (DOE) reports *Remedial Investigation Report for the 200-ZP-1 Groundwater Operable Unit* (DOE/RL-2006-24), the *200 West Area 200-ZP-1 Pump-and-Treat Remedial Design/Remedial Action Work Plan* (DOE/RL-2008-78), and the 200-ZP-1 OU ROD (EPA et al., 2008).

This RDR was prepared in accordance with the following documents:

- DOE/RL-2008-78, *200 West Area 200-ZP-1 Pump-and-Treat Remedial Design/Remedial Action Work Plan* (hereafter referred to as the remedial design/remedial action work plan [RD/RAWP])
- *Hanford Federal Facility Agreement and Consent Order* (Tri-Party Agreement) (Ecology et al., 1989a)
- Guidance provided in 40 CFR 300.435(f), "National Oil and Hazardous Substances Pollution Contingency Plan," "Remedial Design/Remedial Action, Operation and Maintenance"

This RDR presents information that is based on the 90 percent design; as such, portions of this document may be updated as substantive changes are made through final design.

This report is intended to transmit the design requirements from information collected during the remedial design and delineated in the ROD. The limited objective of this design report, the ongoing nature of the project, and the evolving knowledge of site conditions and chemical effects on the environment and human health, must be considered when reviewing the design.

1.1 Purpose and Scope

The following discussion presents the purpose, scope, and content of the RDR.

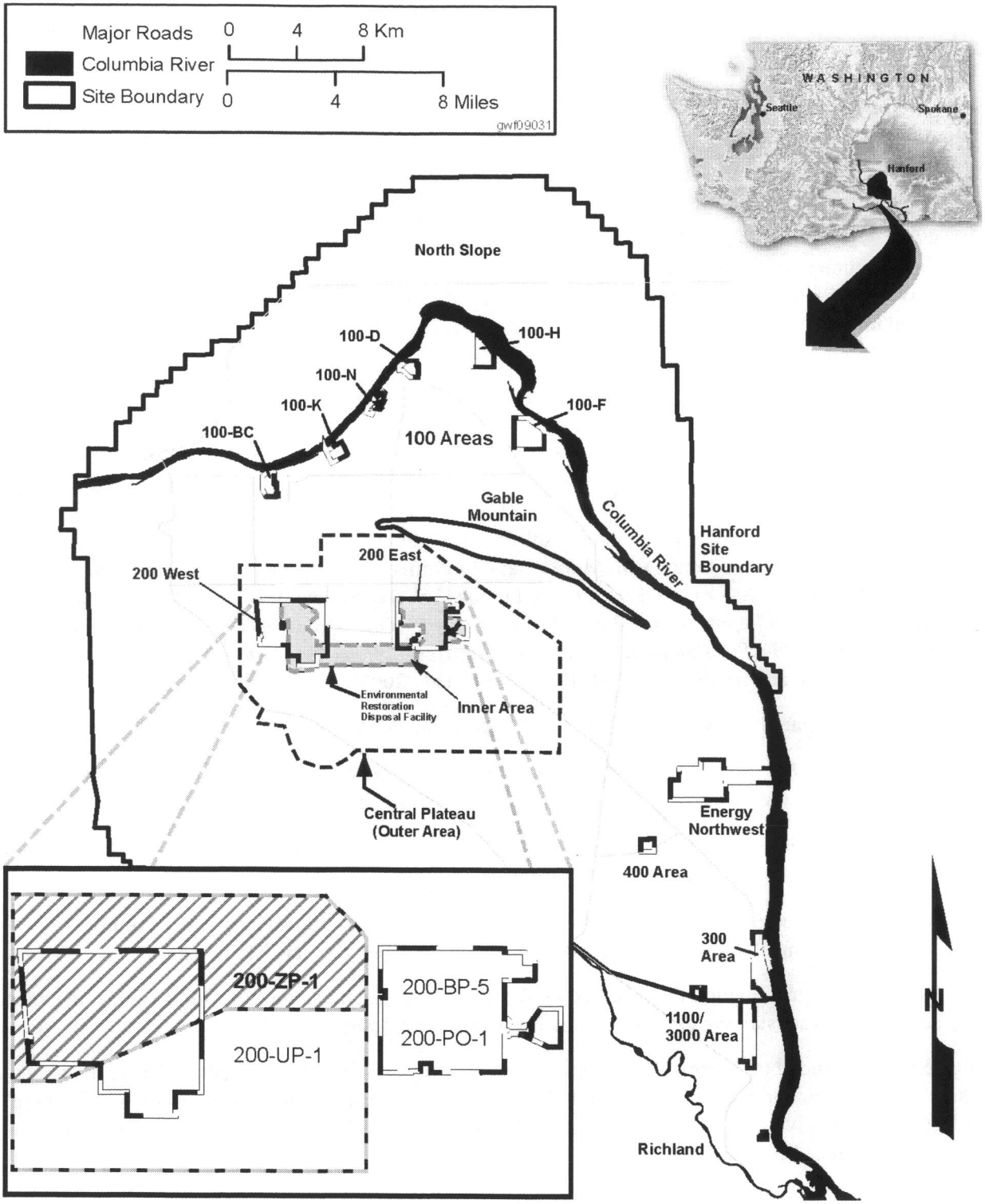

Figure 1-1. Hanford Site Map Showing Central Plateau Groundwater OUs

1.1.1 Purpose of the Remedial Design Report

The RDR presents the site-specific data and considerations needed to successfully complete the remedial actions identified in the ROD. This RDR will be used in conjunction with the RD/RAWP (DOE/RL-2008-78). These design documents, as well as the other supporting documents, will be used to identify tasks for the 200-ZP-1 OU remedial action, prepare a schedule with project milestones, assign appropriate personnel and equipment to accomplish each task, and submit remedial action deliverables.

The overarching requirement in the ROD is to meet the groundwater cleanup levels within the 125-year IC period. The remedial actions in the ROD were chosen in accordance with the *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA), as amended by the *Superfund Amendments and Reauthorization Act of 1986*, the Tri-Party Agreement, and 40 CFR 300.

This RDR describes the design and installation of the site remedy in order to meet the RAOs identified in the ROD. This document does not discuss information regarding operations; that information is presented in the *200 West Groundwater Pump-and-Treat Facility Operations and Maintenance Plan* (DOE/RL-2009-124) and the to-be-prepared 200 West Area groundwater systems operations and maintenance (O&M) manual. The selected remedy for the site includes a combination of pump-and-treat, MNA, flow-path control, and ICs to address non-radiological and radionuclide COCs.

1.1.2 Scope of the Remedial Design Report

This RDR is being submitted to the U.S. Environmental Protection Agency (EPA), the lead regulatory agency, in accordance with Section 7.3.9 of the Tri-Party Agreement Action Plan (Ecology et al., 1989b), as modified by Change Request P-11-06-01, which requires the following:

> *An RD report will be prepared that includes the designs and schedules for construction of any remediation facility and development of support facilities (lab services, etc.). The RDR shall contain at least a 90 percent design. If less than 90 percent design submission is required by the lead regulatory agency, it will be documented in the RD/RA work plan.* (Ecology et al., 1989a)

The design presented in this RDR is considered 90 percent complete. Further refinements to the design and the planned implementation will be finalized as design and construction are completed. The project will be constructed within a design/build format; it will not be released as a typical construction project wherein the design is completed to 100 percent and then issued for bidding and construction. The DOE is following an engineer/procure/construct process and, as such, the various component drawings will be at different stages of completeness at any given time. When the drawings for specific component parts of the project are incrementally complete, those drawings will be released for construction to the general construction contractor. CH2M HILL Plateau Remediation Company (CHPRC) is serving in the role of construction managers/services during construction. For the initial parts of the project, construction managers/services includes road crossings, pipe laying, and the transfer building drawings, which have been released for construction (the same will be done for the civil and architectural drawings). The structural, mechanical, and electrical drawings will follow. Key components that span across all disciplines are being evaluated for impact as the drawings are released.

Although the majority of this RDR addresses the design of the 200 West Area groundwater pump-and-treat system, other remedy components are also described briefly. The ICs for the Hanford Site are already in place, as described in the *Sitewide Institutional Controls Plan for Hanford CERCLA Response Actions* (DOE/RL-2001-41).

1.1.3 Contents of the Remedial Design Report

This RDR contains the following:

- Chapter 1, Introduction: Presents the purpose and scope of the RDR, provides a summary of the site description and background, and includes an overview of the RDR document revision process.
- Chapter 2, Remedial Design: Provides a summary of the selected remedy, overview of the treatment process description, basis of design, and materials for construction of major components and unit processes for the 200 West Area groundwater pump-and-treat system.
- Chapter 3, Construction Schedule: Provides a summary of the major milestones for construction of the 200 West Area groundwater pump-and-treat system.
- Chapter 4, Cost Estimate: Describes the major cost components that have been estimated for construction of the 200 West Area groundwater pump-and-treat system. Provides an overview of the methods of estimating, basis of estimate, accuracy level, quality assurance (QA), quality control (QC), and limitations of use of the construction cost estimate.
- Chapter 5, References: Lists the references cited in this document.

Key design documents constituting the detailed information needed for construction of the selected remedy were developed and presented to EPA in briefings at design development stages of 30 percent and 90 percent. In association with the 90 percent design briefing conducted February 17, 2010, the 90 percent design documents were provided to EPA as follows:

- Volume 1, Basis of Design Report
- Volume 2, Specifications
- Volume 3, Specifications
- Volume 4, Facility Design Drawings
- Volume 5, Balance of Plant Design Drawings

The basis of design report, provided in Volume 1, presents key design assumptions and criteria for each major unit process and system component (e.g., biological treatment system, radiological treatment system, and air stripper), as well as applicable design codes and standards. Volumes 2 and 3 provide technical engineering specifications that dictate the material, product, and equipment requirements; installer qualifications; submittal requirements; and execution requirements. Volume 4 provides the design drawings (e.g., site plans, elevations, cross-sections, process flow diagrams, and panel schedules) for the treatment facilities. Volume 5 provides similar design drawings for the balance of plant.

1.2 Site Description and Background

The 200-ZP-1 OU includes several groundwater contaminant plumes that cover an area of approximately 10 km^2 (4 mi^2) beneath part of the 200 West Area. The 200 West Area is approximately 8 km^2 (3 mi^2), and is located near the middle of the Hanford Site. The 200 West Area is about 8 km (5 mi) south of the Columbia River and 4.5 km (2.8 mi) from the nearest Hanford Site boundary (State Route 240). The 200 West Area is located on an elevated flat area that is often referred to as the Central Plateau; there are no wetlands, perennial streams, or floodplains.

The following subsections briefly describe the site setting, nature, and extent of contamination within the 200-ZP-1 OU; ongoing 200 West Area interim remedial actions; and groundwater monitoring. More detailed information describing the Hanford Site, the 200 West Area, and the 200-ZP-1 OU is provided

in the remedial investigation report (DOE/RL-2006-24), the *Feasibility Study Report for the 200-ZP-1 Groundwater Operable Unit* (DOE/RL-2007-28), and the ROD (EPA et al., 2008).

1.2.1 Physical Setting

The Hanford Site lies in a sediment-filled basin on the Columbia Plateau in southeastern Washington State (Figure 1-1). The Central Plateau is a relatively flat, prominent terrace near the center of the Hanford Site. The 200-ZP-1 OU underlies the northern portion of the 200 West Area, which is on the western end of the Central Plateau.

Basalt of the Columbia River Basalt Group and a sequence of overlying sediments comprise the local geology. The overlying sediments are approximately 169 m (555 ft) thick and primarily consist of the Ringold Formation and Hanford formation, which are composed of sand and gravel with some silt layers. Surface elevations range from approximately 200 to 217 m (660 to 712 ft).

The sediment thickness in the 200 West Area above the water table (the vadose zone) ranges from 40 to 75 m (132 to 246 ft). Sediments in the vadose zone include the Ringold Formation (the uppermost Ringold Unit E and the upper Ringold), the Cold Creek unit, and the Hanford formation. Estimates of recharge from precipitation at the Hanford Site range from 0 to 10 cm/yr (0 to 4 in./yr); artificial recharge historically occurred when effluents (e.g., cooling water and process wastewater) were disposed to the ground during the 1940s through the 1990s. Artificial recharge that continues today in the Central Plateau consists of limited onsite sanitary sewage treatment and disposal systems; leaks from potable and raw water lines; two state-approved land disposal structures; and small-volume, uncontaminated, miscellaneous waste streams.

Groundwater beneath the Hanford Site is found in an upper, primarily unconfined, aquifer system and in deeper confined aquifers within the basalt. The Columbia River is the primary discharge area for both the unconfined and confined aquifers. The unconfined aquifer in the 200-ZP-1 OU occurs in the Ringold Formation. Groundwater in the unconfined aquifer flows from areas where the water table is higher (west of the Hanford Site) to areas where it is lower (the Columbia River). In general, groundwater flow through the Central Plateau occurs in a predominantly easterly direction from the 200 West Area to the 200 East Area. Historical discharges to the ground greatly altered the groundwater flow regime, especially around the 216-U-10 Pond in the 200 West Area and the 216-B-3 Pond in the 200 East Area, which deflected the water flow to the north. As drainage from these discharges has ceased, the water flow direction is expected to again flow on a more easterly course through the Central Plateau.

The depth to the water table in the 200 West Area varies from approximately 50 m (164 ft) in the southwestern corner near the former 216-U-10 Pond to greater than 100 m (328 ft) in the north. The groundwater flow is primarily to the east, except in the northern portion of the 200 West Area where the flow is east-northeast. Groundwater flow is locally influenced by the 200-ZP-1 OU interim remedial measure pump-and-treat system and permitted effluent discharges at the State-Approved Land Disposal Site. The groundwater flow rates typically range from 0.0001 to 0.5 m/day (0.00033 to 1.64 ft/day) across the 200-ZP-1 OU; however, the water table continues to decline at a rate of approximately 0.21 m/yr (0.69 ft/yr) since the large influx of artificial recharge has ceased.

1.2.2 Nature and Extent of Contamination

In the 200-ZP-1 OU, the COCs identified are carbon tetrachloride, total chromium (trivalent and hexavalent), nitrate, trichloroethylene (TCE), iodine-129, technetium-99, and tritium. The 200-ZP-1 OU has been well characterized over the years by well drilling and groundwater sampling. More than 100 monitoring wells are currently within the footprint of the 200-ZP-1 OU.

The primary cribs and trenches that contributed contaminants to the 200-ZP-1 OU groundwater through discharges from 1945 to the early 1970s included the 216-Z-1A Trench, 216-Z-9 Crib, 216-Z-18 Trench, 216-Z-19 Ditch, 216-Z-20 Crib, and 216-U-10 Crib. After effluents were discharged to these vadose zone disposal sites, the more mobile contaminants migrated to the groundwater. Less mobile contaminants remain in the vadose zone and will be addressed in the source OU or other OU remedies. Data collected indicate that no carbon tetrachloride dense non-aqueous phase liquid source terms are present in 200-ZP-1 OU groundwater, which is documented in the *Carbon Tetrachloride Dense Non-Aqueous Phase Liquid (DNAPL) Source-Term Interim Characterization Report* (DOE/RL-2006-58) and its addendum (DOE/RL-2007-22).

As stated in the 200-ZP-1 OU ROD, contaminant distributions within the OU can be represented by three categories:

1. A high-concentration zone near the ponds, cribs, and trenches that were used to dispose the liquid wastes. Data do not indicate the presence of significant dense non-aqueous phase liquid in groundwater acting as a continuing source.

2. A larger, dispersed or low-concentration zone that has migrated from the discharge locations or overlies the high-concentration zone. This less contaminated groundwater can occur above the high-concentration zone where large quantities of lower concentration effluent were discharged during or after the high-concentration waste discharges.

3. An area of technetium-99 contamination occurs near Waste Management Area (WMA) T and WMA TX/TY. The results from depth-discrete groundwater sampling in the newly installed wells in these areas show that the peak concentration of technetium-99 is typically found within the upper 15 m (50 ft) of the aquifer. These results will be considered in the final design and implementation of the remedy for 200-ZP-1 OU groundwater.

Groundwater contamination is present from the top to the base of the unconfined aquifer, which is approximately 61 m (200 ft) thick. Distribution maps from data collected at the water table (data set from DOE/RL-2010-11, *Hanford Site Groundwater Monitoring and Performance Report for 2009*) that present the contaminants that exceed the maximum contaminant levels (MCLs) in 200 West Area (200-ZP-1 and 200-UP-1 OUs) groundwater are presented Figures 1-2 through 1-8. The 200-ZP-1 feasibility study (DOE/RL-2007-28) includes depth-specific maps presenting the vertical plume geometry contamination conditions. For scaling purposes, the extent of carbon tetrachloride contamination in the 200-ZP-1 OU encompasses an area of approximately 10 km^2 (4 mi^2).

1.2.3 200-ZP-1 OU Interim Remedial Measure

The DOE currently operates an interim remedial measure pump-and-treat system to minimize further migration of carbon tetrachloride, chloroform, and TCE in 200 West Area groundwater in accordance with the *Record of Decision for the USDOE Hanford 200-ZP-1 Operable Unit, 200 Area NPL Site Interim Remedial Measure* (EPA/ROD/R10-95/114). This system has been in operation since 1994, extracting more than 4 billion L (1,057 million gal) of groundwater, removing more than 11,415 kg (25,165 lb) of carbon tetrachloride. Additional information on the interim remedial measure is provided in the *Proposed Plan for Remediation of the 200-ZP-1 Groundwater Operable Unit* (DOE/RL-2007-33) and the 200-ZP-1 feasibility study (DOE/RL-2007-28).

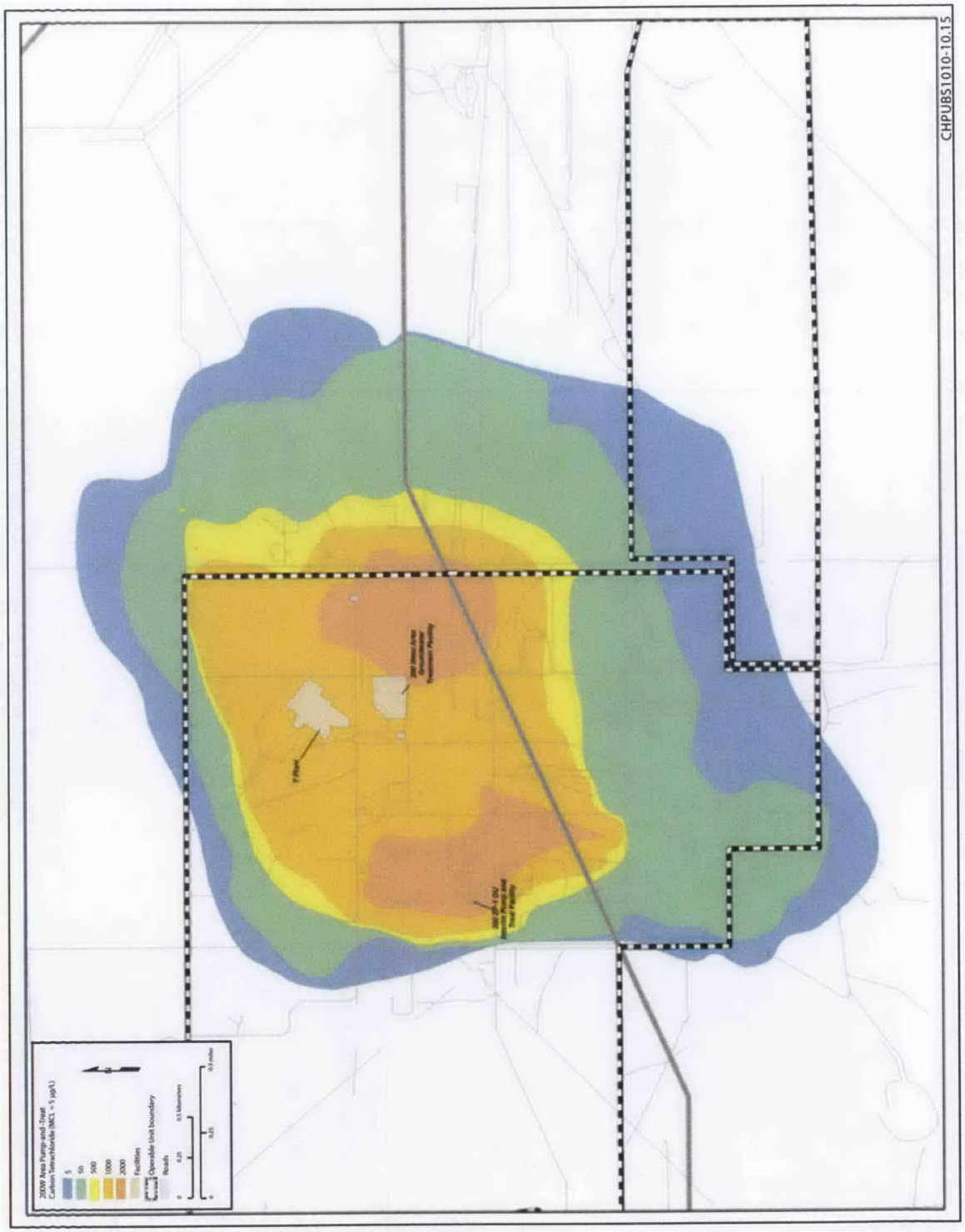

Figure 1-2. Estimated Lateral Extent of Carbon Tetrachloride

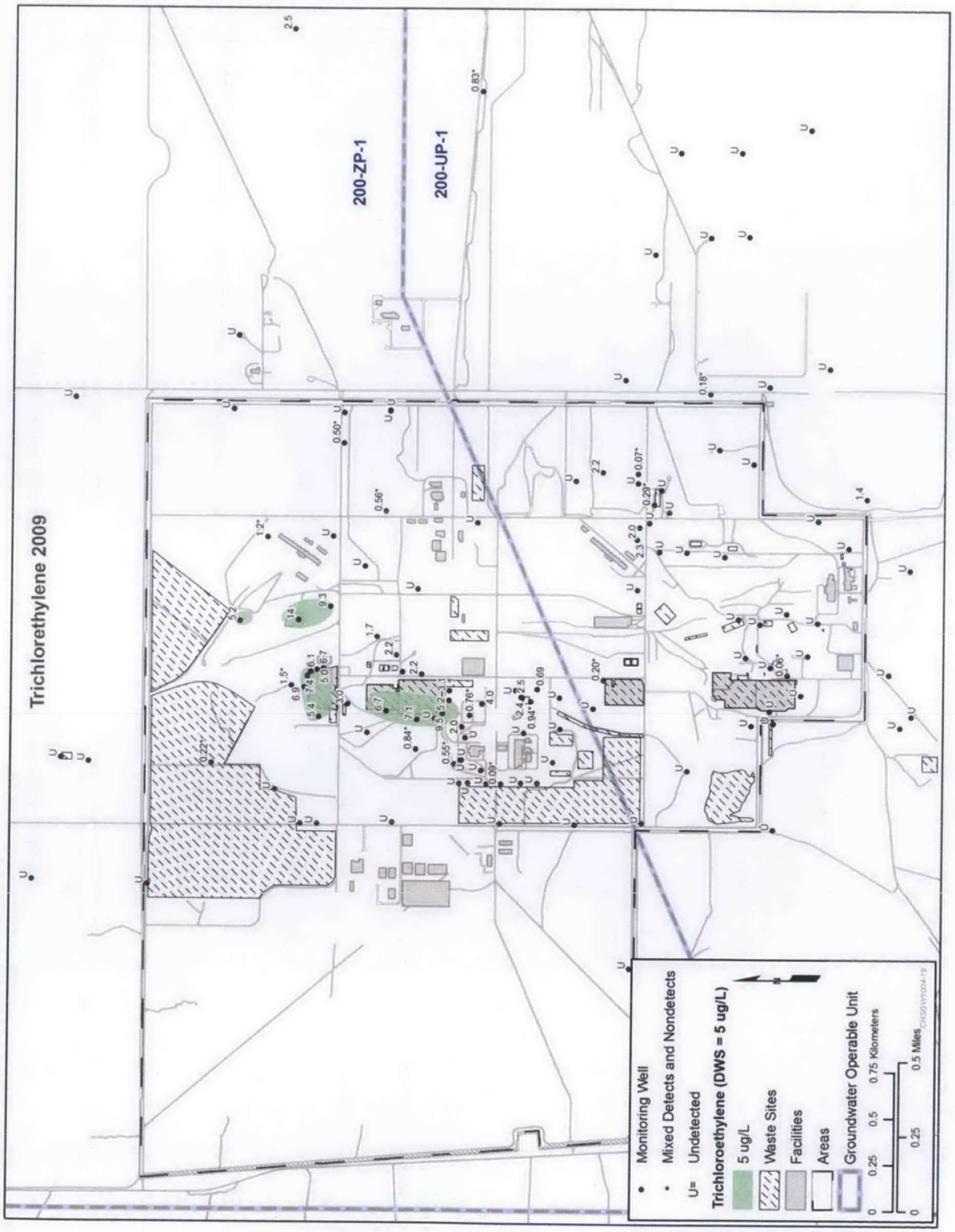

Figure 1-3. Estimated Lateral Extent of TCE

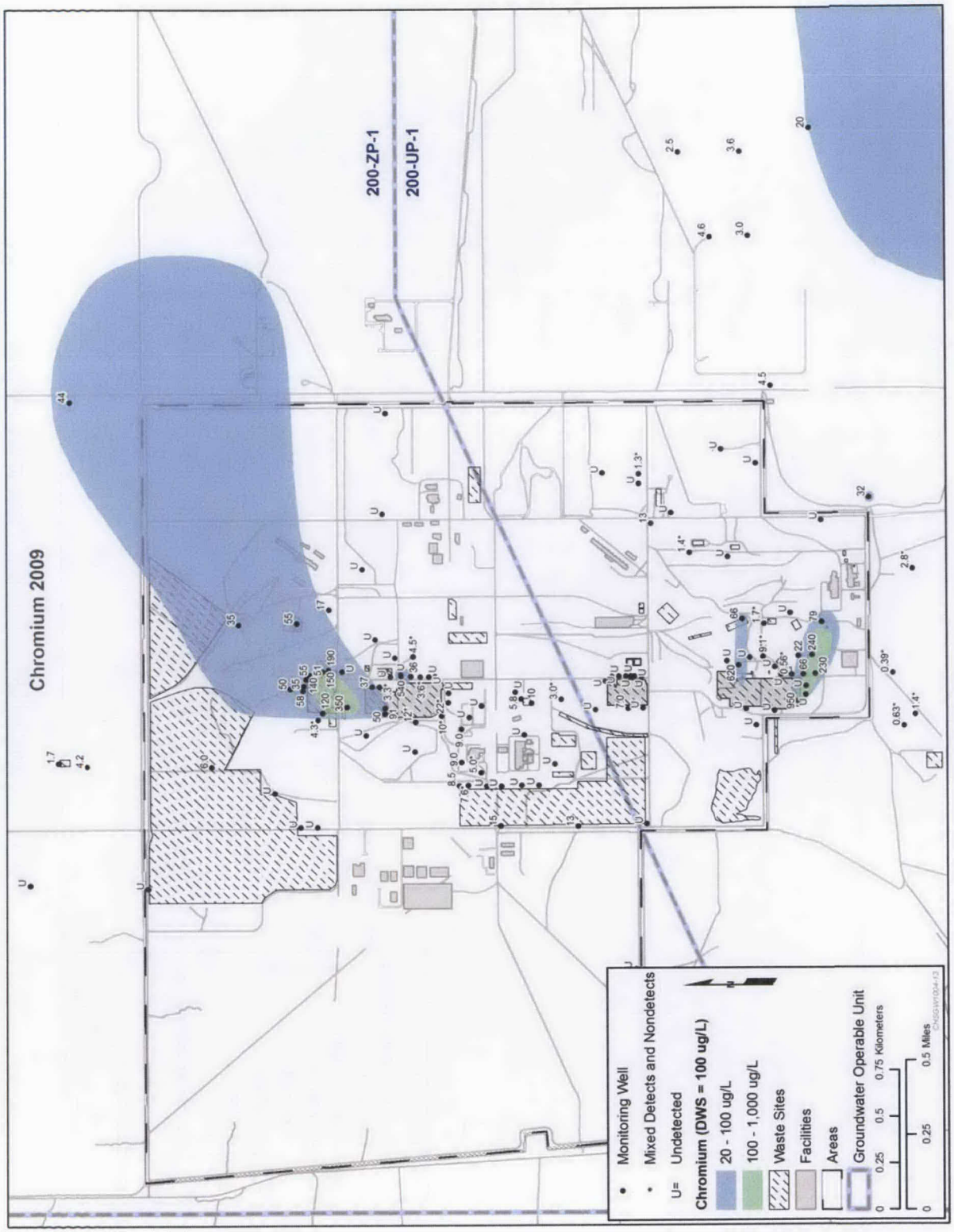

Figure 1-4. Estimated Lateral Extent of Chromium (Total) in Groundwater

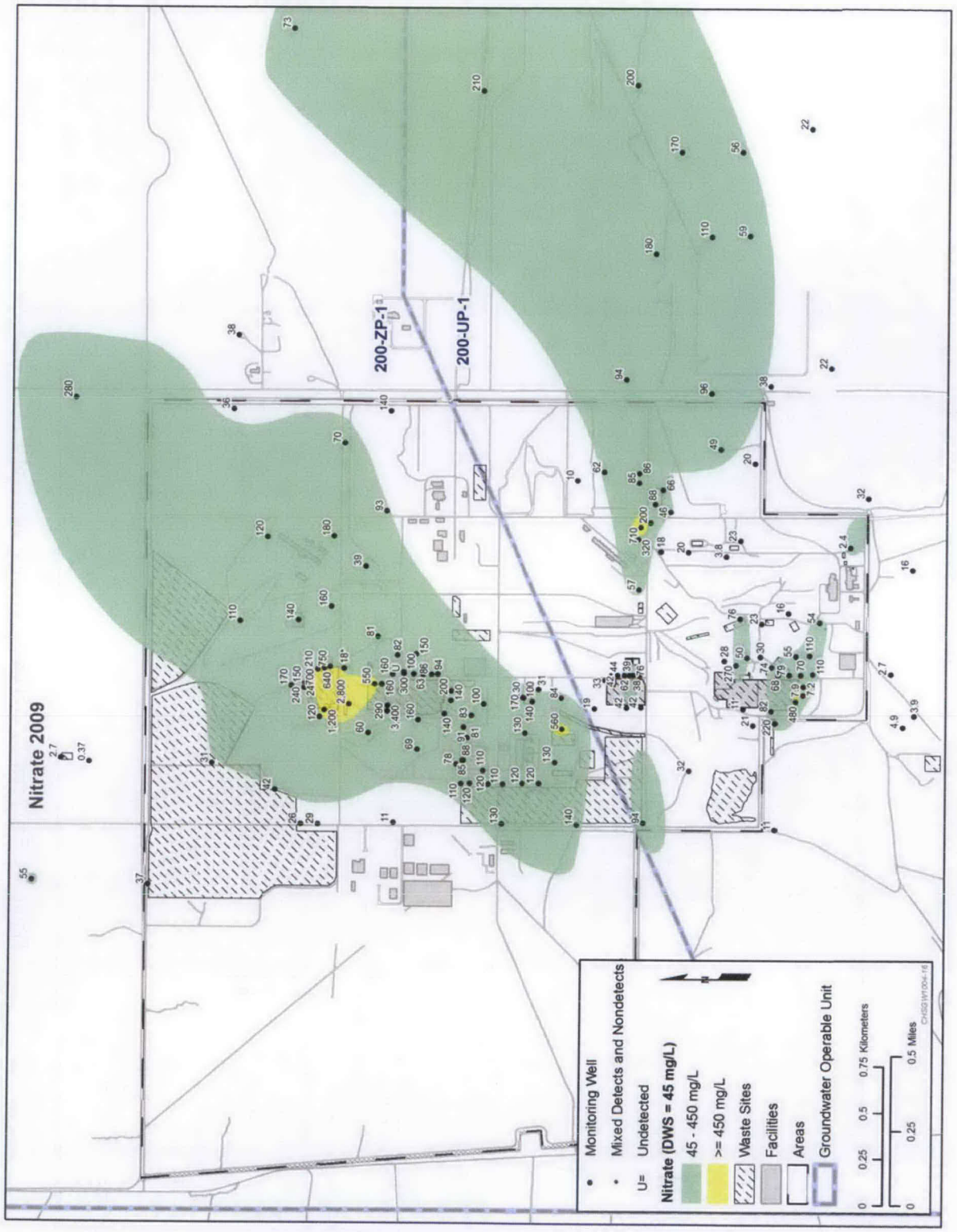

Figure 1-5. Estimated Lateral Extent of Nitrate in Groundwater

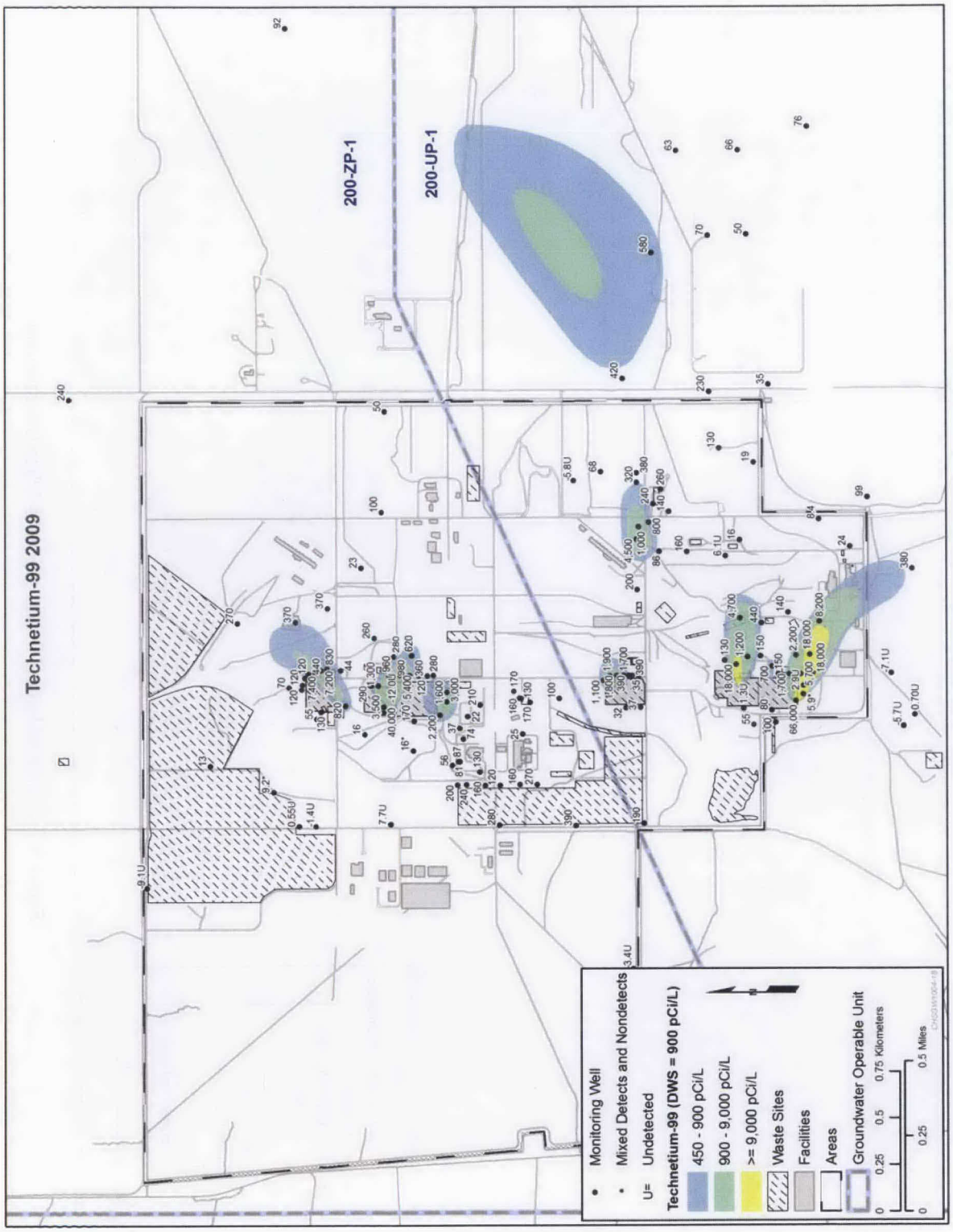

Figure 1-6. Estimated Lateral Extent of Technetium-99

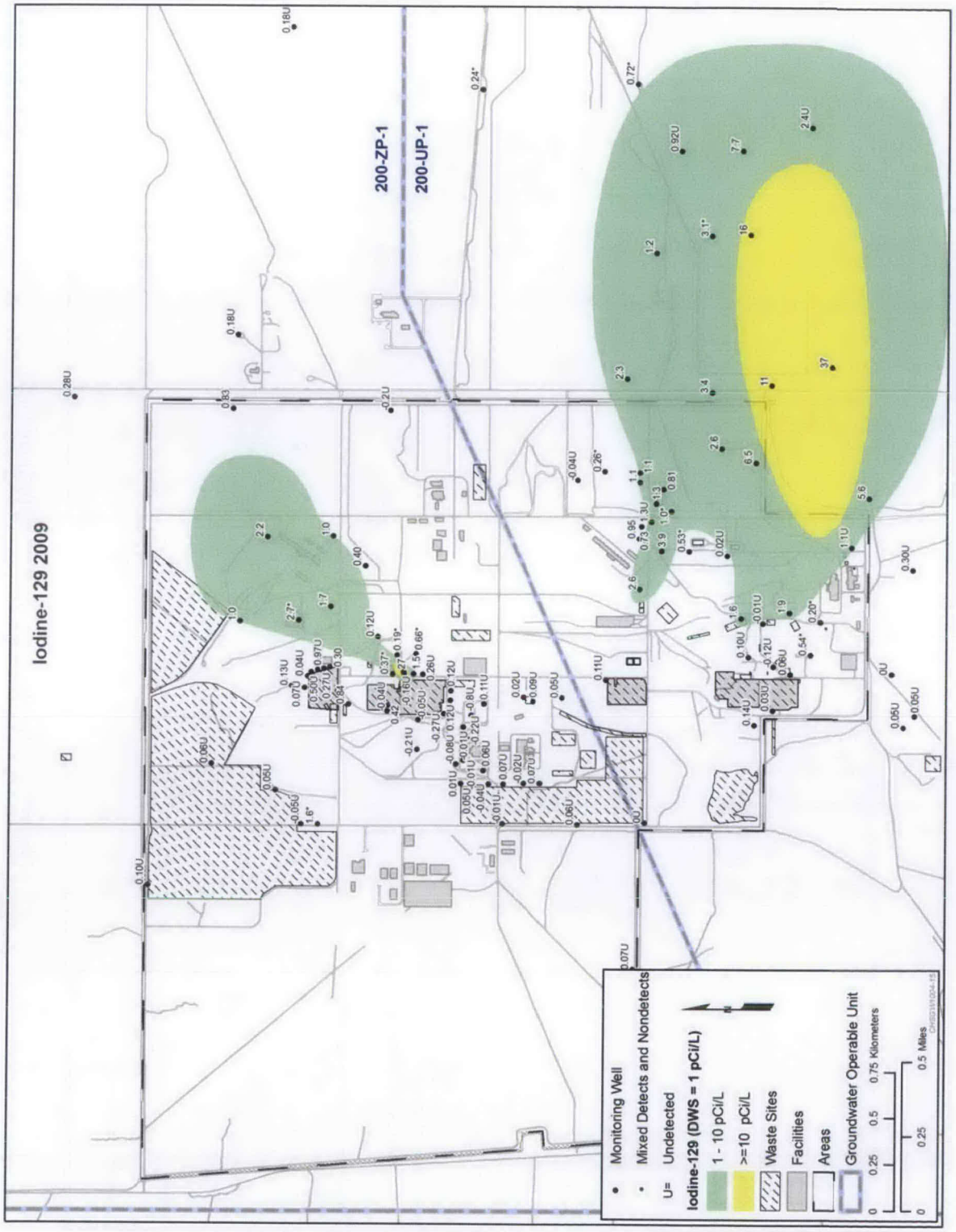

Figure 1-7. Estimated Lateral Extent of Iodine-129 in Groundwater

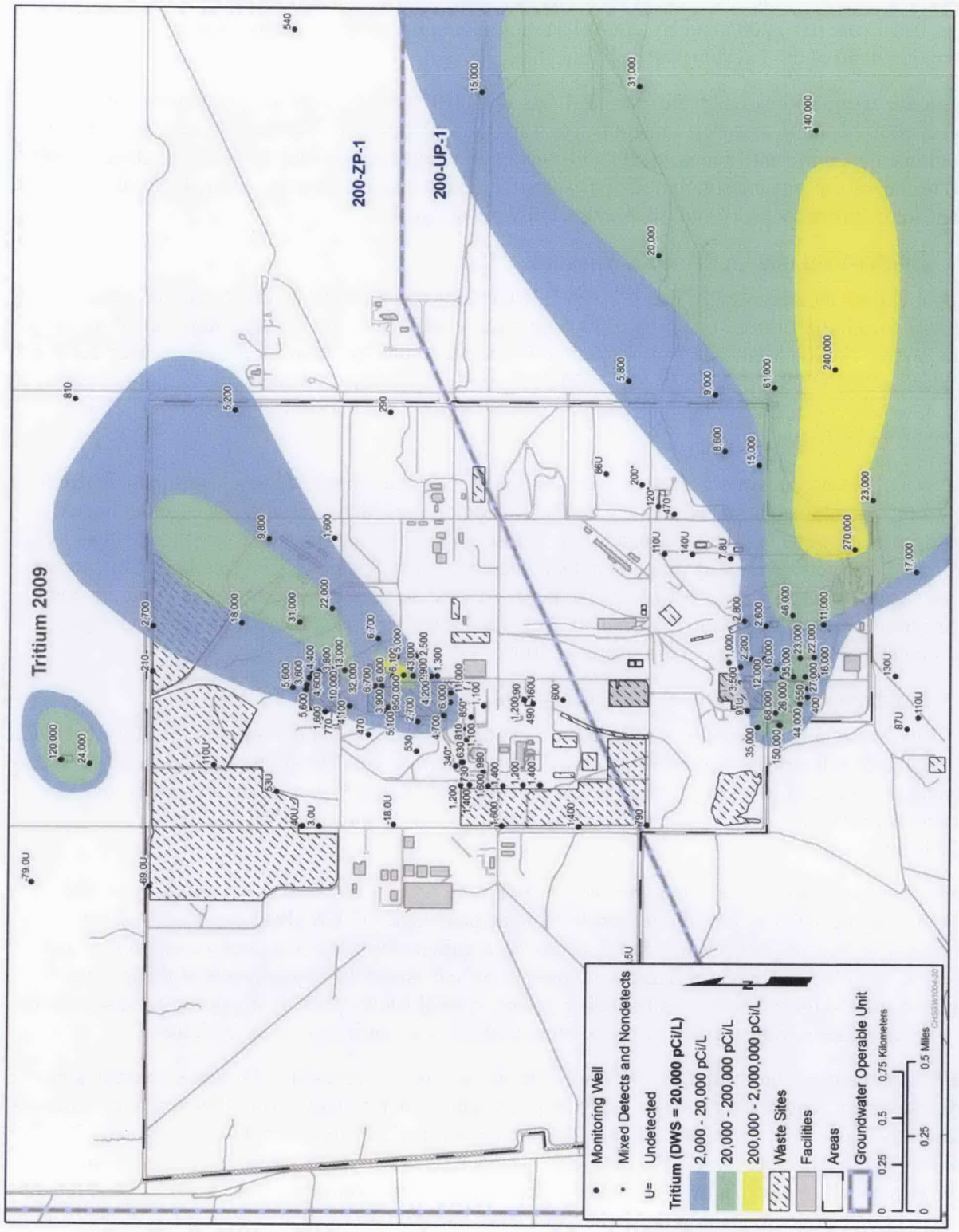

Figure 1-8. Estimated Lateral Extent of Tritium in Groundwater

During interim remedial measure pump-and-treat system operations, carbon tetrachloride concentrations have decreased in the original target area (defined as the concentration within the 2,000 to 3,000 µg/L contour). The interim pump-and-treat system was expanded by adding additional extraction wells between fiscal year (FY) 2005 and FY 2008. The interim pump-and-treat system currently includes 14 extraction wells and 5 injection wells (Figure 1-9).

The response action addressed by the 200-ZP-1 OU ROD (EPA et al., 2008) will implement the final components of the pump-and-treat remedial action for the 200-ZP-1 OU. The interim remedial measure will continue to operate until such time that the new pump-and-treat system is operational. Once the new system is operational, the interim remedial measure extraction and injection wells may be used to augment contaminant recovery and flow-path control, respectively.

1.2.4 200-PW-1 OU Interim Remedial Measure

Soil vapor extraction was initiated in 1992 as a CERCLA interim remedial action to remove carbon tetrachloride from the vadose zone in the 200 West Area. The objective of the interim remedial measure, as stated in the "Action Memorandum: Expedited Response Action Proposal for 200 West Area Carbon Tetrachloride Plume" (Smith and Stanley, 1992), is to mitigate the threat to site workers, public health, and the environment caused by the migration of carbon tetrachloride vapors through the soil column and into the groundwater.

The soil vapor extraction system has been in operation at the three primary disposal sites that received liquid wastes containing carbon tetrachloride. The soil vapor extraction system extracts contaminated soil vapor through wells that are screened in the vadose zone. The contaminated vapor is treated using aboveground canisters containing granular activated carbon (GAC), which adsorbs carbon tetrachloride from the vapor. Between April 1991 (when the pilot test was conducted) and September 2008, the total mass of carbon tetrachloride removed from all sites was 79,400 kg (175,047 lb). Two new soil vapor extraction units began operation in the spring of 2009.

1.2.5 Groundwater Monitoring at the 200-ZP-1 OU

The CERCLA groundwater performance monitoring and interim remedial measures at the 200-ZP-1 OU, as required by regulatory agreement, are outlined in the interim ROD (EPA/ROD/R10-95/114), as implemented in the *200-ZP-1 IRM Phase II and III Remedial Design Report* (DOE/RL-96-07) and the *Sampling and Analysis Plan for the 200-ZP-1 Groundwater Monitoring Well Network* (DOE/RL-2002-17).

Groundwater monitoring is performed for two treatment, storage, or disposal units consisting of tank farm WMAs T and TX-TY, Low-Level Waste Management Area 3 (LLWMA-3), and LLWMA-4. Groundwater at these facilities is monitored under the requirements of the *Resource Conservation and Recovery Act of 1976* (RCRA) for hazardous waste constituents and the requirements of the *Atomic Energy Act of 1954* for radionuclides including source, special nuclear, and byproduct materials. Data for facility-specific monitoring are also integrated into CERCLA groundwater investigations.

Groundwater at single-shell tank farm WMA T is monitored under RCRA interim status groundwater quality assessment requirements (40 CFR 265.93[d], "Interim Status Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities," "Preparation, Evaluation, and Response," as referenced by WAC 173-303-400, "Dangerous Waste Regulations," "Interim Status Facility Standards"). The objective for groundwater quality assessment is to assess the extent and rate of movement of dangerous waste in groundwater that has a source from the WMA. Waste constituents found in groundwater near WMA T include chromium, fluoride, carbon tetrachloride, and nitrate. Radioactive constituents include tritium and technetium-99.

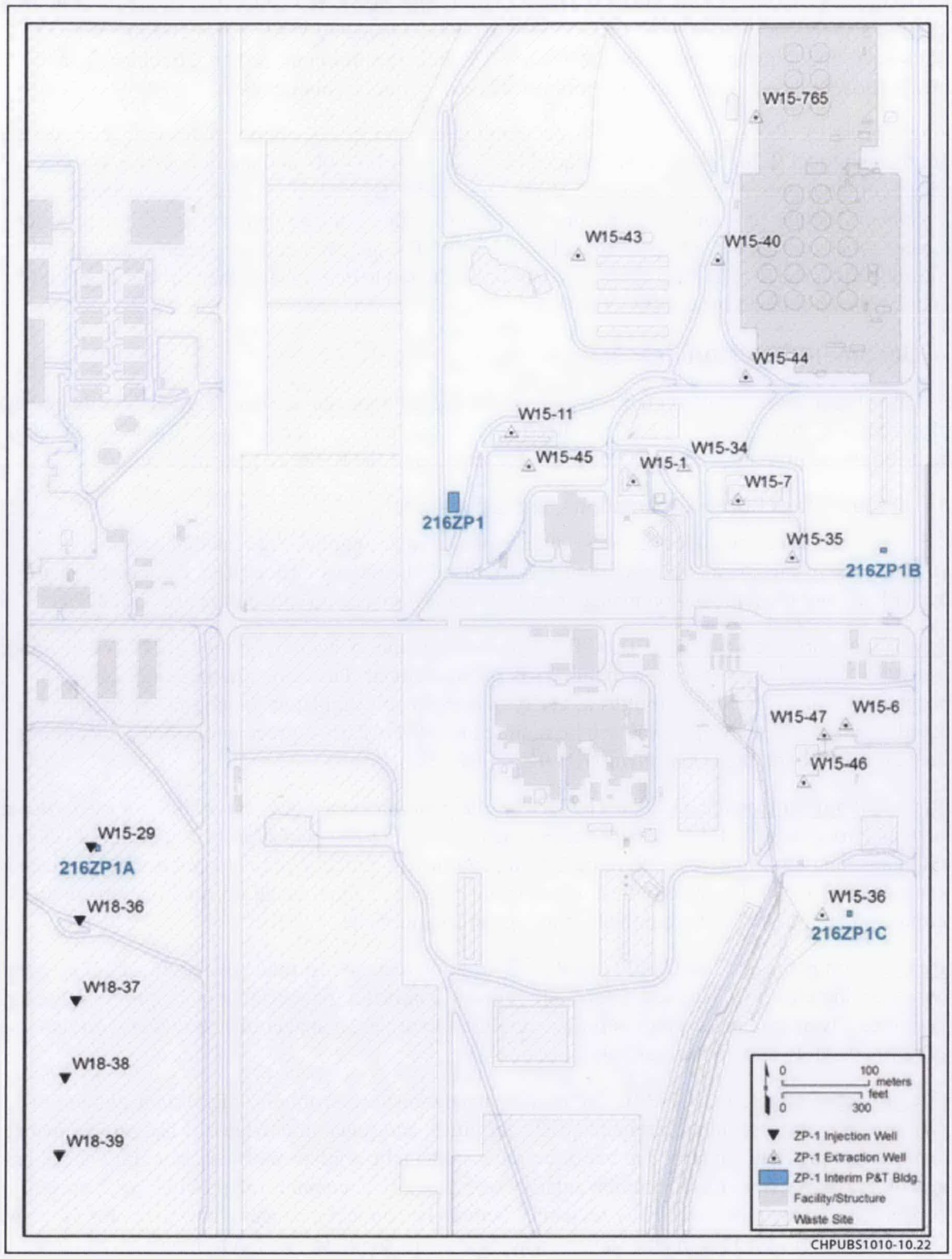

Figure 1-9. 200 West Area Interim Pump-and-Treat System

Groundwater at single-shell tank farms WMA TX-TY is also monitored under interim status groundwater quality assessment requirements (40 CFR 265.93[d], as referenced by WAC 173-303-400). Waste constituents found in groundwater near WMA TX-TY include chromium, carbon tetrachloride, and nitrate. Radioactive constituents include iodine-129, tritium, and technetium-99.

Groundwater at LLWMA-3 and LLWMA-4 is monitored under RCRA interim status indicator evaluation requirements (40 CFR 265.93[b], as referenced by WAC 173-303-400) and the radioactive waste management requirements of the *Atomic Energy Act of 1954* (DOE O 435.1, *Radioactive Waste Management*). Monitoring for RCRA is conducted to determine if the unit has impacted groundwater with dangerous constituents. Samples are collected for RCRA indicator and site-specific parameters. Monitoring under the *Atomic Energy Act of 1954* is conducted to determine if the unit has impacted groundwater with radioactive constituents.

1.3 Document Revision Process

The RDR is based on information representing the 90 percent remedial design. As such, additional design development and changing site conditions discovered during construction may necessitate modifications to the information presented herein. Guidelines for revision of the RDR are presented below.

1.3.1 Project Team Roles, Expectations, and Limitations

The term "project team" includes the individuals working to accomplish the remedial action. Accordingly, the project team includes the DOE Richland Operations Office (RL), the lead regulatory agency (EPA), and the remediation manager and site project manager (both contractors of DOE).

- Lead regulatory agency (EPA): The EPA is the lead regulatory agency for the CERCLA remediation activities at the site, as described in the Tri-Party Agreement. The lead regulatory agency is responsible for overseeing activities to verify that applicable regulatory requirements are met. Lead regulatory agency approval will be required on all Tri-Party Agreement primary documents (e.g., this RDR and the O&M plan [DOE/RL-2009-124]).

- Remedial project manager (DOE): The DOE is the government agency responsible for the remedial actions throughout the Hanford Site and, as such, has assigned remedial project managers to each main area and task involved with remediation activities. A remedial project manager is responsible for managing the assigned activities, which include scope, budget, schedule, quality, personnel, communication, risk/safety, contracts, and regulatory interface.

- Remediation manager: The CHPRC or RL remediation managers provide oversight for all activities and coordinate with RL, the regulators, and primary contractor management in support of remediation activities. Oversight and support is provided to the site project manager to ensure that work is performed safely and cost effectively.

- Site project manager: The CHPRC site project manager is responsible for direct management of sampling documents and requirements, field activities, and subcontracted tasks. The project manager ensures that the field construction manager, environmental compliance officer, sampling coordinator, and others responsible for the implementation of regulatory documents are provided with current copies of these documents and any revisions thereto. The project manager also works closely with the QA organization, the Health and Safety organization, and the field construction manager to integrate these and the other lead disciplines in planning and implementing the workscope. The project manager also coordinates with and reports to DOE, the regulators, and remediation and environmental managers on all remediation activities.

- Environmental manager: The CHPRC environmental manager provides environmental oversight for document preparation and field activities. In addition, the environmental manager supports both the remediation manager and site project manager to ensure work is performed in accordance with environmental requirements. The environmental manager coordinates with DOE and the regulatory agencies in support of remediation activities.

1.3.2 Remedial Design Report Components

This RDR includes the following components, which were provided to EPA during the 90 percent design review briefing:

- A design analysis (basis of design), which delineates the criteria and standards for the project. This includes horizontal and vertical extents of contamination, the area (location), and media (soil, water, etc.) containing constituents known to exceed cleanup standards.
- A set of engineering specifications that describe the level of effort necessary to implement the design (available to EPA upon request).
- Design drawings that show the areas of remediation and existing site features to be considered while implementing the remedial action (available to EPA upon request).
- A general remedial action project schedule.
- A construction cost estimate.

The above remedial design elements will be revised and updated in accordance with the change management procedures outlined below.

1.3.3 Change Management

The following three types of changes in the remedial actions could affect compliance with the requirements in the ROD (40 CFR 300.435[c][2]):

- A **fundamental change** is a change that fundamentally alters the basic features of the selected remedy with respect to scope, performance, or cost. A fundamental change requires a ROD amendment to be prepared and issued for public comment.
- A **significant change** generally involves a change to a component of a remedy that does not fundamentally alter the overall cleanup approach. Significant changes will be addressed in an explanation of significant difference.
- A **minor change** is one that will not have a significant impact on the scope, performance, or cost of the remedy. These minor changes should be documented in the appropriate post-decision project file (e.g., through interoffice memoranda or logbooks). A minor (non-significant) change will not impact the requirements of the ROD, nor will it impact functional requirements and, as such, will not require modification to this RDR.

Determining the significance of the change is the responsibility of DOE and the lead regulatory agency (EPA). The EPA has the right to review and approve fundamental and significant changes to documents. The remediation or environmental manager is responsible for tracking all changes and obtaining appropriate reviews by contractor staff who will discuss the change with DOE, and DOE will then discuss the type of change that is necessary with the lead regulatory agency, up to and including the Tri-Party Agreement Action Plan (Ecology et al., 1989b), Section 9.3 and Section 12.0 changes. Appropriate documentation will follow, in accordance with the requirements for that type of change.

2 Remedial Design

This chapter presents a summary of the overall project, the regulatory basis, and the designed groundwater pump-and-treat system being used for remedy implementation.

2.1 Summary of Selected Remedy

The 200-ZP-1 Groundwater OU is one of four groundwater OUs located on the Central Plateau. Each groundwater OU has its own plan of study and enforceable schedule, and each will eventually have its own ROD and cleanup action, as needed. The selected remedy for the 200-ZP-1 OU combines groundwater pump-and-treat, MNA, flow-path control, and ICs.

The following RAOs are specified in the ROD for the 200-ZP-1 Groundwater OU and are incorporated into the design of the pump-and-treat system:

- RAO #1: Return 200-ZP-1 OU groundwater to beneficial use (restore groundwater to achieve domestic drinking water levels) by achieving the cleanup levels (provided in the ROD, Table 11 [EPA et al., 2008]). 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.[1]
- RAO #2: Apply ICs to prevent the use of groundwater until the cleanup levels (provided in the ROD, Table 11) have been achieved. Within the entire OU groundwater plumes, ICs must be maintained and enforced until the cleanup levels are achieved, which is estimated to be within 150 years.[1]
- RAO #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.[1]

The final cleanup levels for the 200-ZP-1 OU groundwater COCs, following implementation of the selected remedy, are identified in the ROD and are listed in Table 2-1 of this RDR. The cleanup levels were developed using federal drinking water MCLs; the criteria and equations provided in WAC 173-340-720(4)(b)(iii)(A) and (B) ("Model Toxics Control Act – Cleanup," "Ground Water Cleanup Standards") and WAC 173-340-720(7)(b); and federal and drinking water standards for radionuclides.

2.1.1 Remedy Description

The selected remedy for the 200-ZP-1 Groundwater OU is designed to meet the objective of achieving cleanup levels for COCs in the 200-ZP-1 OU in 125 years (Table 2-1). The effectiveness of the pump-and-treat system will diminish over time as COC concentrations are reduced, whereas the effectiveness of natural attenuation is relatively constant. As a result, natural attenuation will eventually become the dominant mechanism for continued reduction of COC concentrations. The effectiveness of the remedy is further enhanced by controlling the direction and rate of groundwater flow throughout the 200-ZP-1 OU using strategically placed extraction and injection wells for flow-path control. The ICs provide protection from exposure to groundwater contamination for both site workers and potential future users of groundwater, at least through the 125-year period to achieve cleanup levels and potentially beyond (Section 2.1.4.3).

[1] The RAOs identify the estimated timeframe to achieve cleanup levels as 150 years. Further requirements in the ROD (EPA et al., 2008) identify this timeframe as 125 years, which is more conservative than the RAO.

Table 2-1. Final Cleanup Levels for the 200-ZP-1 Groundwater OU

COC	Units	Final Cleanup Level	Cleanup Level Basis
Carbon tetrachloride	µg/L	3.4[c,d]	MTCA – Method B
Chromium (total)	µg/L	100	Federal/State MCL
Hexavalent chromium	µg/L	48[a]	MTCA – Method B
Nitrate-nitrogen	µg/L	10,000[b]	Federal/State MCL
TCE	µg/L	1[c,d]	MTCA – Method B
Iodine-129	pCi/L	1	Federal MCL
Technetium-99	pCi/L	900	Federal MCL
Tritium	pCi/L	20,000	Federal MCL

a. There is no MCL specific to hexavalent chromium.

b. Nitrate may be expressed as total nitrate (NO_3) or as nitrogen (N). The MCL for nitrate as NO_3 is 45,000 µg/L, and the same concentration expressed as nitrate-N is 10,000 µg/L.

c. The MTCA Method B cleanup levels for carbon tetrachloride and TCE are from the Washington State Department of Ecology's Cleanup Levels and Risk Calculations (CLARC) database, current as of September 25, 2008.

d. The DOE will clean up COCs for the 200-ZP-1 OU subject to WAC 173-340, "Model Toxics Control Act – Cleanup" (carbon tetrachloride and TCE), so the excess lifetime cancer risk does not exceed 1×10^{-5} at the conclusion of the remedy.

2.1.2 Pump-and-Treat System Description

The new 200 West Area groundwater treatment facility will be located on Beloit Avenue between 22nd and 23rd Streets (south of T Plant) in the 200 West Area (Figure 2-1). Prior to siting the facility at this location, a biological review of the proposed site was performed. The findings from the review were that no plant or animal species protected under the *Endangered Species Act of 1973*, candidates for such protection, or species listed by the Washington State government as threatened or endangered were observed in the vicinity. The findings, along with some recommendations were documented in "Biological Review of the 200 West Area Groundwater Treatment Facility's Proposed Sites, ECR #2009-200-004" (Sackschewsky, 2008).

This system is designed to capture, treat, and/or manage contaminated groundwater to reduce the mass of COCs (carbon tetrachloride, total chromium [trivalent and hexavalent], nitrate, TCE, iodine-129, and technetium-99) throughout the 200-ZP-1 OU. Following treatment, the water is injected back into the aquifer to serve as a recharge source and to promote flow-path control (Figure 2-2). The system design also includes provisions for future treatment of groundwater from the 200-UP-1 OU, including the removal of uranium.

This RDR presents the overall system design of the 200 West Area groundwater pump-and-treat facility. The design is defined as 90 percent complete at this time but varies in detail and specificity for some components of the system based on the engineer/procure/construct delivery model being used. Final decisions are being made and will continue to be made throughout the design/build process regarding facility configuration. The system is scheduled to be constructed in calendar years 2009 through 2011 (see discussion in Chapter 3).

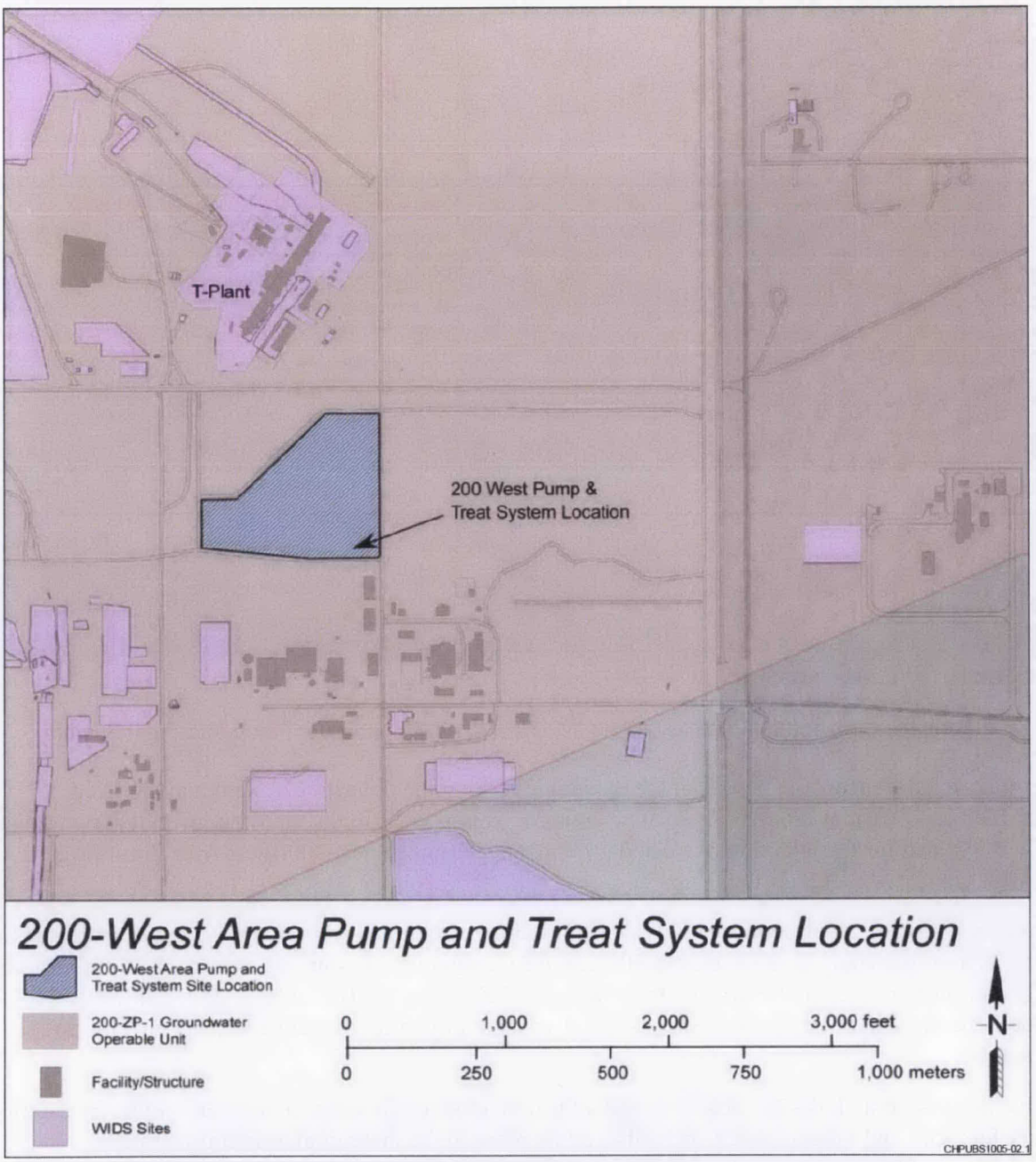

Figure 2-1. 200 West Area Groundwater Pump-and-Treat System Location

Construction of the treatment facility will provide an initial installed capacity to treat up to 9,464 L/min (2,500 gal/min) of extracted groundwater (7,571 L/min [2,000-gal/min] nominal flow rate) using two parallel treatment trains. The initial extraction and injection well network is projected to include 15 extraction wells and 5 injection wells. The number and location of these wells are being finalized and will depend on site-specific conditions.

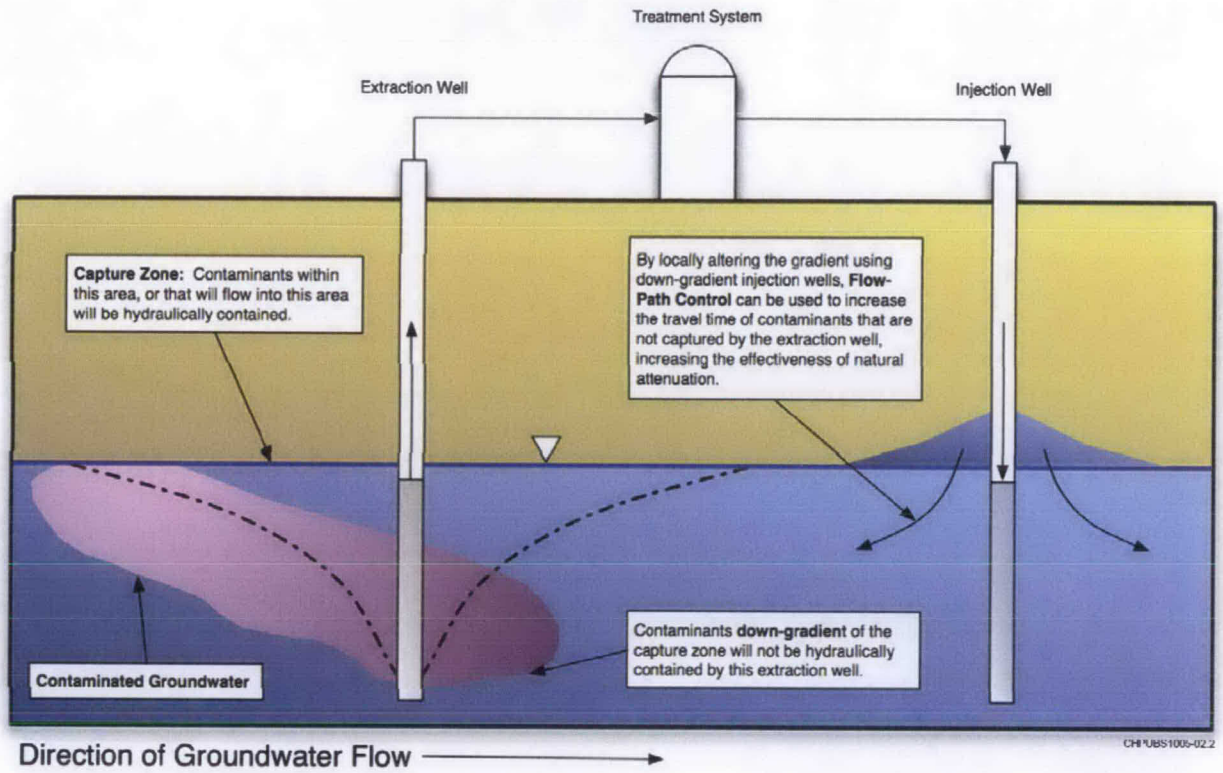

Figure 2-2. Conceptual Summary of the 200 West Area Groundwater Pump-and-Treat System

After full system startup, operations at the existing interim remedial action system may be idled, mothballed, or decommissioned. There are existing injection wells in the interim remedial action system that may be used for the injection of treated groundwater from the new 200 West Area groundwater treatment facility.

Upon completion of construction, facility commissioning, and initial startup, the system is projected to operate at approximately 3,785 L/min (1,000 gal/min), including an estimated 189 to 379 L/min (50 to 100 gal/min) of groundwater extracted from WMA S-SX in the 200-UP-1 OU. Additional wells will gradually be brought online over the next several years to utilize additional treatment capacity at the facility.

The facility design includes the ability to add a third treatment train (also in parallel) within the existing facility footprint and infrastructure, as well as an increase in the maximum design flow rate to 14,195 L/min (3,750 gal/min). The need for additional treatment capacity will be based on the treatment capacity required for 200-ZP-1 OU groundwater and groundwater that may be extracted as part of the final remedy for the 200-UP-1 OU.

2.1.3 Other Remedy Components

This section describes the additional components of the groundwater remedy that augment the pump-and-treat system, including MNA, flow-path control, and ICs.

2.1.3.1 Monitored Natural Attenuation

In addition to the pump-and-treat system, the remedy for the 200-ZP-1 OU includes natural attenuation processes for reducing COC concentrations to meet cleanup levels. Natural attenuation will eventually

become the dominant mechanism for continued reduction of COC concentrations in the 200-ZP-1 OU as the effectiveness of the pump-and-treat system decreases over time. Because there is no viable treatment technology for tritium from the groundwater, the short half-life of tritium will allow natural attenuation to reduce its concentration to meet the cleanup levels.

For the remaining portion of the carbon tetrachloride and nitrate (as well as tritium) not captured by the pump-and-treat component, natural attenuation processes will be used to reduce concentrations to the cleanup levels.

Natural attenuation processes to be relied on as part of this component includes biotic and abiotic degradation, dispersion, sorption, and (for tritium) natural radioactive decay. Monitoring conducted under the O&M plan (DOE/RL-2009-124) and the *Performance Monitoring Plan for the 200-ZP-1 Groundwater Operable Unit Remedial Action* (DOE/RL-2009-115) will be used to evaluate the effectiveness of the pump-and-treat system and natural attenuation processes. Fate and transport analyses conducted as part of the feasibility study (DOE/RL-2007-28) and the *Description of Modeling Analyses in Support of the 200-ZP-1 Remedial Design/Remedial Action Work Plan* (DOE/RL-2009-38) indicate that the timeframe necessary to reduce the remaining COC concentrations to acceptable levels through MNA will be approximately 100 years after the active pumping phase is completed.

2.1.3.2 Flow-Path Control

The flow-path control component of the 200-ZP-1 Groundwater OU remedial action consists of injecting treated groundwater into the aquifer to the west and east of the groundwater contaminant plume. Injecting water at these locations contains the contaminant plume and, as a result, keeps the higher concentration areas within the extraction well capture zone while also managing the flow path and related travel time for natural attenuation processes to reduce contaminant concentrations not captured by the extraction wells.

Flow-path control is also used to minimize the potential for groundwater in the northern portion of the aquifer to flow northward through Gable Mountain Gap and toward the Columbia River. The injection wells are located to redirect groundwater flow to the east, which provides the longest flow path to the river (about 26 km [16 mi]). Monitoring data collected under the O&M plan (DOE/RL-2009-124) will be assessed to determine the effectiveness of flow-path control.

2.1.3.3 Institutional Controls

The 200-ZP-1 OU ROD requires ICs for 200-ZP-1 groundwater until the cleanup levels are met. A description of these controls and their implementation is provided in the sitewide IC plan (DOE/RL-2001-41). The following specific controls are required by the 200-ZP-1 OU ROD:

- No intrusive work shall be allowed in the 200-ZP-1 OU unless the EPA has approved the plan for such work and that plan is followed.
- The DOE shall prohibit well drilling in the 200-ZP-1 OU, except for monitoring, characterization, or remediation wells authorized in EPA-approved documents.
- Groundwater use in the 200-ZP-1 OU is prohibited, except for limited research purposes, monitoring, and treatment authorized in EPA-approved documents. The sitewide IC plan will contain the ICs and implementing details prohibiting well drilling and groundwater use in the 200-ZP-1 OU, as defined in the ROD.
- The DOE shall post and maintain warning signs along pipelines conveying untreated groundwater to caution site visitors and workers of potential hazards from the 200-ZP-1 OU groundwater.

- In the event of any unauthorized access to the site (e.g., trespassing), DOE shall report such incidents to the Benton County Sheriff's Office for investigation and will consider administrative debarment of the trespasser, as well as prosecution in state or federal court, as deemed appropriate.
- Activities that would disrupt or lessen the performance of the pump-and-treat, MNA, and flow-path control components of the remedy are to be prohibited.
- The DOE shall prohibit activities that would damage the pump-and-treat, MNA, and flow-path control components (e.g., extraction wells, injection wells, piping, treatment plant, and monitoring wells).
- The DOE shall report on the effectiveness of ICs for the 200-ZP-1 OU remedy in an annual report, or on an alternative reporting frequency specified by EPA. Such reporting may be for this OU alone or may be part of a Hanford Site report.
- The DOE will prevent the development and use of property above the 200-ZP-1 OU for residential housing, elementary and secondary schools, childcare facilities, and playgrounds.
- Land-use controls will be maintained until cleanup levels are achieved and the concentrations of hazardous substances in groundwater are at such levels to allow for unrestricted use and exposure and EPA authorizes the removal of restrictions.

Most of the land within the 200-ZP-1 OU has been designated by DOE, through the *Final Hanford Comprehensive Land-Use Plan Environmental Impact Statement* (DOE/EIS-0222-F), for industrial exclusive use for the foreseeable future. The ROD for 200-ZP-1 OU requires that DOE proceed as follows in the event of the transfer or sale of any land located in the OU:

- The DOE will provide notice to EPA at least 6 months prior to transfer or sale of the land within the 200-ZP-1 OU so EPA can be involved in discussions to ensure that appropriate provisions are included in the transfer terms or conveyance documents to maintain effective ICs.
- If it is not possible for DOE to notify EPA at least 6 months prior to transfer or sale, then DOE will notify EPA as soon as possible, but no later than 60 days prior to the transfer or sale of property subject to ICs.
- In addition to the land transfer notice and discussion provisions above, DOE further agrees to provide EPA with similar notice, within the same timeframes, as to federal-to-federal transfer of property. The DOE shall provide a copy of executed deed or transfer assembly to EPA.

2.2 Extraction and Injection Well Field

The following sections provide an overview of the basis of design, groundwater modeling, well installation, and materials of construction for the extraction and injection well field components of the remedy. Figure 2-3 shows the planned layout of the extraction wells, injection wells, and conveyance piping in the 200 West Area. Groundwater conveyance piping and transfer buildings are included as part of the balance of plant design described in Section 2.4.

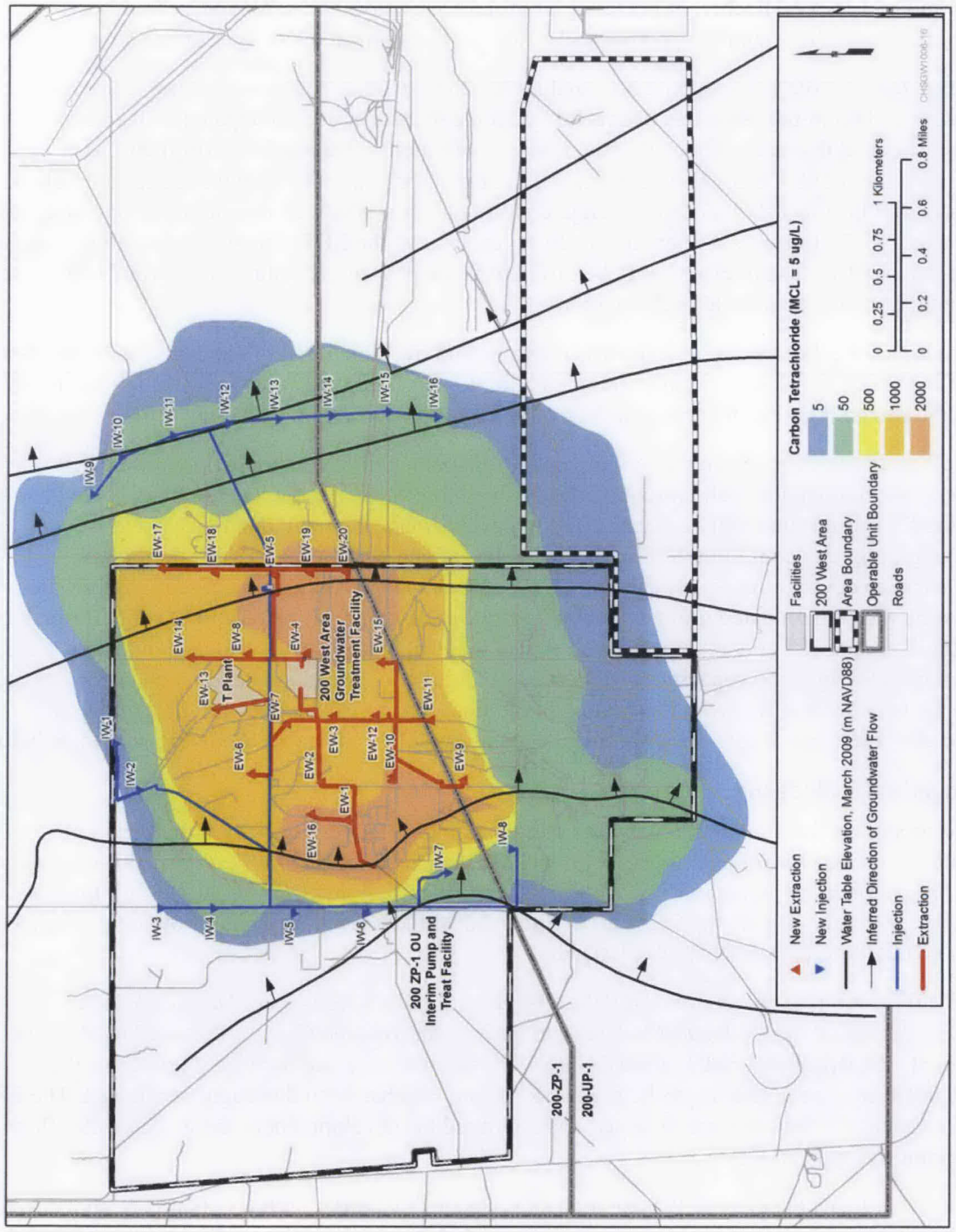

Figure 2-3. Proposed Extraction and Injection Well Locations and Conveyance Pipe Routing for the 200 West Area Groundwater Pump-and-Treat System

2.2.1 Basis of Design

Initial extraction and injection well locations were sited using a groundwater flow and contaminant transport model to maximize carbon tetrachloride mass removal by extracting groundwater from portions of the aquifer with the highest concentrations while providing plume containment. Final well locations will be determined based on further optimization of groundwater flow and contaminant transport modeling during the well installation process and a field walk-down survey of current site conditions.

Wells will be sited to avoid Hanford Site National Historic restrictions, roads, waste sites, and other obstructions. Based on initial estimates of aquifer hydraulic properties and anticipated well screen lengths, it is estimated that each of the 20 extraction wells (initially 15 wells for startup) will have a pumping capacity of 568 L/min (150 gal/min) and are expected to provide a nominal pumping rate of approximately 409 L/min (108 gal/min) at design conditions, for a total well field nominal operating rate of approximately 8,176 L/min (2,160 gal/min). However, to meet the ROD-specified restoration timeline, actual extraction well yields are expected to be different and will vary depending on the final well screen length and aquifer characteristics at each location.

To reduce future costs, the system has capacity to extract and treat the plumes in and around WMA S-SX and U Plant in the 200-UP-1 OU. To that end, the ability to add additional wells in the future has been included in the design. Final well yields will be evaluated following well installation.

Injection well locations were selected to optimize the flow-path control component of the selected remedy. The planned injection well array includes 16 injection wells (5 initial injection wells are planned to be installed for startup) that will be divided into two well groups (an upgradient group and downgradient group, both consisting of 8 wells each). The alignment of each well group forms a sweeping curve to cover the depicted contaminant footprint and to produce convergent groundwater flow that directs the contaminated groundwater toward the extraction well field capture zone. Based on aquifer hydraulic properties and anticipated well screen lengths, it is estimated that each injection well will have a minimum injection capacity of 473 L/min (125 gal/min). Actual injection well capacities are expected to be different and will vary depending on the final well screen length, and the aquifer and vadose zone characteristics at each location. Final capacities will be estimated following well installation.

2.2.2 Groundwater Modeling

As indicated in Section 2.2.1, extraction and injection well locations were selected with the aid of a groundwater flow and contaminant transport model. As described in the *200 West Area Pre-Conceptual Design for Final Extraction/Injection Well Network: Modeling Analyses* (DOE/RL-2008-56), the initial modeling effort consisted of constructing a three-dimensional modular groundwater flow model based on the U.S. Geological Survey MODFLOW platform.

The MODFLOW-2000 release version (*MODFLOW-2000, The U.S. Geological Survey Modular Ground-Water Model – User Guide to Modularization Concepts and the Ground-Water Flow Process* [Harbaugh et al., 2000]) of this widely used desktop software was selected because it possesses the necessary simulation capabilities, is public domain software, and has been thoroughly reviewed. The EPA and the U.S. Geological Survey were involved and approved the development of the groundwater flow and contaminant transport model.

The model domain spans the Central Plateau area and contains five different layers that correspond to the principal hydrostratigraphic units present beneath the Central Plateau. Once the model grid, layers, and boundary conditions were defined, the model was run and calibrated to historic groundwater elevations that were recorded at monitor wells throughout the 200-ZP-1 OU. The calibration step was performed by adjusting selected model input parameters, using both manual and automated parameter estimation

techniques, until a relatively good correspondence between the simulated and measured changes in groundwater elevations at monitoring wells; contoured, simulated, and measured groundwater elevations; and hydraulic gradients were obtained. No formal statistical methods were used to assess calibration; rather, calibration was interpreted qualitatively by comparing simulated and observed groundwater elevation hydrographs at monitoring wells located throughout the 200-ZP-1 OU. Following development and calibration of the groundwater flow model, contaminant plume shells were developed using the Modular 3-D Transport Multi-Species (MT3DMS), as described in the description of modeling analyses in DOE/RL-2009-38. Plume shells were developed for each of the 200-ZP-1 OU contaminants (i.e., carbon tetrachloride, technetium-99, iodine-129, nitrate, TCE, chromium, tritium, and uranium). Contaminant transport terms represented in the simulation included advection, dispersion, and instantaneous sorption/desorption. The degradation of carbon tetrachloride and decay of radionuclides was not simulated in the contaminant model.

Based on the integrated groundwater flow and contaminant transport model simulations, it is estimated that 20 extraction wells and 16 injection wells operating at approximately 8,176 L/min (2,160 gal/min) for 25 years would achieve the 95 percent carbon tetrachloride mass reduction requirement identified in the ROD. The contaminant transport simulations were also used to estimate initial extraction well influent concentrations for each of the COCs. The influent concentration simulation results were used in the design of the pump-and-treat system.

Depth-discrete groundwater samples will be collected while the wells are installed, and the samples will be tested in the laboratory for the COCs. Based on the laboratory analysis results, the contaminant plume shells will be updated. Aquifer testing conducted at extraction well EW-1, and any other locations where testing is warranted, will be used to measure the aquifer's hydraulic conductivity. The results from this testing will be compared with the hydraulic conductivity values determined through the model calibration process. If there are large differences (order of magnitude or greater) between the measured and modeled values, additional refinement of the model will be performed and new simulations will be run. The results of these simulations will be presented annually in addendum to the modeling reports.

2.2.3 Well Installation

As described in the *Sampling and Analysis Plan for the First Set of Remedial Action Wells in the 200-ZP-1 Groundwater Operable Unit* (DOE/RL-2008-57) and the *Sampling Analysis Plan for Eleven ARRA Wells to Support the 200 West Groundwater Treatment System in FY 2010* (DOE/RL-2009-95), the extraction and injection wells are being installed in campaigns. Nine extraction wells were installed during the first campaign as part of the FY 2009 drilling. Six extraction wells and five injection wells are being installed in the second campaign as part of the FY 2010 drilling campaign. Two additional drilling campaigns (#3 and #4) are planned for installation of the remaining 5 extraction and 11 injection wells.

2.2.3.1 Well Installation Methods

Well drilling will be performed in accordance with WAC 173-160, "Minimum Standards for Construction and Maintenance of Wells." The drilling method employed to date uses an air rotary and telescoped casing advancement method to drill the boreholes to the total depth. The drilling method for sequences #3 and #4 is expected to use a similar method.

2.2.3.2 Test Well Installation and Aquifer Test

Aquifer testing was conducted at the first extraction well location, identified as 299-W15-225 (EW-1), to obtain detailed hydrologic data to support the 200 West Area pump-and-treat system RDR. The aquifer testing includes the following hydrologic test methods:

- Depth-discrete interval slug testing
- Dynamic electromagnetic flow meter survey
- Step-drawdown test
- Constant-rate pump test

The aquifer test results were used to measure the lateral and vertical distribution of aquifer hydraulic properties and to estimate the lateral extent of the well's capture zone under pumping conditions. The results from this testing were used to validate the initial extraction well-spacing intervals determined from the groundwater flow and contaminant transport modeling.

Additional aquifer testing may be conducted after extraction well EW-1 is connected to the interim remedial action pump-and-treat system.

2.2.3.3 Extraction Well Installations

The extraction wells will be drilled to the Ringold lower mud unit or basalt based on rapid-turnaround laboratory results for samples collected during drilling. Specific well information, including estimated borehole depths for the first two sets of wells, is provided in Table 2-2. The wells in the table shown in bold/italic represent those wells that have been installed (to total depth) or are planned to be installed in FY 2010. Actual depths will likely vary and will be determined in the field based on geologic logging information. Estimated borehole depths for the remaining wells will be determined in the sampling and analysis plans prepared for the third and fourth well group sequences.

Table 2-2. Estimated Location and Total Depth of Proposed Extraction Wells

Well Name	Extraction Well No.	Well No.	Northing	Easting	Ground Elevation (m)	Total Depth (ft)	Total Depth (m)
299-W15-225	EW-1	C7017	136108.88	566657.25	204.44	410.5	125
299-W14-20	EW-2	C7018	136284.62	566909.21	204.16	409.0	125
299-W14-73	EW-3	C7021	136204.21	567359.14	216.41	507.5	155
299-W14-74	EW-4	C7024	136383.00	567780.91	221.06	508.0	155
299-W12-2	EW-5	C7027	136609.97	568312.99	223.05	505.0	154
299-W11-50	EW-6	C7020	136756.64	566966.26	211.93	498	152
299-W11-90	EW-7	C7022	136519.63	567306.69	217.76	520	158
299-W11-96	EW-8	C7754	136777.95	567776.40	220.49	480.5	146
299-W17-3	EW-9	C7577	135324.90	566925.96	205.75	440	134
299-W17-2	EW-10	C7576	135806.14	566951.59	204.38	405	123
Future	EW-11	TBD					
299-W11-49	EW-12	C7019	135924.61	567361.68	215.93	431	131
Future	EW-13	TBD					
Future	EW-14	TBD					
299-W14-21	EW-15	C7494	135886.84	567721.42	218.94	525.0	160

Table 2-2. Estimated Location and Total Depth of Proposed Extraction Wells

Well Name	Extraction Well No.	Well No.	Northing	Easting	Ground Elevation (m)	Total Depth (ft)	Total Depth (m)
299-W11-92	EW-16	C7025	136351.76	566692.79	204.40	405	123
Future	EW-17	TBD					
299-W12-3	EW-18	C7028	137000.00	568324.77	223.94	496.0	151
299-W12-4	EW-19	C7029	136363.44	568328.96	223.13	525.8	160
299-W14-22	EW-20	C7030	136116.03	568330.14	223.39	530	162

Notes:

The wells in bold/italic represent wells that have been installed (to total depth) or are planned to be installed in FY 2010. Actual depths will likely vary and will be determined in the field based on geologic logging information.

The wells without numbers (labeled as "future" in the "Well Name" column) are planned for future drilling.

The extraction wells will be constructed using 8-in.-diameter casing. The extraction well screens are constructed of Schedule 10, Type 304 or Type 316, stainless-steel, V-slot, continuous wire-wrap screen equipped with an approximate 1.5 m (5-ft)-long, stainless-steel bottom sump and end cap. The blank riser casing will extend from the top of the screen interval to approximately 0.61 m (2 ft) above ground surface.

Extraction well screen intervals will generally be placed such that the aquifer zones with carbon tetrachloride concentrations greater than 100 µg/L are open to the well. Each of the extraction wells may have a long screen, possibly greater than 45.7 m (150 ft) in length, potentially extending from the water table to the lowermost portion of the 100 µg/L carbon tetrachloride concentration isopach. Final well screen lengths and screen depths will be determined in the field using the depth-discrete groundwater sampling analytical results for carbon tetrachloride, technetium-99, and nitrate; contaminant concentrations present in nearby monitoring wells; and the extraction well's location within the carbon tetrachloride plume. A conceptual illustration of a typical extraction well is provided in Figure 2-4. Blank casing sections may be placed between screen intervals in areas of low permeability or low contaminant concentration to optimize groundwater and contaminant mass removal efficiency.

Well screen slot size and filter pack gradation will be determined in the field following evaluation of grain-size (sieve analysis) results obtained from testing of samples collected at approximately 6.1 m (20-ft) intervals. Colorado silica sand (unless otherwise determined by the drilling contract) will be used for the sand pack. Sodium bentonite pellets and/or natural sodium bentonite chunks, crumbles, or powdered bentonite will be used for bentonite sealing material. Type I/II Portland cement will be used for cement grout. A bentonite seal will be emplaced between the well screens, as required by the design. Granular bentonite shall not be poured down the long annulus.

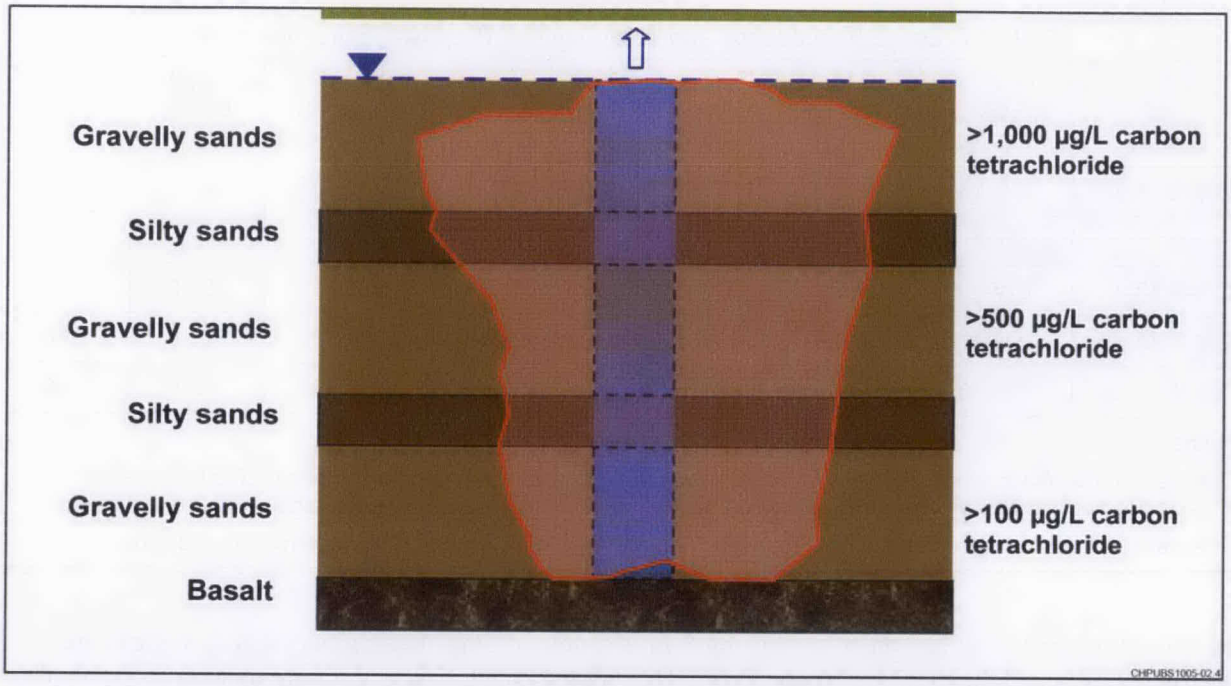

Figure 2-4. Conceptual Illustration of Extraction Well Screen Design

The surface completion will include a protective casing, protective guard posts, and a cement pad. The protective casing is a minimum 2 in. larger in diameter than the permanent casing and rises approximately 0.9 m (3 ft) above the ground surface, and 0.3 m (1 ft) above the top of the well casing. The protective casing includes a lockable well cap. If changes are required to the proposed construction based on actual conditions encountered in the field or updated modeling simulations, DOE will ensure that the requirements of WAC 173-160 are satisfied by discussing changes with the lead regulatory agency.

Following installation, each extraction well will be developed to remove drilling-induced turbidity sources and to restore the natural hydraulic conductivity around the well screen interval. Well development and aquifer testing (as applicable) will generally follow the same approach as described in the *Description of Work for Aquifer Testing at Well 299-W15-225* (SGW-40266), unless it is determined that other well development methods or variations are more appropriate. Airburst Technology™ is currently being evaluated as a means to improve well efficiency. Each extraction well has a pump and motor assembly designed for a capacity of up to 568 L/min (150 gal/min) but will operate at various flow ranges depending on the given well production capability. Extraction well pump motors are powered from adjustable frequency drives to match aquifer conditions. Each adjustable frequency drive can be controlled manually at its local panel or remotely by the programmable logic controller. Electric supply power is routed above grade from the power distribution system to the local wellhead electrical rack. Extracted well water is piped to a tank in each of the transfer buildings, with a few wells piped directly from the well field to the process building influent equalization tank. The 200 West Area pump-and-treat control system will automatically react to balance the system if the respective transfer tank level reaches the high-level set point. Pump operation will be controlled until the tank level drops to the reset point.

™ Airburst Technology is a trademark of Frazier Industries, Inc., Muskego, Wisconsin.

The control system will also respond when the flow signal comparison results in a difference greater than 5 percent of the readings (indicating a possible line break) or when the extraction well level is too low.

2.2.3.4 Injection Well Installations

The planned injection well locations and depths are presented in Table 2-3. The wells shown in bold/italic in the table represent those wells that are planned to be installed in FY 2010. The well capacities are dependent on the length of the screen, aquifer thickness, and aquifer hydraulic properties at each location. Injection well screens will generally be installed at a depth of approximately 82.3 m (270 ft) and have a screen length of approximately 45.7 m (150 ft), as illustrated in Figure 2-5. The current assumption for each well's capacity is 18.6 L/min/m (1.5 gal/min/ft) of well screen. An injection well with 45.7 m (150 ft) of well screen is expected to be capable of injecting 852 L/min (225 gal/min). Given the heterogeneity known to be present (particularly the mixed sedimentary sequences and the variability of cementing in the Ringold Formation), it is not possible to ensure that each well will accept between 473 and 852 L/min (125 and 225 gal/min). It is assumed that some wells may accept water at the upper end of this estimate, while others may be closer to the lower end of performance, at least initially. Sieve analyses will be used to size the filter pack and well screen slot size as described for the extraction wells. A typical injection well installation is shown in Figure 2-5.

Table 2-3. Estimated Location and Total Depth of Proposed Injection Wells

Well Name	Injection Well No.	Well No.	Northing	Easting	Ground Elevation (m)	Total Depth (ft)	Total Depth (m)
299-W6-13	IW-1	C8064	137630.48	567313.27	216.41	450	137.16
299-W6-14	IW-2	C8065	137388.85	566939.86	211.54	463	141.12
299-W10-36	IW-3	C8066	137380.00	566028.00	210.92	505	153.92
299-W10-35	IW-4	C7573	136987.06	566067.33	210.31	432	131.71
299-W15-226	IW-5	C7574	136450.13	566033.26	212.06	456	139.02
299-W15-227	IW-6	C7575	135966.32	566034.41	213.36	470	143.60
Future	IW-7	TBD					
Future	IW-8	TBD					
Future	IW-9	TBD					
699-46-68	IW-10	C8067	137600.00	569110.00	216.86	417	127.10
699-45-67	IW-11	C7578	137263.00	569257.00	219.52	307	93.60
699-44-67	IW-12	C8068	136894.00	569338.00	224.03	485	147.83
699-43-67	IW-13	C7579	136560.00	569370.00	227.06	351	107.01
699-42-67	IW-14	C8069	136200.00	569390.00	227.98	508	154.84
699-40-67	IW-15	C8070	135816.00	569420.00	228.30	518	157.89
Future	IW-16	TBD					

Table 2-3. Estimated Location and Total Depth of Proposed Injection Wells

Well Name	Injection Well No.	Well No.	Northing	Easting	Ground Elevation (m)	Total Depth (ft)	Total Depth (m)

Notes:

The wells in bold/italic represent those wells that are planned to be installed in FY 2010.

The wells without numbers (labeled as "future" in the "Well Name" column) are planned for future drilling.

Horizontal Coordinate System: WCS83S/91 (meters), Vertical Datum: NAVD88 (meters); equipment used was Trimble® (registered trademark of Trimble Navigation Ltd., Sunnyvale, California) GPS 5800 RTK.

2.3 Groundwater Treatment System

This section summarizes the unit processes included in the 200 West Area groundwater treatment facilities, the basis of design of the treatment system, and specification of construction materials.

2.3.1 200 West Area Groundwater Treatment System Process Summary

The 200 West Area groundwater treatment system includes seven primary system components: (1) radiological pre-treatment, (2) biological groundwater treatment, (3) sludge handling, (4) sludge stabilization, (5) chemical feed system, (6) air stripping, and (7) off-gas treatment. The major components for each part of the system are presented below.

The radiological pre-treatment system components include the following:

- Technetium-99 ion exchange (IX)
- Uranium IX

The primary biological system groundwater treatment components include the following:

- Anoxic/anaerobic biodegradation in a fluidized bed reactor (FBR)
- Aerobic biodegradation/membrane filtration

The sludge system primary components are as follows:

- Sludge thickening in rotary drum thickeners
- Sludge aeration in aerated sludge holding tanks
- Sludge dewatering in centrifuges
- Centrate return system

The sludge stabilization system primary components include the following:

- Lime silos
- Pug mills
- Conveyors
- Screw conveyors

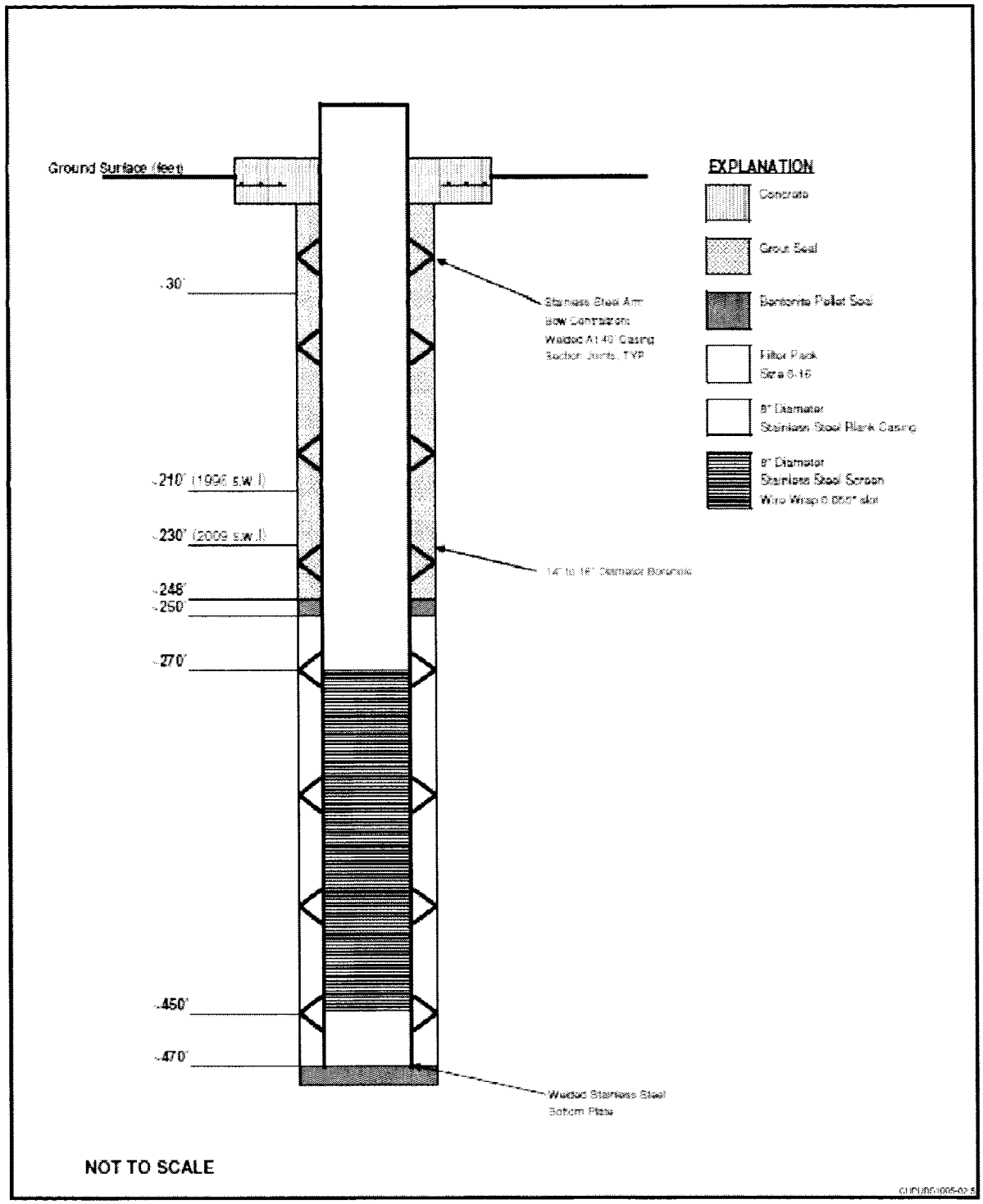

Figure 2-5. Conceptual Illustration of Injection Well Screen Design

The chemical treatment systems primary components include finished water chemistry adjustment through chemical addition. The air-stripping systems primary components are as follows:

- Packed tower air stripper
- Demisters

The off-gas treatment system's primary components include capture of air stripper and tank off-gas emissions through vapor-phase GAC.

The groundwater treatment approach involves multiple treatment steps to remove the various COCs (Table 2-1). The relationship between each unit process and the targeted COCs is presented in Table 2-4. Additional information on each treatment step is provided in the following subsections. The finished water quality design treatment goals for the system are as follows:

- Carbon tetrachloride (2 μg/L)
- Total chromium (60 to 100 μg/L)
- Hexavalent chromium (29 to 48 μg/L)
- Nitrate, as nitrogen, (2,000 μg/L)
- TCE (0.6 to 1 μg/L)
- Iodine-129 (0.3 to 1 pCi/L)
- Technetium-99 (540 pCi/L)
- Tritium (12,000 to 20,000 pCi/L)
- Uranium (18 to 30 pCi/L)

Table 2-4. 200 West Area Groundwater Pump-and-Treat System Unit Process Descriptions

Unit Process	Process Benefit	Targeted Parameter
IX	Removal of technetium-99, uranium, and iodine-129	Technetium-99 Iodine-129 Uranium*
Anoxic/anaerobic Biodegradation (FBR)	Removal of nitrate and carbon tetrachloride and conversion of hexavalent chromium to trivalent form	Nitrate Carbon tetrachloride Hexavalent chromium TCE
Aerobic biodegradation	Degradation/removal of residual organic carbon substrate Removal of carbon tetrachloride and TCE	BOD Carbon tetrachloride TCE
Membrane filtration	Removal of particles, biomass, and precipitated trivalent chromium	Trivalent chromium Turbidity and BOD
Air stripping	Removal of VOCs (carbon tetrachloride and TCE)	Carbon tetrachloride TCE
Sludge thickening	Thicken biological solids for dewatering process	Solids content
Sludge dewatering	Reduce water content to allow for landfill disposal	Water content

Table 2-4. 200 West Area Groundwater Pump-and-Treat System Unit Process Descriptions

Unit Process	Process Benefit	Targeted Parameter
Lime treatment of dewatered sludge	Lyse micro-organism cells and kill biomass	Stabilized sludge for disposal
Treated water chemistry adjustment	Provide treated water stability	pH and alkalinity

* Uranium treatment is only required for groundwater from the 200-UP-1 OU.

The instrumentation and control components of the 200 West Area pump-and-treat system provide a physical link with the operators and the plant processes for monitoring and control functions with process equipment, instrumentation, and computer system components. The process control system designed to monitor and control the treatment processes used at the facility is referred to as the supervisory control and data acquisition (SCADA) system.

Normal plant control and monitoring functions will be performed using the SCADA system. Normal automatic and manual controls for most equipment will be implemented in the system. Exceptions include controls that are part of standard package control systems furnished with specific equipment, although provisions will be made in the SCADA system to monitor and provide necessary operator interface with the package system automatic controls.

The SCADA system monitors the following items:

- Process conditions (flows, levels, pressures, turbidity, pH, etc.)
- Equipment status and control mode status (on/off, open/close, local/remote, etc.)
- Equipment and process alarms (fail, high, low, tripped, etc.)
- Chemical storage tanks and hopper inventory (level and/or weight)
- Equipment run times (based on on/off status)
- Electrical power at motor control centers

The SCADA system uses programmable logic controllers and human/machine interface control system software for operator control and monitoring of the facility. The human/machine interface software will run on standard personal computer systems. Software to support the SCADA system is under development as part of the engineering design.

2.3.1.1 Radiological Pre-Treatment System

Groundwater from selected wells in the 200-ZP-1 OU and the 200-UP-1 OU (after separate pre-treatment for uranium, as required) is pre-treated to reduce technetium-99 to less than 900 pCi/L (Figure 2-6) prior to conveyance to the main treatment process building. Influent groundwater is first filtered to remove fine particulate matter and then flows to the technetium-99 IX vessels before passing through a final set of filters and transfer to the main process building.

Prior to the IX resin reaching its loading limit, it will be removed from the vessel by sluicing it with treated water into a carbon tetrachloride stripping tank (Figure 2-7), where the resin will be submerged with treated water. The tank will be heated with air bubbled through the resin bed to mix the bed and to strip off carbon tetrachloride. The water will be routed back to the IX system (radiological building) inlet feed tank (Figure 2-6) for treatment. The vapor emissions will be treated using vapor-phase GAC.

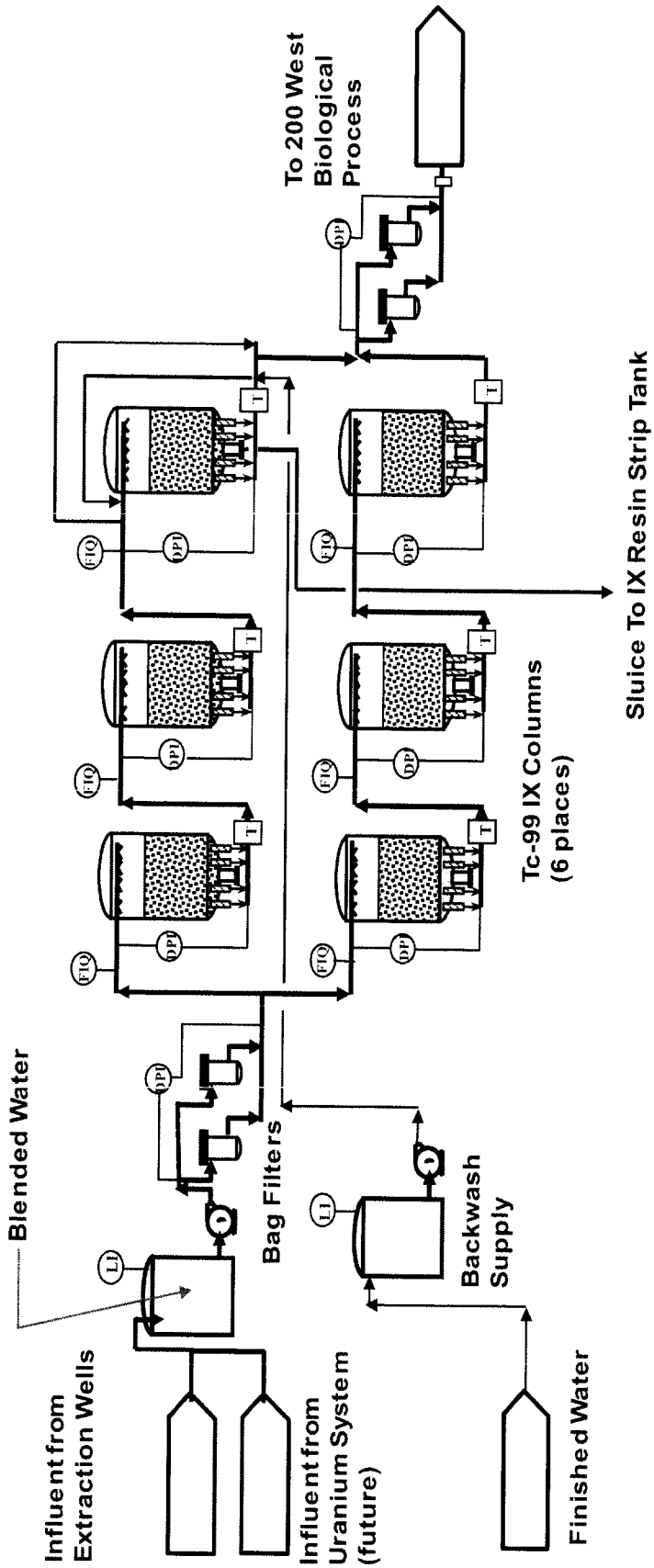

Figure 2-6. Radiological Pre-Treatment System (Technetium-99) IX Process Schematic

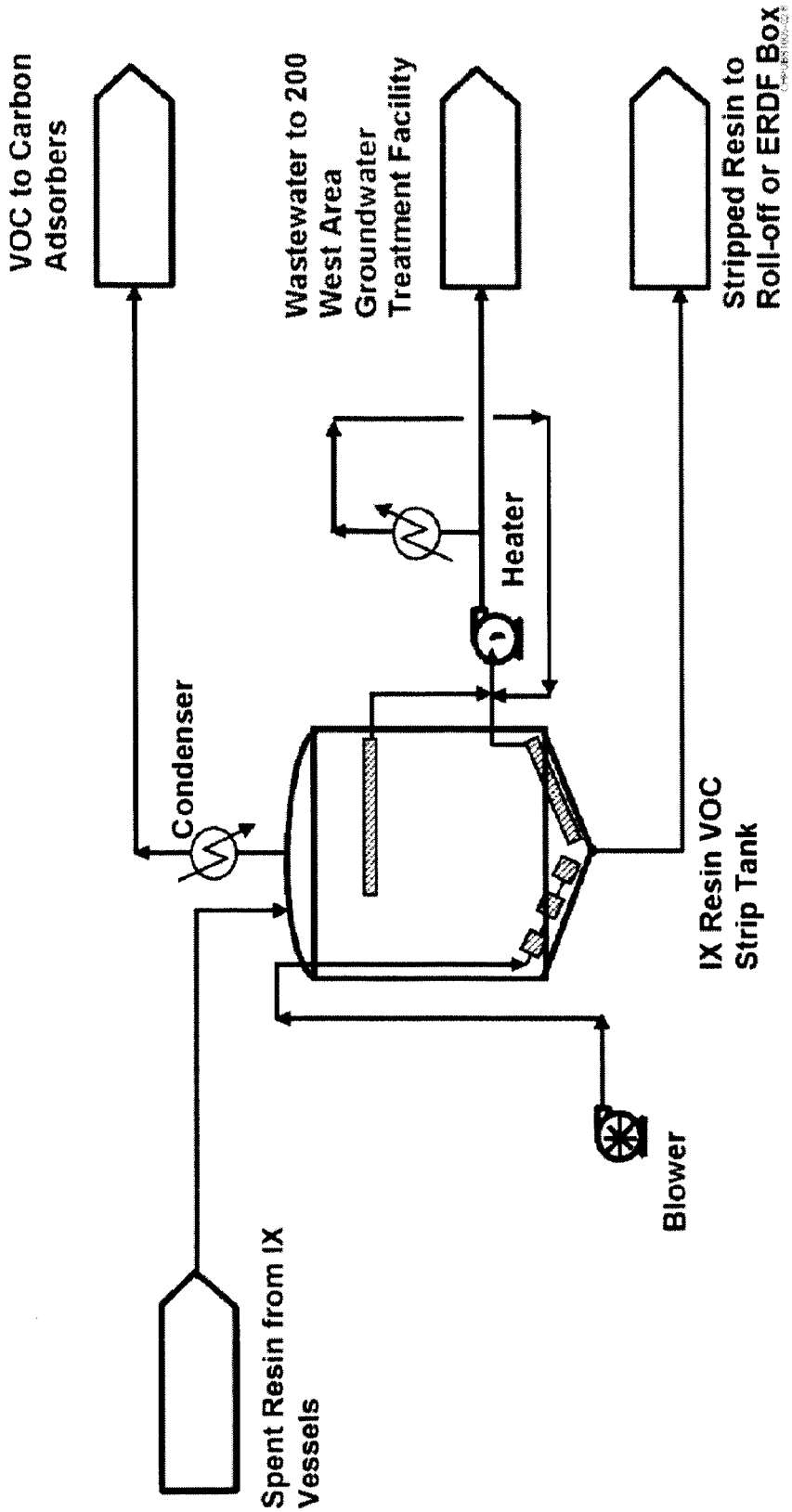

Figure 2-7. Radiological Pre-Treatment System (Technetium-99) IX Resin Strip Tank Schematic

The resin in the strip tank will be sluiced with treated water to a plastic-lined Environmental Restoration Disposal Facility (ERDF) burial box or geotextile tube placed in a container to allow drainage (Figure 2-8). The filtrate from the waste container will be collected and pumped back into the feed tank (Figure 2-6). The dewatered resin will be transported for placement at the ERDF. The spent resin will be profiled to verify that ERDF limits for technetium-99, iodine-129, uranium, and carbon tetrachloride are met. If these limits cannot be met, stabilization of the resin may be required.

The design also considers, as necessary, the need for treatment of other constituents (e.g., uranium) that may be captured by the 200-ZP-1 OU extraction wells. While not COCs for the 200-ZP-1 OU, these constituents may be encountered during restoration from sources related to the other adjacent groundwater OUs (200-UP-1). Additionally, in anticipation of future expansion, the treatment system will also have the capability to treat some contaminated groundwater (including uranium) from the 200-UP-1 OU. Following initial operations, it is anticipated that the 200 West Area groundwater pump-and-treat system will be expanded to provide the necessary treatment capabilities for additional contaminated groundwater from the 200-UP-1 OU following issuance of a final ROD for that OU.

Based on the need to address uranium concentrations, groundwater from these sources will be pre-treated to remove uranium using IX resin vessels prior to conveyance to the technetium-99 IX pre-treatment system. The uranium IX pre-treatment system will be similar to the technetium-99 IX system previously described. Ongoing resin testing is being conducted to further optimize resin use for both technetium-99 and uranium removal.

2.3.1.2 200 West Area Groundwater Treatment Facility

The treatment processes for carbon tetrachloride and nitrate removal are configured in two parallel, 4,732 L/min (1,250-gal/min) treatment trains to accommodate increasing flow ranges up to 9,464 L/min (2,500 gal/min). The treatment facility infrastructure is designed to accommodate a third treatment train, if required, to increase the total installed treatment capacity to 14,195 L/min (3,750 gal/min).

Water from the technetium-99 IX system flows to the main process building where it is blended in an equalization tank (Figure 2-9) with the extracted groundwater. It is then conveyed through the extraction transfer building serving several extraction wells or directly to the facility from individual extraction wells.

Biological Groundwater Treatment. Water is pumped from the equalization tank to a recycle tank, and then to a FBR where nitrate is converted to nitrogen gas. Carbon tetrachloride is also treated in the FBR, which operates under anoxic conditions (i.e., in the absence of dissolved oxygen).

Water is pumped into the bottom of the FBR, creating upflow to suspend the GAC bed media to which micro-organisms attach and grow anoxically and anaerobically. The FBR will be seeded with microbes that are suited for nitrate/nitrogen removal (denitrification) and carbon tetrachloride degradation under anoxic and anaerobic conditions. An organic carbon substrate and phosphorus will be added into the FBR to serve as the electron donor and nutrient to promote microbial growth. As the microbes grow on the GAC, the fluidized bed height will increase and excess biomass will be removed with a biomass separator.

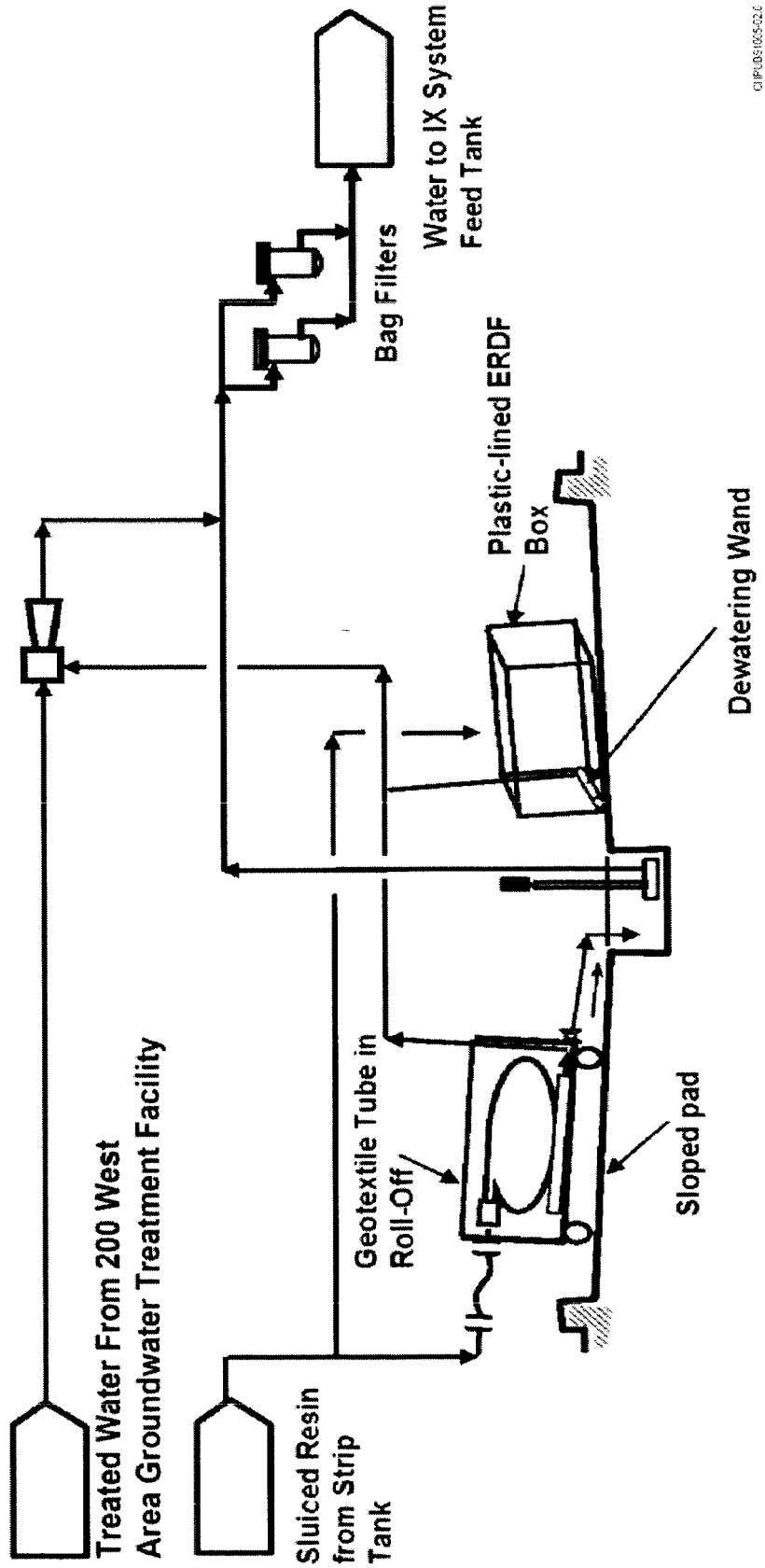

Figure 2-8. Radiological Pre-Treatment System (Technetium-99) IX Resin Dewatering Schematic

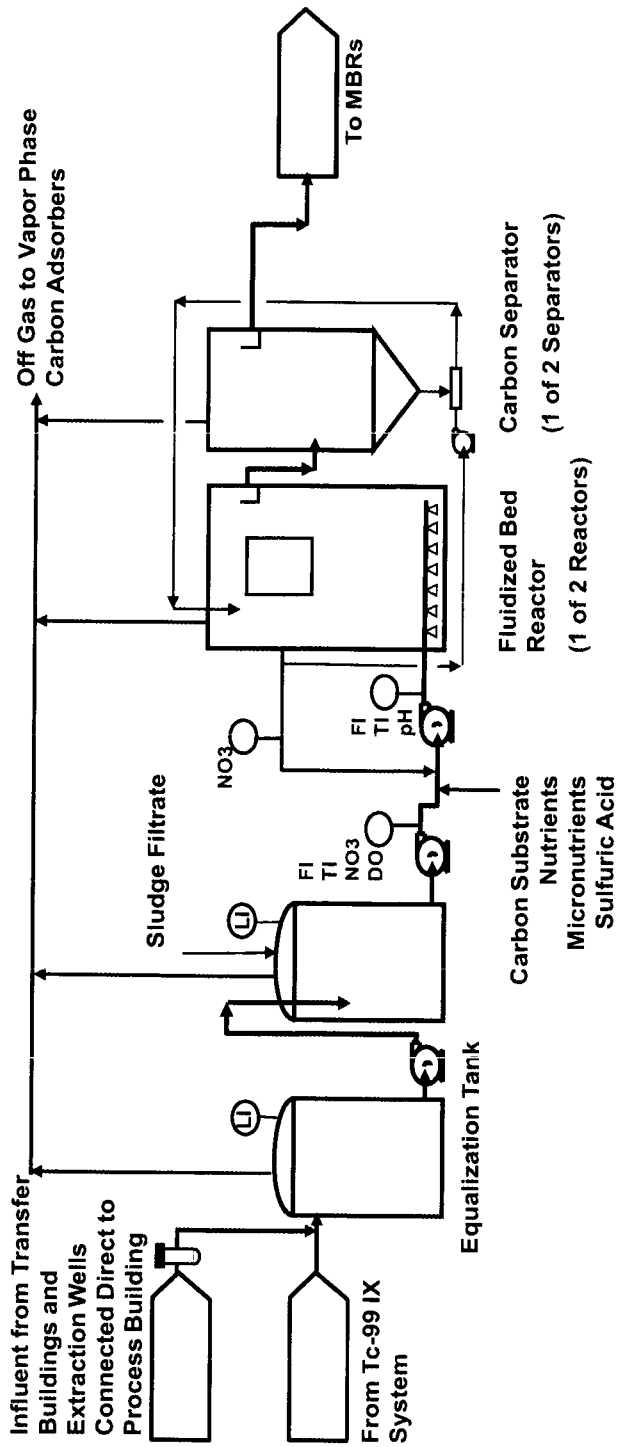

Figure 2-9. Biological Process – Anoxic FBR Schematic

The effluent from the FBR flows by gravity to the aerated splitter box and aerobic membrane tanks (Figure 2-10) for removal of residual carbon substrate through aerobic biodegradation and removal of total suspended solids, including biomass generated in the FBR. The membrane tanks have aeration capacity to provide sufficient oxygen for maintaining the aerobic biological process to reduce the residual carbon substrate. The membrane tanks have submerged membranes for filtration. The aeration is maintained by a blower that diffuses air into the tank and provides air scouring to remove accumulated organic debris from the membrane surface to maintain its water permeability. The aeration and air scouring processes will strip off carbon tetrachloride. Vapor emissions will be collected for treatment with vapor-phase GAC.

Multiple modules of vertically or horizontally strung membrane fibers are found in the membrane zone. Water is filtered by applying a slight vacuum to the end of each fiber, which draws water through the tiny pores into the fibers. The filters reject solids, which are retained in the tank concentrate. A portion of the concentrate is recycled to the aerated splitter box to maintain the biomass concentration necessary to reduce biochemical oxygen demand (BOD).

Sludge Handling. Solids from the membrane tanks are pumped to rotary drum thickeners (Figure 2-11). Thickened sludge leaving the rotary drum thickeners is sent to aerated sludge storage tanks. A bypass line is used to maintain the solids content in the aerated sludge storage tanks within an optimum range. As the solids concentration in the aeration tanks decreases, less flow is bypassed around the thickeners; conversely, as the solids concentration in the tank increases, more flow is bypassed around the thickening process. Polymer is added upstream of the rotary drum thickeners, as necessary, to thicken the solids. The aerated sludge storage tanks also provide further digestion of biomass and maintain aerobic conditions for odor control.

The thickened solids are then pumped from the aerated sludge storage tanks to centrifuges for dewatering (Figure 2-12). Polymer is added upstream of the centrifuges to aid in solids dewatering. The filtrate from the rotary drum thickeners and centrate from the centrifuges are piped to a collection sump, then pumped to aerated centrate storage tanks, and then bled to the recycle tank located upstream of the FBR.

Lime Stabilization of Sludge. The treatment system will produce biological sludge as a residual from the treatment of nitrate in the groundwater. This sludge will be disposed at the ERDF. The sludge material must be absent of free liquids and must pass the paint filter test to meet ERDF disposal criteria; it must also be stabilized to minimize biological breakdown and control odor prior to disposal at ERDF. A screw conveyor is used to move the dewatered sludge from the centrifuge to a lime sludge stabilization system where a mechanical mixer (e.g., pug mill) mixes lime with the thickened sludge (Figure 2-12) to control free water to meet ERDF disposal criteria and kill the biomass to prevent further decomposition and generation of objectionable gases and odors. Once the lime is added, the conditioned sludge will be transferred into ERDF containers for disposal.

Air Stripper. The treated water from the membranes is pumped to an air stripper (Figure 2-13) for removal of the remaining carbon tetrachloride and other volatile organic compounds (VOCs). The air stripper effluent is then pumped to an effluent tank. Acid is added upstream of the effluent tank through an inline static mixer to adjust the pH.

The air stripper tower is piped so this treatment step can occur before the FBR in the event degradation of the carbon tetrachloride in the FBR is less than anticipated. For the latter scenario, water from the influent equalization tank is pumped through strainers to remove larger particles before entering the air strippers. Process monitoring conducted during initial operations will be used to determine the optimum air stripper configuration.

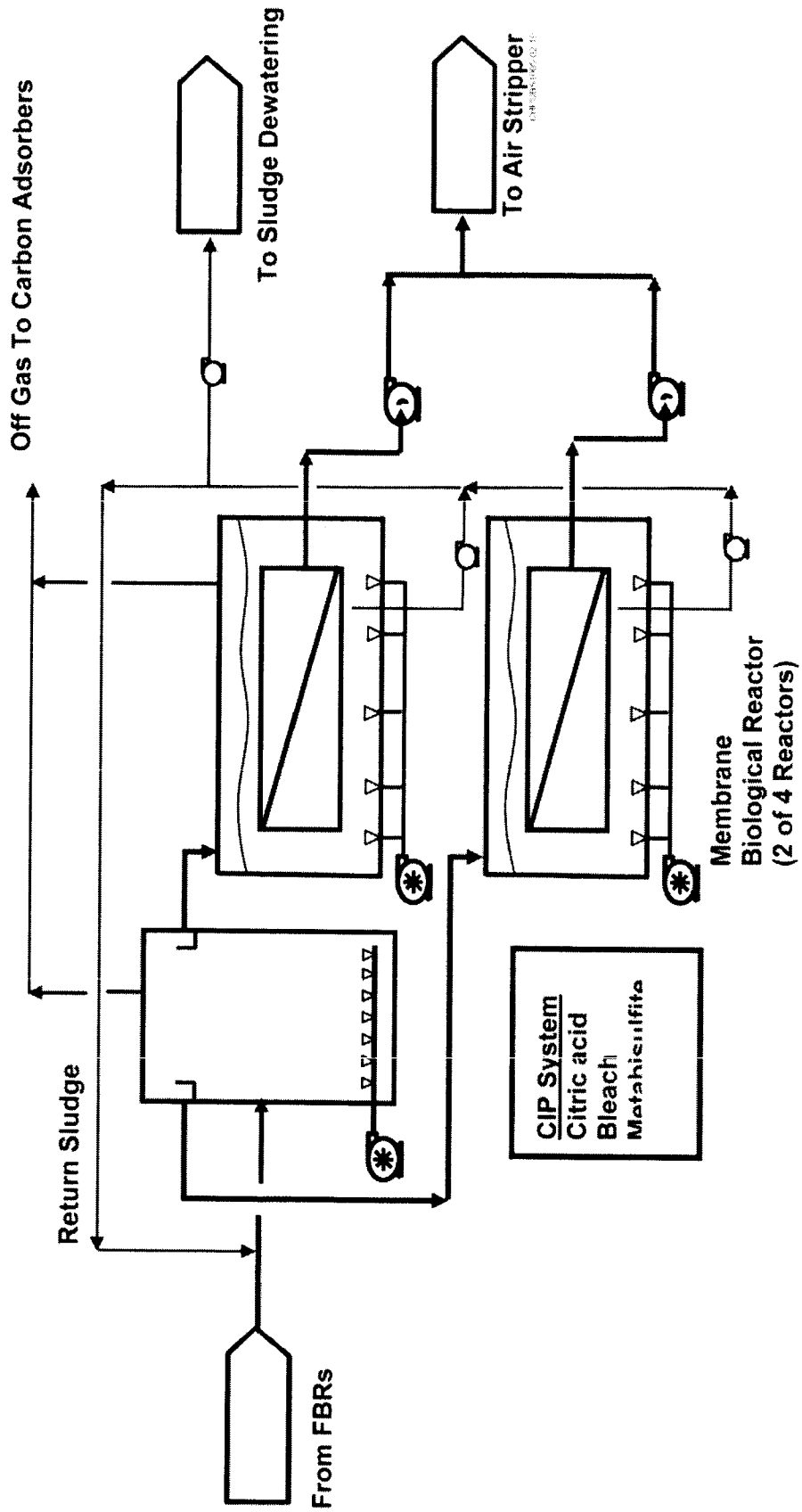

Figure 2-10. Biological Process – Aerobic Membrane Tanks Schematic

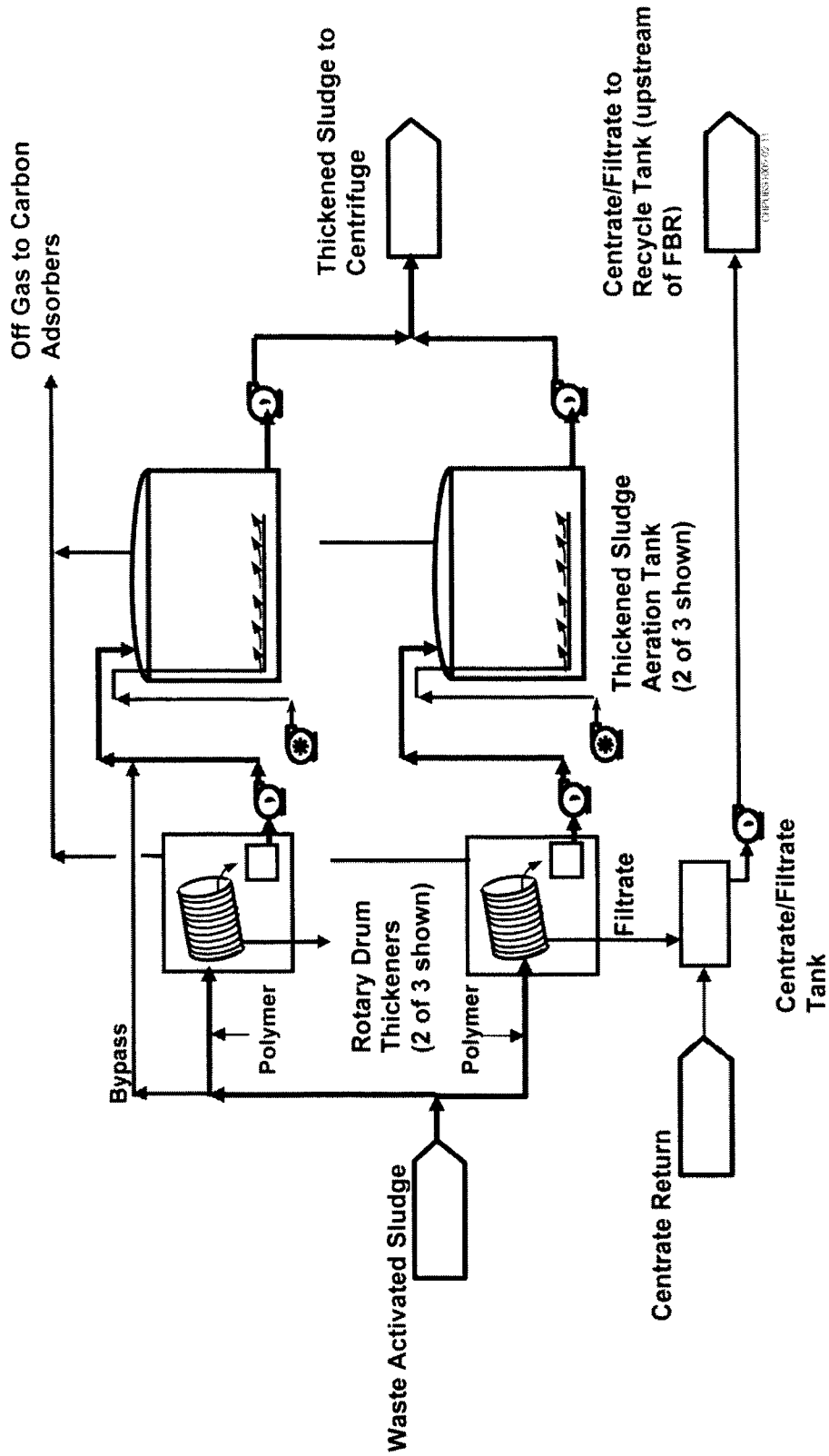

Figure 2-11. Solids Handling System – Thickeners and Thickened Sludge Aeration Tank Schematic

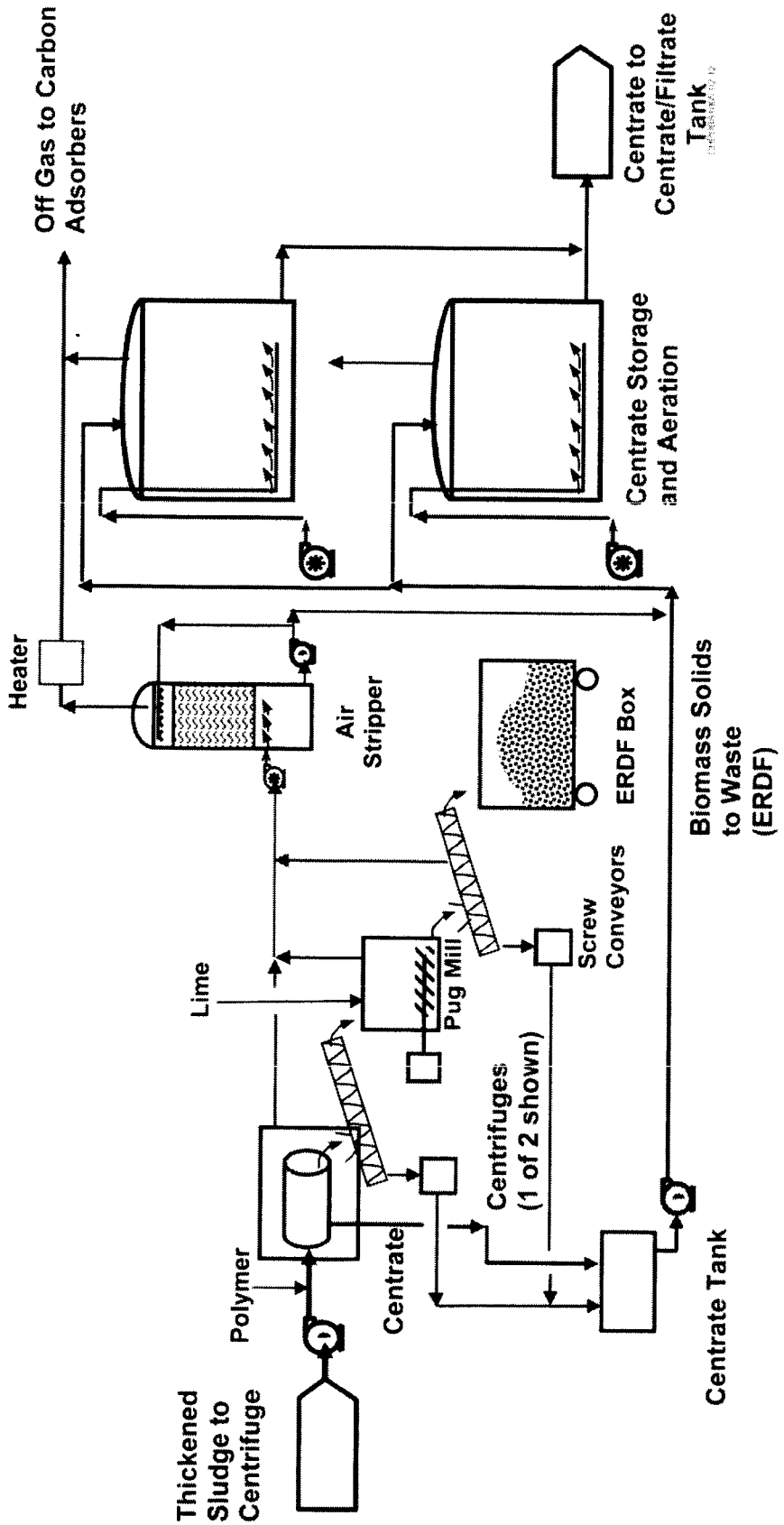

Figure 2-12. Solids Handling System – Centrifuge Dewatering and Lime Treatment Schematic

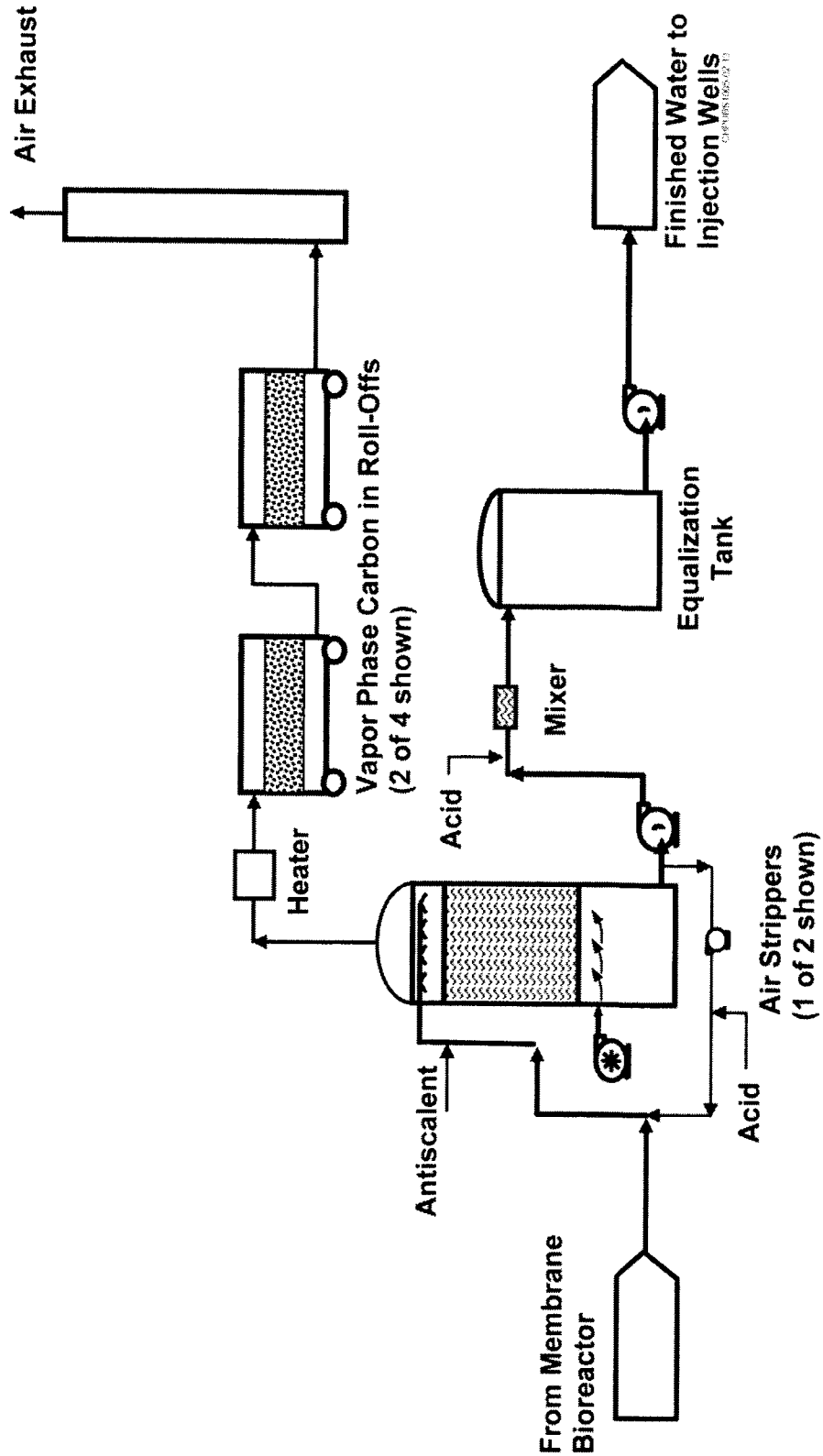

Figure 2-13. Air Stripper System Schematic

Off-Gas Treatment. Off-gas from the air stripper, influent equalization tank, radiological building strip tanks (technetium-99 and uranium), FBRs, membrane tanks, sludge holding tanks, rotary drum thickeners, and centrifuges is combined and treated by vapor-phase GAC. To avoid buildup of radionuclides in the vapor-phase GAC, air streams to the vapor-phase GAC system will be pre-treated by a demister to minimize liquid carryover.

Chemical Feed Systems. Various chemicals are added during the treatment processes to adjust water chemistry (including pH and alkalinity). The pump-and-treat system will use numerous chemical feeds. Table 2-5 provides a list of these chemical feeds and the primary use of each.

Table 2-5. Summary of Expected Chemical Feeds

Chemical	Primary Use
Anti-scalant (Nalco CL-50 or equivalent)	Air stripper anti-scalant
Calcium oxide (quicklime)	Sludge stabilization
Carbon substrate	Biological FBR carbon substrate
Citric acid	Membrane in-place cleaning
Ferric chloride	Coagulant upstream of membranes
Hydrochloric acid	Air stripper cleaning
Micronutrient	Biological FBR micronutrient feed
Phosphoric acid	Biological FBR phosphorus nutrient feed
Polymer	Solids thickening and dewatering aids
Sodium bisulfite	Dechlorinate membrane cleaning wastewater
Sodium hydroxide	Neutralize citric acid membrane cleaning wastewater and odor control chemical scrubber
Sodium hypochlorite	Membrane in-place cleaning and odor control chemical scrubber
Sodium nitrate	Biological FBR nitrate feed for startup and interim plant shutdowns only
Sulfuric acid	pH adjustment and odor control chemical scrubber

2.3.2 Groundwater Treatment System Basis of Design

The finished water quality requirements for the 200 West Area groundwater treatment facility are stated in the ROD. The final groundwater cleanup levels are federal and state drinking water MCLs and state groundwater cleanup standards (where more stringent than the MCLs) that are the applicable or relevant and appropriate requirements for the selected remedy (EPA et al., 2008). However, the design treatment goal is for the finished water quality to be less than the target finished water quality standard. These goals are presented in Table 2-6.

Table 2-6. Finished Water Quality Requirements and Goals

Parameter	Point of Compliance	Finished Water Quality Standard		Acceptance Standard Description	Design Treatment Goal
		Value	Units		
Carbon tetrachloride[a]	Pipeline to injection wells	3.4	µg/L	Specified by ROD[b]	2 µg/L
Chromium (total)	Pipeline to injection wells	100	µg/L	Federal MCL	60 to 100 µg/L
Hexavalent chromium	Pipeline to injection wells	48	µg/L	Specified by ROD[b]	29 to 48 µg/L
Nitrate as nitrogen	Pipeline to injection wells	10,000	µg/L	Federal MCL	2,000 µg/L
TCE[a]	Pipeline to injection wells	1	µg/L	Specified by ROD[b]	0.6 to 1 µg/L
Iodine-129	Pipeline to injection wells	1	pCi/L	Federal MCL	0.3 to 1 pCi/L
Technetium-99	Pipeline to injection wells	900	pCi/L	Federal MCL	540 pCi/L
Tritium	Pipeline to injection wells	20,000	pCi/L	Federal MCL	12,000 to 20,000 pCi/L
Uranium	Pipeline to injection wells	30	pCi/L	Federal MCL	18 to 30 pCi/L

a. The DOE will clean up contaminants of concern for the 200-ZP-1 OU subject to WAC 173-340, "Model Toxics Control Act – Cleanup," which includes carbon tetrachloride and TCE, so the excess lifetime cancer risk does not exceed 1×10^{-5} at the conclusion of the remedy.

b. *Record of Decision Hanford 200 Area 200-ZP-1 Superfund Site Benton County, Washington* (EPA et al., 2008).

For three of the primary COCs requiring active treatment to meet the cleanup levels (carbon tetrachloride, technetium-99, and uranium), the aboveground treatment system will be designed to achieve a nominal operating treated effluent target of 60 percent of the final cleanup level under normal operations (thus, 2 µg/L for carbon tetrachloride, 540 pCi/L for technetium-99, and 18 pCi/L for uranium). This will provide an allowance for a slight upward trend during stressed operating periods. The upward trend will be acted on by the operations staff to bring the system back to normal operations. Nitrate, which also must be treated to meet the cleanup levels, will be designed to achieve a nominal operating treated effluent target of 20 percent of the cleanup level (thus, 2,000 µg/L as nitrogen). This lower level is being selected because biological treatment systems can be less stable and an extra operating margin is desired.

The system will not be specifically designed to treat to 60 percent of the final cleanup levels for the other COCs (chromium [hexavalent and total], TCE, and iodine-129) because the blended influent will be below or close to the cleanup levels, and/or these COCs will be removed concurrently with the primary COCs. For example, TCE will be removed with the carbon tetrachloride, and hexavalent chromium will be removed with the nitrate.

The nominal design life for the groundwater pump-and-treat system is estimated to be 25 years, based on Part 1, Section 4.3.1 of the ROD (EPA et al., 2008). Replacement of equipment and piping during this period is allowed to meet this goal if lifecycle cost analysis shows it is the lowest cost option of meeting this criterion.

Key design criteria for each of the major process steps described above are summarized in the following subsections.

2.3.2.1 Reliability and Redundancy Provisions

To achieve the cleanup goals, reliability and redundancy provisions have been included in the design of the 200 West Area groundwater treatment facility. These provisions are in place to ensure that the system has operational flexibility to continue operations during routine and preventative maintenance procedures, as well as backup provisions in case of unscheduled maintenance or equipment failure. Table 2-7 presents the reliability and redundancy provisions.

Table 2-7. Reliability and Redundancy Provisions

Unit Process or System	Reliability and Redundancy Provisions
Uranium IX	(Future) One 50-gal/min system (three vessels in series per system)
Technetium-99 IX	Two 335-gal/min systems (three vessels in series per system)
Anoxic/anaerobic biodegradation	Two 1,250-gal/min systems
Membrane filtration system	Four 625-gal/min systems
Air stripping	Two 1,250-gal/min systems Four vapor-phase GAC roll-off units (two pair operating in series)
VOC off-gas (other sources)	Four vapor-phase GAC roll-off units (two pair operating in series)
Sludge thickening	Three rotary drum thickeners Three aerated sludge holding tanks
Sludge dewatering	Two centrifuges/conveyors Three aerated centrate holding tanks
Chemical storage	Spare totes each for phosphoric acid, micronutrients, citric acid, sodium hypochlorite, sodium hexametaphosphate, and sludge-dewatering polymer (one tote in use, and one tote as supply to first tote) Four storage tanks for carbon substrate for a minimum of 14 days storage at average flow and dose Two storage tanks for sulfuric acid for a minimum of 14 days storage at average flow and dose
Chemical feeds	One duty pump and one standby pump of largest capacity for each main chemical application point

2.3.2.2 Radiological Treatment Basis of Design

The objective of the technetium-99 IX system is to reduce the concentration of technetium-99 to less than 900 pCi/L prior to conveyance to the main treatment building. Table 2-8 summarizes the anticipated influent water quality to the technetium-99 IX system, and Table 2-9 provides a summary of the anticipated and estimated effluent treated water quality discharged from the technetium-99 IX system to

the main treatment building. Table 2-10 provides a summary of the estimated design criteria for the technetium-99 IX system. These tables are presented for reference and comparative purposes and may vary.

Table 2-8. Estimated Technetium-99 IX Influent Water Quality Values

Parameter	Average Value	
Influent water temperature (raw well water)	65°F	
Estimated influent water temperature	Recommended design range is minimum of 40°F, maximum of 90°F	
pH	7.7 (average)	
COCs	**Average Value**	**Units**
Carbon tetrachloride	491	µg/L
Nitrate as nitrogen	69	mg/L
Hexavalent chromium	161	µg/L
Chromium (total)	161	µg/L
TCE	3.2	µg/L
Iodine-129	0.9	pCi/L
Technetium-99	14,700	pCi/L
Tritium	23,800	pCi/L
Uranium	5.9	pCi/L
Non-COCs	**Average Value**	**Units**
Alkalinity (as $CaCO_3$)	103	mg/L
Calcium	75	mg/L
Chloride	18	mg/L
Chloroform	0.025	mg/L
Fluoride	0.37	mg/L
Iron (dissolved)	0.19	mg/L
Magnesium	24	mg/L
Manganese (dissolved)	0.049	mg/L
Potassium	7	mg/L
Sodium	24	mg/L
Sulfate	34	mg/L
TOC	1.3	mg/L
TSS	3.0	mg/L
TDS	614	mg/L

Table 2-9. Approximate Radiological IX Finished Water Quality Requirements and Goals

Parameter	Point of Compliance	Finished Water Quality Standard		Acceptance Standard Description	Design Treatment Goal
		Value	Units		
Iodine-129	Pipeline to injection wells	1	pCi/L	Federal MCL	0.6 to 1 pCi/L
Technetium-99	Pipeline to injection wells	900	pCi/L	Federal MCL	540 pCi/L
Tritium	Pipeline to injection wells	20,000	pCi/L	Federal MCL	12,000 to 20,000 pCi/L
Uranium	Pipeline to injection wells	30	pCi/L	Federal MCL	18 to 30 pCi/L

Table 2-10. Generalized Technetium-99 IX Design Criteria

Parameter	Value	Units
Number of trains	2	#
Nominal flow rate (per train)	350	gal/min
Maximum sustained flow rate (per train)	400	gal/min
IX Vessels		
Number per train	3	#
Number of trains (skids)	2	#
Resin volume per vessel	300	ft^3
Hydraulic loading rate (maximum)	7 to 8	$gal/min/ft^2$
Resin loading rate (maximum)	1 to 1.5	$gal/min/ft^3$
Pumps		
Number	2 (one standby)	#
Capacity	700 to 1,200 (needs to be verified)	gal/min
Filters		
Inlet cartridge filters	3	#
• Cartridges (number per filter)	52	#
• Particle-size rating	5	micron

Table 2-10. Generalized Technetium-99 IX Design Criteria

Parameter	Value	Units
Effluent bag filters	3	#
• Filter bags (number per filter)	4	#
• Particle-size rating	50	micron
Resin Holding Tank		
Material	FRP	--
Diameter	11	ft
Height (with cone)	13 ft 9 in.	--
Maximum working capacity	8,886	gal

2.3.2.3 Biological Groundwater Treatment Facilities Basis of Design

Groundwater from the technetium-99 IX system will flow to the biological treatment system equalization tank where it will be blended with the extracted groundwater from the remainder of the well field. The treatment process for carbon tetrachloride and nitrate removal will initially have two treatment trains to accommodate flow ranges up to 9,464 L/min (2,500 gal/min), an space within the facility will be reserved for a third parallel train that can be added in the future to accommodate a higher flow rate of 14,195 L/min (3,750 gal/min).

The biological groundwater treatment facilities include an anoxic FBR and an aeration/membrane filtration system. The objective of this system is to remove nitrate and carbon tetrachloride from the groundwater prior to reinjection. The FBR uses micro-organisms that use nitrate as an electron acceptor (like an oxygen source) for biological growth. The addition of external carbon and phosphorus sources is required to provide food and nutrient sources for growth of the organisms.

Table 2-11 provides a summary of the anticipated influent water quality to the biological treatment system for the 9,464 L/min (2,500-gal/min) capacity operation, and Table 2-12 summarizes the anticipated influent water quality for the 14,195 L/min (3,750-gal/min) capacity operation. Table 2-13 provides the finished water quality requirements and the goals for the biological groundwater treatment systems.

The primary components of the biological groundwater treatment system include the following:

- Anoxic/anaerobic biodegradation in a FBR
- Aerobic biodegradation/membrane filtration

Table 2-14 summarizes key design criteria for the FBR, and Table 2-15 summarizes key design criteria for the aeration/membrane filtration units.

Table 2-11. Estimated Biological Treatment System Influent Water Quality with Technetium-99 Pre-Treatment (2,500-gal/min Capacity)[a]

Parameter	Estimated Raw Water Quality	Units
Influent water temperature[b]	65	°F
Estimated influent water temperature[c]	Design range 47 to 78	°F
pH	Average 7.7	Standard units
COCs	**Average**	**Units**
Carbon tetrachloride	650 to 750	µg/L
Nitrate as nitrogen[e,g]	35 to 45	mg/L
Hexavalent chromium[e]	27	µg/L
TCE[e]	3.7	µg/L
Iodine-129[e]	0.15	pCi/L
Technetium-99[d,e]	227	pCi/L
Tritium[e]	8,180	pCi/L
Uranium[e]	3.6	pCi/L
Non-COCs	**Value**	**Units**
Chromium (total)[f]	26	µg/L
Alkalinity (as $CaCO_3$)[f]	112	mg/L
Calcium[f]	67	mg/L
Chloride[f]	20	mg/L
Chloroform[f]	0.044	mg/L
Fluoride[f]	0.35	mg/L
Iron (dissolved)[f]	0.26	mg/L
Magnesium[f]	20	mg/L
Manganese (dissolved)[f]	0.089	mg/L
Potassium[f]	5	mg/L
Sodium[f]	20	mg/L
Sulfate[f]	38	mg/L
TOC[f]	1.7	mg/L
TSS[f]	1.6	mg/L
TDS[f]	465	mg/L

Table 2-11. Estimated Biological Treatment System Influent Water Quality with Technetium-99 Pre-Treatment (2,500-gal/min Capacity)[a]

Parameter	Estimated Raw Water Quality	Units

a. Influent chemistry based on blended concentrations of wells EW-1 to EW-8, EW-12, EW-15, EW-16, EW-18, EW-19, and EW-20; S Tank Farm wells 26, 44, and 48; SX Tank Farm well 19; existing 200-ZP-1 well 765. Refer to 382519-CALC-020 and 382519-CALC-021.

b. Native groundwater temperature data based on site data. Refer to 382519-CALC-001.

c. Estimate influent temperature based on planned pipe layouts and pumping rates. Refer to 382519-CALC-001 for low temperature and 382519-CALC-0032 for high temperature.

d. Estimate assumes groundwater from two extraction wells (EW-6 and EW-7) in the 200 West Area, wells in the S/SX Tank Farms, and existing 200-ZP-1 well 765 are treated by the IX system to less than or equal to 900 pCi/L technetium-99.

e. Maximum credible value based on hydrogeologic modeling and limited well data (email from M. Tonkin [S.S. Papadopulos & Assoc., Inc.], dated January 12, 2009, and email from S. Simmons [CHPRC], dated February 4 and 17, 2009). Additional, more precise references pending update for 30 percent design.

f. Average value based on limited well data (email from S. Simmons [CHPRC], dated January and February 2009).

g. Average values used for nitrate loading per agreement with client.

Table 2-12. Estimated Biological Treatment System Influent Water Quality with Technetium-99 and Uranium Pre-Treatment (3,750-gal/min Capacity)[a]

Parameter	Estimated Raw Water Quality	Units
Influent water temperature[b]	65	°F
Estimated influent water temperature[c]	Design range 47 to 78	°F
pH	Average 7.7	
COCs	**Average**	**Units**
Carbon tetrachloride[e]	661	µg/L
Nitrate as nitrogen[e,g]	40	mg/L
Hexavalent chromium[e]	47	µg/L
TCE[e]	4.1	µg/L
Iodine-129[e]	0.27	pCi/L
Technetium-99[d,e]	273	pCi/L
Tritium[e]	9,250	pCi/L
Uranium[e]	3.6	pCi/L

Table 2-12. Estimated Biological Treatment System Influent Water Quality with Technetium-99 and Uranium Pre-Treatment (3,750-gal/min Capacity)[a]

Non-COCs	Value	Units
Chromium (total)[f]	47	µg/L
Alkalinity (as $CaCO_3$)[f]	110	mg/L
Calcium[f]	69	mg/L
Chloride[f]	20	mg/L
Chloroform[f]	0.041	mg/L
Fluoride[f]	0.35	mg/L
Iron (dissolved)[f]	0.25	mg/L
Magnesium[f]	21	mg/L
Manganese (dissolved)[f]	0.084	mg/L
Potassium[f]	5	mg/L
Sodium[f]	21	mg/L
Sulfate[f]	37	mg/L
TOC[f]	1.6	mg/L
TSS[f]	1.9	mg/L
TDS[f]	484	mg/L
Dissolved oxygen	11.3	mg/L

a. Influent chemistry based on blended concentrations of wells EW-1 to EW-20; 200-UP-1 wells 36, 39, and 43; S Tank Farm wells 26, 44, and 48; SX Tank Farm well 19; existing 200-ZP-1 well 765. Refer to 382519-CALC-020 and 382519-CALC-021.

b. Native groundwater temperature data based on site data. Refer to 382519-CALC-001.

c. Estimate influent temperature based on planned pipe layouts and pumping rates. Refer to 382519-CALC-001 for low temperature and 382519-CALC-0032 for high temperature.

d. Estimate assumes groundwater from three new extraction wells (EW-6, EW-7, and EW-13), existing wells in the S/SX Tank Farms, an existing well in 200-UP-1, and 200-ZP-1 well 765 well are treated by the technetium-99 IX system to less than or equal to 900 pCi/L technetium-99.

e. Estimate assumes groundwater from one extraction well in the 200-UP-1 OU is treated by the uranium IX system to less than or equal to 30 µg/L uranium.

f. Maximum credible value based on hydrogeologic modeling and limited well data (email from M. Tonkin [S.S. Papadopulos & Assoc., Inc.], dated January 12, 2009, and email from S. Simmons [CHPRC], dated February 4 and 17, 2009).

g. Average value based on limited well data (email from S. Simmons [CHPRC], dated January and February 2009). Additional, more precise references pending update for 30 percent design.

h. Average value used for nitrate loading per agreement with client.

Table 2-13. Finished Water Quality Requirements and Goals for the Biological Groundwater Treatment System

Parameter	Point of Compliance	Finished Water Quality Standard		Acceptance Standard Description	Design Treatment Goal
		Value	Units		
Carbon tetrachloride[a]	Pipeline to injection wells	3.4	µg/L	Specified by ROD[b]	2 µg/L[c]
Chromium (total)	Pipeline to injection wells	100	µg/L	Federal MCL	60 to 100 µg/L
Hexavalent chromium	Pipeline to injection wells	48	µg/L	Specified by ROD[b]	29 to 48 µg/L
Nitrate as nitrogen	Pipeline to injection wells	10,000	µg/L	Federal MCL	2,000 µg/L

a. The DOE will clean up contaminants of concern for the 200-ZP-1 OU subject to WAC 173-340, "Model Toxics Control Act – Cleanup," which includes carbon tetrachloride and TCE, so the excess lifetime cancer risk does not exceed 1×10^{-5} at the conclusion of the remedy.

b. *Record of Decision Hanford 200 Area 200-ZP-1 Superfund Site Benton County, Washington* (EPA et al., 2008).

c. The design treatment goal for carbon tetrachloride is met by the air-stripping system and is not a design parameter for the biological treatment system, although some degradation may occur.

Table 2-14. Fluidized Bed Reactor Design Criteria

Parameter	Value	Units
Hydraulic flux	20	gal/min/ft^2
Hydraulic residence time, minimum	1,100	seconds
Maximum tank diameter	14	ft
Minimum tank height	20	ft
Media type	GAC	NA
Media volume per reactor, minimum	1,850	ft^3
Nitrate loading per 1,000-ft^3 media, maximum	300	lb NO_3-N
Design discharge nitrate concentration	0.5	mg/L NO_3-N
Maximum allowable discharge nitrate concentration	6.0	mg/L NO_3-N
Maximum external carbon dosing ratio: • Agriculturally derived carbon source • Glycerin-based carbon source	 6.0:1 6.5:1	NA
Average discharge soluble BOD5 concentration	8.0	mg/L
Maximum discharge soluble BOD5 concentration	14.0	mg/L

Table 2-15. Aeration/Membrane Filtration Units Design Criteria

Parameter	Value	Units
Influent TSS concentration*	153	mg/L
Influent BOD5 concentration:* • Average soluble • Maximum soluble	98 5 to 8 8 to 14	mg/L mg/L mg/L
Influent solubility TKN + nitrate: • Average • Maximum	 1.0 4.0	 mg/L mg/L
Influent alkalinity concentration (as $CaCO_3$)	100 to 220	mg/L
Minimum hydraulic retention time	30	minutes
Splitter structure mixed liquor suspended solids range	1,000 to 5,000	mg/L
Design discharge nitrate concentration	2.0	mg/L NO_3-N
Maximum discharge nitrate concentration	8.0	mg/L NO_3-N
Effluent BOD5, maximum	7.0	mg/L
Effluent TSS, maximum	1.0	mg/L
Effluent turbidity, maximum	0.5	NTU
Number of systems for 2,500-gal/min capacity	2 active, 0 standby	#
Number of systems for 3,750-gal/min capacity	3 active, 0 standby	#
Number of units: • 2,500-gal/min capacity • 3,750-gal/min capacity	 4 6	 # #
Membrane Design Configuration		
Number of cassettes per train: • 2,500-gal/min capacity • 3,750-gal/min capacity	 5 5	 # #
Maximum number of cassette spaces per unit	6	#
Maximum transmembrane pressure	12	psi
Membrane system recovery: • Without backwash recovery • With backwash recovery	 91 96	 % %

* Safety factor has been added to FBR effluent values to provide aeration/membrane filtration influent values.

2.3.2.4 Sludge Handling Basis of Design

The purpose of the biological sludge handling facilities is to process the biological solids removed by the biological treatment systems. The sludge handling facilities include waste activated sludge storage, sludge thickening, and sludge dewatering systems. Tables 2-16, 2-17, and 2-18 provide summaries of the anticipated sludge quantities generated at groundwater treatment flow rates of 3,785 L/min, 9,464 L/min, and 14,195 L/min (1,000 gal/min, 2,500 gal/min, and 3,750 gal/min), respectively.

Table 2-16. Estimated Sludge Quantities for Startup (1,000-gal/min) Operation

Parameter	Out of Membrane Tank[a]	Out of Aerated Sludge Storage[b,c]	Dewatered Sludge[c]
Expected average solids volume			
Dry solids (ton/yr)	500	364	346
Expected case solids (% solids)	0.3 to 0.5	2.5 to 3.0	18 to 20
Volume (ft^3/week)	NA	NA	700 to 1,100
Worst-case solids volume			
Dry solids (ton/yr)	508	396	376
Worst-case solids (% solids)	0.4	2.5	20
Volume (ft^3/week)	NA	NA	1,300

a. Assumes 1.2 days solids retention time in aeration/membrane tanks.

b. Assumes 20% to 25% solids reduction in aerated holding tank.

c. Assumes 97% capture of solids during thickening process and 95% capture during the dewatering process.

Table 2-17. Estimated Sludge Quantities for 2,500-gal/min Plant Capacity

Parameter	Out of Membrane Tank[a]	Out of Aerated Sludge Storage[b,c]	Dewatered Sludge[c]
Expected average solids volume			
Dry solids (ton/yr)	719	523	429
Expected case solids (% solids)	0.3 to 0.5	2.5 to 3.0	18 to 20
Volume (ft^3/week)	NA	NA	1,550 to 1,770
Worst-case solids volume			
Dry solids (ton/yr)	754	588	559
Worst-case solids (% solids)	0.4	2.5	18
Volume (ft^3/week)	NA	NA	1,940

a. Assumes 1.2 days solids retention time in aeration/membrane tanks.

b. Assumes 20% to 25% solids reduction in aerated holding tank.

c. Assumes 97% capture of solids during thickening process and 95% capture during the dewatering process.

Table 2-18. Estimated Sludge Quantities for 3,750-gal/min Plant Capacity

Parameter	Out of Membrane Tank[a]	Out of Aerated Sludge Storage[b,c]	Dewatered Sludge[c]
Expected average solids volume			
Dry solids (ton/yr)	1,080	784	745
Expected case solids (% solids)	0.5	3.0	20
Volume (ft^3/week)	134,000	16,300	2,320
Worst-case solids volume			
Dry solids (ton/yr)	1,130	882	838
Worst-case solids (% solids)	0.4	3.0	18
Volume (ft^3/week)	176,000	22,000	2,900

a. Assumes 1.2 days solids retention time in aeration/membrane tanks.

b. Assumes 20% to 25% solids reduction in aerated holding tank.

c. Assumes 97% capture of solids during thickening process and 95% capture during the dewatering process.

The primary process equipment for the sludge handling system includes the following:

- Aerated sludge holding tank
- Rotary drum thickeners
- Dewatering centrifuges
- Centrate sump
- Centrate aeration tank

Tables 2-19 through 2-22 provide summaries of the key design criteria for each of these components of the sludge handling system.

Table 2-19. Aerated Sludge Holding Tank Design Criteria

Parameter	Value	Units
Type	Heated and insulated FRP	NA
Tank volume	32,225	gal
Diameter	14	ft
Height	28	ft
Air requirements	600/tank	scfm
Diffuser type	Course bubble	NA

Table 2-20. Rotary Drum Thickener Design Criteria

Parameter	Value	Units
Type	Wedge wire or screen fabric	NA
Sludge flow applied to thickener	25 to 50	gal/min
Influent sludge percent dry solids	0.2 to 0.5	%
Solids concentration out of thickener	3.5 to 5.0	%
Percent recovery of suspended solids	95 to 98	%
Polymer dosage to influent sludge	12 to 20	lb/dry ton solids
Power	3	horsepower

Table 2-21. Dewatering Centrifuge Design Criteria

Parameter	Value	Units
Type of centrifuge	High solids horizontal	NA
Sludge flow applied to centrifuges	130	gal/min
Influent sludge percent dry solids	2.0 to 3.0	%
Dewatered solids concentration out of centrifuges	15 to 20	%
Maximum solids loading rate, each	1,780	lb/hr
Percent recovery of suspended solids	95 to 98	%
Polymer dosage to influent sludge	12 to 20	lb/dry ton solids
Expected hours of operation for 2,500-gal/min capacity	6	hours/week
Expected hours of operation 3,750-gal/min capacity	12	hours/week

Table 2-22. Aerated Centrate Tank Design Criteria

Parameter	Value	Units
Type	Heated and insulated FRP	NA
Tank volume	32,225	gal
Diameter	14	ft
Height	28	ft
Air requirements	60/tank	scfm
Diffuser type	Course bubble	NA

2.3.2.5 Sludge Stabilization System Basis of Design

Dewatered sludge from the centrifuges will be stabilized with lime to control free water and to kill the biomass to prevent further decomposition and generation of objectionable gases and odors. Dewatered sludge screw conveyors will transfer dewatered sludge from the centrifuges to the pug mill where lime will be added and mixed with the sludge. Screw conveyors will transport the stabilized sludge to containers for disposal. The system also includes two lime silos and lime transfer screw conveyors.

The lime/sludge stabilization system is designed to meet the following system objectives:

- Remove additional moisture to ensure no free liquids.
- Stabilize the sludge to minimize odor generation.
- Maintain a sludge consistency adequate to facilitate loading and unloading the ERDF roll-off containers.
- Size the stabilization system to allow one day per week operation during the first phase of operation (up to 9,464 L/min [2,500-gal/min] groundwater treatment capacity), and 2 days per week operation after the system is expanded to full design capacity (groundwater treatment up to 14,195 L/min [3,750 gal/min]).
- Provide sufficient system redundancy and flexibility commensurate with the balance of the treatment system.
- Provide a degree of maintenance and operability consistent with the balance of the treatment system.
- Use 22 yd^3 ERDF roll-off containers and already established procedures for tarping the roll-off containers, loading them onto the trucks, and unloading new roll-off containers.
- Contain the sludge to minimize spillage and odor release.
- Provide a system design life of 25 years.

The selected sludge stabilization process is quicklime stabilization. Quicklime stabilization consists of mixing sufficient quicklime (calcium oxide, or CaO) with the centrifuge cake to absorb residual moisture and minimize biological odor-causing activity due to the high pH. The system will be configured to achieve Class B stabilization requirements. The Class B stabilization requirements are defined in 40 CFR 503, "Standards for the Use or Disposal of Sewage Sludge." The pH will be elevated to greater than 12.0 for 2 hours and will remain at a pH greater than 11.5 for an additional 22 hours to meet the Class B vector attraction reduction requirements.

Quicklime stabilization is recommended because it is a highly effective, relatively simple, robust, and flexible process. The process of mixing sufficient lime with the sludge can be volumetrically controlled, it is readily started and stopped, and it can be quickly adjusted to meet varying sludge cake production rates. These traits are desirable given the need to operate the system once or twice per week, or on an as-needed basis.

Table 2-23 provides a summary of key design criteria for sizing the lime stabilization system.

Table 2-23. Sludge Stabilization Sizing Basis

Parameter	Units	2,500-gal/min Plant Capacity		3,750-gal/min Plant Capacity	
		Average Annual	Maximum Month	Average Annual	Maximum Month
Total dry solids from both centrifuges (at 365 days/year operation)	dry lb/day	2,350 to 2,800	3,105	4,140	4,657
% solids by weight from centrifuge	wt%	18	18	18	18
Wet centrifuge cake density	wet lb/cf	52	52	52	52
Days per week system operates	day/wk	1	1	2	2
Hours per day system operates	hr/day	6	6	6	6
Total dry solids from both centrifuges (per day of operation)	dry lb/day	19,332	21,732	14,491	16,299
Total cake volume from both centrifuges (per day of operation)	yd^3/day	76	86	57	65

2.3.2.6 Chemical Feed Systems Basis of Design

The maximum design flow of 14,195 L/min (3,750 gal/min) was used to determine chemical storage and equipment space requirements for each of the chemicals used in the treatment processes. Table 2-24 provides the key design criteria for the major process equipment, vessels, and containment areas that make up the chemical feed systems.

Table 2-24. Chemical Feed Systems Design Criteria

Item	Value	Units	Comments
Storage Vessels			
Quantity at maximum flow and maximum dose	14	days	NA
Maximum vessel height	16	ft	Reserve a minimum 4-ft clearance from vessel top to roof framing structure for access.
Maximum vessel diameter	14	ft	Larger diameter tanks would require field fabrication.
Chemical Truck Containment Area and Unloading Panels			
Chemical truck unloading area	NA	NA	A concrete chemical unloading pad will be provided along the south side of the bioprocess facility by the chemical storage room. A sump pump will be provided with a capacity of 15 gal/min at 10 psi.
Chemical unloading panel	NA	NA	The carbon substrate system will have a chemical unloading panel along the exterior wall face adjacent to the carbon substrate tank location. The sulfuric acid system will have a chemical unloading panel adjacent to the sulfuric acid tanks.

Table 2-24. Chemical Feed Systems Design Criteria

Item	Value	Units	Comments
Secondary Containment			
Minimum chemical spill volume	120 30	% %	Greater of 120% of largest vessel volume or 30% of total vessel volume per chemical.
Minimum fire sprinkler water volume	0.15	gal/min/ft^2	30-minute duration.
Minimum containment volume freeboard	6	In	NA
Number of secondary containment areas	1	each	Separate containment for each chemical.
Secondary containment area sump pump criteria	15	gal/min	Provided for carbon substrate and sulfuric acid containment areas. Also provided for common chemical room trench drain. Pump capacity of 15 gal/min at 10 psi.
Motor-Driven Metering Pumps			
Speed adjustment ratio	10:1	ratio	Speed adjustment will be from 0 to 100% with a guaranteed accuracy of ±0.5% steady state on set point over a 10:1 flow turn-down range.
Electronic stroke length ratio	10:1	ratio	Adjusted through pump controls.
Overall turn-down ratio	100:1	ratio	Resulting overall turn-down based on speed and stroke-length adjustments.
Net-positive suction head	3	psia	Suction hydraulics to provide proper net-positive suction head.

2.3.2.7 Air-Stripping System Basis of Design

The air-stripping system is designed to remove carbon tetrachloride and other VOCs from the groundwater and to control VOC emissions within the treatment area to acceptable workplace levels. The air-stripping system is designed to remove carbon tetrachloride that is not removed in the biological treatment processes.

Because the air stripper tower will be piped so treatment can occur before or after the biological treatment process, the tower must be designed for a dual set of operating parameters for each phase of treatment. Table 2-25 presents the estimated water quality analysis for the influent to the air stripper for all four treatment options (startup and full capacity, both before and after biological process). Table 2-26 provides a summary of key design criteria for the air-stripping system.

The 200 West Area groundwater treatment facility will be capable of meeting the requirements of the ROD. The finished water quality requirements and goals for the air stripper facility are presented in Table 2-27. The final cleanup levels for the groundwater VOCs are based on groundwater cleanup standards. However, the design treatment goal is for the finished water quality to be less than the target finished water quality standard to allow for an operational factor. The nominal operating treated effluent target will be 60 percent of the final cleanup level under normal operations.

Table 2-25. Estimated Air Stripper Influent Water Quality

Parameter	Average Value Before Bioprocess[a]		Average Value After Bioprocess[a]		Units
	Startup[b]	2,500-gal/min Capacity[b]	Startup[b]	2,500-gal/min Capacity[b]	
Carbon tetrachloride	738	660 to 670	738	20 to 30	µg/L
Nitrate as nitrogen (average)	35	40 to 50	2	2	mg/L
Hexavalent chromium	27	47	nil	20 to 50	µg/L
TCE	3.7	4.1	3.7	<1	µg/L
Iodine-129	0.15	0.20 to 0.30	0.15	0.2 to 0.3	pCi/L
Technetium-99	227	83	227	<10	pCi/L
Tritium	8,200	9,315	8,200	9,315	pCi/L
Uranium	3.6	3.2	3.6	3.2	µg/L
Chromium (total)	26	47	<26	<47	µg/L
Alkalinity (as $CaCO_3$)	112	110	150	217	mg/L
Calcium as Ca	67	69	67	69	mg/L
Chloride	20	20	20	20	mg/L
Chloroform	0.044	0.041	0.044	<0.5	mg/L
Fluoride	0.35	0.035	0.35	0.035	mg/L
Iron (dissolved)[c]	0.26	0.025	nil	nil	mg/L
Magnesium	20	21	20	21	mg/L
Manganese (dissolved)[c]	0.089	0.084	<0.089	<0.084	mg/L
Potassium	5	5	5	5	mg/L
Sodium	20	21	20	21	mg/L
Sulfate	38	37	38	37	mg/L
TOC	1.7	1.6	1.7	1.6	mg/L
TSS[c]	1.6	1.9	nil	nil	mg/L
TDS	305	484	305	484	mg/L

a. The analyses indicated are estimated analyses for two potential operating scenarios that affect specified process influent conditions, treatment before biological treatment, and treatment after the biological treatment.

b. Startup incoming groundwater flow rate is 1,250-gal/min maximum and full operational flow rate is 2,500 gal/min maximum.

c. Indicated contaminants may deviate up to twice the indicated value. Information concerning the recommended anti-scalant and dosage, as well as the maximum allowable concentration of the specified parameters when using the anti-scalant, will be requested from the air stripper manufacturer.

Table 2-26. Air Stripper Design Criteria

Parameter	Value	Units
Type	Forced-draft, counter-current	NA
Capacity	600 to 1,250	gal/min
Design flux	15 to 25	gal/min/ft^2
Air-to-water ratio	15:1 minimum, 42:1 maximum	NA
Housing		
Material	Heated and insulated FRP	NA
Diameter	12	ft
Height	70	ft
Packing		
Type	Polypropylene	NA
Number of beds	2	#
Bed depth, minimum	20	ft
Packing size, maximum	2.3	in.
Allowable head loss (clean packing material at maximum air and water flow rates)	0.02	in. WC/ft
Packed bed safety factor	25	%
Minimum free area of packing supports (percentage of cross-sectional area)	90	NA
Inlet water distributor		
Type	V-notch distribution and parting boxes	NA
Distribution points	6	#/ft^2
Water redistributor		
Type	Orifice-riser	NA
Minimum water level above orifice	2	in.
Distribution points	6	#/ft^2
Inlet air distributor		
Allowable air face velocity distribution gradient	5	%

Table 2-26. Air Stripper Design Criteria

Parameter	Value	Units
Mist eliminator		
Type	Mesh-type	NA
Thickness	6	in.
Water droplet removal	Adjustable speed	NA
>10 microns in diameter	99.5	%

Table 2-27. Air Stripper Finished Water Quality Requirements and Goals

Parameter	Point of Compliance	Finished Water Quality Standard		Acceptance Standard Description	Design Treatment Goal
		Value	Units		
Carbon tetrachloride[a]	Pipeline to injection wells	3.4	µg/L	Specified by ROD[b]	2 µg/L
TCE[a]	Pipeline to injection wells	1	µg/L	Specified by ROD[b]	0.6 to 1 µg/L

a. The DOE will clean up contaminants of concern for the 200-ZP-1 OU subject to WAC 173-340, "Model Toxics Control Act – Cleanup," which includes carbon tetrachloride and TCE, so the excess lifetime cancer risk does not exceed 1×10^{-5} at the conclusion of the remedy.

b. *Record of Decision Hanford 200 Area 200-ZP-1 Superfund Site Benton County, Washington* (EPA et al., 2008).

2.3.2.8 Off-Gas Treatment System Basis of Design

The 200 West Area groundwater treatment facility requires emission controls for off-gassing from the equalization tank, air stripper(s), FBR(s), membrane tanks, sludge holding tank(s), recycle tank, rotary drum thickeners, and centrifuges. Preliminary estimates of air emissions toxicity values indicated that the off-gas treatment system would require a minimum capture rate of 96 percent to meet the proposed local air emission limit for carbon tetrachloride.

Off-gas treatment will be accomplished with vapor-phase GAC vessels. Air stripper, tank, and process vessel off-gas will be treated to remove VOCs prior to discharge to the atmosphere. Table 2-28 presents the influent data, model results, current emission limits, and proposed emission limit for carbon tetrachloride that the design is intended to meet.

Table 2-29 provides a summary of key design criteria for the vapor-phase GAC vessels.

Table 2-28. Finished Air Quality Requirements and Goals

Pollutant	Maximum 1-Hour Concentration ($\mu g/m^3$)	Annual Average Concentration ($\mu g/m^3$)	Annual ASIL ($\mu g/m^3$)
Carbon tetrachloride	0.0149	0.0012	0.0238
Chloroform	0.1120	0.0090	0.0435
Vinyl chloride	0.0035	0.0003	0.0128

Notes: See air emissions calculation (CALC-053, Rev. 1) for modeling inputs and results.

Table 2-29. Vapor-Phase GAC Vessel Design Criteria

Parameter	Value	Units
Type	Horizontal roll-off	NA
Bed capacity	20,000	lb
Design velocity	0.5 to 1.2	ft/s
Humidity (percent relative)	40 to 60	%
Bed depth	5 to 6	ft
Configuration	Series operation	NA
VOC removal:		
• At startup of vessel	99	%
• At exhaustion of vessel	90	%
Number of active units per phase	2.0	#

2.3.3 Specification of Construction Materials

A brief narrative of the construction materials that will be used for the 200 West Area groundwater pump-and-treat system is provided in the following subsections. This narrative is intended to provide a summary of the construction materials related to the treatment process, not as a comprehensive list of all material types for every piece of equipment or structure in each respective unit process or structure. Details on the selection of materials are provided in the design drawings and specifications, which are available to EPA upon request.

The following discussion focuses on exposures that warrant special consideration for material selection:

- Buried exposure
- Atmospheric exposure
- Technetium-99 exposure
- Chemical exposure

2.3.3.1 Buried Exposure

The majority of buried process piping will be high-density polyethylene (HDPE), which will not require special corrosion mitigation. It is not anticipated that there will be much buried metallic piping. Any buried ductile iron pipe should be protected with polyethylene encasement in accordance with American Waste Water Association Standard AWWA C105. Galvanized pipe should not be used for underground service. Copper pipe may be used underground; however, it should be electrically isolated from ferrous structures to eliminate galvanic (two metal) corrosion.

2.3.3.2 Atmospheric Exposure

The use of aluminum, stainless steel, fiber-reinforced plastic (FRP), and other non-metallic materials can be used in addition to coated carbon steel for most plant atmospheres. The application of high-performance coating systems to carbon-steel surfaces is recommended throughout the facility. High-performance coating systems are defined further in the design documentation provided under separate cover.

2.3.3.3 Technetium Exposure

Technetium-99 bonds with ferrous metals. Uncoated carbon steel, ductile iron, and other ferrous metals will not be used in immersion service with technetium-99 exposure. Stainless steel (Type 304), polyvinyl chloride (PVC), chlorinated polyvinyl chloride, or FRP wetted parts and piping are specified for these services.

2.3.3.4 Chemical Exposure

The majority of these chemicals will be delivered and stored in chemical-resistant totes. Table 2-30 provides recommendations applicable to the storage tanks and associated pumps and piping, and Table 2-31 provides pipe material guidelines for chemical feeds.

Table 2-30. Chemical Exposure Material Specifications

Chemical	Tanks	Pump	Piping	Valves
Alum	PE totes, FRP	Non-metallic wetted parts	PVC or CPVC	PVC or CPVC
Anti-scalant	PE totes, FRP	Non-metallic wetted parts	PVC or CPVC	PVC or CPVC
Calcium oxide	PE totes, FRP	Non-metallic, steel	PVC, steel	PVC, steel
Carbon substrate	FRP	Non-metallic wetted parts	PVC, CPVC, FRP	Non-metallic
Citric acid	PE totes, FRP	Non-metallic wetted parts	PVC, CPVC, FRP	Non-metallic
Hydrochloric acid	PE totes, FRP	Non-metallic wetted parts	PVC, CPVC	PVC, CPVC
Micronutrient	PE totes	Non-metallic wetted parts	PVC, CPVC	PVC, CPVC
Phosphoric acid	PE totes, FRP	Non-metallic wetted parts	CPVC, FRP	PVC, CPVC
Polymer	FRP, FRP	Non-metallic wetted parts	PVC, CPVC, FRP	Non-metallic
Sodium bisulfite	PE totes, FRP	Non-metallic wetted parts	PVC, CPVC	Non-metallic
Sodium hydroxide	PE totes, FRP	Cast steel	PVC, CPVC	PVC, CPVC
Sodium hypochlorite	PE totes, FRP	Non-metallic wetted parts	FRP, CPVC, PVC	Non-metallic
Sodium nitrate	PE totes, FRP	Non-metallic wetted parts	PVC, CPVC, FRP	Non-metallic

Table 2-30. Chemical Exposure Material Specifications

Chemical	Tanks	Pump	Piping	Valves
Sulfuric acid	PE totes	Alloy 20	Type 304 or 316 stainless steel (6 fps max. velocity)	CF-8 or CF-8M for shutoff; Alloy 20 for throttling

Notes: When two materials are listed, the first is preferred.

Table 2-31. Chemical Feed Pipe Material Specifications

Chemical	Pipe Material
Anti-scalant	PVC
Calcium oxide carbon substrate	STL with Hammertek lining
Citric acid	PVC
Ferric chloride	PVC
Hydrochloric acid	PVC
Micronutrient	PVC
Phosphoric acid	CPVC
Polymer	PVC
Cationic (RDT) polymer	PVC
Cationic (centrifuge) sodium bisulfite	PVC
Sodium hydroxide	PVC
Sodium hypochlorite	PVC
Sodium nitrate	PVC
Sulfuric acid	SST

2.4 Balance of Plant

The balance of plant design includes conveyance piping, transfer pumps, and transfer buildings necessary to pump extracted groundwater to the 200 West Area groundwater treatment facility, and from the treatment facility to the injection wells. The balance of plant also includes any administrative, maintenance, or other infrastructure (e.g., site grading and access roads) and utilities designed to support the treatment facilities. The balance of plant design includes the following:

- Utilities
- Access roads and road crossings
- Grading and drainage
- Yard piping
- Groundwater conveyance (piping, transfer pumps and transfer buildings)

2.4.1 Basis of Design

The basis of design for key elements of the balance of plant design is discussed below.

2.4.1.1 Major Site Features

The plant facility contains a radiological building and a biological process building. A biological process equipment pad is provided on the north side of the biological process building. Unloading areas are provided for GAC canisters and chemical deliveries. A paved asphalt apron surrounds the buildings and equipment pad to provide facility access and serves as a fire buffer zone.

2.4.1.2 Access Roads

Two access points are provided to the 200 West Area groundwater treatment facility. A paved driveway is provided on the west side of Beloit Avenue, between 22nd Street and 23rd Street. A second paved driveway is provided on the north side of 22nd Street, between Beloit Avenue and Bridgeport Avenue. Beloit Avenue is a paved road, and 22nd Street is a gravel road.

2.4.1.3 Grading and Drainage

The existing topography of the 200 West Area groundwater treatment facility site is generally flat terrain, sloping to the northwest. Native vegetation currently exists onsite, with an area that appears to have been previously cleared. The site will be graded away from the buildings to the exterior of the apron and onto the existing ground surface and allowed to infiltrate. Stormwater infiltration is an aspect of the design. Existing drainage flow paths will be preserved.

2.4.1.4 Yard Piping

A 12-in.-diameter sanitary water line is provided in a loop around the 200 West Area groundwater treatment facility site to provide building fire and service water and to supply the fire hydrants. This water line ties into an existing 12-in.-diameter sanitary water line that runs along the northwest corner of the site.

A sewage line will exit the building and will be routed to a sewage holding tank. Piping to/from the transfer buildings and wells will exit the site through open trenches with grating through the asphalt apron.

2.4.1.5 Groundwater Conveyance Piping

Aboveground HDPE pipelines convey the contaminated groundwater from the extraction wells to the transfer buildings and from the treatment facility to the injection wells. The HDPE pipelines are essentially an unrestrained piping system since changes in the piping temperature result in dimensional changes. Decrease in temperature results in shortening of the piping, while increase in temperature results in lengthening of the piping. End-point anchors are provided at the transfer buildings.

Insulation and heat trace are provided at each wellhead for freeze protection in winter conditions, as required. The minimum expected temperature is -32°C (-25°F). Heat tracing is adjusted to operate at 4°C (40°F) and below. Pipe sizes are designed to provide flow rates that will not allow groundwater to freeze before it reaches the treatment building or the injection wells. The extracted groundwater should reach the treatment building at 10°C (50°F) or more in order to maintain a healthy biomass in the FBR. Heat tracing has been added to those portions of the piping system that are believed to be more susceptible to freeze damage. During rare, extreme cold weather excursions, some piping may temporarily freeze and unplanned shutdowns during may result.

During operations, a combination of daily pipe walk-downs and flow meter monitoring for early leak detection will be used. Flow meter measurements will be taken between the wellhead and the transfer station and/or between the transfer station and the 200 West Area groundwater treatment facility. If a significant variance in the measured flows between these points occurs, the system will automatically shut down and the potential leak will be inspected. The measured difference representing this shutdown condition will be defined after steady-state operations have commenced. In summary, daily pipe walk-downs will be initiated during normal operating periods, as required by WAC 173-303-640, "Tank Systems." After the system has operated successfully through the shake-down period with no leaks, consideration could be given to reducing the frequency of the pipe walk-downs and relying more on automation/instrumentation for leak detection; however, this change would require written approval by RL and EPA.

2.4.1.6 Transfer Buildings

Each of the four transfer buildings includes a transfer tank made from FRP. Extraction building 2 (289TC) includes two transfer tanks: one tank for technetium-99-contaminated groundwater, and one tank for non-technetium-99-contaminated groundwater. Each tank is approximately 3.1 m (122 in.) in height with varying diameters. The storage tanks receive water from the extraction wells and function as supply reservoirs for the transfer pumps. Each tank includes a level transmitter indicator, a "high-high-level" float switch, a low-level float switch, temperature indicator, vent, and a discharge pipeline. The "high-high-level" float switch prevents the tank from overflowing. The low-level switch prevents the transfer pumps from running below the minimum net-positive suction head of the pumps, which would damage the equipment.

A leak detection system in each transfer building uses optical-type liquid level probes mounted below finished floor grade in strategic locations. The probes are connected in series to the programmable logic controller. The system is designed to enable the pump adjustable frequency drives in each building; otherwise, the system will alarm when any one of the probes detects the presence of leaking process water. Leak detection in the HDPE well piping and the transfer building conveyance piping will be electronically monitored using the differential flow rates between inline flow meters, as well as by operations personal inspecting/walking the lines, at defined periods.

Each transfer building contains pumps for pumping water from the transfer building storage tanks to the treatment buildings or the injection wells. Table 2-32 summarizes the pump locations, capacities, and design head criteria.

Table 2-32. Transfer Building Pumps

Equipment Name	Location	Capacity (gal/min)	Design Head (ft)
Extraction transfer pump A	Extraction transfer bldg. 1 (289TB)	650	81.5
Extraction transfer pump B	Extraction transfer bldg. 1 (289TB)	650	81.5
Extraction transfer pump A	Extraction transfer bldg. 2 (289TC)	455	86.5
Extraction transfer pump B	Extraction transfer bldg. 2 (289TC)	455	86.5
Extraction transfer pump C	Extraction transfer bldg. 2 (289TC)	455	86.5
Extraction transfer pump A	Extraction transfer bldg. 2 (289TC)	700	72.5
Extraction transfer pump B	Extraction transfer bldg. 2 (289TC)	700	72.5

Table 2-32. Transfer Building Pumps

Equipment Name	Location	Capacity (gal/min)	Design Head (ft)
Injection booster pump A	Injection transfer bldg. 1 (289TD)	960	100
Injection booster pump B	Injection transfer bldg. 1 (289TD)	960	100
Injection booster pump C	Injection transfer bldg. 1 (289TD)	720	180
Injection booster pump D	Injection transfer bldg. 1 (289TD)	720	180
Injection booster pump A	Injection transfer bldg. 2 (289TE)	1,200	160
Injection booster pump B	Injection transfer bldg. 2 (289TE)	1,200	160
Injection booster pump C	Injection transfer bldg. 2 (289TE)	960	285
Injection booster pump D	Injection transfer bldg. 2 (289TE)	960	285

2.4.2 Specification of Construction Materials

The final piping materials will be defined in the final design package; currently, however, piping from the extraction well pump to the top of the well would be constructed of stainless steel. Galvanized steel would transition from the stainless-steel extraction pipe to HDPE piping that serves as the conveyance system from each wellhead to the transfer building.

The pipelines used to transport groundwater from each of the extraction wells are constructed of HDPE piping conforming to American Waste Water Association Standard AWWA C906. The HDPE piping is specified for a pressure rating of 200 psi at 23°C (73°F). At a service temperature of 43°C (110°F), the piping has a pressure rating of 150 psi.

2.5 200 West Area Groundwater Pump-and-Treat System-Related Primary Documents

Two primary documents support this RDR: an O&M plan and a performance monitoring plan. These two documents are described below. Both of these documents are DOE-designated primary documents and have been submitted for review under separate cover, and each document is on separate review and approval paths.

2.5.1 Operations and Maintenance Plan

The O&M plan (DOE/RL-2009-124) outlines the activities necessary to operate, maintain, and monitor operation of the 200 West Area groundwater pump-and-treat systems, from the completion of construction through decommissioning of the system.

The O&M plan serves as a regulatory/administrative document that describes how O&M of the remedy will be conducted. An adequate and functioning O&M program throughout a remedy's lifecycle is critical for successful implementation and ultimate achievement of the RAOs. The measures described in the O&M plan are designed to provide guidance on implementing the requirements necessary for maintaining the remedy to ensure protection of human health and the environment. Specifically, the O&M plan presents discussions on process controls/instrumentation, response to off-normal events, data reporting

requirements, the operating transition from the existing interim remedy to the final remedy, QA/QC, and health and safety.

The appendices of the O&M plan present a compliance matrix discussing the applicable or relevant and appropriate requirements, as well as how the facility will address each requirement, waste management and handling/disposal requirements, sampling and analysis procedures for the well field and the process treatment system, and the air emission monitoring/sampling requirements.

2.5.2 Performance Monitoring Plan

The performance monitoring plan (DOE/RL-2009-115) has been prepared to guide groundwater monitoring data collection activities associated with implementation of 200-ZP-1 OU remedial action. The performance monitoring plan was prepared in a data quality objective-type format and presents recommendations for the types of data that should be collected, the well networks that should be monitored, the frequency for data collection, and analysis of the data to satisfy the requirements of the ROD.

3 Construction Schedule

Construction of the 200 West Area groundwater pump-and-treat system will be completed in several separate efforts. The initial construction effort will provide an installed capacity to treat up to 9,464 L/min (2,500 gal/min) of extracted groundwater using two parallel treatment trains.

This chapter provides a description of the Tri-Party Agreement (Ecology et al., 1989a) milestones and the key schedule elements for construction of the 200 West Area groundwater pump-and-treat system.

3.1 Tri-Party Agreement Milestones

The Tri-Party Agreement milestones associated with construction of the 200 West Area groundwater pump-and-treat system are summarized in Table 3-1. Each of the milestones is discussed further within the schedule summary (Section 3.2).

Table 3-1. Summary of Tri-Party Agreement Milestones for the 200 West Area Groundwater Pump-and-Treat System Construction

Milestone	Description	Date
M-16-124	Submittal of RDR, Draft A (reflecting 90% design).	August 31, 2010
M-16-122	Begin Phase 1 operation of the new 200 West Area pump-and-treat system per the RD/RAWP[a] and the 200-ZP-1 OU ROD.[b] This action will provide the initial portion of the overall pump-and-treat capacity expected to be required by the 200-ZP-1 ROD[b] and 200-UP-1 ROD.[c] This initial operation can provide treatment of the technetium-99 plume at the S/SX Tank Farms within the 200-UP-1 OU.	December 31, 2011

a. DOE/RL-2008-78, *200 West Area 200-ZP-1 Pump-and-Treat Remedial Design/Remedial Action Work Plan.*

b. *Record of Decision Hanford 200 Area 200-ZP-1 Superfund Site Benton County, Washington* (Ecology et al., 2008).

c. EPA/ROD/R10-97/048, *Interim Remedial Action Record of Decision for the 200-UP-1 Operable Unit, Hanford Site, Benton County, Washington.*

3.2 Schedule Summary

The 200 West Area groundwater pump-and-treat system construction schedule is provided in Figure 3-1. Key schedule elements are summarized below:

- Prepare RDR
- Install wells
- Construct balance of plant
- Construct radiological treatment facility
- Construct biological process facility
- Perform commissioning and startup
- Conduct system expansion and optimization

Tri-Party Agreement Milestone M-16-124 requires submittal of Draft A of the RDR (presenting the 90 percent design) by August 31, 2010. Construction of selected elements started under the design/build delivery model in November 2009 with the installation of access road crossings, HDPE piping, and

extraction wells. Construction of transfer buildings will commence prior to completion of design activities. These early activities have been started in advance of completion of the remedial design to accelerate the construction schedule. Completion of construction activities for the initial construction efforts (achieving an installed capacity to treat 9,464 L/min [2,500 gal/min]) is anticipated by September 30, 2011.

Construction acceptance testing will be conducted to ensure that equipment is installed as designed and that individual components operate as expected. The construction acceptance testing requirements are defined in the construction specifications. The end state of construction acceptance testing is the systematic demonstration that the systems were installed per the design and the system is ready for functional testing during implementation of the acceptance testing procedure (ATP).

After completion of construction, commissioning and startup (acceptance and operational testing) will be performed to ensure that the system is operational and functional. This testing will be accomplished through the aforementioned ATP and the operational testing procedure (OTP). The ATP demonstrates that fabrication, assembly, installation, and construction requirements meet the design requirements and verifies that final systems and subsystems are installed successfully per the functional design criteria. The OTP facilitates validation of operating procedures and completion of operator training. Calibration and necessary preventative maintenance will be conducted prior to ATP/OTP. The ATP and OTP documents are prepared during the final design period and will be completed in time to support commissioning and startup of the system. Tri-Party Agreement Milestone M-16-122 requires that Phase 1 operation of the 200 West Area pump-and-treat system begins by December 31, 2011. Additional phases of ATP/OTP will be conducted as additional capacity and/or wells are brought online.

Upon completion of construction, facility commissioning, and initial startup, the system is projected to operate at approximately 3,785 L/min (1,000 gal/min) using approximately 15 extraction wells, 5 injection wells, and associated conveyance infrastructure. By December 31, 2012, additional extraction and injection wells will be brought online (optimization phase), based on aquifer performance, to further utilize the designed 9,464 L/min (2,500-gal/min) treatment capacity of the facility. Currently, a total of 20 extraction wells and 16 injection wells are projected to be installed.

Design of the facility includes the ability to add a third treatment train (also in parallel) within the existing facility footprint and infrastructure, increasing the design flow rate to 14,195 L/min (3,750 gal/min). This expansion phase (if necessary) is anticipated to occur after 2012.

Activity Name	Start	Finish
RDR - Primary Document Preparation and Support		
Prepare ZP-1 Remedial Design Report	Dec-2009	Aug-2010
TPA Milestone M-16-124: Submit Draft A, ZP-1 Remedial Design		Aug-2010
Well Installation		
Drill and Develop 15 Extraction Wells and 5 Injection Wells Supporting 1000 gpm Process Flow	Jun-2009	Jan-2011
Drill and Develop 5 Extraction Wells and 11 Injection Wells Supporting 2500 gpm Process Flow	Jan-2011	Sep-2012
Construct Balance of Plant		
Install Road Crossings and Transfer Piping for 15 Extraction Wells & 5 Injection Wells	Oct-2009	Nov-2010
Install Well Power for 15 Extraction Wells & 5 Injection Wells	Jun-2010	Dec-2010
Construct 2 Injection Transfer Buildings	Mar-2010	Jan-2011
Construct 2 Extraction Transfer Buildings	Mar-2010	Jan-2011
Perform Well Tie in Activities for 15 Extraction Wells & 5 Injection Wells	Aug-2010	May-2011
Install Road Crossings and Transfer Piping for 5 Extraction Wells & 11 Injection Wells	Jan-2012	Nov-2012
Install Well Power for 5 Extraction Wells & 11 Injection Wells	Jun-2012	Dec-2012
Perform Well Tie in Activities for 5 Extraction Wells & 11 Injection Wells	Aug-2012	May-2013
Construct Rad Building		
Construct Rad Building - Civil & Infrastructure	Jun-2010	Sep-2010
Construct Rad Building - Concrete & Building	Aug-2010	Dec-2010
Construct Rad Building - Install Process Equipment	Oct-2010	Jul-2011
Construct Rad Building - Perform Construction Acceptance Testing	Jun-2011	Sep-2011
Construct Bio Process Facility		
Construct Bio Process Facility - Civil & Infrastructure	Jun-2010	Sep-2010
Construct Bio Process Facility - Concrete & Building	Aug-2010	Feb-2011
Construct Bio Process Facility - Install Process Equipment	Jan-2011	Aug-2011
Construct Bio Process Facility - Perform Construction Acceptance Testing	Jun-2011	Sep-2011
200W Pump & Treat Facility Construction Substantially Complete		Sep-2011
Commissioning and Startup		
Perform ATP/OTP	Aug-2011	Jun-2012
TPA Milestone M-16-122: Begin Phase 1 Operations	Dec-2011	
Expansion & Optimization		
Expansion/Optimization	Jun-2012	Sep-2014

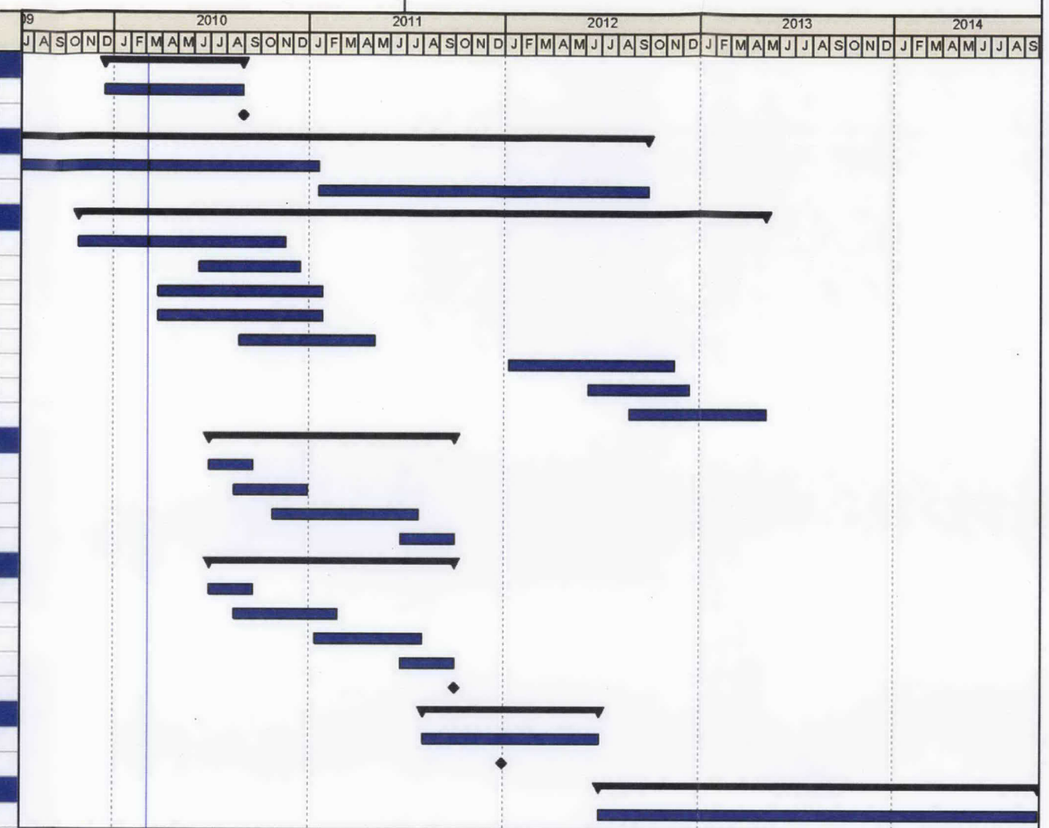

Figure 3-1. 200 West Area Groundwater Pump-and-Treat Facility Construction Schedule

4 Cost Estimate

The 200 West Area groundwater pump-and-treat systems construction cost estimate has been prepared in coordination with the 90 percent design submittal. This estimate reflects the current design development, and, as such, is subject to change based on completion of the final design.

4.1 Basis of Estimate

The major elements of the cost estimate for constructing the 200 West Area groundwater pump-and-treat system are presented in the following subsections.

The basis of estimate establishes the conditions and certain key assumptions (often not stated in the project scope) that provide a firm foundation for the development and presentation of costs for a given construction project. The cost items presented herein are designed to closely match the elements of the schedule for comparative purposes.

4.1.1 Scope of Estimate

The scope of the estimate includes the engineering, design, construction, testing startup, and commissioning of the 200 West Area groundwater pump-and-treat system, with an initial installed treatment capacity of 9,464 L/min (2,500 gal/min). Initial construction activities include groundwater extraction and injection wells that will have been installed at the time the treatment facility construction is complete (expected to be 15 extraction and 5 injection wells at startup). These wells are expected to extract groundwater at a combined rate of approximately 3,785 L/min (1,000 gal/min) to support initial operations and will include wells from the vicinity of T Tank Farm and S-SX Tank Farms. The treatment facility will be capable of treating the COCs (carbon tetrachloride, TCE, total chromium, hexavalent chromium, nitrate, iodine-129, and technetium-99), as specified in the RD/RAWP (DOE/RL-2008-78). Tritium is a COC but will be managed through monitored flow-path control and natural attenuation. The pump-and-treat system will also be able to treat uranium once the 200-UP-1 OU extraction and treatment systems are added (in the optimization and expansion effort) after initial startup.

After initial construction and operation of the system at 3,785 L/min (1,000 gal/min), the remaining extraction wells (approximately 5 total), remaining injection wells (approximately 11), and associated transfer piping will be installed and hooked up to approach the 9,464 L/min (2,500-gal/min) pumping rates. This will bring the total number of wells to approximately 20 extraction wells and 16 injection wells. The estimate also reflects treatment of technetium-99 from the 200-UP-1 OU's WMA S-SX, as well as adding the uranium IX treatment train (up to 1,325 L/min [350 gal/min]). Uranium treatment will be added to the system (as required by the *Interim Remedial Action Record of Decision for the 200-UP-1 Operable Unit, Hanford Site, Benton County, Washington* [EPA/ROD/R10-97/048]) once the remedial design is complete. This is expected to occur in the optimization and expansion effort.

4.1.2 Exclusions

The cost estimate does not include costs to drill and install the 200-UP-1 (S-SX and U Plant) groundwater wells, to lay transfer lines, or to install pump stations to transfer 200-UP-1 groundwater to the 200 West Area groundwater treatment facility. Those costs will be covered by the final remedy selected for 200-UP-1 OU. Also, the estimate does not include any capital equipment or other balance of plant costs to provide, deliver, or install a third biological process treatment train to increase the current designed process flow from 9,464 L/min (2,500 gal/min) to 14,195 L/min (3,750 gal/min).

The cost estimate does not include contingencies for the defined scope of responsibility.

4.1.3 Cost Basis

The cost estimates include the costs and capital expenditures associated with the engineering, design, construction, services, and fees to deliver the system as intended and necessary to meet defined objectives. These costs include, but are not limited to, the following:

- Engineering costs
- Design costs
- General and administrative costs
- Capital costs for procurement and delivery of equipment
- Taxes and fees
- Field mobilization and demobilization costs, insurance, and bonds
- Direct field construction costs
- Engineering services during construction
- Construction management services
- O&M manuals and startup plans
- Startup costs and commissioning
- Escalation costs during construction
- Other defined or determined costs as necessary

The estimate was prepared in accordance with CHPRC cost-estimating procedures and guidance documents, which establish the process and tools used in the development of CHPRC cost estimates. These documents control the development, review, documentation, and archiving of CHPRC cost estimates. The cost estimate was developed using Timberline® cost estimating software, unit cost data from *RS Means Facilities Construction Cost Data* (RS Means, 2010), other available cost and catalog data, and the estimator's professional judgment.

Engineering, design, and construction of the pump-and-treat facility have already commenced. A minor portion of the estimate is based on actual cost and performance available at the time of estimation, and an extrapolation of that data has been applied to the work remaining where applicable.

The majority of the estimate is based upon current engineering and design documents as developed through current design development. Capital equipment pricing is based on developed process equipment lists and competitive cost quotations as received from manufacturers through an approved solicitation and procurement process. Where applicable, costs for pricing of long-lead items included in this estimate were provided by CHPRC Procurement.

Current cost information pertaining to buildings and other structures, site utilities, balance of plant systems, etc., was derived from the current design drawings (including equipment installation, mechanical systems, and process system interconnections). Other costs for mechanical systems, electrical systems, and instrumentation and control systems (as provided) are factored from the single line diagrams and the process and instrument diagrams to determine the remaining balance of process costs to derive the estimated capital cost for the facility.

4.1.4 Accuracy of Estimate

This cost estimate is based on multiple methods and approaches used to develop the capital and construction costs for this facility. CHPRC has solicited and obtained price quotations for most of the

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capital equipment, as well as representative quotations for other cost components, including buildings and other structures. Other costs are developed using process flow diagrams, process and instrument diagrams, single line diagrams, and applied factors to determine costs most probable for this type of groundwater treatment facility.

The final costs of the project will depend on actual labor and material costs, competitive market conditions, final project scope, implementation schedule, and other variable conditions. As a result, the final project costs will vary from the estimate as developed and presented.

The classification of the construction cost estimate provided herein is considered to be Class 2 (Title II), with engineering and design less than 80 percent complete overall. As previously stated, the project is using a design/build approach and, therefore, portions of the design are further defined than others (ranging from 60 to 90 percent overall). The accuracy of the estimate ranges between -10 percent to 20 percent and +10 percent to +30 percent. A Title II design estimate is defined as an estimate that uses detailed design drawings and specifications to develop costs for construction projects. These estimates are (1) produced at the completion of definitive design, (2) based on approved or "issued for approval" design documents, and (3) used as the basis for establishing the project construction budget.

4.2 Summary of Estimate

The 200 West Area groundwater pump-and-treat system construction cost estimate is summarized in Table 4-1. Key elements of the construction cost estimate are broken down into the following categories:

- Well installation
- Balance of plant
- Radiological process facility
- Biological treatment facility
- Commissioning and startup

Table 4-1. 200 West Area Groundwater Pump-and-Treat System Construction Costs

Description	Cost
Wells	
Drill and develop 20 extraction wells and 16 injection wells supporting a 2,500-gal/min process flow	$31,571,961
Subtotal	$31,571,961
Balance of Plant	
Install road crossings and transfer piping for 20 extraction wells and 16 injection wells	$18,642,655
Install power to 20 extraction wells and 16 injection wells	$ 2,474,883
Perform well tie in activities for 15 extraction wells and 5 injection wells	$3,841,758
Construct extraction transfer buildings 1 and 2	$7,967,990
Construct injection transfer buildings 1 and 2	$5,822,795
Subtotal	$38,750,081

Table 4-1. 200 West Area Groundwater Pump-and-Treat System Construction Costs

Description	Cost
Radiological Process Facility	
Construct radiological process facility (civil and infrastructure)	$1,130,535
Construct radiological process facility (concrete and building)	$9,428,730
Construct radiological process facility (process equipment and installation)	$19,808,726
Subtotal	$30,367,991
Biological Treatment Facility	
Construct biological treatment facility (civil and infrastructure)	$7,391,785
Construct biological treatment facility (concrete and building)	$28,496,084
Construct biological treatment facility (process equipment and installation)	$73,185,171
Subtotal	$109,073,040
Commissioning and Startup	
Commissioning (ATP/OTP)	$5,759,594
Total	**$215,522,667**

4.2.1 Well Installation

The cost estimate for well installation includes a total of 20 groundwater extraction and 16 groundwater injection wells. Cost activities related to well installation include, but are not limited to, the following:

- Providing management support, labor support, and associated documentation (e.g., borehole compliance reports, and closeout activities)
- Drilling, installing, and developing groundwater wells
- Preparing well pads
- Sampling groundwater
- Conducting civil surveys of well locations

4.2.2 Balance of Plant

The balance of plant cost estimate includes, but is not limited to, the following:

- Conveyance piping installation (including road crossings)
- Well hookup to conveyance piping
- Power hookup for wells
- Construction of extraction transfer buildings 1 and 2
- Construction of injection transfer buildings 1 and 2

4.2.3 Radiological Process Facility

The cost estimate for the radiological process facility includes, but is not limited to, the following:

- Civil and infrastructure (e.g., site preparation, clearing, grading, yard piping, and utilities)
- Concrete and building (e.g., building foundation, equipment pads, and secondary containment structures)
- Process equipment installation (e.g., purchase/install equipment, piping, valves, mechanical and electrical hookups, and instrumentation and controls)

4.2.4 Biological Treatment Facility

The cost estimate for construction of the biological treatment facility to a capacity of 9,464 L/min (2,500 gal/min) includes, but is not limited to, the following:

- Civil and infrastructure (e.g., site preparation, clearing, grading, yard piping, and utilities)
- Concrete and building (e.g., building foundation, equipment pads, and secondary containment structures)
- Process equipment installation (e.g., purchase/install equipment, piping, valves, mechanical and electrical hookups, and instrumentation and controls)

4.2.5 Commissioning and Startup

The cost estimate for commissioning and startup (ATP and OTP) includes the costs associated with performance of ATP and OTP. The ATP includes development of the ATP by operations staff with technical support from design staff, training, performance of acceptance testing with design staff support, and documentation of test results. The OTP includes development of the operational test plan and performance of operational testing by operations staff with technical support from design staff, as well as documentation of the test results.

5 References

40 CFR 265.93, "Interim Status Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities," "Preparation, Evaluation, and Response," *Code of Federal Regulations*. Available at: http://edocket.access.gpo.gov/cfr_2009/julqtr/40cfr265.93.htm.

40 CFR 300, "National Oil and Hazardous Substances Pollution Contingency Plan," *Code of Federal Regulations*. Available at: http://www.access.gpo.gov/nara/cfr/waisidx_10/40cfr300_10.html.

300.430, "Remedial Investigation/Feasibility Study and Selection of Remedy."

300.435, "Remedial Design/Remedial Action, Operation and Maintenance."

40 CFR 503, "Standards for the Use or Disposal of Sewage Sludge," *Code of Federal Regulations*. Available at: http://ecfr.gpoaccess.gov/cgi/t/text/text-idx?c=ecfr&sid=3a0c3cd8f07ba3e882b71133b0363936&rgn=div5&view=text&node=40:29.0.1.2.41&idno=40.

Atomic Energy Act of 1954, 42 USC 2011, et seq. Available at: http://www.nrc.gov/reading-rm/doc-collections/nuregs/staff/sr0980/ml022200075-vol1.pdf.

Comprehensive Environmental Response, Compensation, and Liability Act of 1980, 42 USC 9601, et seq. Available at: http://uscode.house.gov/download/pls/42C103.txt.

DOE/EIS-0222-F, 1999, *Final Hanford Comprehensive Land-Use Plan Environmental Impact Statement*, U.S. Department of Energy, Washington, D.C. Available at:
http://www5.hanford.gov/arpir/?content=findpage&AKey=D199158842.
http://www5.hanford.gov/arpir/?content=findpage&AKey=D199158843.
http://www5.hanford.gov/arpir/?content=findpage&AKey=D199158844.
http://www5.hanford.gov/arpir/?content=findpage&AKey=D199158845.
http://www5.hanford.gov/arpir/?content=findpage&AKey=D199158846.
http://www5.hanford.gov/arpir/?content=findpage&AKey=D199158847.

DOE O 435.1, Chg 1, 2001, *Radioactive Waste Management*, U.S. Department of Energy, Washington, D.C. Available at: https://www.directives.doe.gov/directives/current-directives/435.1-BOrder-c1/view.

DOE/RL-96-07, 1996, *200-ZP-1 IRM Phase II and III Remedial Design Report*, Rev. 1, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://www5.hanford.gov/arpir/?content=findpage&AKey=D196154133.

DOE/RL-2001-41, 2009, *Sitewide Institutional Controls Plan for Hanford CERCLA Response Actions*, Rev. 4, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://www5.hanford.gov/arpir/?content=findpage&AKey=0095932.

DOE/RL-2002-17, 2002, *Sampling and Analysis Plan for the 200-ZP-1 Groundwater Monitoring Well Network*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://www5.hanford.gov/arpir/?content=findpage&AKey=D9103853.

DOE/RL-2006-24, 2006, *Remedial Investigation Report for the 200-ZP-1 Groundwater Operable Unit*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE/RL-2007-28, 2008, *Feasibility Study Report for the 200-ZP-1 Groundwater Operable Unit*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://www5.hanford.gov/arpir/?content=detail&AKey=0808050315. http://www5.hanford.gov/arpir/?content=detail&AKey=00098828.

DOE/RL-2007-33, 2008, *Proposed Plan for Remediation of the 200-ZP-1 Groundwater Operable Unit*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://www5.hanford.gov/arpir/?content=findpage&AKey=00098832.

DOE/RL-2008-56, 2008, *200-West Area Pre-Conceptual Design for Final Extraction/Injection Well Network: Modeling Analyses*, (Draft in review prior to publication), U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE/RL-2008-57, 2009, *Sampling and Analysis Plan for the First Set of Remedial Action Wells in the 200-ZP-1 Groundwater Operable Unit*, Rev. 1, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://www5.hanford.gov/arpir/?content=findpage&AKey=0095302.

DOE/RL-2008-78, 2009, *200 West Area 200-ZP-1 Pump-and-Treat Remedial Design/Remedial Action Work Plan*, Draft A, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://www2.hanford.gov/arpir/?content=findpage&AKey=0904130567.

DOE/RL-2009-38, 2009, *Description of Modeling Analyses in Support of the 200-ZP-1 Remedial Design/Remedial Action Work Plan*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://www5.hanford.gov/arpir/?content=findpage&AKey=0095363.

DOE/RL-2009-95, 2009, *Sampling Analysis Plan for Eleven ARRA Wells to Support the 200 West Groundwater Treatment System in Fiscal Year 2010*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://www5.hanford.gov/arpir/?content=findpage&AKey=0095205.

DOE/RL-2009-115, 2010, *Performance Monitoring Plan for the 200-ZP-1 Groundwater Operable Unit Remedial Action*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://www5.hanford.gov/arpir/?content=findpage&AKey=1007190651.

DOE/RL-2009-124, 2010, *200 West Area Groundwater Pump-and-Treat Facility Operations and Maintenance Plan*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://www5.hanford.gov/arpir/?content=findpage&AKey=1009071206.

DOE/RL-2010-11, 2010, *Hanford Site Groundwater Monitoring and Performance Report for 2009*, Volumes 1 & 2, Rev. 1, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

Ecology Cleanup Levels and Risk Calculations (CLARC) database, Washington State Department of Ecology, Olympia Washington. Available at: https://fortress.wa.gov/ecy/clarc/.

Ecology, EPA, and DOE, 1989a, *Hanford Federal Facility Agreement and Consent Order*, 2 vols., as amended, Washington State Department of Ecology, U.S. Environmental Protection Agency, and U.S. Department of Energy, Olympia, Washington. Available at: http://www.hanford.gov/?page=81.

Ecology, EPA, and DOE, 1989b, *Hanford Federal Facility Agreement and Consent Order Action Plan*, Washington State Department of Ecology, U.S. Environmental Protection Agency, and U.S. Department of Energy, Olympia, Washington. Available at: http://www.hanford.gov/?page=82.

EPA, Ecology, and DOE, 2008, *Record of Decision Hanford 200 Area 200-ZP-1 Superfund Site Benton County, Washington*, U.S. Environmental Protection Agency, Washington State Department of Ecology, and U.S. Department of Energy, Olympia, Washington. Available at: http://www.epa.gov/superfund/sites/rods/fulltext/r2008100003103.pdf.

EPA/ROD/R10-95/114, 1995, *Record of Decision for the USDOE Hanford 200-ZP-1 Operable Unit, 200 Area NPL Site Interim Remedial Measure*, U.S. Environmental Protection Agency, Washington State Department of Ecology, and U.S. Department of Energy, Olympia, Washington. Available at: http://www.epa.gov/superfund/sites/rods/fulltext/r1095114.pdf.

EPA/ROD/R10-97/048, 1997, *Interim Remedial Action Record of Decision for the 200-UP-1 Operable Unit, Hanford Site, Benton County, Washington*, U.S. Environmental Protection Agency, Washington State Department of Ecology, and U.S. Department of Energy, Olympia, Washington. Available at: http://www.epa.gov/superfund/sites/rods/fulltext/r1097048.pdf.

Endangered Species Act of 1973, 16 USC 1531, et seq. Available at: http://www.fws.gov/endangered/pdfs/ESAall.pdf.

Harbaugh, A.W., E.R. Banta, M.C. Hill, and M.G. McDonald, 2000, *MODFLOW-2000, The U.S. Geological Survey Modular Ground-Water Model – User Guide to Modularization Concepts and the Ground-Water Flow Process*, U.S. Geological Survey Open File Report 00-92, U.S. Geological Survey, Reston, Virginia.

Resource Conservation and Recovery Act of 1976, 42 USC 6901, et seq. Available at: http://www4.law.cornell.edu/uscode/42/6901.html.

RS Means, 2010, *RS Means Facility Construction Cost Data*, 24th Annual Edition, Robert S. Means Company, Kingston, Massachusetts.

Sackschewsky, Michael R., 2008, "Biological Review of the 200 West Area Groundwater Treatment Facility's Proposed Sites, ECR #2009-200-004," (letter to Bruce Sasser, CH2M HILL Plateau Remediation Company), December 16, Pacific Northwest National Laboratory, Richland, Washington.

SGW-40266, 2010, *Description of Work for Aquifer Testing at Well 299-W15-225*, Rev. 2, CH2M HILL Plateau Remediation Company, Richland, Washington.

Smith, Randall F. and Roger Stanley, 1992, "Action Memorandum: Expedited Response Action Proposal for 200 West Area Carbon Tetrachloride Plume" (letter to Ronald D. Izatt, U.S. Department of Energy, Richland Operations Office, from Randall F. Smith, U.S. Environmental Protection Agency, Region 10, and Roger Stanley, Washington State Department of Ecology), Letter #9200423, January 21, Lacey, Washington. Available at: http://www5.hanford.gov/arpir/?content=findpage&AKey=D196088487.

Superfund Amendments and Reauthorization Act of 1986, 42 USC 103, et seq. Available at: http://www.epa.gov/superfund/policy/sara.htm.

WAC 173-160, "Minimum Standards for Construction and Maintenance of Wells," *Washington Administrative Code*, Olympia, Washington. Available at: http://apps.leg.wa.gov/WAC/default.aspx?cite=173-160.

WAC 173-303, "Dangerous Waste Regulations," *Washington Administrative Code*, Olympia, Washington. Available at: http://apps.leg.wa.gov/WAC/default.aspx?cite=173-303.

303-400, "Interim Status Facility Standards."

303-640, "Tank Systems."

WAC 173-340, "Model Toxics Control Act – Cleanup," *Washington Administrative Code*, Olympia, Washington. Available at: http://apps.leg.wa.gov/WAC/default.aspx?cite=173-340.

340-720, "Ground Water Cleanup Standards."

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4. Document Number(s)/Title(s)	5. Program/Project/Building Number	6. Reviewer	7. Organization/Group	8. Location/Phone
200 West Area Groundwater Pump-and-Treat Remedial Design Report/DOE/RL-2010-13, Draft A (June 2010)		Emerald Laija	US EPA and Washington Department of Ecology	

9. Comment Submittal Approval (optional)	10. Concurrence with indicated comment disposition(s)	11. Closure Approval
Reviewing Organization Manager (print/sign)	Date / Reviewer/POC (print/sign)	Date / Reviewer/POC (print/sign)
Date	Date / Author/Originator (print/sign)	Date / Author/Originator (print/sign)

Item	12. Page/Line	13a. Comment (include technical/regulatory basis)	13b. Recommended Change	14. (A)ccept or (R)eject	15. Disposition (provide justification if **NOT** accepted)	16. Status
1	Pg. 1-1, line 9	Change the sentence as follows: "This remedial alternative will address groundwater with contaminants of concern concentrations that pose a potential human risk and will meet the remedial action objectives (RAOs) identified in the ROD."		Accepted	The text will be modified as suggested	In process
2	Pg. 1-4, line 10	DOE and EPA agreed not to meet for the 60% design. Change the sentence accordingly to reflect that meetings were held for the 30% and 90% design.		Accepted	The text will be modified as suggested	In process
3	1Pg. -18, line 22 and 24	Change "(not supplied at EPA request)" to "(Available to EPA upon request)."		Accepted	The text will be modified as suggested	In process
4	Pg. 1-19, line 8	Add the following sentence: "EPA reserves the right to review and approve fundamental and significant changes."		Accepted	The text will be modified as suggested	In process
5	Pg. 2-4, line 17	This section states that following construction, facility commissioning and initial startup, the system is projected to operate at approximately 1000 gpm. The ROD (p. 56, Section 12.2.1) states that the "estimated rate required to reduce the mass of carbon tetrachloride by 95% in the expected timeframe is 1600 gpm". Address this discrepancy.		Acknowledged	At startup of operations (December 2011) the facility will be operating at about 1,000 gpm. The facility will be constructed with a maximum operating capacity of 2500 gpm and it is expected to be operational at or above the referenced 1600 gpm rate shortly after operational testing.	In process
6	Pg. 2-6, lines 22-	EPA does not agree with the reasoning regarding why the 200 area was principally		Accepted	The text will be modified as suggested	In process

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Item	12. Page/Line	13a. Comment (include technical/regulatory basis)	13b. Recommended Change	14. (A)ccept or (R)eject	15. Disposition (provide justification if **NOT** accepted)	16. Status
	31	withdrawn from the public domain. Change the paragraph to read as follows: "Most of the land within the 200-ZP-1 OU has been designated by DOE, through the *Final Hanford Comprehensive Land-Use Plan Environmental Impact Statement* (DOE/EIS-0222-F), for industrial exclusive use for the foreseeable future. The ROD for 200-ZP-1 requires that DOE do the following in the event of the transfer or sale of any land located in the OU:"				
7	Pg. 2-9, *first paragraph*	A reader could misinterpret the first paragraph. Add language to clarify the EPA and USGS were involved and approved the development of the groundwater flow and contaminant transport model.		Accepted	The text will be modified as suggested	In process
8	Pg. 29, line 24	Change the following sentence: "Aquifer testing conducted at extraction well EW-1…"		Accepted	The text will be modified as suggested	In process
9	Pg. 2-9, line 34	Change the following sentence: "Nine extraction wells were installed during the first campaign…"		Accepted	The text will be modified as suggested	In process
10	Pg. 2-10, line 7:	Fix the bulleted items. "A constant-rate pump test" should be listed under a separate bullet.		Accepted	The text will be modified as suggested	In process
11	Pg. 2-10, line 12	Change "IRM" (interim remedial measure) to "IRA" (interim remedial action). The Tri-Party Agreement does not list "IRM" as an acronym.		Accepted	The text will be modified as suggested	In process
12	Pg. 2-10, line 15	Change the following sentence: "The extraction wells will be drilled into…"		Accepted	The text will be modified as suggested	In process

13	Pg. 2-12, line 11	Change the following sentence: "The protective casing is a minimum of 5.1 cm…"		Accepted	The text will be modified as suggested	In process
14	Pg. 2-12, lines 13-15	Variances from Ecology are not required on the CERCLA action at 200-ZP-1. Delete the last sentence from this paragraph and use the following language: "If changea are required to the proposed construction based on actual conditions encountered in the field or updated modeling simulations, DOE will ensure that WAC 173-160 is satisfied by discussing changes with the lead agency."		Accepted	The text will be modified as suggested	In process
15	Pg. 2-16, *Table 2-4*	This is a useful table; however, the design treatment goal value for COCs should be listed in this table or on the same page. Although this information is available in Table2-6, a reader could find it difficult to make the connection between how each COC is being treated to achieve appropriate water cleanup levels for reinjection.		Accepted	The text will be modified as suggested	In process
16	Pg. 2-21, line 20	The following sentence is unclear. "As the microbes grow on the GAC, the fluidized bed height will *excess biomass removed* with a biomass separator." Correct wording accordingly.		Accepted	The text will be modified as suggested	In process
17	Pg. 2-49, line 6 and 24	Change 'provided under separate cover" to "available to EPA upon request."		Accepted	The text will be modified as suggested	In process
18	Pg. 2-52, lines 7-10	The "Grading and Drainage" section states that run-off is going to be directed to the edge of concrete apron and then allowed to infiltrate. Is this an accurate statement? Please clarify if the design of the pump and treat system will capture run-off or allow to infiltration.		Accepted with response	Storm water infiltration is an aspect of the LEED gold certification. The text will be clarified.	In process
19	Pg. 2-52, Lines 17-22	The "Groundwater Conveyance Piping" section should be further discussed. Add a brief discussion of measures that will be taken to prevent lines from freezing in cold temperatures. Also explain how WAC 173-		Accepted	The following discussion will be generally added to the document text… …. *The conveyance piping is above ground HDPE piping, consistent with piping systems in use at existing pump and treats.*	In process

		303-640 will be achieved by explaining if it will be possible to visually inspect all piping or if other requirements are needed.			*Piping sizes are designed to provide flow rates that will not allow groundwater to freeze before it reaches the treatment building or the injection wells. In fact, calculations are performed that demonstrate the extraction water will reach the treatment building at 50^0 F in order to maintain a healthy biomass in the fixed bed reactor. Portions of the lines susceptible to freeze damage are provided with heat trace. Consistent with current pump and treat operations, there is no active freeze protection on the HDPE lines. During rare extreme cold weather excursions, some piping may temporarily freeze and unplanned shutdowns during freezing conditions may result. Piping is planned to be visually inspected periodically.*	
20	Editorial Comments	The draft document contains many typographical errors. Please send the document through technical editing before the final version is issued.		Acknowledged	The document will be re-edited.	In process
21	Editorial Comments	Ensure that the text on figures is legible and the shading neatly done.		Accepted	The text on figures and tables will be checked before the document is released	To be performed