DOE/RL-2014-44
Revision 0

Integrated Remedial Design Report/Remedial Action Work Plan for 100-F/IU

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

U.S. DEPARTMENT OF ENERGY | Richland Operations Office

P.O. Box 550
Richland, Washington 99352

Approved for Public Release;
Further Dissemination Unlimited

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Date Published
August 2015

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APPROVED
By Ashley R Jenkins at 11:07 am, Aug 20, 2015

Release Approval Date

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Title Remedial Design/Remedial Action Work Plan for 100-F/IU

R. J. Corey

U.S. Department of Energy

Richland Operations Office

Signature 8/17/15 Date

C. Guzzetti

U.S. Environmental Protection Agency

Signature 8/18/15 Date

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Terms

amsl	above mean sea level
ARAR	applicable or relevant and appropriate requirement
bgs	below ground surface
CERCLA	*Comprehensive Environmental Response, Compensation, and Liability Act of 1980*
COC	contaminant of concern
Cr(VI)	hexavalent chromium
DOE	U.S. Department of Energy
DOE-RL	DOE Richland Operations Office
DQO	data quality objective
DWS	drinking water standard
EAF	Experimental Animal Farm
Ecology	Washington State Department of Ecology
EPA	U.S. Environmental Protection Agency
ERDF	Environmental Restoration Disposal Facility
ESD	Explanation of Significant Differences
FS	feasibility study
HASP	health and safety plan
HHE	human health and the environment
IC	institutional control
LIGO	Laser Interferometer Gravitational-Wave Observatory
LRA	lead regulatory agency
MNA	monitored natural attenuation
MTCA	"Model Toxics Control Act—Cleanup" (WAC 173-340)
NCP	National Contingency Plan (40 CFR 300, "National Oil and Hazardous Substances Pollution Contingency Plan")
NPL	"National Priorities List" (40 CFR 300, Appendix B)
O&M	operations and maintenance
OU	operable unit
QA	quality assurance

RA	remedial action
RAO	remedial action objective
RAWP	remedial action work plan
RD	remedial design
RDR	remedial design report
RI	remedial investigation
ROD	record of decision
RTD	removal, treatment (as required), and disposal
RWP	radiological work permit
SAP	sampling and analysis plan
TCE	trichloroethene
TPA	Tri-Party Agreement
TPH	total petroleum hydrocarbon
Tri-Party Agreement	*Hanford Federal Facility Agreement and Consent Order*
UU/UE	unlimited use/unrestricted exposure

1 Introduction

The U.S. Department of Energy (DOE) Hanford Site is a 1,517 km^2 (586 mi^2) federal facility located in southeastern Washington State along the Columbia River (Figure 1-1). For administrative purposes, the Hanford Site was divided into four National Priorities List (NPL) sites (40 CFR 300, "National Oil and Hazardous Substances Pollution Contingency Plan," hereafter referred to as the National Contingency Plan [NCP], Appendix B) under the *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA) in 1989, one of which is the 100 Area. In anticipation of the NPL (40 CFR 300, Appendix B) listing, DOE, the U.S. Environmental Protection Agency (EPA), and the Washington State Department of Ecology (Ecology) entered into the *Hanford Federal Facility Agreement and Consent Order* (Ecology et al., 1989a), hereinafter called the Tri-Party Agreement (TPA), in May 1989, which established a procedural framework and schedule for developing, implementing, and monitoring CERCLA response actions and *Resource Conservation and Recovery Act of 1976* compliance and permitting on the Hanford Site.

The 100 Area (CERCLA site identification number WA38900900076) includes the River Corridor areas of the Hanford Site in Benton County, Washington. The 100-FR-1, 100-FR-2, 100-FR-3, 100-IU-2, and 100-IU-6 Operable Units (OUs), hereinafter referred to as 100-F/IU, are part of the Hanford Site 100 Area. 100-F/IU comprises approximately 380 km^2 (145 mi^2) and can be divided into two primary areas of use: the 100-F Reactor Area and the 100-IU-2 and 100-IU-6 Areas. The 100-F Area encompasses approximately 2.8 km^2 (1.1 mi^2) and includes the F Reactor operating region. Within the 100-F Area are the 100-FR-1 and 100-FR-2 Source OUs. Groundwater contamination from these two source OUs is included in the 100-FR-3 Groundwater OU. The 100-IU-2/IU-6 Area includes the 100-IU-2 and 100-IU-6 Source OUs, and encompasses a large area outside of Hanford's primary reactor operating areas (Figure 1-1). This integrated remedial design report (RDR)/remedial action work plan (RAWP) addresses all five 100-F/IU OUs.

Contaminated groundwater originating from Central Plateau source OUs extends to the groundwater beneath the 100-IU-2/IU-6 Area. Groundwater contamination at 100-IU-2/IU-6 is addressed by the CERCLA decisions for the groundwater OUs (200-PO-1 and 200-BP-5) associated with the Central Plateau sources of contamination.

The DOE Richland Operations Office (DOE-RL) is the lead agency responsible to perform the remedial actions (RAs), and EPA is the lead regulatory agency (LRA) as identified in Section 5.6 and Appendix C of the TPA (Ecology et al., 1989a). In accordance with the TPA (Ecology et al., 1989a), Article XIV, Paragraph 54, DOE developed and proposed RAs for 100-F/IU through previous investigations and remedial decisions. The 100-F/IU remedial investigation (RI)/feasibility study (FS) report (DOE/RL-2010-98, *Remedial Investigation/Feasibility Study for the 100-FR-1, 100-FR-2, 100-FR-3, 100-IU-2, and 100-IU-6 Operable Units*) was the basis for the proposed plan. A 60-day public comment period for the proposed plan (DOE/RL-2012-41, *Proposed Plan for Remediation of the 100-FR-1, 100-FR-2, 100-FR-3, 100-IU-2, and 100-IU-6 Operable Units*) occurred from June 9 through August 11, 2014. The proposed plan and responsiveness summary resulted in a record of decision (ROD) for 100-F/IU.

The 100-F/IU ROD (EPA and DOE, 2014, *Record of Decision Hanford 100 Area Superfund Site 100-FR-1, 100-FR-2, 100-FR-3, 100-IU-2, and 100-IU-6 Operable Units*) was signed by EPA and DOE in September 2014. The selected remedies were chosen in accordance with CERCLA, as amended by the *Superfund Amendments and Reauthorization Act of 1986*, the TPA (Ecology et al., 1989a), and, to the extent practicable, the NCP (40 CFR 300). The selected remedies for the five OUs include a combination

of no further action; removal, treatment (as required), and disposal (RTD); monitored natural attenuation (MNA); and institutional controls (ICs) to address the contaminants of concern (COCs). RTD is a remedy for waste sites in the 100-IU-2 and 100-IU-6 OUs only. ICs restricting excavation and prohibiting irrigation are identified for specified 100-FR-1 and 100-FR-2 OU waste sites to prevent exposure until levels protective of unlimited use/unlimited exposure (UU/UE) are met. ICs restricting groundwater use from the 100-FR-3 OU until levels protective of UU/UE are achieved are also identified.

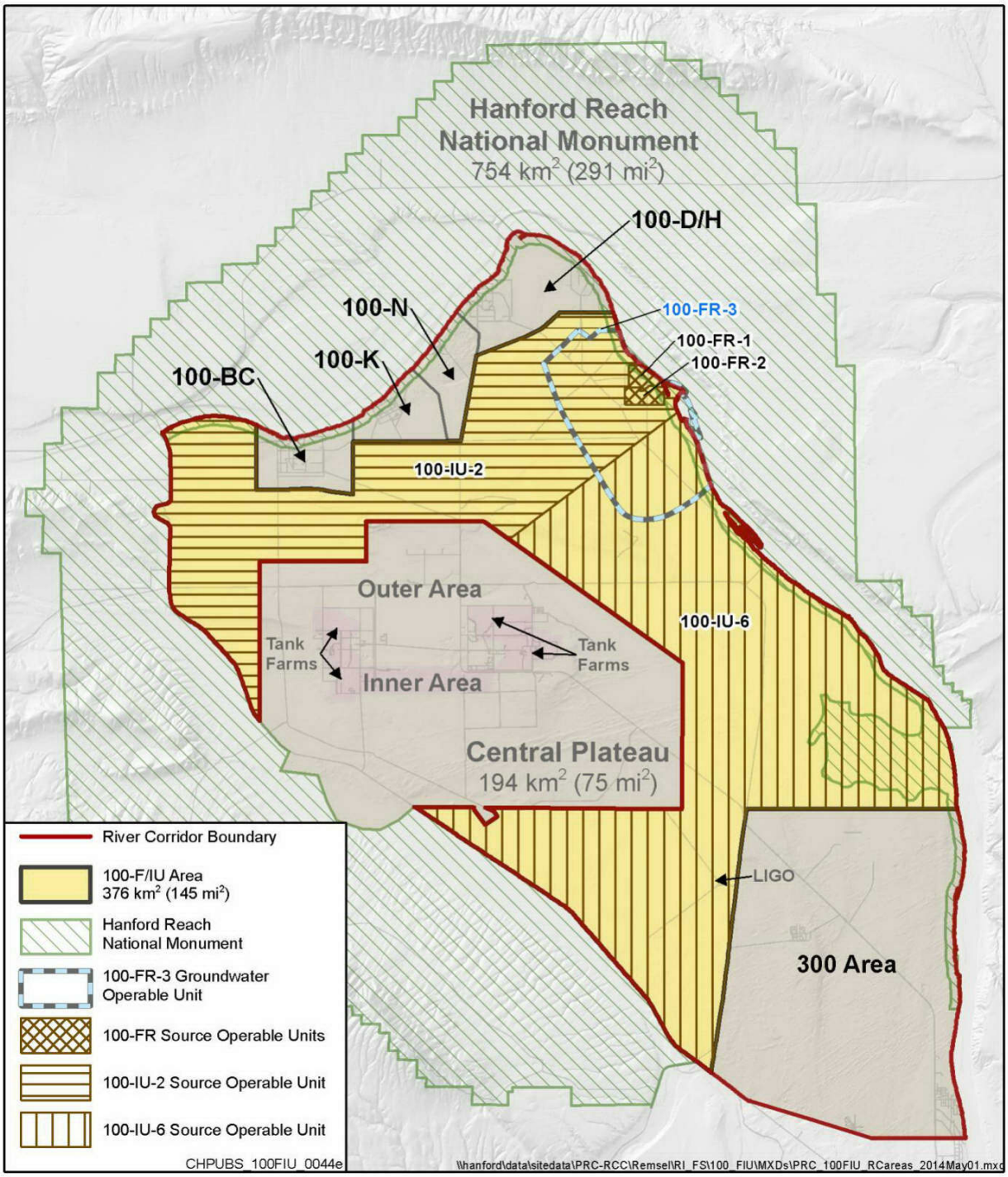

Figure 1-1. 100-FR-1, 100-FR-2, 100-FR-3, 100-IU-2, and 100-IU-6 Operable Units

Achievement of UU/UE will occur when the cleanup levels have been attained. This is defined as attaining shallow zone cleanup levels and cleanup levels for the protection of groundwater and surface water. For ICs applied to restrict groundwater use at the 100-FR-3 OU, UU/UE will be attained when cleanup levels for the protection of groundwater and surface water are achieved. The process for demonstrating attainment of cleanup levels is described in the Soil Addendum and the Groundwater Addendum. For ICs applied to deep zone radiological contamination at specified 100-FR-1 and 100-FR-2 OU waste sites, UU/UE will be achieved when the cumulative excess lifetime cancer risk is less than 1×10^{-4} based on direct contact exposure, as calculated in the 100-F/IU RI/FS report (DOE/RL-2010-98), using the verification sampling data from the RA documented with the waste site reclassification form. These time frames for decay are shown in Table 8 of the 100-F/IU ROD (EPA and DOE, 2014). For ICs applied to restrict irrigation, UU/UE will be achieved when the soil cleanup level for protection of groundwater and surface water is achieved for the site.

RAs for the five OUs will minimize the release or threat of release of hazardous substances that pose a risk to human health and the environment (HHE). Completion of the RAs will provide an end state consistent with the 100-F/IU ROD (EPA and DOE, 2014). The following interim action decisions have been implemented for the 100-FR-1, 100-FR-2, 100-IU-2, and 100-IU-6 OUs:

- 1995 – *Interim Remedial Action Record of Decision for the 100-BC-1, 100-DR-1, and 100-HR-1 Operable Units, Hanford Site, Benton County, Washington* (EPA/ROD/R10-95/126)
- 1997 – *Amendment to the Interim Remedial Action Record of Decision for the 100-BC-1, 100-DR-1, and 100-HR-1 Operable Units, Hanford Site, Benton County, Washington* (EPA/AMD/R10-97/044) (Note: This amendment added the 100-FR-1 and 100-FR-2 waste sites to the interim RA ROD for the 100-BC-1, 100-DR-1, and 100-HR-1 OUs [EPA/ROD/R10-95/126].)
- 1999 – *Interim Action Record of Decision for the 100-BC-1, 100-BC-2, 100-DR-1, 100-DR-2, 100-FR-1, 100-FR-2, 100-HR-1, 100-HR-2, 100-KR-1, 100-KR-2, 100-IU-2, 100-IU-6, and 200-CW-3 Operable Units, Hanford Site, Benton County, Washington (100 Area Remaining Sites)* (EPA/ROD/R10-99/039)
- 2000 – *Interim Remedial Action Record of Decision for the 100-BC-1, 100-BC-2, 100-DR-1, 100-DR-2, 100-FR-2, 100-HR-2, and 100-KR-2 Operable Units, Hanford Site (100 Area Burial Grounds), Benton County, Washington* (EPA/ROD/R10-00/121)
- 2000 – *Explanation of Significant Differences for the 100 Area Remaining Sites Record of Decision:100-IU-6 Operable Unit* (EPA/ESD/R10-00/045)
- 2004 – *Explanation of Significant Differences for the 100 Area Remaining Sites Interim Remedial Action Record of Decision* (EPA et al., 2004)
- 2009 – *Explanation of Significant Differences for the 100 Area Remaining Sites Interim Remedial Action Record of Decision: Hanford Site, Benton County, Washington* (EPA et al., 2009)
- 2011 – *100 Area "Plug-In" and Candidate Waste Sites for Fiscal Year 2010* (DOE et al., 2011)
- 2012 – *100 Area "Plug-In" and Candidate Waste Sites for Calendar Year 2011* (DOE et al., 2012)
- 2013 – *100 Area "Plug-In" and Candidate Waste Sites for Calendar Year 2012* (DOE et al., 2013)

These interim actions are replaced with this final action remedy.

1.1 Purpose

This Integrated RDR/RAWP, along with the Soil and Groundwater Addenda, describes how the site remedies will be designed, installed, and operated to meet the remedial action objectives (RAOs) identified in the 100-F/IU ROD (EPA and DOE, 2014).

This Integrated RDR/RAWP establishes the general size, scope, and character of the RA and identifies the common technical requirements. This document includes the following three parts:

1. An integrated RDR/RAWP that contains common information to support remedy implementation
2. An addendum containing information specific to waste site remedies for the 100-FR-1, 100-FR-2, 100-IU-2, and 100-IU-6 OUs
3. An addendum containing information specific to groundwater remedies for the 100-FR-3 OU

The Integrated RDR/RAWP identifies the information detailed in the soil and groundwater remedy-specific addenda.

Each addendum includes or utilizes additional implementing documents as indicated in Figure 1-2. The work scopes for the two addenda have been split for ease of implementation, based on the services provided by the two remediation contractors. The two addenda include the following scope:

- RDR/RAWP for 100-FR-1, 100-FR-2, 100-IU-2, and 100-IU-6 OU soils (herein referred to as the Soil Addendum). The Soil Addendum describes the work elements, performance measurements, construction management and oversight, and schedule specific to RTD and associated ICs of waste sites within the 100-IU-2 and 100-IU-6 OUs.
- RDR/RAWP for 100-FR-3 OU groundwater (herein referred to as the Groundwater Addendum). The Groundwater Addendum describes the work elements, performance measurements, construction management and oversight, and schedule specific to MNA at the 100-FR-3 OU.

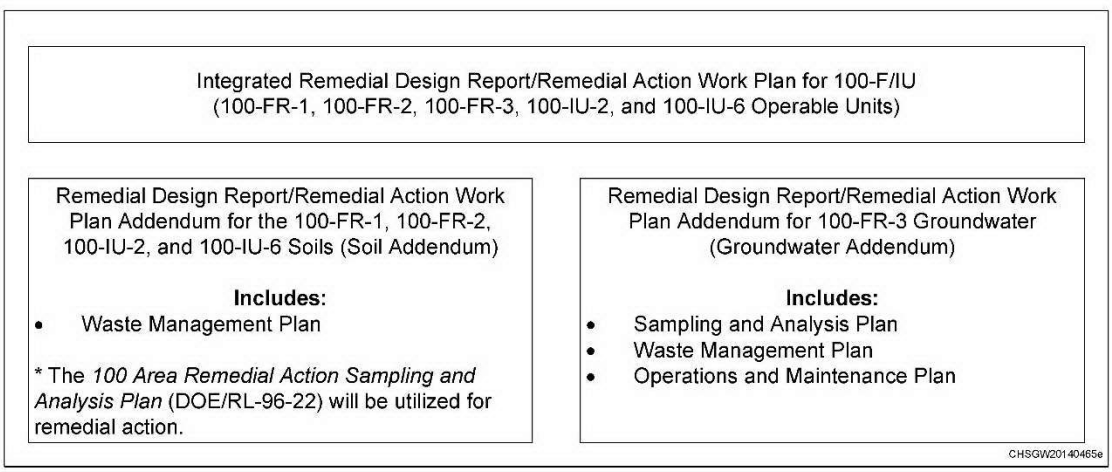

Figure 1-2. 100-F/IU Record of Decision Implementation Document Structure

Implementation, maintenance, and periodic inspection requirements for ICs at the Hanford Site are described in approved work plans and DOE/RL-2001-41, *Sitewide Institutional Controls Plan for Hanford CERCLA Response Actions and RCRA Corrective Actions*, hereinafter called the Sitewide IC Plan. Unique ICs identified in the 100-F/IU ROD (EPA and DOE, 2014) prohibiting irrigation and/or

excavation at identified 100-FR-1 and 100-FR-2 OU waste sites, and controlling access to 100-FR-3 OU contaminated groundwater will be included in, and implemented through, the Sitewide IC Plan (DOE/RL-2001-41).

The Integrated RDR/RAWP, including the Soil Addendum and Groundwater Addendum, serves as the RDR.

The Integrated RDR/RAWP and Soil and Groundwater Addenda are being submitted in accordance with the 100-F/IU ROD (EPA and DOE, 2014) and Section 11.6 of the TPA Action Plan (Ecology et al., 1989b, *Hanford Federal Facility Agreement and Consent Order Action Plan*).

1.2 Scope

This Integrated RDR/RAWP and Soil and Groundwater Addenda provide the plan and schedule for design, construction, and monitoring activities necessary for successful implementation of the RA selected in the 100-F/IU ROD. The selected remedies for the five OUs are described in Table 1-1.

Table 1-1. Major Components of the Selected Remedy

100-FR-1 OU	100-FR-2 OU	100-FR-3 OU	100-IU-2 OU	100-IU-6 OU
ICs[a]	ICs[a]	MNA for hexavalent chromium, nitrate, strontium-90, and trichloroethene in groundwater[c]	RTD at waste sites[b]	RTD at waste sites[b]
		ICs[a,c]		

a. Details are described in the Integrated Remedial Design Report/Remedial Action Work Plan (this document).

b. Details are described in the Soil Addendum.

c. Details are described in the Groundwater Addendum.

IC = institutional control

MNA = monitored natural attenuation

OU = operable unit

RTD = removal, treatment (as required), and disposal

RTD will be used to remove contaminated soil, structures, and debris from 100-IU-2 and 100-IU-6 OU waste sites via excavation; treat material, as necessary, to meet disposal facility requirements; protect workers and prevent unacceptable environmental releases; and dispose of waste. Waste will be disposed at Hanford's Environmental Restoration Disposal Facility (ERDF). The remediated sites will be backfilled, recontoured, and planted with native vegetation.

MNA will be implemented for groundwater COCs hexavalent chromium (Cr(VI)), nitrate, strontium-90, and trichloroethene (TCE) in the 100-FR-3 OU. These groundwater COCs will be monitored until cleanup levels are met.

ICs will be established to control access to residual contamination in soil and groundwater above standards for UU/UE. In the 100-FR-1 and 100-FR-2 OUs, ICs are identified to prohibit irrigation and/or deep excavation at specified waste sites. In 100-IU-2 and 100-IU-6, access restriction ICs will be

implemented for waste sites identified for RTD until the cleanup levels have been met. In the 100-FR-3 OU, ICs will restrict well drilling and groundwater use.

The Laser Interferometer Gravitational-Wave Observatory (LIGO) is located within the 100-IU-6 OU (Figure 1-1). LIGO operates under a DOE permit granted to the National Science Foundation that expires in 2018, unless the permit is extended or terminated. The Hanford town school and White Bluffs bank are two historic structures preserved in the 100-IU-6 and 100-IU-2 OUs, respectively. Historic structures and LIGO are not part of the 100-F/IU addressed by this Integrated RDR/RAWP.

1.3 Site Description and Background

The Hanford Site is divided into numerically designated areas. These areas served as the location for reactor, chemical separation, and related activities for production and purification of special nuclear materials and other nuclear activities. The reactors and their support facilities were located along the south shore of the Columbia River in the 100 Area, due to the need for large quantities of water to dissipate the heat generated during reactor operations. The 200 Area, located about 11 km (7 mi) from the Columbia River, contained all the facilities used to separate, isolate, store, and ship the plutonium. The 300 Area, located adjacent to and north of the city of Richland, contained the reactor fuel manufacturing plants and the research and development laboratories. The 400 Area, located 8 km (5 mi) northwest of the 300 Area, contained the Fast Flux Test Facility designed for testing liquid metal reactor systems. The 600 Area consisted of facilities that served more than one specific area or, in some cases, the entire project.

The F Reactor area encompasses approximately 2.8 km^2 (1.1 mi^2). The reactor's primary mission was plutonium production. The water-cooled nuclear reactor, associated structures, and processes that generated solid and liquid wastes were the primary sources of contamination at the 100-F Area. Solid waste was placed in unlined burial grounds. Liquid contaminants were released to the environment via retention basins, trenches, cribs, ditches, and outfall piping to the Columbia River. The secondary mission of the 100-F Area was the Experimental Animal Farm (EAF), a biological laboratory used to examine the effects of radiation and radioactive contamination on plants, animals, and fish. Waste sites within the F Reactor area are included in the 100-FR-1 and 100-FR-2 OUs. Groundwater contamination from these source OUs is part of the 100-FR-3 OU.

Operation of F Reactor (1945 through 1965) and associated processes generated large quantities of liquid and solid waste. Large volumes of river water were used as cooling water during reactor operations. The river water was treated to remove particulates and, with sodium dichromate, to reduce corrosion. Cooling water contaminants included fuel particles, fission and irradiation byproducts, and Cr(VI). Solid wastes consisted of sludge, reactor components, and various other contaminated items associated with reactor operations. Waste generated from reactor operations was contaminated with radionuclides, hazardous chemicals, or both.

The 100-IU-2 and 100-IU-6 OUs consist of an area between and outside the reactor and production areas within the 100 Area. The pre-Hanford agriculture-based town of White Bluffs and the Hanford Townsite were located within these OUs. Waste sites associated with pre-Hanford activities include landfills and surface debris. During development of the Hanford Site, the area was used for housing and staging equipment and materials for the Hanford Site. Waste sites generally originated from industrial chemical use and include landfills, dumpsites, surface debris, and unplanned releases.

1.3.1 Physical Setting

A detailed description of the 100-F/IU Area is presented in the 100-F/IU RI/FS report (DOE/RL-2010-98) and is summarized in the following paragraphs.

The topography of the reactor area at 100-F is relatively flat, with elevations generally between 120 and 128 m (394 and 420 ft) above mean sea level (amsl) inland from the Columbia River. The area has been disturbed and graded extensively since reactor construction through present-day waste site remediation activities. The elevation at the river shore is approximately 115 m (377 ft) amsl. A low bench of land southeast of 100-F, with elevations below 114 m (374 ft) amsl, is submerged when the river stage is above average.

Topography within 100-IU-2/IU-6 varies widely. Portions of this region are relatively flat, but the area also includes Gable Butte and Gable Mountain, which rise approximately 60 m (200 ft) and 180 m (590 ft), respectively, above surrounding land.

Physical characteristics most affecting contaminant transport at 100-F are hydrogeology and the rate of infiltration. The vadose zone comprises up to 15 m (49 ft) of unconsolidated gravel and sand of the Hanford formation. The unconfined aquifer beneath 100-F comprises Hanford formation gravels that range in thickness from less than 1 m (3 ft) in southwestern 100-F to 8 m (26 ft) in eastern 100-F nearest the Columbia River. The Ringold Formation upper mud (a zone of low permeability composed of intermixed sand, clay, and silt zones) forms the base of the unconfined aquifer. The direction of groundwater flow is east-northeast in the northern part of 100-F and east-southeast in the southern part, with flow velocities ranging from 0.19 to 0.62 m/day (0.58 to 1.9 ft/day). Normal seasonal variability observed in the water table at 100-F is more than 3 m (10 ft) in wells near the river and decreases farther inland.

The hydrostratigraphy of the 100-IU-2/IU-6 OUs is variable because of the large area covered. Groundwater flows toward the east-northeast in the northern portion near the 100-F Area, toward the east in the southwestern portion, and approximately parallel to the river southeast of 100-F Area. Groundwater flow is not always directed toward the river, as the hydraulic gradients change direction in response to river stage. This interaction with the river not only affects groundwater flow patterns but also contaminant transport rates, groundwater geochemistry, contaminant concentrations, and attenuation rates.

The thickness of the vadose zone in the 100-IU-2/IU-6 OUs ranges from near zero, adjacent to the Columbia River, to greater than 107 m (350 ft). The uppermost aquifer is unconfined and comprises the Ringold Formation unit E, the Hanford formation, and the Cold Creek unit. The base of the unconfined aquifer is one of several low-permeability units in the Ringold Formation. Groundwater flows west to east, beneath the southern portion of the 100-IU-2/IU-6 OUs, discharging to the Columbia River at the eastern edge of the Hanford Site.

Recharge rates are dependent on vegetation. Currently in the 100-F Area, there is little to no vegetation, whereas 100-IU-2/IU-6 is composed of large areas of mature vegetation. Recharge rates may be as low as 1.5 mm/yr (0.059 in./yr) where mature vegetation is present, and as high as 52 mm/yr (2.0 in./yr) on disturbed soil. There is little recharge in areas with natural vegetation due to evapotranspiration.

Groundwater in the unconfined aquifer discharges to the Columbia River via upwelling through the riverbed and riverbank seeps (Figure 1-3). The rate of discharge from the Hanford Site aquifer is very low compared to the flow of the river. Because the river stage regularly fluctuates up and down, flow beneath the shoreline is back and forth, with river water intruding into the unconfined aquifer and mixing with groundwater. When the river stage drops to a low elevation, riverbank seeps appear.

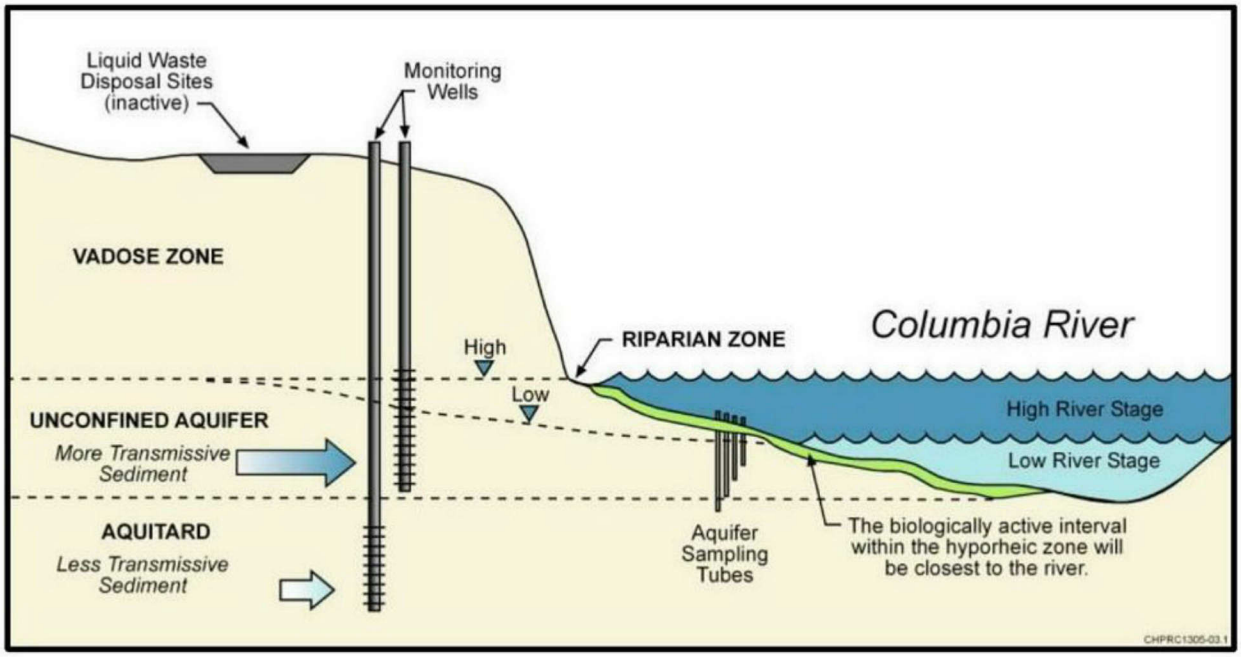

Figure 1-3. Illustration of Zone of Interaction and River Bank Seepage

1.3.2 Nature and Extent of Contamination

DOE performed two limited field investigations in the early 1990s for the 100-FR-1 and 100-FR-3 OUs (DOE/RL-93-82, *Limited Field Investigation Report for the 100-FR-1 Operable Unit*; DOE/RL-93-83, *Limited Field Investigation Report for the 100-FR-3 Operable Unit*) to characterize the nature and extent of contamination in the vadose zone and groundwater. An RI of all areas within 100-F/IU was completed in 2011. The nature and extent of waste site and groundwater contamination are summarized in the following subsections. A thorough evaluation of nature and extent for the 100-F/IU OUs is presented in the 100-F/IU RI/FS report (DOE/RL-2010-98).

1.3.2.1 Waste Site Contamination

The 100-F Reactor was supported by multiple facilities associated with services for water treatment, air filtration, nuclear fuel handling, effluent disposal, and laboratories, with various other administrative buildings. The 100-F Area also included EAF, where biological research studies were performed to examine the effects of radiation and radioactive contamination on plants, animals, and fish. Operations within 100-IU-2 and 100-IU-6 were primarily related to other uses, such as historical agricultural uses and other uses associated with human occupation.

Reactor operations and processes were the primary sources of contamination in the 100-F Area. Experimentation associated with the 100-F EAF secondary mission, coupled with waste disposal associated with the reactor, comprised secondary sources of contamination associated with the 100-F/IU Area.

Liquid wastes from reactor operations and associated facilities were released to the soil column and the Columbia River. Solid wastes were disposed in burial grounds associated with the facilities. Wastes released to or buried within the environment created secondary sources of contamination, such as liquid waste sites (ponds, trenches, cribs, and french drains), burial grounds, and numerous small miscellaneous waste sites scattered throughout the river corridor.

Low-mobility contaminants, including many metals and radionuclides, sorbed to sediment grains in the vadose zone. These contaminants were found at the greatest concentrations within and near the areas of discharge. When little or no liquid effluent was discharged to a waste site, soil contamination remained in the shallow sediment. Most of this shallow contamination has been removed during remediation activities. Sufficiently high volumes of liquid discharged into a waste site expanded the depth of contamination in the vadose zone.

Strontium-90 is a slightly mobile contaminant in the subsurface and was present in several 100-F waste sites. Facilities producing biological waste materials contaminated with strontium-90 included EAF, formerly located in the northeast portion of 100-F near the 116-F-9 and 116-F-2 Trenches, and the radioecology laboratory. Strontium-90 also was present in discharges to the 116-F-9 Trench and in solid waste disposed at various burial grounds, including the 118-F-1 and 118-F-6 Burial Grounds. Strontium-90 sorbs to sediment grains in the vadose zone and in the aquifer but also migrated into groundwater, especially at sites with a significant driving force (for example, liquid effluent disposal).

Mobile and moderately mobile contaminants include nitrate, TCE, and Cr(VI). During the period of reactor operations, large volumes of contaminated water were discharged to the soil via trenches, cribs, and leaks from pipelines and retention basins, primarily in eastern 100-F. Liquid effluent also was released through outfall piping to the Columbia River. During the operational period, large groundwater mounds helped spread mobile and moderately mobile contaminants in groundwater in a radial pattern. It is likely that groundwater carried these contaminants rapidly to the river, based on reactor operations and liquid discharge history. As early as September 1945, effluent springs began to appear along the riverbank in association with retention basin leakage. Multiple springs were identified along the 100-F shoreline during this period.

A relatively low concentration of Cr(VI) contaminated waste was discharged to the subsurface at 100-F because of the production facility design. There was a much longer period of using dry dichromate powder to mix corrosion control solutions for 105-F Reactor water treatment, as compared to other 100 Area reactors, and installation of newer equipment during the plant upgrades diminished the opportunity for leaks of the concentrated 70 percent solution. However, delivery of the 70 percent solution into the storage tanks at 185/190-F, waste site 100-F-57, was not completely efficient, and yellowish-stained soil around the storage tank location indicated some losses. The fraction of delivered 70 percent solution lost to the subsurface is not known. However, current concentrations observed in groundwater do not indicate the presence of a highly concentrated, persistent source. Cr(VI) contaminated waste sites in 100-FR-1 and 100-FR-2, including 100-F-57, were remediated during interim RAs, and known Cr(VI) sources were removed.

EAF was a source of nitrate contamination because nitrate is a common component of animal urine and feces. A portion of the nitrate that reached groundwater near the animal pens was transported inland as a result of the groundwater mounding caused by reactor operations.

The source of TCE contamination in and near 100-F has not been definitely identified, but it is suspected to be one of a group of waste sites west of 100-F. TCE can be present as a gas in the vadose zone and as a dissolved species in soil moisture and groundwater.

Most of the 100-F contaminated vadose zone materials have been removed during previous RAs. Remaining vadose zone material consists of radionuclide contamination above background at a depth greater than 4.6 m (15 ft) below ground surface (bgs) following implementation of the interim action ROD. All 100-F waste sites addressed under the interim action RODs have been remediated or were determined not to require remediation.

Waste sites and facilities in the 100-IU-2 and 100-IU-6 OUs were mainly associated with housing and staging equipment and material for the Hanford project; most of the area was previously occupied by homesteads and farms. The area includes roads, railroads, a fire station, fuel stations, storage facilities, an old concrete batch plant site, storage vaults in the east end of Gable Mountain, and pre-Hanford Site farm sites and landfills (e.g., pre-1943 municipal and farm waste sites). Contamination in this area generally originated from light industrial chemical use and agriculture, rather than nuclear material production and chemical processing.

Remediation under the interim action ROD has been completed for most of the 100-IU-2/IU-6 waste sites. The remaining waste sites were not the type that received concentrated or high-volume liquid waste that typically contributes to groundwater contamination.

Although the TCE groundwater plume southwest of 100-F may have originated from 100-IU-2/IU-6, no current source remains. No other groundwater contaminant plumes originate in 100-IU-2/IU-6, but contamination from other OUs is present (e.g., tritium from 200-PO-1). These constituents will be evaluated further in their respective OUs.

1.3.2.2 Groundwater Contamination

Groundwater contaminants that exceed federal or state drinking water standards (DWSs) or ambient water quality criteria in the 100-FR-3 OU are Cr(VI), nitrate, TCE, and strontium-90 (Figure 1-4). Groundwater contaminants do not exceed federal or state ecological protection standards near the river or where groundwater discharges into the river at 100-F. Pore water at the Hanford Townsite (100-IU-2/IU-6) is contaminated with tritium from a groundwater plume originating in the 200 East Area.

Cr(VI) in the 100-FR-3 OU exceeds the 10 µg/L Washington State surface water quality standard over an area of approximately 29 ha (72 ac) based on 2013 data. The maximum concentration of Cr(VI), measured in 2013, was 25.5 µg/L (DOE/RL-2014-32, *Hanford Site Groundwater Monitoring Report for 2013*). Cr(VI) concentrations are currently below the 2007 WAC 173-340, "Model Toxics Control Act-Cleanup," hereinafter called MTCA, Method B, groundwater cleanup level of 48 µg/L in the relatively small plume near the river. While the plume exceeds the 10 µg/L state surface water quality standard in the groundwater, aquifer tubes and pore water samples indicate infrequent exceedances of this level near the surface water interface.

Former sources of Cr(VI) in 100-F included facilities near the reactor building, trenches, and retention basins near the Columbia River and pipelines from the reactor building to these near-river facilities, primarily in northern and eastern 100-F Area. The current distribution of Cr(VI) in groundwater (Figure 1-4) shows no obvious relation to the locations of former sources. The contamination apparently migrated and attenuated before most of the groundwater monitoring wells were installed in the early 1990s. Cr(VI) associated waste sites have been remediated, and groundwater concentrations are expected to continue declining.

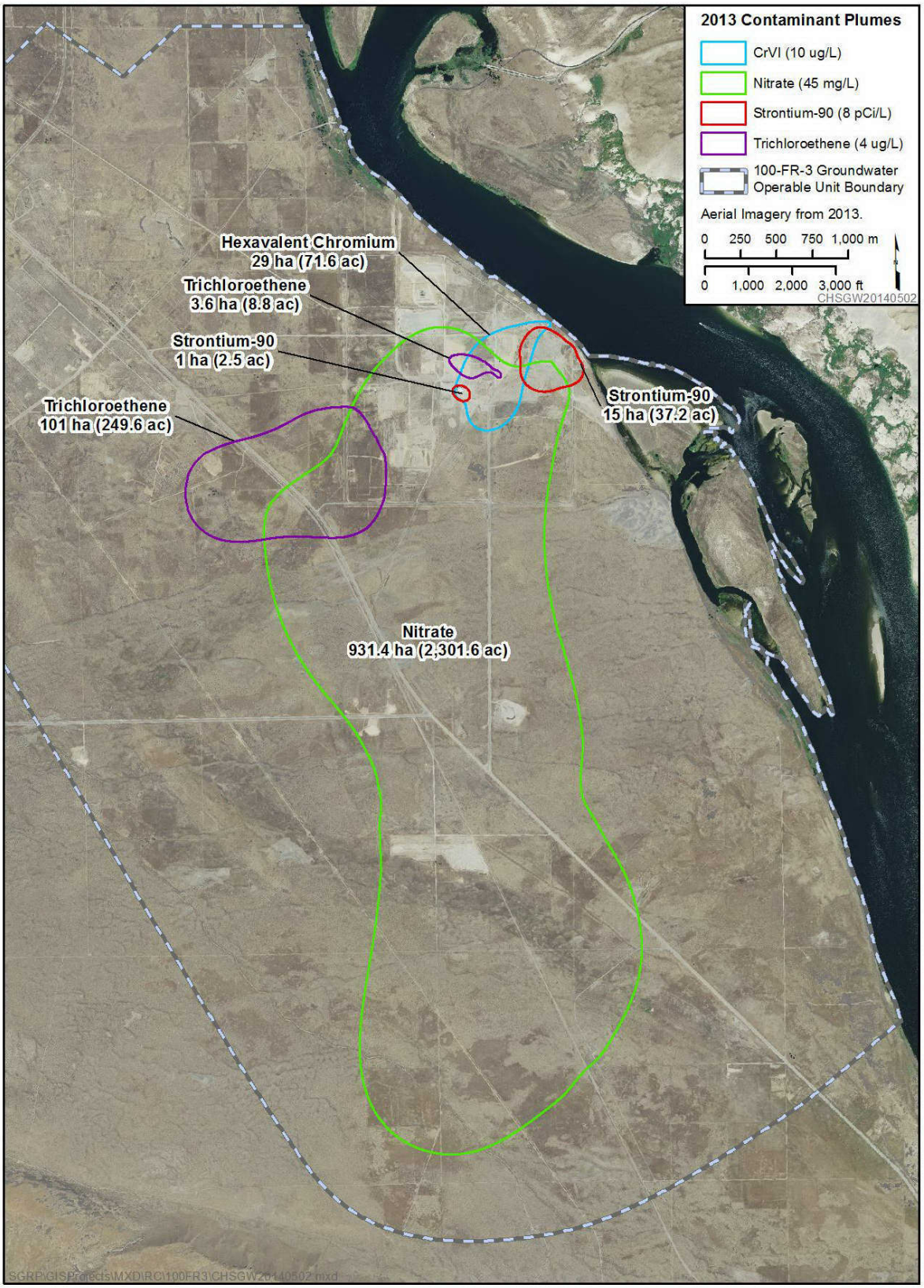

Figure 1-4. Groundwater Contaminant Plumes in the 100-FR-3 Operable Unit

Nitrate contamination of groundwater in the 100-FR-3 OU is greater than the 45 mg/L DWS[1] over an area of approximately 931 ha (2,302 ac) based on 2013 data, extending southward approximately 5 km (3.1 mi) from 100-F (Figure 1-4). The maximum concentration of nitrate measured in 2013 was 189 mg/L (DOE/RL-2014-32). Past sources of nitrate contamination included EAF (for example, 116-F-9 animal leach trench; 118-F-6 Burial Ground) and various septic tanks and leach fields located throughout 100-F. Nitrate contamination was likely transported inland during operations when an effluent discharge resulted in groundwater mounding and changes in hydraulic gradients.

Between 2002 and 2013, nitrate concentrations declined or were stable in 19 of 25 wells and increased in 5 wells. Because plume sources have been remediated, declining concentrations are expected to continue through natural attenuation. However, due to the size and multiple past sources of the plume, concentrations in some wells are variable. The wells with variable or increasing trends above 45 mg/L are all located in central 100-F Area. The nitrate concentrations in aquifer tubes are less than 45 mg/L.

Concentrations of strontium-90 in groundwater above the 8 pCi/L DWS are present in an area of 16 ha (40 ac) based on 2013 data (Figure 1-4). The maximum concentration of strontium-90 measured in 2013 was 180 pCi/L (DOE/RL-2014-32). Sources of strontium-90 included the 116-F-14 Retention Basin and the 116-F-2 Trench, located in northeastern 100-F. The main groundwater plume is in eastern 100-F Area near these former sources. A smaller plume is present in central 100-F Area

The area of groundwater with TCE concentrations greater than the 4.0 µg/L 2007 MTCA (WAC 173-340) level is approximately 105 ha (259 ac) based on 2013 data. TCE concentrations exceed the MTCA (WAC 173-340) level of 4 µg/L in several wells in southwestern 100-F, and sporadically in wells in central 100-F. The maximum concentration of TCE measured in 2013 was 15 µg/L (DOE/RL-2014-32). Three wells in southwestern 100-F and a single well in central 100-F exceed the DWS. It is probable that the plume extends farther south; however, there are no wells in this area from which to draw conclusions.

TCE below the MTCA (WAC 173-340) groundwater cleanup level of 4 µg/L was previously measured approximately 2 km (1.2 mi) south of 100-F, suggesting that a plume extends southward at concentrations below the DWS. However, TCE was not detected at this location during the 2013 sampling.

Groundwater beneath 100-IU-2/IU-6 is contaminated with tritium and iodine-129 (Figure 1-5), but the sources of those contaminants are in the 200 Areas; remediation of these contaminant sources will be addressed in 200 Area CERCLA documents. Because wells on the Hanford Site are monitored at different periods and frequencies, the plumes in Figure 1-5 are based on annual average concentrations.

[1] Nitrate may be expressed as nitrate-nitrogen (NO_3-N) or as nitrate (NO_3). The DWS for NO_3-N is 10,000 µg/L, and the mathematical equivalent value for NO_3 is 45,000 µg/L.

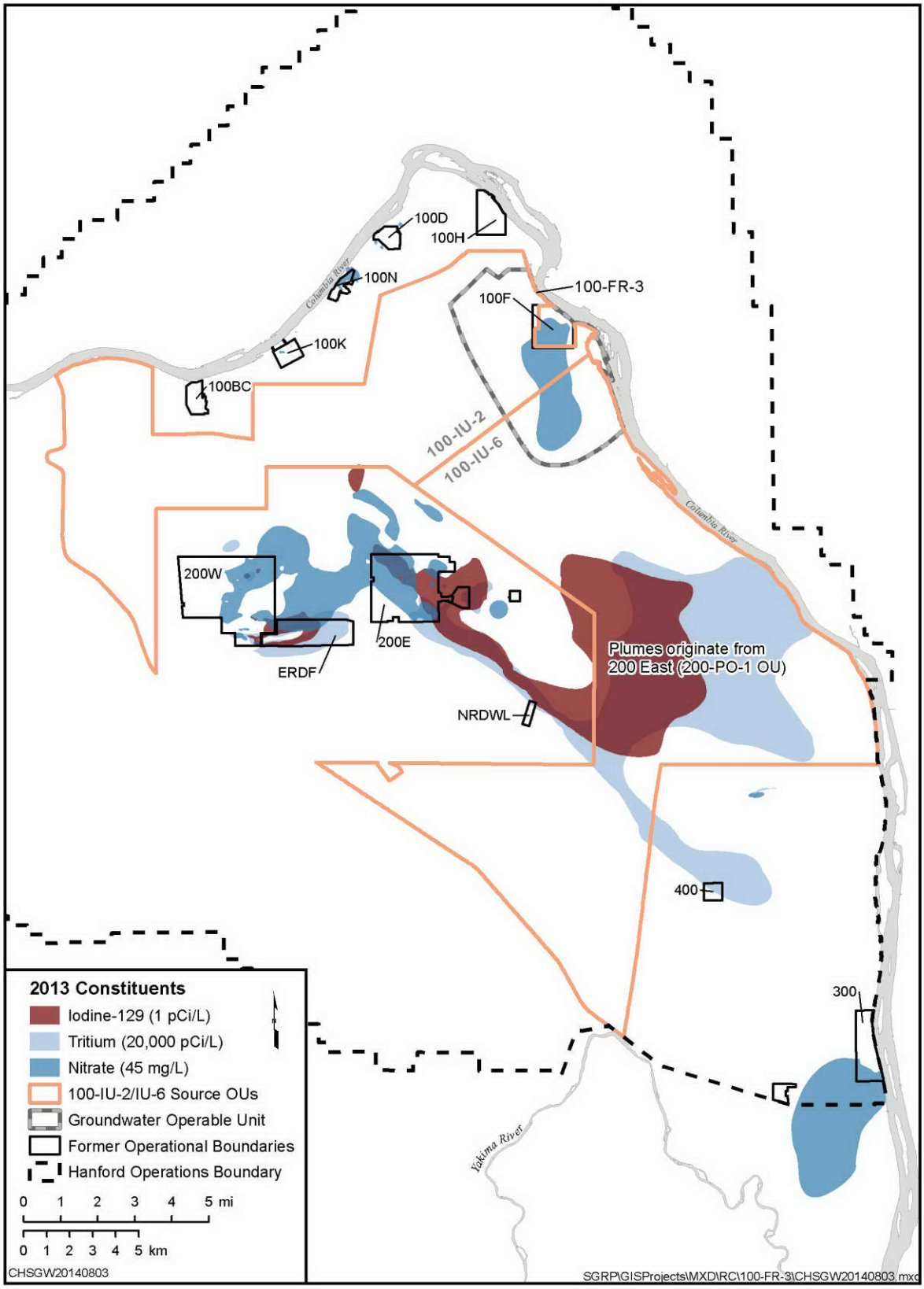

Figure 1-5. Groundwater Contaminant Plumes beneath the 100-IU-2 and 100-IU-6 Operable Units

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2 Basis for Remedial Action

The risk assessment in the 100-F/IU RI/FS report (DOE/RL-2010-98) reported that cleanups in vadose zone material conducted as part of the interim actions were effective in reducing human health risks to within EPA's target risk range. 100-IU-2 and 100-IU-6 OU waste sites that have not been remediated were determined to pose an unacceptable risk to HHE from direct exposure. Based on the results of the 100-FR-3 OU groundwater risk evaluation, concentrations of Cr(VI), nitrate, strontium-90, and TCE are present at levels in the groundwater that provide a basis for RA.

The risk assessment also reported that groundwater contamination beneath the 100-IU-2 and 100-IU-6 OUs exceeds action levels in some areas; however, the groundwater contaminants originate from the 200-BP-5 or 200-PO-1 OUs. Because groundwater contaminants underlying 100-IU-2 and 100-IU-6 OUs are addressed by other OUs, a groundwater risk assessment for these OUs was not included in the 100 F/IU RI/FS report (DOE/RL-2010-98).

The 100-F/IU ROD (EPA and DOE, 2014) stated that the selected response actions are necessary to protect the public health or welfare or the environment from actual or threatened releases of hazardous substances, pollutants, or contaminants into the environment. Such a release or the threat of release may present an imminent and substantial endangerment to public health, welfare, or the environment.

2.1 Selected Remedy

An overview of the basis for the selected RA for each OU is summarized in the following paragraphs as presented in the 100-F/IU ROD (EPA and DOE, 2014). The details of the designs and any refinements are described in the Soil and Groundwater Addenda.

The selected remedies presented in the 100-F/IU ROD (EPA and DOE, 2014) may be modified and refined as a result of remedial design (RD) and monitoring results. Any changes to the remedies described in the 100-F/IU ROD (EPA and DOE, 2014) will be documented using a technical memorandum in the administrative record, Change Notices to the RDR/RAWP, an Explanation of Significant Differences (ESD), or a ROD amendment, as appropriate.

2.1.1 RTD of Waste Sites for 100-IU-2 and 100-IU-6 OUs

Contaminated soil, structures, debris, and pipelines with concentrations above the cleanup levels will be removed from 100-IU-2 and 100-IU-6 waste sites, treated as necessary to meet disposal facility requirements, and disposed at ERDF. The remediated sites will be backfilled, recontoured, and planted with native vegetation.

2.1.2 Institutional Controls

ICs are used to protect the integrity of a response action and/or minimize exposure to contamination in soil and groundwater until such contamination is at levels that allow for UU/UE. ICs are mechanisms to control uses of land, facilities, and environmental media in order to prevent unacceptable human health and environmental exposure to residual contaminants that could pose risks above levels deemed protective. ICs generally include nonengineered restrictions on activities and access to land, groundwater, surface water, waste sites, waste disposal areas, and other areas or media that may contain hazardous substances. Common types of ICs include procedural restrictions for access, warning notices, permits, easements, deed notifications, leases and contracts, and land-use controls.

2.1.2.1 Institutional Controls Common Elements for 100-F/IU

ICs are required before, during, and after the active phase of RA implementation where ICs are needed to protect HHE. ICs are used to control access to residual contamination in soil and groundwater above standards for UU/UE. DOE shall be responsible for implementing, maintaining, reporting on and

enforcing ICs. Although DOE may later transfer these procedural responsibilities to another party by contract, property transfer agreement or through other means, DOE shall retain ultimate responsibility for remedy integrity and ICs. In the event that land is transferred out of federal ownership, deed restrictions (proprietary controls such as easements and covenants) are required that are legally enforceable against subsequent property owners.

The current implementation, maintenance, and periodic inspection requirements for ICs at the Hanford Site are described in approved work plans and the Sitewide IC Plan (DOE/RL-2001-41), which was prepared by DOE and approved by EPA and the Washington State Department of Ecology (Ecology) in 2002. No later than 180 days after the ROD is signed, DOE shall update the Sitewide IC Plan (DOE/RL-2001-41) to include the ICs required by this ROD and specify the implementation and maintenance actions that will be taken, including periodic inspections. The revised Sitewide IC Plan (DOE/RL-2001-41) shall be submitted to EPA and Ecology for review and approval as a TPA (Ecology et al., 1989) primary document. DOE shall comply with the Sitewide IC Plan (DOE/RL-2001-41), as updated and approved by EPA and Ecology.

The following IC performance objectives are required to be met as part of this RA. Land-use controls will be maintained until cleanup levels are achieved, and the concentrations of hazardous substances are at such levels to allow for UU/UE; EPA authorizes the removal of restrictions. ICs to be implemented by DOE to support achievement of the RAOs include the following:

- In the event that land is transferred out of federal ownership, deed restrictions (proprietary controls such as easements and covenants) are required that are legally enforceable against subsequent property owners.
- In the event of any unauthorized access (e.g., trespassing), DOE shall report such incidents to the Benton County Sheriff's Office for investigation and evaluation of possible prosecution.
- Activities that would disrupt or lessen the performance of any component of the remedies are prohibited.
- Signage and access control to waste sites with contamination above cleanup levels will be provided.
- Maintain the integrity of any current or future remedial or monitoring system such as monitoring wells.
- Prohibit the development and use of property for residential housing, elementary and secondary schools, childcare facilities and playgrounds until cleanup levels are met.
- DOE shall employ and maintain an excavation permit program for protection of human health against unacceptable exposure, and protection of environmental and cultural resources.
- DOE shall report on the effectiveness of ICs for all OUs that are the subject of this ROD in an annual report, or on an alternative reporting frequency specified by the LRA. Such reporting may be for OUs individually or may be part of the Sitewide IC Plan (DOE/RL-2001-41).

Measures that are necessary to ensure continuation of ICs shall be taken before any lease or transfer of any land subject to ICs. DOE will provide notice to Ecology and EPA at least 6 months before any transfer or sale of land subject to ICs so that the LRA 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 Ecology and EPA at least 6 months before any transfer or sale, DOE will notify Ecology and EPA as soon as possible, but no later than 60 days before the transfer or

sale of any property subject to ICs. In addition to the land transfer notice and discussion provisions, DOE further agrees to provide Ecology and EPA with similar notice, within the same time frames, as to federal-to-federal transfer of property. DOE shall provide a copy of the executed deed or transfer assembly to Ecology and EPA. DOE shall notify EPA and Ecology immediately upon discovery of any activity inconsistent with the specific ICs.

2.1.2.2 Institutional Controls Unique Elements for 100-FR-1 and 100-FR-2 OU

The following IC performance objectives are required to be met as part of this RA for 100-FR-1 and 100-FR-2 OUs. Land-use controls will be maintained until cleanup levels are achieved and the concentrations of hazardous substances allow for UU/UE, and EPA authorizes the removal of restrictions. The following ICs are to be implemented by DOE to support achievement of the RAOs:

- Exposure to contamination deeper than 4.6 m (15 ft) bgs is not anticipated. Where contamination at depth exceeds the cleanup levels attained for the waste site, ICs are required to ensure future activities do not bring this contamination to the surface or otherwise result in exposure to contaminant concentrations that exceed the cleanup levels that were attained at the waste site. A total of 15 100-FR-1 and 100-FR-2 OU waste sites require drilling and excavation ICs for specified time periods due to radionuclide contamination exceeding human health direct contact cleanup levels. The waste sites are presented in Table 2-1. The expected year that ICs can be removed is indicated after the site number.

- Prohibit irrigation over or near waste site 116-F-14 (100-FR-1) that represents an unacceptable surface water protection risk.

The ICs for these sites are implemented through the Sitewide IC Plan (DOE/RL-2001-41). The IC boundaries for the 100-FR-1 and 100-FR-2 OUs are presented in Figure 2-1.

The IC boundaries for 100-IU-2 and 100-IU-6 RTD sites are presented in Figure 2-2.

2.1.2.3 Institutional Controls Unique Elements for 100-FR-3 OU Groundwater

The following IC performance objectives are required to be met as part of this RA for the 100-FR-3 OU. Land-use controls will be maintained until cleanup levels are achieved, and the concentrations of hazardous substances are at such levels to allow for UU/UE; EPA authorizes the removal of restrictions. DOE will implement the following ICs to support achievement of RAOs:

- DOE shall employ and maintain an excavation permit program limiting 100-FR-3 OU groundwater access and use to research purposes and for monitoring and treatment in areas where groundwater is above cleanup levels (Figure 2-3).

- Prevent access or use of the groundwater for drinking water purposes until cleanup levels are met.

These ICs are implemented though the Sitewide IC Plan (DOE/RL-2001-41). The IC boundary for the 100-FR-3 OU is shown in Figure 2-3.

2.1.3 MNA of Groundwater for 100-FR-3 OU

MNA will be used in the 100-FR-3 OU to reduce groundwater COCs to concentrations less than the cleanup levels. Overall plume behavior is controlled by a combination of the source strength (flux of contaminants into the groundwater) and the rate and capacity of attenuation in the groundwater. Without a continuing source, the net plume response will be to diminish over time. The primary natural attenuation processes for COCs present in the 100-FR-3 OU include biodegradation and abiotic degradation, radioactive decay, dispersion, volatilization, and sorption.

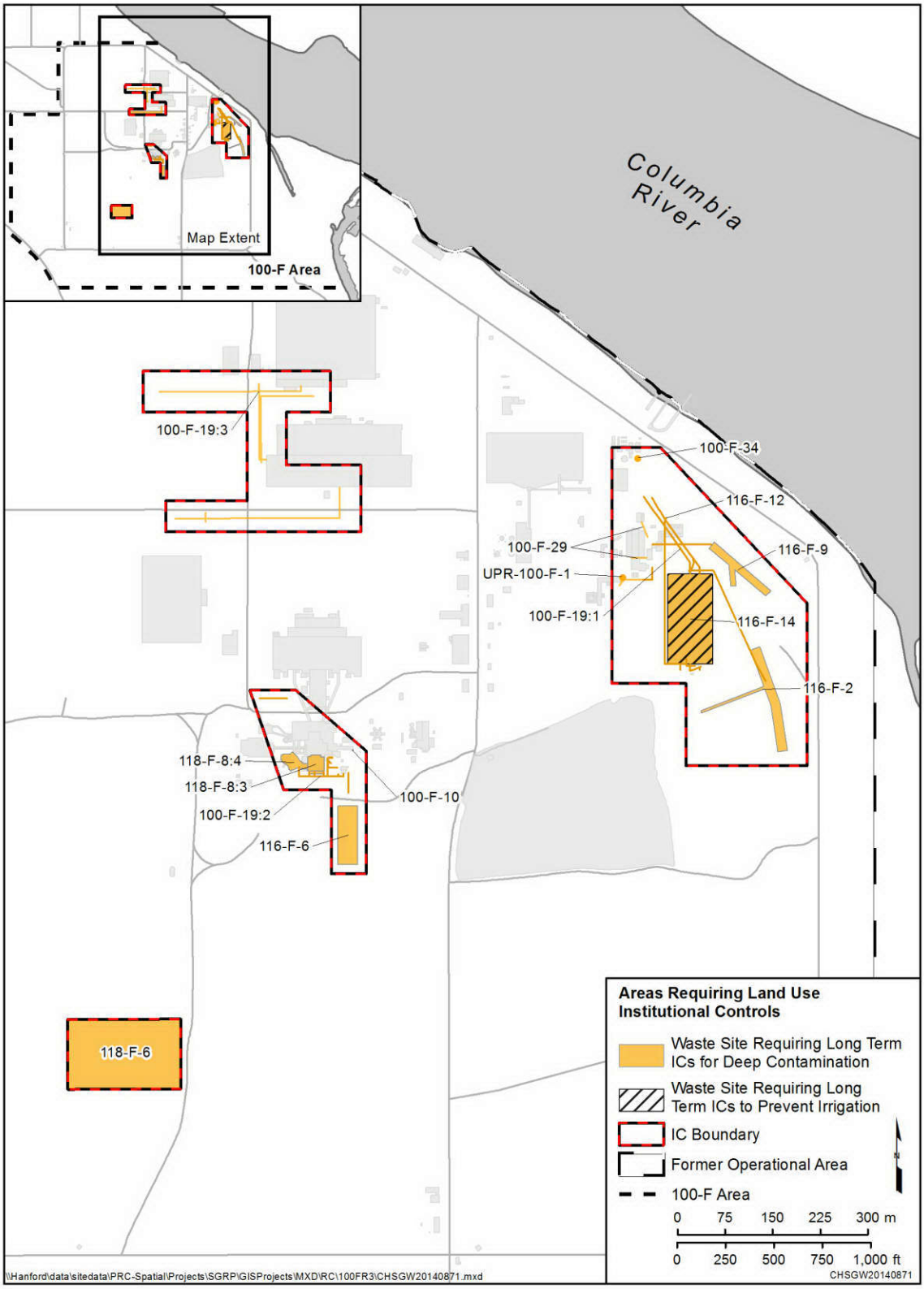

Figure 2-1. 100-FR-1 and 100-FR-2 Operable Unit Institutional Control Boundaries

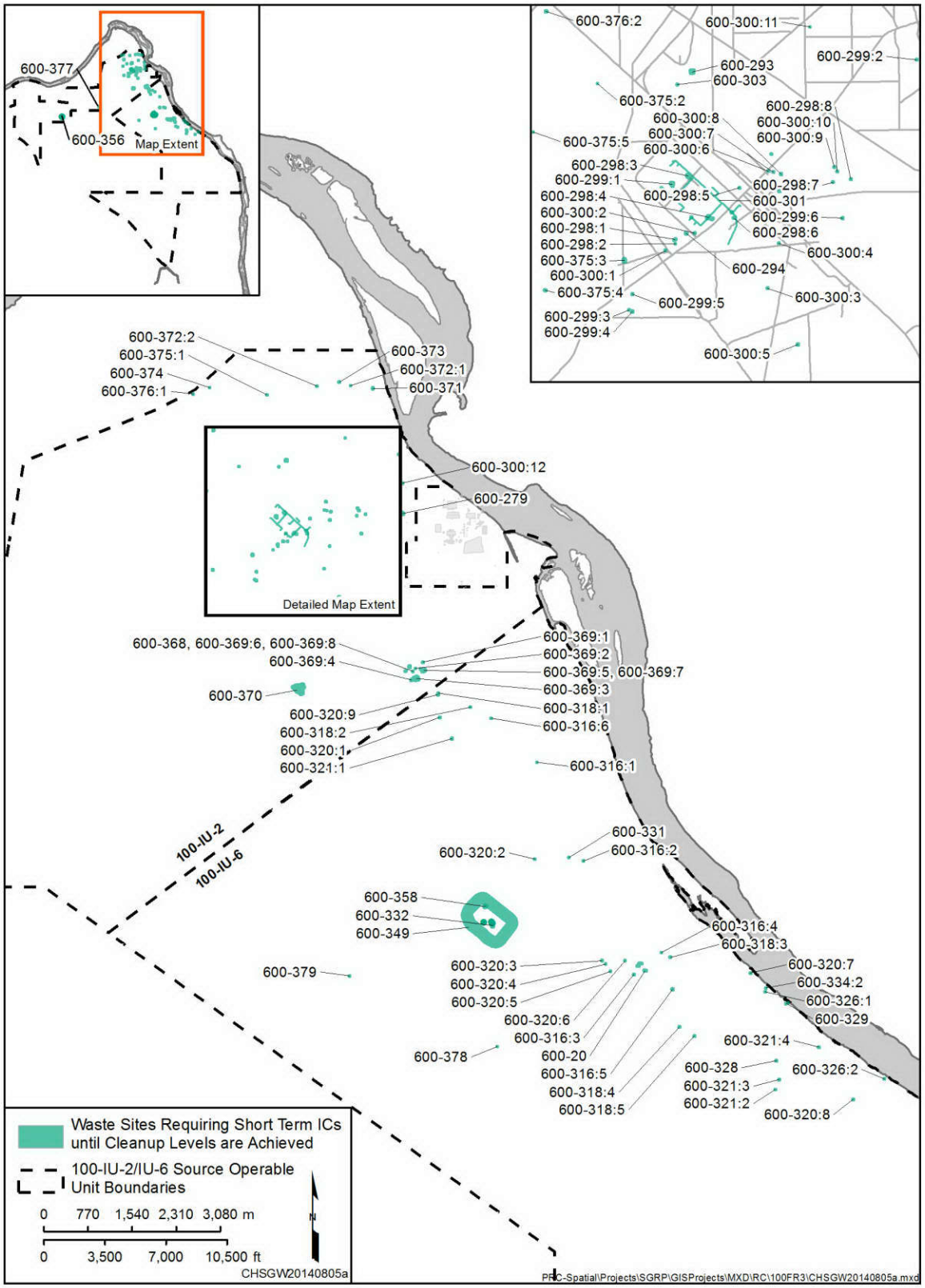

Figure 2-2. 100-IU-2 and 100-IU-6 Operable Unit Institutional Controls Boundaries

Table 2-1. Institutional Controls at Remediated 100-FR-1 and 100-FR-2 Operable Unit Waste Sites

Risk Driver	Institutional Controls
Waste sites with deep (greater than 4.6 m [15 ft] bgs) radiological contamination exceeding human health direct contact cleanup levels.*	**Excavation Restrictions:** 100-F-10—2057 100-F-19:1—2113 100-F-19:2—2057 100-F-19:3—2113 100-F-29—2057 100-F-34—2113 116-F-2—2108 116-F-6—2122 116-F-9—2074 116-F-12—2113 116-F-14—2110 118-F-6—2033 118-F-8:3—2278 118-F-8:4—2059 UPR-100-F-1—2057
Waste site with groundwater/surface water protection risk if irrigation were applied.	**Prohibit Irrigation:** 116-F-14

* These sites have contamination at depth where human exposure is not expected and at concentrations that will not cause exceedances of drinking water standards. Institutional controls are applied to prevent material from being brought to the surface or other unacceptable exposure from drilling or digging.

bgs = below ground surface

The required performance monitoring component includes installation of new monitoring wells, periodic sampling, laboratory analysis, and data evaluation needed to assess and confirm the natural attenuation processes, rates of attenuation, and overall protectiveness. Operations and maintenance (O&M) activities for this remedy include inspection, maintenance, and periodic replacement of monitoring wells.

Performance monitoring for the 100-FR-3 groundwater OU was developed using the data quality objective (DQO) process to assess the responses of the groundwater plumes to the remedy over time. Performance monitoring is integrated into the 100-FR-3 Groundwater Sampling and Analysis Plan (Groundwater SAP), which is an appendix to the Groundwater Addendum. Sampling will be sufficient to document changes in contaminant plumes for all groundwater COCs. As part of monitoring the lateral extent of plumes, groundwater will be monitored in the near vicinity of the Columbia River to ensure that the lateral extent of the plumes is defined. Monitoring will continue until COCs have attained the cleanup levels and are expected to continue to meet cleanup levels and EPA approves termination of the monitoring. Considered in the evaluation are processes that can affect concentrations such as river fluctuations, waste site activities, and land use activities. Groundwater monitoring will be performed to evaluate the effectiveness of the selected 100-FR-3 OU remedy to achieve cleanup levels and will include the groundwater COCs (Cr(VI), nitrate, TCE, and strontium-90).

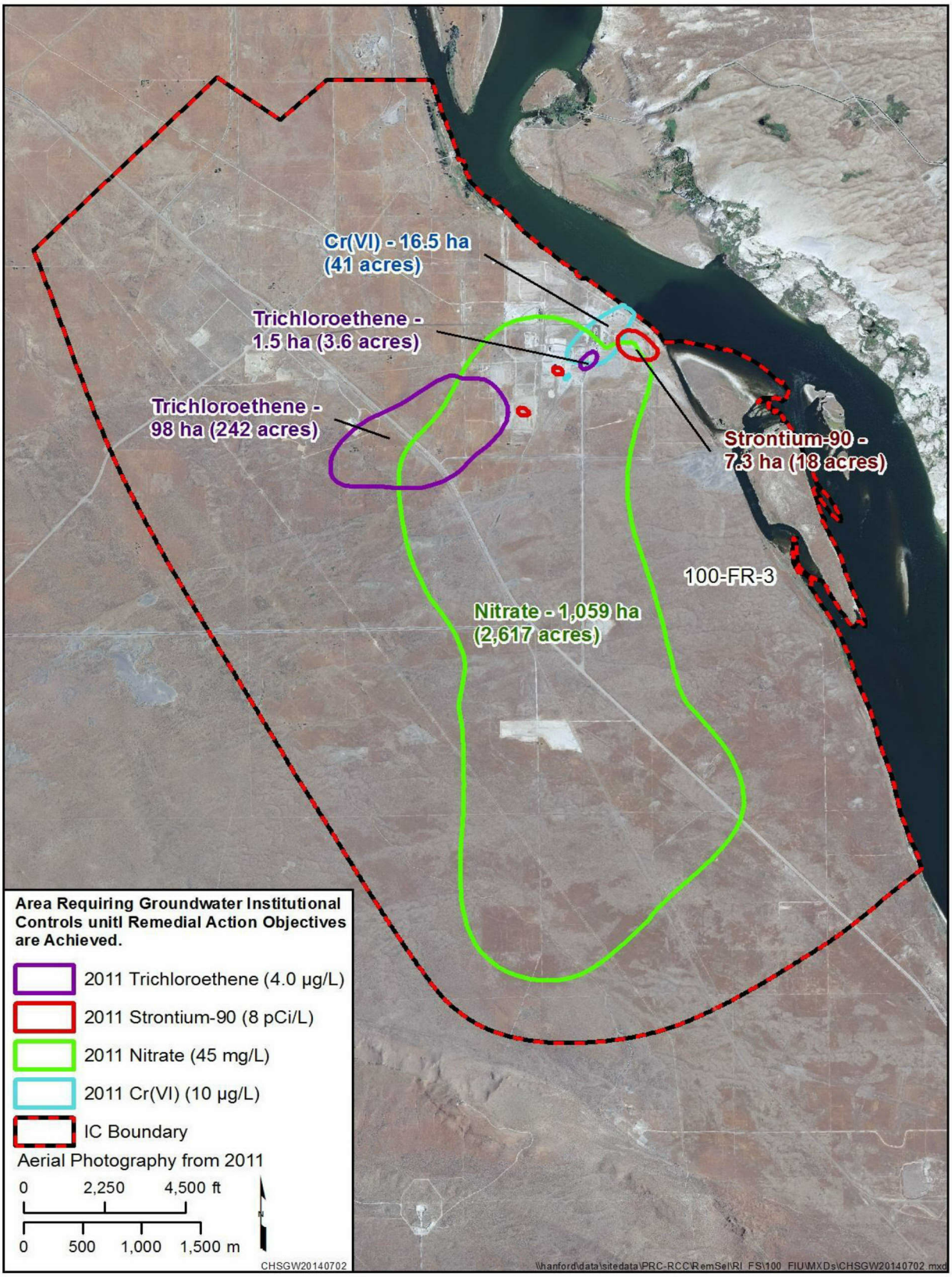

Figure 2-3. 100-FR-3 Operable Unit Institutional Controls Boundary

2.2 Remedial Action Objectives

RAOs describe what the RA is expected to accomplish. RAOs generally include information on the media, COCs, potential exposure pathways, and remediation goals, taking into account the current and reasonably anticipated future land use.

RAOs identified in the 100-F/IU ROD (EPA and DOE, 2014) are summarized in Table 2-2, and referenced to the sections of the Integrated RDR/RAWP, Soil Addendum, or Groundwater Addendum that describe the actions that address each RAO. The RAOs for the 100-FR-1, 100-FR-2, 100-IU-2, and 100-IU-6 OUs are RAOs 3 through 6. The RAOs for the 100-FR-3 OU are RAOs 1, 2, and 7.

These RAOs address the risks identified in the 100-F/IU RI/FS report (DOE/RL-2010-98), are protective of HHE, and are compatible with the RAOs in the previous interim RODs for these OUs.

2.3 Cleanup Levels

Cleanup levels for 100-F/IU were selected in the 100-F/IU ROD (EPA and DOE, 2014). Soil cleanup levels for the 100-FR-1, 100-FR-2, 100-IU-2, and 100-IU-6 OUs were developed based on direct human contact (Table 2-3) as well as groundwater and surface water protection (Table 2-4). These cleanup levels apply to soil and debris. Groundwater cleanup levels for the 100-FR-3 OU are based on site-specific data, current federal DWSs, state water quality standards and risk-based concentrations that are more stringent than the DWS for TCE using a MTCA (WAC 173-340) calculation method plus EPA-approved toxicity information (Table 2-5).

Table 2-2. Remedial Action Objectives

RAO	Integrated RDR/RAWP	Soil Addendum	Groundwater Addendum
RAO 1. Prevent unacceptable risk to human health from ingestion of and incidental exposure to groundwater containing contaminant concentrations above federal and state standards and risk-based thresholds.	Sections 2.1.2.1, 2.1.2.3, and 2.1.3		Sections 3 and 4
RAO 2. Prevent unacceptable risk to human health and ecological receptors from groundwater discharges to surface water containing contaminant concentrations above federal and state standards and risk-based thresholds.	Sections 2.1.1, 2.1.2.1, 2.1.2.2, and 2.1.3		Sections 3 and 4
RAO 3. Prevent unacceptable risk from contaminants migrating and/or leaching through soil that will result in groundwater concentrations that exceed standards and risk-based thresholds for protection of surface water and groundwater.	Sections 2.1.1, 2.1.2.1, and 2.1.2.2	Sections 3 and 4	
RAO 4. Prevent unacceptable risk to human health and ecological receptors from exposure to the upper 4.6 m (15 ft) of soil, structures, and debris contaminated with nonradiological constituents at concentrations above the unrestricted land-use standards for human health (provided in MTCA Method B) or soil contaminant levels protective of ecological receptors.	Sections 2.1.1, 2.1.2.1, and 2.1.2.2	Sections 3 and 4	

Table 2-2. Remedial Action Objectives

RAO	Integrated RDR/RAWP	Soil Addendum	Groundwater Addendum
RAO 5. Prevent unacceptable risk to human health and ecological receptors from exposure to the upper 4.6 m (15 ft) of soil, structures, and debris contaminated with radiological constituents. For human health and ecological receptors: – Prevent exposure to radiological constituents at concentrations at or above a dose rate limit that causes an excess lifetime cancer risk threshold of 1×10^{-6} to 1×10^{-4} above background for the residential exposure scenario. – Protect ecological receptors based on a dose rate limit of 0.1 rad/day for terrestrial wildlife populations.	Sections 2.1.1, 2.1.2.1, and 2.1.2.2	Sections 3 and 4	
RAO 6. Manage direct exposure to contaminated soils deeper than 4.6 m (15 ft) to prevent an unacceptable risk to human health and the environment.	Sections 2.1.2.1 and 2.1.2.2	Sections 3 and 4	
RAO 7. Restore groundwater impacted from 100-FR-1, 100-FR-2, 100-IU-2, and 100-IU-6 releases to proposed cleanup levels, which include DWSs, within a time frame that is reasonable given the particular circumstances of the site.	Sections 2.1.2.1, 2.1.2.3, and 2.1.3		Sections 3 and 4

DWS = drinking water standard
RAO = remedial action objective
RDR/RAWP = remedial design report/remedial action work plan

Table 2-3. 100-FR-1, 100-FR-2, 100-IU-2, and 100-IU-6 Operable Units Soil Cleanup Levels for Protection of Human Health

Contaminant of Concern	Units	Cleanup Level (≤4.6 m [15 ft] bgs)	Basis for Cleanup Level
Radionuclides			
Cesium-137	pCi/g	4.4	Direct contact residential scenario
Cobalt-60	pCi/g	1.4	Residential interim remedial action cleanup level
Europium-152	pCi/g	3.3	Residential interim remedial action cleanup level
Europium-154	pCi/g	3.0	Residential interim remedial action cleanup level
Nickel-63	pCi/g	608	Direct contact residential scenario
Strontium-90	pCi/g	2.3	Direct contact residential scenario
Chemicals			
Arsenic	mg/kg	20	MTCA Method A
Hexavalent Chromium	mg/kg	240	MTCA Method B
Lead	mg/kg	250	MTCA Method A

Table 2-3. 100-FR-1, 100-FR-2, 100-IU-2, and 100-IU-6 Operable Units Soil Cleanup Levels for Protection of Human Health

Contaminant of Concern	Units	Cleanup Level (≤4.6 m [15 ft] bgs)	Basis for Cleanup Level
Mercury	mg/kg	24	MTCA Method B
Nitrate	mg/kg	568,000	MTCA Method B
Aroclor 1254	mg/kg	0.50	MTCA Method B
Aroclor 1260	mg/kg	0.50	MTCA Method B
Benzo(a)pyrene	mg/kg	0.14	MTCA Method B
TPH–Diesel Range	mg/kg	2,000	MTCA Method A
TPH–Motor Oil (High Boiling)	mg/kg	2,000	MTCA Method A

bgs = below ground surface
MTCA = "Model Toxics Control Act—Cleanup" (WAC 173-340)
TPH = total petroleum hydrocarbon

Table 2-4. 100-FR-1, 100-FR-2, 100-IU-2, and 100-IU-6 Operable Units Soil Cleanup Levels for Protection of Groundwater and Surface Water

Contaminant of Concern	100-FR-1 and 100-FR-2	100-IU-2	100-IU-6
Radionuclides			
Cesium-137	—[a]	—[a]	—[a]
Cobalt-60	—[a]	—[a]	—[a]
Europium-152	—[a]	—[a]	—[a]
Europium-154	—[a]	—[a]	—[a]
Nickel-63	—[a]	—[a]	—[a]
Strontium-90	24,600[b]	64,200[b]	104,000[b]
Chemicals			
Arsenic	—[a]	—[a]	—[a]
Hexavalent Chromium	2.0	2.0	2.0
Lead	—[a]	—[a]	—[a]
Mercury	—[a]	—[a]	—[a]
Nitrate	1,790	6,360	11,300
Aroclor 1254	—[a]	—[a]	—[a]
Aroclor 1260	—[a]	—[a]	—[a]
Benzo(a)pyrene	—[a]	—[a]	—[a]
TPH–Diesel Range	2,000[c]	2,000[c]	2,000[c]

Table 2-4. 100-FR-1, 100-FR-2, 100-IU-2, and 100-IU-6 Operable Units Soil Cleanup Levels for Protection of Groundwater and Surface Water

Contaminant of Concern	100-FR-1 and 100-FR-2	100-IU-2	100-IU-6
TPH–Motor Oil (High Boiling)	2,000[c]	2,000[c]	2,000[c]

Note: Soil cleanup levels for the protection of groundwater and surface water were calculated based on site-specific data and specific parameters using the Subsurface Transport Over Multiple Phases code with a one-dimensional model for all contaminants. The cleanup levels for contaminated soil in the top 4.6 m (15 ft) will be the more conservative of the human health (Table 2-3) and groundwater and surface water protection (Table 2-4). For contaminated soil at depths greater than 4.6 m (15 ft) bgs, cleanup levels are protective of groundwater and surface water.

For highly mobile contaminants (distribution coefficient less than 2), the model assumed that the entire vadose zone from ground surface to groundwater is contaminated. For less mobile contaminants (distribution coefficient greater than or equal to 2), the model assumes that the top 70 percent is contaminated and the bottom 30 percent is not contaminated. For the residential scenario, a groundwater recharge rate of approximately 72 mm/year was used representing an irrigated condition. Model details are contained in DOE/RL-2010-98, *Remedial Investigation/Feasibility Study for 100-FR-1, 100-FR-2, 100-FR-3, 100-IU-2, and 100-IU-6 Operable Units* (Section 5.7 and Table 5.4).

a. The cleanup level for groundwater and surface water protection is not identified because model predictions indicate that there is no breakthrough of the analyte within 1,000 years; therefore, the analyte will not impact groundwater or surface water at levels that pose a risk.

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

c. The proposed cleanup level for TPHs is a default screening level obtained from WAC 173-340-900, "Tables," Table 747-5, "Residual Saturation Screening Levels for TPH."

TPH = total petroleum hydrocarbon

WAC = *Washington Administrative Code*

Table 2-5. 100-FR-3 Operable Unit Groundwater Cleanup Levels

Contaminant of Concern	Units	Cleanup Level	Basis for Cleanup Level
Strontium-90	pCi/L	8	DWS
Hexavalent Chromium	µg/L	10/48[a]	WAC 173-201A/WAC 173-340-720
Trichloroethene	µg/L	4	WAC 173-340-720
Nitrate	µg/L	45,000	DWS[b]

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

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

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

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

b. Nitrate may be expressed as nitrate-nitrogen (NO_3-N) or as nitrate (NO_3). The DWS for NO_3-N is 10,000 µg/L, and the mathematical equivalent value for nitrate (NO3) is 45,000 µg/L.

DWS = drinking water standard

WAC = *Washington Administrative Code*

2.4 Applicable or Relevant and Appropriate Requirement Compliance

Applicable or relevant and appropriate requirements (ARARs) are determined based on analysis of which requirements are applicable or relevant and appropriate to the distinctive set of circumstances and actions at a specific site. The NCP (40 CFR 300, Appendix B) requires that ARARs be attained or appropriately waived during implementation and at completion of the RA. No ARAR waivers are authorized as part of the ROD for 100-F/IU. Appendix A presents a summary of federal and state ARARs that are selected in the 100-F/IU ROD (EPA and DOE, 2014).

3 Remedial Design Approach

This chapter is intended to provide general RD information and a description of RA activities necessary to support implementation of the selected remedy. As described in Chapter 1 (Figure 1-2), design details specific to waste site remedies (RTD) are described in the Soil Addendum. Design details for MNA and performance monitoring are presented in the Groundwater Addendum. IC implementation for soil and groundwater is described in Section 2.1.2 and also discussed in the Soil Addendum and Groundwater Addendum.

3.1 Design Basis

Contaminant fate and transport modeling and results of the risk assessment, as documented in the 100-F/IU RI/FS report (DOE/RL-2010-98), were used to identify areas needing remediation and for the design basis of the groundwater and soil RAs. The design basis of specific soil and groundwater remedies is described in detail in the addenda.

3.2 Conceptual Design Summary

Conceptual design approaches for 100-F/IU remedies are presented in the Soil and Groundwater Addenda. A high-level summary of remedy conceptual designs is presented in the following subsections.

3.2.1 RTD

The RTD remedy component includes removal (by excavation) of contaminated soil and structures, as necessary, to meet soil cleanup levels; treatment, as necessary, to meet disposal criteria; and disposal at ERDF. The sites are then backfilled and recontoured, followed by revegetation. No additional post-ROD field investigations are anticipated to support the RTD remedy. Actions to complete RTD are discussed further in the Soil Addendum.

3.2.2 MNA of Groundwater

The MNA remedy includes performance monitoring to determine the progress and effectiveness of natural attenuation to meet cleanup levels. Performance monitoring consists of remediation monitoring followed by attainment monitoring. Performance monitoring will include analyses for the COCs (nitrate, Cr(VI), TCE, and strontium-90) in the respective plume areas. Analysis for TCE degradation products (vinyl chloride and *cis*-1,2-dichloroethene) will be performed in the TCE plume areas. Due to analytical uncertainties identified in the 100-F/IU RI/FS report (DOE/RL-2010-98), sampling and analysis will be conducted for antimony, cadmium, and cobalt at selected locations. Field parameters (specific conductance, pH, dissolved oxygen, turbidity, and temperature) will also be reported with the analytical data. To refine understanding of the hydraulic gradients, an automated water level network will be utilized for at least the first 5 years of monitoring.

No additional post-ROD field investigations will be implemented to support the design of MNA. A performance monitoring plan was developed to assess the responses of COC plumes to the remedy over time. Performance monitoring is described in the Groundwater Addendum and the Groundwater SAP. The Groundwater SAP identifies the groundwater monitoring locations, parameters, and frequency to support the MNA remedy. Monitoring will continue until COCs have attained the cleanup levels, and are expected to continue to meet cleanup levels, and EPA approves termination of the monitoring. Estimated durations of MNA are based on the model-estimated time frame for each COC to achieve its cleanup level as described in the 100-F/IU RI/FS report (DOE/RL-2010-98). The estimated time frames for each COC were determined in 2011 and are presented in Table 3-1.

Table 3-1. Estimated Time Frame for Groundwater Cleanup Levels to be Attained through Monitored Natural Attenuation

COC	Cleanup Level	Estimated Years to Attain Cleanup Level[a]
Hexavalent Chromium	10 µg/L[b]	35
Hexavalent Chromium	48 µg/L[b]	20
Nitrate	45,000 µg/L	80
Trichloroethene	4 µg/L	50
Strontium-90	8 pCi/L	150

a. The remedial action time frame estimates were determined in 2011 and are based on modeling as presented in DOE/RL-2010-98, *Remedial Investigation/Feasibility Study for 100-FR-1, 100-FR-2, 100-FR-3, 100-IU-2, and 100-IU-6 Operable Units*. Some areas of the COC plume will achieve the cleanup level earlier than the estimate for the entire plume.
b. The cleanup levels for hexavalent chromium are 48 µg/L in the upland groundwater and 10 µg/L where groundwater discharges to surface water.

COC = contaminant of concern

Performance monitoring includes installation of new wells to monitor plume sizes and update the rates of attenuation that are occurring to reflect post-source remediation conditions. Locations for the new wells were determined using a phased approach based on available sampling and analysis results. The first phase of new wells was identified through a DQO process and includes eight locations. The second phase of new wells, if needed, will be determined using data collected from both new and existing wells in the monitoring network.

3.3 Design Approach

Methods and sampling designs summarized in Section 3.2 of this Integrated RDR/RAWP and corresponding addenda represent the overall design and implementation approach that will be followed. The design and planning for completion of RAs at the 100-IU-2 and 100-IU-6 OUs are described in the Soil Addendum. Details of the RD for performance monitoring of the MNA remedy are provided in the Groundwater Addendum. Refinements to the monitoring design may be made after sampling results for the first phase of new wells are evaluated, as described in the Groundwater Addendum.

The Integrated RDR/RAWP, Soil Addendum, and Groundwater Addendum serve as the RDR. The Integrated RDR/RAWP and addenda will be submitted to EPA for review as a primary document in accordance with the TPA (Ecology et al., 1989a), Section 9.2.1.

4 Remedial Action Management and Approach

This chapter describes the work elements and management approach associated with implementation of the selected remedies that are common to all of 100-F/IU. The Soil and Groundwater Addenda include the elements that are specific to each.

4.1 Project Team

The term "project team" includes the individuals working to accomplish the RA. Accordingly, the project team includes the DOE-RL 100-F/IU Project Manager, the LRA, and the remediation contractors. Figure 4-1 shows the RDR/RA Project Organization. The roles and responsibilities for these team members are discussed in the addenda. The overall project team common to both remediation contractors is briefly discussed in the following paragraphs:

- **Lead Agency (U.S. Department of Energy)** – DOE is the lead agency under CERCLA (delegated by Executive Order 12580, *Superfund Implementation*), the primary authority under Section 104, "Response Authorities," and Section 121, "Cleanup Standards," to conduct removal and RAs at DOE facilities. DOE is responsible for RAs throughout the Hanford Site and, as such, has assigned remedial project managers to each main area and task involved with remediation activities. The lead agency is responsible for managing the assigned activities, which include scope, budget, schedule, quality, personnel, communication, risk/safety, contracts, and regulatory interface, and works under EPA oversight in accordance with CERCLA Section 120, "Federal Facilities," as implemented through the TPA (Ecology et al, 1989a). DOE obtains Congressional funding for these activities.

- **Lead Regulatory Agency (U.S. Environmental Protection Agency)** – EPA is the LRA for CERCLA remediation activities at the 100-F/IU OUs, as described in the TPA (Ecology et al., 1989a). The LRA is responsible for overseeing activities to verify that applicable regulatory requirements are met. LRA approval will be required on all TPA (Ecology et al., 1989a) primary documents (for example, this Integrated RDR/RAWP and addenda).

Remediation Contractors:

- The waste site remediation contractor will implement the RDR/RAWP for RTD and associated ICs at 100-IU-2 and 100-IU-6 waste sites. The RDR/RAWP elements specific to the RA management and approach are provided in the Soil Addendum.

- The groundwater remediation contractor will implement the RDR/RAWP activities associated with MNA. The RDR/RAWP elements specific to the RA management and approach are provided in the Groundwater Addendum.

- The Hanford Site administration contractor will implement the activities associated with long-term ICs restricting drilling and excavation and prohibiting irrigation at identified 100-FR-1 and 100-FR-2 OU waste sites and ICs restricting access to groundwater within the 100-FR-3 boundary identified in the 100-F/IU ROD (EPA and DOE, 2014). The site administration contractor reports directly to DOE.

- Contractors for Operations, Waste Management, Field Construction, Radiological Control, Engineering, Quality Assurance (QA), Health and Safety, Environmental Compliance, and Sample Management may be used for both soil and groundwater work and would report to the Remediation Contractors.

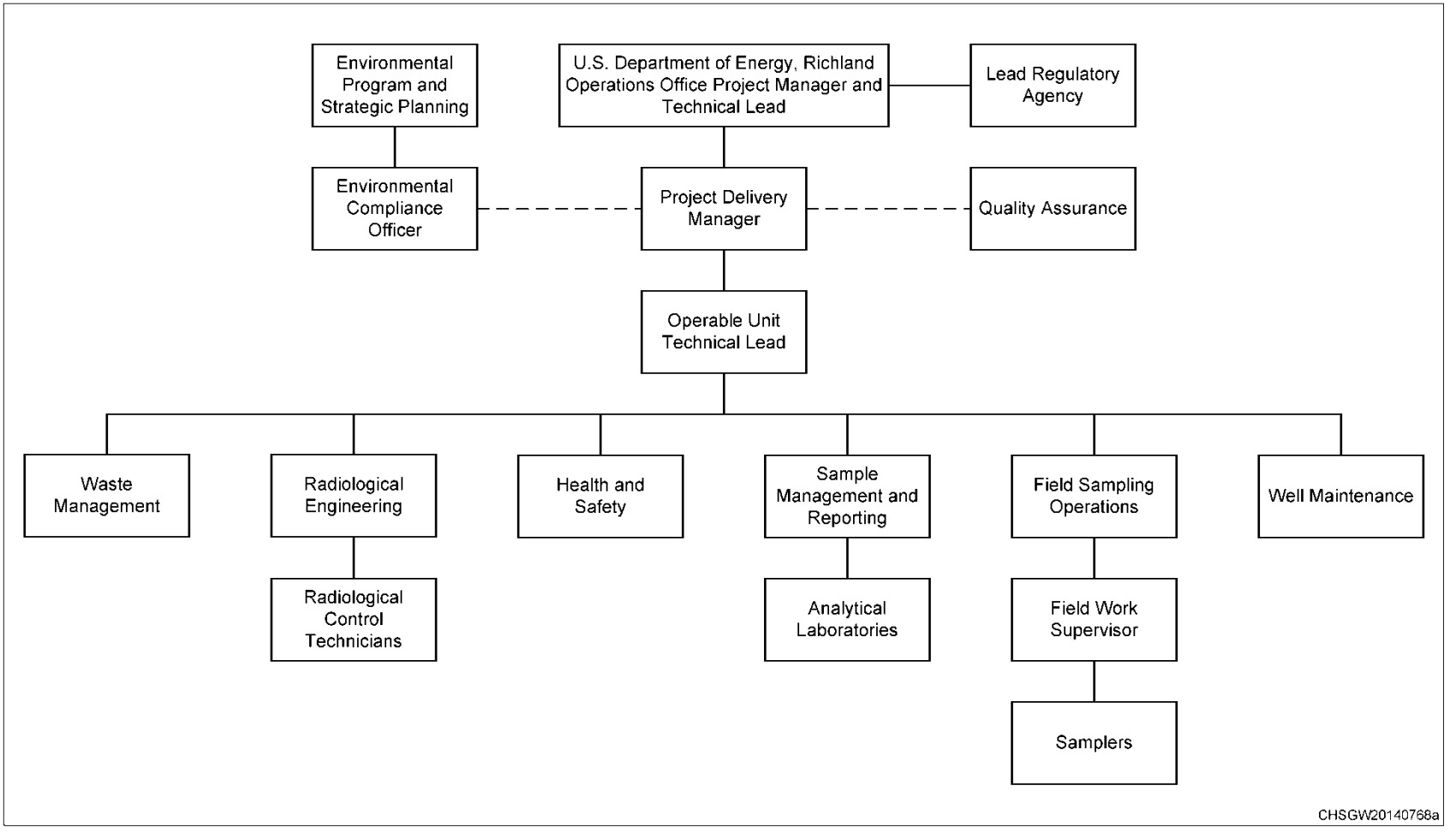

Figure 4-1. Remedial Design/Remedial Action Project Organization

4.2 Change Management

Three types of changes in the RAs could affect compliance with the requirements in the 100-F/IU ROD (EPA and DOE, 2014):

- A nonsignificant or minor change does not impact the remedy identified in the 100-F/IU ROD (EPA and DOE, 2014). An example of a nonsignificant change may include modifications to the RA schedule that do not impact an agreed-upon milestone. Minor changes should be documented in the appropriate post-decision project file (for example, through interoffice memoranda or in logbooks), Project Manager's Meeting minutes, or Unit Manager's Meeting minutes.
- A significant change is defined as a change that significantly modifies the scope, performance, or component cost for the remedy as presented in the 100-F/IU ROD (EPA and DOE, 2014). All significant changes will be addressed in an ESD.
- A fundamental change does not meet the requirements set forth in the 100-F/IU ROD (EPA and DOE, 2014) or incorporates remedial activities that are not defined in the scope of the ROD. Should this situation arise, the ROD must be amended.

Determining the significance of the change is the responsibility of DOE and the LRA. The remediation or environmental manager is responsible for tracking all changes and obtaining appropriate reviews by contractor staff. The remediation or environmental manager will discuss the change with DOE, and DOE will then discuss the type of change that is necessary with the LRA. Appropriate documentation will follow, in accordance with the requirements for that type of change.

4.3 Remedial Action Work Tasks

RA work tasks include procurement and construction, operational approach, and data use and interpretation. RA activities that are specific to the soil or groundwater RA are described in the Soil and Groundwater Addenda, respectively.

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5 Environmental Management and Controls

This chapter describes environmental management and controls associated with implementation of the 100-F/IU remedies.

5.1 Air Emissions

The requirements for environmental management and controls of radiological and nonradiological air emissions are described in the following sections.

5.1.1 Radiological Air Emissions

The remedial activities will be evaluated on a waste site-specific basis with respect to determining the potential-to-emit radionuclides from any point source or diffuse/fugitive source. Any radiological air emissions associated with RTD at waste sites for the 100-IU-2 and 100-IU-6 OUs will be managed with treatment conducted, as necessary, in advance or during removal to control worker exposure and minimize airborne releases. Additional information regarding evaluation and management of radiological emissions from waste site RA is presented in the Soil Addendum. Air monitoring requirements for waste site RTD are also described further in the Soil Addendum.

Radiological air emissions associated with MNA of groundwater are not anticipated.

5.1.2 Nonradiological Air Emissions

To demonstrate compliance with the ARARs of WAC 173-400, "General Regulations for Air Pollution Sources," and WAC 173-460, "Controls for New Sources of Toxic Air Pollutants," fixatives and dust suppression methods will be used.

Nonradiological air emissions associated with MNA of groundwater are not anticipated.

5.2 Reporting Requirements for Nonroutine Releases

40 CFR 302, "Designation, Reportable Quantities, and Notification," requires immediate notification to the National Response Center upon discovery of a release of a hazardous substance into the environment in excess of a reportable quantity in a 24-hour period. 40 CFR 355, "Emergency Planning and Notification," requires immediate notification to the community emergency coordinator for the local emergency planning committee and to the State Emergency Response Commission for a release of a reportable quantity of an extremely hazardous substance or a CERCLA hazardous substance in a 24-hour period, except for releases exempted from reporting under 40 CFR 355.31, "What Types of Releases are Exempt from the Emergency Release Notification Requirements of this Subpart?" The Hanford Site has comprehensive policies and procedures in place to report nonroutine releases to the environment. These procedures will be followed at the 100-F/IU OUs.

5.3 Waste Management

Waste management requirements for project waste streams, waste characterization, designation and disposal, waste generation management, management of waste containers, final disposal/storage, waste disposal records, waste transportation, waste treatment, and waste minimization and recycling are included in the 100-F/IU Soil Addendum and Groundwater Addendum.

5.4 Cultural/Ecological Resources

As of August 6, 2015, DOE has completed cultural resource reviews and made its determinations for two-hundred and eighty-seven (287) waste sites covered by the ROD. DOE will complete cultural

resource reviews, make its determinations, and provide notifications for the remaining waste sites and for any remaining subsurface and groundwater work prior to undertaking ground disturbing activities at those sites in accordance with the National Historic Preservation Act implementing regulations at 36 C.F.R. § 800.3 through § 800.6 using the Hanford Cultural Resource Management Plan as guidance. Further procedures, including entering into Memoranda of Agreement ("MOAs") or other agreement documents, may be conducted for some activities but are not required.

5.5 Safety and Health Program

A health and safety plan (HASP) addresses routine job site hazards and physical hazards and specifies general controls and requirements for work activities. Access and work activities are controlled in accordance with approved work packages, as required by established internal work requirements and processes. The HASP includes the requirements for hazardous waste operations and/or construction activities, as specified in 29 CFR 1910.120, "Occupational Safety and Health Standards," "Hazardous Waste Operations and Emergency Response." Depending on the specific hazards present, one or more HASPs could be written for this RA. As part of work package development, a job or activity hazards analysis will be written to identify the hazards associated with specific tasks in addition to the HASP.

In addition to the HASP, in accordance with contractor-level procedures and programs, radiological work permits (RWPs) will be prepared, as needed, for work in areas with potential radiological hazards. The RWP extends the Radiological Protection Program to the specific work site or operation. All personnel assigned to the project and all work site visitors shall strictly adhere to the provisions identified in the HASP and RWP. Before work and before each activity begins, a pre-job briefing will be held with the involved workers. This briefing will include reviews of the hazards that could be encountered and the associated requirements. Throughout an activity, daily briefings could also be held, as well as special briefings before major evolutions.

5.6 Emergency Response

During construction and operations, emergency response for project activities will be covered by the project-specific HASP, and related health and safety procedures and work instructions. The HASP, health and safety procedures, and work instructions contain primary emergency response actions for site personnel, area alarms, implementation of the emergency action plan, and emergency equipment at each task site, as well as emergency coordinators, emergency response procedures, and spill containment. A copy of the HASP will be kept in the construction field office. When emergencies arise that are beyond the limitations of the project-specific HASP, DOE-0223, *Emergency Plan Implementing Procedures*, will govern project staff response, as specified in the HASP.

5.7 Quality Assurance Program

Overall QA for the RDR/RAWP will be planned and implemented in accordance with 10 CFR 830, "Nuclear Safety Management," Subpart A, "Quality Assurance Requirements"; EPA/240/B-01/003, *EPA Requirements for Quality Assurance Project Plans* (EPA QA/R-5); EPA/240/R-02/009, *Guidance for Quality Assurance Project Plans* (EPA QA/G-5); and EPA/240/B-05/001, *Guidance on Quality Assurance for Environmental Technology Design, Construction, and Operation* (EPA QA/G-11). QA activities will use a graded approach based on the potential impact to the environment, safety, health, reliability, and continuity of operations. QA for the Soil and Groundwater remedy implementation is discussed in the applicable SAPs and will comply with the following requirements:

- DOE/RL-96-68, *Hanford Analytical Services Quality Assurance Requirements Document* (HASQARD)

- DOE O 414.1D, *Quality Assurance*

The SAPs prepared to support the 100-F/IU RA contain a QA project plan, which establishes the quality requirements for environmental data collection, including planning, implementation, and assessment of sampling, field measurements, and laboratory analysis.

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6 Remedial Action Completion

This chapter describes how the effectiveness of the remedies will be evaluated for RA completion. Performance standards were established for 100-FR-3 OU groundwater and 100-FR-1, 100-FR-2, 100-IU-2, and 100-IU-6 OU waste sites. Performance standards for groundwater are cleanup levels that are based on the DWSs for strontium-90 and nitrate, state surface water quality standards for Cr(VI), and risk-based standards that are more stringent than DWSs for TCE. Performance standards selected for 100-F/IU soil, structures, and debris within the top 4.6 m (15 ft) bgs are protective of residential use. Cleanup levels for soil at all depths are based on protection of groundwater and surface water. Additional details for remedy completion are provided in the 100-F/IU Soil and Groundwater Addenda.

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7 Cost and Schedule

This chapter discusses the cost and schedule associated with implementation of the 100-F/IU remedies.

7.1 Cost Summary

Cost estimates for the 100-F/IU RDR/RAWP are reported in ECE-100FR314-00007, *Environmental Cost Estimate for 100 F/IU RD/RAWP*.

Cost estimates for remediation of remaining 100-IU-2/IU-6 waste sites were prepared as part of the 100-F/IU RI/FS report (DOE/RL-2010-98) and subsequently carried forward into the 100-F/IU ROD (EPA and DOE, 2014). The estimates for RTD and ICs were prepared with an accuracy of -30 percent to +50 percent to support evaluation of remedial alternatives and selection of a remedy. Cost estimates are updated based on design work. In accordance with CERCLA requirements, an ESD will be pursued by the Tri-Parties if remediation costs change significantly from those identified in the 100-F/IU ROD (EPA and DOE, 2014).

The estimated cost for RTD of remaining 100-IU-2/IU-6 waste sites was $9.6 million.

ICs for the 100-FR-1 and 100-FR-2 OUs restrict excavation at 15 waste sites and prohibit irrigation at one waste site until cleanup levels are achieved. ICs for the 100-FR-3 OU include a prohibition on groundwater use except for monitoring, remediation, or research purposes as authorized in EPA-approved documents. ICs will be maintained until cleanup levels are achieved. The cost for 150 years of ICs is estimated at $23.5 million.

The estimated costs for MNA and performance monitoring are $19.5 million. This estimate was prepared with an accuracy of –20 percent to +30 percent to support RA implementation.

7.2 Schedule

The schedule for implementation of 100-F/IU remedies is presented in the respective 100-F/IU Soil and Groundwater Addenda. RTD at 100-IU-2 and 100-IU-6 waste sites is planned to be completed in 3 to 5 years.

Implementation of the 100-FR-3 OU performance monitoring will begin after approval of the RDR/RAWP. Installation of new Phase 1 monitoring wells is anticipated to be initiated immediately following RDR/RAWP approval. Phase 1 well installation is anticipated to be completed within 6 months of initiation.

The duration of the MNA performance monitoring period is based on the model-estimated time frame for each COC to achieve its cleanup level as described in the 100-F/IU RI/FS report (DOE/RL-2010-98). The estimated attenuation time frames were determined in 2011 and are rounded up to account for model uncertainties. The following time frames are estimated for each COC:

- Cr(VI) = 35 years based on 10 µg/L cleanup level
- Trichloroethene = 50 years
- Nitrate = 80 years
- Strontium-90 = 150 years

Five years of attainment monitoring will be performed at each well once cleanup levels for each COC are achieved, as described in the Groundwater Addendum. The 5-year attainment monitoring period is not included in the time frame estimates.

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Appendix A

Applicable or Relevant and Appropriate Requirements

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Table

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Terms

ACM	asbestos-containing material
ALARA	as low as reasonably achievable
ARAR	applicable or relevant and appropriate requirement
BACT	best available control technology
CFR	*Code of Federal Regulations*
MCL	maximum contaminant level
MCLG	maximum contaminant level goal
MNA	monitored natural attenuation
NESHAP	"National Emission Standards for Hazardous Air Pollutants" (40 CFR 61)
OU	operable unit
PCB	polychlorinated biphenyl
RCW	*Revised Code of Washington*
RTD	removal, treatment (as required), and disposal
TAP	toxic air pollutant
WAC	*Washington Administrative Code*

.

A1 Introduction

A list of applicable or relevant and appropriate requirements (ARARs) are identified in *Record of Decision Hanford 100 Area Superfund Site 100-FR-1, 100-FR-2, 100-FR-3, 100-IU-2, and 100-IU-6 Operable Units* (EPA and DOE, 2014). Only the substantive requirements of listed ARARs are included. The application column of Table A-1 identifies if the ARARs apply to the selected remedy for 100-FR-1, 100-FR-2, 100-FR-3, 100-IU-2, and/or 100-IU-6.

Table A-1. Applicable or Relevant and Appropriate Requirements

Regulatory Citation	Description of Regulatory Requirement	Rationale for Including	Application
Groundwater			
***Safe Drinking Water Act of 1974* (Public Law 93-523, as amended; 42 USC 300f, et seq.); "National Primary Drinking Water Regulations" (40 CFR 141)**			
"Maximum Contaminant Levels for Organic Contaminants" (40 CFR 141.61) "Maximum Contaminant Level Goals for Organic Contaminants" (40 CFR 141.50(b))	Establishes MCLs and nonzero MCLGs for drinking water. The standards/goals are designed to protect human health from adverse effects of organic contaminants in the drinking water.	These levels regulate the concentrations of contaminants in public drinking water supplies and are considered relevant and appropriate for groundwater and for surface water used potentially for drinking water. Although 100-FR-3 groundwater is not currently used for drinking water, it is a potential drinking water source and discharges into the Columbia River, which is used for drinking water.	100-FR-3. To be met through MNA and source control measures.
"Maximum Contaminant Levels for Inorganic Contaminants" (40 CFR 141.62) "Maximum Contaminant Level Goals for Inorganic Contaminants" (40 CFR 141.51(b))	Establishes MCLs and nonzero MCLGs for drinking water. The standards/goals are designed to protect human health from adverse effects of inorganic contaminants in the drinking water.	These levels regulate the concentrations of contaminants in public drinking water supplies and are considered relevant and appropriate for groundwater and for surface water used potentially for drinking water. Although 100-FR-3 groundwater is not currently used for drinking water, it is a potential drinking water source and discharges into the Columbia River, which is used for drinking water.	100-FR-3. To be met through MNA and source control measures.
"Maximum Contaminant Levels for Radionuclides" (40 CFR 141.66)	Establishes MCLs for drinking water. The standards are designed to protect human health from the adverse effects of radionuclides in the drinking water.	These levels regulate the concentrations of contaminants in public drinking water supplies and are considered relevant and appropriate for groundwater and for surface water used potentially for drinking water. Although 100-FR-3 groundwater is not currently used for drinking water, it is a potential drinking water source and discharges into the Columbia River, which is used for drinking water.	100-FR-3. To be met through MNA and source control measures.

Table A-1. Applicable or Relevant and Appropriate Requirements

Regulatory Citation	Description of Regulatory Requirement	Rationale for Including	Application
"Hazardous Waste Cleanup – Model Toxics Control Act" (RCW 70.105D, as amended); "Model Toxics Control Act—Cleanup" (WAC 173-340)			
"Potable Groundwater Defined" (WAC 173-340-720(2)) "Method B Cleanup Levels for Potable Ground Water" (WAC 173-340-720(4)(b)(i-iii)(A)&(B)) "Adjustments to Cleanup Levels" (WAC 173-340-720(7)) "Points of Compliance" (WAC 173-340-720(8)) "Compliance Monitoring" (WAC 173-340-720(9)(b-f))	Groundwater shall be classified as potable unless exclusion criteria are met. These groundwater cleanup requirements are ARARs where they are more stringent than federal MCL ARARs. Adjustments to cleanup levels are made in accordance with WAC 173-340-720(7). Points of compliance are established throughout 100-FR-3. Groundwater sample analysis shall be conducted on unfiltered samples unless a filtered sample is shown to be more representative.	Groundwater in 100-FR-3 contains contaminants that require remediation. It is not currently used for drinking water but is a potential drinking water source. Groundwater discharges into the Columbia River, which is used for drinking water.	100-FR-3. The groundwater cleanup levels for chemicals are calculated using Method B equations (720-1 and 720-2) for noncarcinogens and carcinogens, respectively. The selected remedy will comply with the standards using MNA and source control measures, with the 100-FR-3 points of compliance being throughout the 100-FR-3 aquifer.
"Water Well Construction" (RCW 18.104, as amended); "Minimum Standards for Construction and Maintenance of Wells" (WAC 173-160)			
"How Shall Each Water Well Be Planned and Constructed?" (WAC 173-160-161)	Identifies well planning and construction requirements. Water wells must not be a conduit for contamination and be constructed to yield the necessary quantity of water.	Wells are used to monitor groundwater.	100-FR-3. The selected remedy will comply by constructing water wells that meet these standards.
"What Are the Requirements for Preserving the Natural Barriers to Ground Water Movement Between Aquifers?" (WAC 173-160-181)	Identifies the requirements for preserving natural barriers to groundwater movement between aquifers.	Wells are used to monitor groundwater.	100-FR-3. The selected remedy will comply by constructing water wells that meet these standards.
"What Are the Minimum Standards for Resource Protection Wells and Geotechnical Soil Borings?" (WAC 173-160-400)	Identifies the minimum standards for resource protection wells and geotechnical soil borings.	Wells are used to monitor groundwater.	100-FR-3. The selected remedy will comply by building wells that meet these standards.
"What Are the General Construction Requirements for Resource Protection Wells?" (WAC 173-160-420)	Identifies the general construction requirements for resource protection wells.	Wells are used to monitor groundwater.	100-FR-3. The selected remedy will comply by building wells that meet these standards.
"What Are the Minimum Casing Standards?" (WAC 173-160-430)	Identifies the minimum casing standards.	Wells are used to monitor groundwater.	100-FR-3. The selected remedy will comply by building wells that meet these standards.

Table A-1. Applicable or Relevant and Appropriate Requirements

Regulatory Citation	Description of Regulatory Requirement	Rationale for Including	Application
"What Are the Equipment Cleaning Standards?" (WAC 173-160-440)	Identifies the equipment cleaning standards for construction and maintenance of wells.	Wells are used to monitor groundwater.	100-FR-3. The selected remedy will comply by building wells that meet these standards.
"What Are the Well Sealing Requirements?" (WAC 173-160-450)	Identifies the well sealing requirements for resource protection wells.	Wells are used to monitor groundwater.	100-FR-3. The selected remedy will comply by building wells that meet these standards.
"What Is the Decommissioning Process for Resource Protection Wells?" (WAC 173-160-460)	Identifies the decommissioning process for resource protection wells.	Wells are used to monitor groundwater.	100-FR-3. The selected remedy will comply by decommissioning wells and borings to meet these standards.
Surface Water			
***Federal Water Pollution Control Act* (also known as *Clean Water Act of 1972* [Public Law 107-303, as amended; 33 USC 1251, et seq.]), Section 303c; "Water Quality Standards" (40 CFR 131)**			
"Toxics Criteria for Those States Not Complying with Clean Water Act" (40 CFR 131.36(b)(1) as applied to Washington, 40 CFR 131.36(d)(14))	Establishes numeric water quality criteria for priority toxic pollutants for the protection of human health and aquatic organisms which supersede criteria adopted by the state, except where the state criteria are more stringent than the federal criteria.	Groundwater from 100-FR-3 that discharges into the Columbia River contains priority toxic pollutants that require remediation to meet toxics criteria standards.	100-FR-3. These standards apply where groundwater discharges to the river. The selected remedy will comply through MNA, infiltration control and source control measures.
"Water Pollution Control" (RCW 90.48, as amended); "Water Quality Standards for Surface Waters of the State of Washington" (WAC 173-201A)			
"Toxic Substances" (WAC 173-201A-240(3))	Establishes chemical water quality standards for surface waters of the State of Washington for protection of aquatic life.	Groundwater in 100-FR-3 contains contaminants that require remediation and discharges into the Columbia River.	100-FR-3. These standards apply where groundwater discharges to the river. The selected remedy will comply through MNA control and source control measures
"Toxic Substances" (WAC 173-201A-240(6))	Establishes water quality standards for surface waters of the State of Washington. Risk-based criteria for carcinogenic substances shall be selected such that the upper-bound excess cancer risk is less than 1×10^{-6} for individual contaminants.	Contaminated groundwater that requires remediation to protect drinking water uses discharges to the Columbia River. Surface water is not contaminated by 100-FR-3 discharges in excess of this standard.	100-FR-3. Columbia River surface waters of the State currently comply with this standard for discharges from 100-FR-3. The selected remedy will further reduce 100-FR-3 discharges and comply with this standard.

Table A-1. Applicable or Relevant and Appropriate Requirements

Regulatory Citation	Description of Regulatory Requirement	Rationale for Including	Application
Soil and Vadose Zone			
"Hazardous Waste Cleanup – Model Toxics Control Act" (RCW 70.105D, as amended); "Model Toxics Control Act—Cleanup" (WAC 173-340)			
"Unrestricted Land Use Soil Cleanup Standards" (WAC 173-340-740(3)) "Unrestricted Land Use Soil Cleanup Standards, Adjustments to Cleanup Levels" (WAC 173-340-740(5)) "Unrestricted Land Use Soil Cleanup Standards, Point of Compliance" (WAC 173-340-740(6)) "Unrestricted Land Use Soil Cleanup Standards, Compliance Monitoring" (WAC 173-340-740(7))	Requires that soil cleanup levels result in no significant adverse effects on terrestrial ecological receptors. Requires human health protection from both groundwater contaminated due to leaching and direct soil contact. Total excess cancer risk may not exceed 1×10^{-5} or a noncancer hazard index of 1 for chemical contaminants. Soil points of compliance are throughout the site. Soil cleanup levels apply to the less than 2 mm size fraction of dry samples, or also larger-size fractions if they could be crushed.	Soil in 100-IU-2 and 100-IU-6 contains contaminants that require remediation to meet Method B soil cleanup levels calculated based on an unrestricted land use.	100-IU-2 and 100-IU-6. The selected remedy will comply through RTD of contaminants that exceed the standards. Table 5 includes soil cleanup levels to protect direct exposure that meet the risk and hazard requirements. Table 6 includes soil cleanup levels for the protection of groundwater and surface water due to leaching from soil contamination.
"Deriving Soil Concentrations for Groundwater Protection" (WAC 173-340-747(3) through (8))	Establishes soil concentrations that will not cause contamination of groundwater at levels that exceed the groundwater cleanup levels established under "Groundwater Cleanup Standards" (WAC 173-340-720).	Soil in 100-IU-2 and 100-IU-6 contains contaminants that require remediation to ensure protection of groundwater. Although 100-FR-3 groundwater is not currently used for drinking water, it is a potential drinking water source Groundwater discharges into the Columbia River, which is used for drinking water.	100-IU-2 and 100-IU-6. The selected remedy will comply through RTD of contaminants that exceed the standards. Table 6 includes soil cleanup levels to protect groundwater and surface water due to leaching from soil contamination.
Air			
"Washington Clean Air Act" (RCW 70.94, as amended); "General Regulations for Air Pollution Sources" (WAC 173-400)			
"General Standards for Maximum Emissions" (WAC 173-400-040)	All sources and emission units are required to meet the general emission standards unless a specific source standard is available. General standards apply to visible emissions, particulate fallout, fugitive emissions, odors, emissions detrimental to health and property, sulfur dioxide, and fugitive dust.	Soil remedial action at 100-IU-2 and 100-IU-6 provides the potential for emissions subject to these standards because selected remedial action could result in emissions of regulated hazardous air pollutants.	100-IU-2 and 100-IU-6. Remedial actions that have the potential to release hazardous air emissions will meet standards.

Table A-1. Applicable or Relevant and Appropriate Requirements

Regulatory Citation	Description of Regulatory Requirement	Rationale for Including	Application
"Emission Standards for Sources Emitting Hazardous Air Pollutants" (WAC 173-400-075)	Establishes emission standards for hazardous air pollutants. Adopts, by reference, "National Emission Standards for Hazardous Air Pollutants" (NESHAP) (40 CFR 61) and appendices.	100-IU-2 and 100-IU-6 OUs contain hazardous pollutants that could become airborne.	100-IU-2 and 100-IU-6. Remedial actions will be designed and performed in compliance with the standards.
"Washington Clean Air Act" (RCW 70.94, as amended); "Controls for New Sources of Toxic Air Pollutants" (WAC 173-460)			
"Control Technology Requirements" (WAC 173-460-060) "Ambient Impact Requirement" (WAC 173-460-070) "Table of ASIL, SQER and de Minimis Emission Values" (WAC 173-460-150)	Shall not establish, operate or cause to be established or operated any new or modified toxic air pollutant source that is likely to increase TAP emissions without installing and operating BACT. Nonprocess fugitive emissions activities are exempt for the requirement to apply BACT. Requires compliance with the limits air pollutants include carcinogens and noncarcinogens listed in "Table of ASIL, SQER and de Minimis Emission Values" (WAC 173-460-150).	Hazardous contaminants detected in soil and/or 100-FR-3 groundwater include constituents that would constitute toxic air pollutants if released to the air.	100-FR-3, 100-IU-2 and 100-IU-6. Remediation activities with the potential to emit hazardous air emissions identified in this standard will comply.
"Washington Clean Air Act" (RCW 70.94, as amended); "Ambient Air Quality Standards and Emission Limits for Radionuclides" (WAC 173-480)			
"Ambient Standard" (WAC 173-480-040)	Requires that emissions of radionuclides in the air shall not cause a maximum effective dose equivalent of more than 10 mrem/year to the whole body to any member of the public. Per "Applicability" (WAC 173-480-020), the ambient standard applies to the entire state. Measurements may be made at all points up to property lines of point, area, and fugitive emission sources.	Hazardous contaminants detected in soil and 100-FR-3 groundwater contains radionuclides that could be emitted to ambient air during remedial actions.	100-FR-3, 100-IU-2, and 100-IU-6. Remediation activities (e.g., RTD) that have the potential to emit radionuclides above maximum acceptable levels will be controlled to meet standards.
"General Standards for Maximum Permissible Emissions" (WAC 173-480-050(1))	At a minimum, all emission units shall make every reasonable effort to maintain radioactive materials in effluents to unrestricted areas ALARA; control equipment at sites operating under ALARA shall be defined as reasonably available control technology and as low as reasonably achievable control technology.	The potential for fugitive and diffuse emissions because of excavation and related activities will require efforts to minimize those emissions.	100-IU-2 and 100-IU-6. Remediation activities (e.g., RTD) that have the potential to emit radionuclides to residential areas will meet standards.

Table A-1. Applicable or Relevant and Appropriate Requirements

Regulatory Citation	Description of Regulatory Requirement	Rationale for Including	Application
"Emission Monitoring and Compliance Procedures" (WAC 173-480-070(2))	Compliance is determined by calculating the dose to members of the public at the point of maximum annual air concentration in an unrestricted area where any member of the public may be located.	Hazardous contaminants detected in soil in 100-FR-1, 100-FR-2, 100-IU-2, and 100-IU-6 include radionuclides that could be emitted to unrestricted areas during remedial actions.	100-IU-2 and 100-IU-6. Remediation activities (e.g., RTD) that have the potential to emit radionuclides to unrestricted areas will meet standards.
"Emission Standards for New and Modified Emission Units" (WAC 173-480-060)	Requires that construction, installation, or establishment of new air emission control units use best available radionuclide control technology.	Hazardous contaminants detected in soil in 100-FR-1, 100-FR-2, 100-IU-2, and 100-IU-6 includes radionuclides that could be emitted from air emission control units during remedial actions.	100-IU-2 and 100-IU-6. Remediation activities (e.g., RTD) that require air pollution control measures and/or equipment and have the potential to emit radionuclides to the ambient air will meet standards.
"Nuclear Energy and Radiation" (RCW 70.98, as amended); "Radiation Protection—Air Emissions" (WAC 246-247)			
"National Standards Adopted by Reference for Sources of Radionuclide Emissions" (WAC 246-247-035(1)(a)(i)) (adopts by reference, "Prohibited Activities"[40 CFR 61.05])	Identifies prohibition on any owner or operator of any stationary source subject to a national emission standard for hazardous air pollutants from constructing or operating the new or existing source in violation of any such standard.	Remedial actions in 100-FR-1, 100-FR-2, 100-IU-2, and 100-IU-6 have the potential to emit hazardous air pollutants.	100-IU-2 and 100-IU-6. Remedial actions that require air pollution control measures and/or equipment and have the potential to emit radionuclides to the ambient air will meet this standard.
"National Standards Adopted by Reference for Sources of Radionuclide Emissions" (WAC 246-247-035(1)(a)(i) and (ii) Adopts by reference: "General Provisions" (40 CFR 61, Subpart A) "National Emission Standards for Emissions Radionuclides Other Than Radon From Department of Energy Facilities" (40 CFR 61, Subpart H)	Requires the owner or operator of each stationary source of hazardous air pollutants subject to a national emission standard for a hazardous air pollutant to determine compliance with numerical emission limits in accordance with emission tests established in NESHAP Subpart A, "Emission Tests and Waiver of Emission Tests" (40 CFR 61.13), or as otherwise specified in an individual subpart. Compliance with design, equipment, work practice, or operational standards shall be determined as specified in the individual subpart. Also, maintain and operate the source, including associated equipment for air pollution control, in a manner consistent with good air pollution control practice for minimizing emissions.	Remedial actions in 100-FR-1, 100-FR-2, 100-IU-2, and 100-IU-6 have the potential to emit hazardous air pollutants.	100-IU-2 and 100-IU-6. Remedial actions involve stationary sources that provide a potential to emit regulated hazardous air pollutants (e.g., decontamination stations, or waste removal or storage activities). Associated design, equipment, work practice, and/or air emissions controls will be maintained and operated to meet these standards.

Table A-1. Applicable or Relevant and Appropriate Requirements

Regulatory Citation	Description of Regulatory Requirement	Rationale for Including	Application
"Radiation Protection, Air Emissions, General Standards" (WAC 246-247-040(3) and (4))	Requires that ALARA-based control technology Best Available Controls be used to control emissions depending on whether there is new construction or there is an existing emission unit, and whether there is a significant modification of an emission unit.	Hazardous contaminants that would be subject to radionuclide air emission standards and resultant requirements have the potential to be detected in, and emitted from, structures, components, debris, soil, and remediation equipment during remedial actions.	100-IU-2 and 100-IU-6. Remedial actions will use best available (radionuclide) control technology or as low as reasonably achievable control technology to meet this standard.
"Monitoring, Testing and Quality Assurance" (WAC 246-247-075)	Establishes the substantive monitoring, testing, and quality assurance requirements for radioactive air emissions. Emissions from nonpoint and fugitive sources of airborne radioactive material will be measured.	Hazardous contaminants that would be subject to radionuclide air emission standards and resultant requirements have the potential to be detected in and emitted from, structures, debris, soil, and remediation equipment during remedial actions.	100-IU-2 and 100-IU-6. Monitoring, testing and quality assurance requirements will be defined and followed to meet this standard.
***Clean Air Act of 1990* and amendments (42 USC 7401, et seq.); "National Emission Standard for Asbestos" (40 CFR 61, Subpart M)**			
"Applicability" (40 CFR 61.140) "Standard for Demolition and Renovation" (40 CFR 61.145)	Defines regulated ACM and regulated removal and handling requirements. Includes substantive sampling, inspection, handling, and disposal requirements for regulated sources having the potential to emit asbestos. Specifically, no visible emissions are allowed during handling, packaging, and transport of ACM.	Encountering ACM on pipelines or buried asbestos within 100-FR-1, 100-FR-2, 100-IU-2, and 100-IU-6 is possible during remediation activities.	100-IU-2 and 100-IU-6. Site investigation, remediation activities and associated handling, packaging, transportation and disposal of ACM will meet standards.
"Standard for Waste Disposal for Manufacturing, Fabricating, Demolition, Renovation, and Spraying Operations" (40 CFR 61.150)	Includes substantive requirements for the removal and disposal of asbestos from demolition and renovation activities.	Pipelines, other debris, and soil contain ACM.	100-IU-2 and 100-IU-6. Site remediation activities and associated handling, packaging, transportation and disposal of ACM will meet standards.

Table A-1. Applicable or Relevant and Appropriate Requirements

Regulatory Citation	Description of Regulatory Requirement	Rationale for Including	Application
Solid Wastes			
***Toxic Substances Control Act of 1976* (Public Law 107-377, as amended; 15 USC 2605, et seq.); "Polychlorinated Biphenyls (PCBs) Manufacturing, Processing, Distribution in Commerce, and Use Prohibitions" (40 CFR 761)**			
"Applicability," "PCB Waste" (40 CFR 761.50(b)1, 2, 3, and 7) "Applicability," "Storage for Disposal" (40 CFR 761.50(c))	Establishes substantive PCB requirements for the storage and disposal of PCB wastes including liquid PCB wastes, PCB items, PCB remediation waste, PCB bulk product wastes, and PCB/radioactive wastes at concentrations greater than 50 ppm.	Remediation is expected to generate PCB and PCB/ radioactive waste.	100-IU-2 and 100-IU-6. Management and disposal of remediation waste with PCBs will meet standards.
"Disposal Requirements," "PCB Liquids" (40 CFR 761.60(a)) "Disposal Requirements," "PCB Articles" (40 CFR 761.60(b)) "Disposal Requirements," "PCB Containers" (40 CFR 761.60(c))	Establishes substantive requirements applicable to the handling and disposal of PCB liquids, PCB articles, and PCB containers.	PCB liquids, articles, and/or containers may be encountered and/or generated during the remedial actions for 100-IU-2 and 100-IU-6.	100-IU-2 and 100-IU-6. Standards will be met for PCB liquids, articles and debris handling, storage and disposal.
"PCB Remediation Waste" (40 CFR 761.61)	Provides substantive cleanup and disposal options for PCB remediation waste based on the concentration at which the PCBs are found.	PCB remediation wastes may be encountered and/or generated during the remedial actions for 100-IU-2 and 100-IU-6.	100-IU-2 and 100-IU-6. Standards will be met for PCB remediation wastes.
Solid Wastes			
"Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities" (40 CFR 264)			
"Staging Piles" (40 CFR 264.554)	Establishes the substantive requirements for staging and accumulation of remediation waste during remedial operations.	Remediation wastes may be generated and accumulated during remedial actions at 100-IU-2 and 100-IU-6.	100-IU-2 and 100-IU-6. Standards will be met for remediation waste.

Table A-1. Applicable or Relevant and Appropriate Requirements

Regulatory Citation	Description of Regulatory Requirement	Rationale for Including	Application
"Hazardous Waste Management" (RCW 70.105, as amended); "Dangerous Waste Regulations" (WAC 173-303)			
"Identifying Solid Waste" (WAC 173-303-016) "Recycling Processes Involving Solid Waste" (WAC 173-303-017)	Identifies those materials that are and are not solid wastes and identifies those materials that are and are not solid wastes when recycled.	Solid wastes will be generated during 100-IU-2 and 100-IU-6 remedial actions that will be subject to solid waste and dangerous waste designation requirements.	100-IU-2 and 100-IU-6. Standards will be met for remediation activities
"Designation of Dangerous Waste" (WAC 173-303-070)	Establishes the substantive method for determining if a solid waste is a dangerous waste (or an extremely hazardous waste).	Dangerous/hazardous waste will be generated during 100-IU-2 and 100-IU-6 remedial actions.	100-IU-2 and 100-IU-6. Standards will be met for remediation (including waste treatment) activities that generate wastes.
"Requirements for Universal Waste" (WAC 173-303-077)	Identifies certain batteries, mercury-containing equipment and lamps as exempt from regulation under WAC 173-303-140 and WAC 173-303-170 through 173-303-9907 (excluding WAC 173-303-960). These wastes are subject to regulation under "Standards for Universal Waste Management" (WAC 173-303-573).	Waste sites in 100-IU-2 and 100-IU-6 contain universal wastes.	100-IU-2 and 100-IU-6. Remediation activities will meet standards for universal wastes.
"Recycled, Reclaimed, and Recovered Wastes" (WAC 173-303-120) "Recycled, Reclaimed, and Recovered Wastes" (WAC 173-303-120(3)) "Recycled, Reclaimed, and Recovered Wastes" (WAC 173-303-120(5))	Defines the requirements for the recycling of materials that are solid and dangerous waste. Specifically, "Recycled, Reclaimed, and Recovered Wastes" (WAC 173-303-120[3]) provides for the management of certain recyclable materials, including spent refrigerants, antifreeze, and lead acid batteries. "Recycled, Reclaimed, and Recovered Wastes" (WAC 173-303-120[5]) provides for the recycling of used oil.	Wastes that can be recycled, reclaimed, or recovered have the potential to be generated during 100-IU-2 and 100-IU-6 remedial actions.	100-IU-2 and 100-IU-6. Recycling of wastes subject to these requirements will be done in a manner that satisfies standards.
"Land Disposal Restrictions" (WAC 173-303-140)	Establishes treatment requirements and disposal prohibitions for land disposal of dangerous waste and incorporates by and the federal "Land Disposal Restrictions" (40 CFR 268).	Remediation may generate waste subject to land disposal restrictions.	100-IU-2 and 100-IU-6. Wastes subject to these requirements will be treated as required and disposed in a manner that satisfies standards.

Table A-1. Applicable or Relevant and Appropriate Requirements

Regulatory Citation	Description of Regulatory Requirement	Rationale for Including	Application
"Requirements for Generators of Dangerous Waste" (WAC 173-303-170)	Establishes the requirements for dangerous waste generators. "Requirements for Generators of Dangerous Waste" (WAC 173-303-170[3]), which includes the substantive provisions of "Accumulating Dangerous Waste On-Site" (WAC 173-303-200) by reference.	100-IU-2 and 100-IU-6 remedial actions may generate dangerous wastes.	100-IU-2 and 100-IU-6 remediation wastes (contaminated soil, personnel protective gear, treatment chemicals) may be dangerous waste, and will be managed in accord with these requirements.
"Accumulating Dangerous Waste On-Site" (WAC 173-303-200)	Establishes the requirements for accumulating wastes onsite. "Accumulating Dangerous Waste On-Site" (WAC 173-303-200) further includes certain substantive standards from "Use and Management of Containers (WAC 173-303-630) and "Tank Systems" (WAC 173-303-640) by reference.	100-IU-2 and 100-IU-6 remedial actions may generate dangerous wastes.	100-IU-2 and 100-IU-6 remediation wastes (contaminated soil, personnel protective gear, treatment chemicals) may be dangerous waste, and accumulations of such will be in accordance with these requirements.
"Use and Management of Containers" (WAC 173-303-630)	Establishes requirements for dangerous waste facilities that store containers of dangerous waste.	Remedial actions may involve management of dangerous waste in containers that are subject to this standard.	100-IU-2 and 100-IU-6. Investigation and remedial actions that produce or manage containers of dangerous waste will be managed to meet standards.
"Corrective Action Dangerous Waste Regulation Requirements" (WAC 173-303-64620(4))	Requires corrective action to be "consistent with" specified sections of "Model Toxics Control Act—Cleanup" (WAC 173-340).	The substantive portions of this regulation establish minimum requirements for *Washington State Hazardous Waste Management Act of 1976* (RCW 70.105, (as amended) corrective action.	At 100-FR-1, 100-FR-2, 100-FR-3, 100-IU-2, and 100-IU-6.
"Solid Waste Management—Reduction and Recycling" (RCW 70.95, as amended); "Solid Waste Handling Standards" (WAC 173-350)			
"Owner Responsibilities for Solid Waste (WAC 173-350-025) "Performance Standards" (WAC 173-350-040) "On-Site Storage, Collection and Transportation Standards" (WAC 173-350-300) "Remedial Action" (WAC 173-350-900)	Establishes minimum functional performance standards for the proper handling and disposal of solid waste, not otherwise excluded. Provides requirements for the proper handling of solid waste materials originating from residences, commercial, agricultural, and industrial operations, and other sources, and identifies those functions necessary to ensure effective solid waste handling programs at both the state and local level.	Covered solid waste will be generated during implementation of remedial actions.	100-IU-2 and 100-IU-6. Remedial actions that generate covered solid waste will meet standards.

Table A-1. Applicable or Relevant and Appropriate Requirements

Regulatory Citation	Description of Regulatory Requirement	Rationale for Including	Application
Historical and Archeological Resources			
***National Historic Preservation Act of 1966* (Public Law 89-665, as amended, 16 USC 470, et seq.)**			
"Protection of Historic Properties" (36 CFR 800)	Requires federal agencies to consider the impacts of their undertaking on cultural properties through identification and evaluation. Potential project adverse effects are to be avoided or mitigated. Need to take actions as necessary to minimize harm to any National Historic Landmarks.	Cultural and historic sites have been identified within 100-IU-2 and 100-IU-6.	100-IU-2 and 100-IU-6. Historical and cultural reviews have been done to identify cultural and historic sites. Additional reviews will be done at remedial action areas where existing reviews are not sufficient. For any discoveries, appropriate actions will be taken to meet standards.
***Protection and Enhancement of the Cultural Environment* (Executive Order 11593)**			
"National Historic Landmarks Program" (36 CFR 65)	These regulations set forth the criteria for establishing national significance. Requires that federal agencies shall, to the maximum extent possible, undertake such planning and actions as may be necessary to minimize harm to landmarks.	Cultural and historic sites have been identified within 100-IU-2 and 100-IU-6.	100-IU-2 and 100-IU-6. Remedial actions shall comply with this standard.
***Native American Graves Protection and Repatriation Act of 1990* (Public Law 101-601, as amended, 25 USC 3001, et seq.); "Native American Graves Protection and Repatriation Regulations" (43 CFR 10)**			
"Native American Graves Protection and Repatriation Regulations" (43 CFR 10)	Establishes federal agency responsibility for discovery, protection, and appropriate disposition of human remains, associated and unassociated funerary objects, sacred objects, and items of cultural patrimony.	Native American archaeological, cultural, and historic sites have been identified within 100-IU-2 and 100-IU-6; Native American remains and associated objects have the potential to be present.	100-IU-2 and 100-IU-6. Remedial activities will be conducted to identify, protect, and provide for appropriate disposition of covered human remains, objects, and items. Native American Tribal consultation will be conducted in the event of discovery.
***Archeological and Historic Preservation Act of 1974* (Public Law 93-291, as amended; 16 USC 469a-1 through 469a-2(d))**			
"Applicant Requirements" 16 USC 469a-1 through 469a-2(d)	Requires that federal projects do not cause the loss of archaeological or historic data. This act mandates preservation of the data; it does not require protection of the actual waste site or facility.	Archaeological and historic sites have been identified within, 100-IU-2 and 100-IU-6.	100-IU-2 and 100-IU-6. Remediation activities will prevent irreparable loss of significant scientific, prehistoric, or archeological data, the data will be preserved.

Table A-1. Applicable or Relevant and Appropriate Requirements

Regulatory Citation	Description of Regulatory Requirement	Rationale for Including	Application
Natural and Ecological Resources			
***Endangered Species Act of 1973* (Public Law 93-205, as amended; 7 USC Section 136; 16 USC 1531, et seq.)**			
Endangered Species Act of 1973, as amended 16 USC 1531–1544, specifically Sections 7 and 9(a) "Endangered and Threatened Wildlife and Plants" (50 CFR 17) (listings, prohibitions) "Interagency Cooperation—Endangered Species Act of 1973, as Amended" (50 CFR 402), "General Endangered and Threatened Marine Species" (50 CFR 222) to "Endangered Marine Anadromous Species" (50 CFR 224) "Critical Habitat for 13 Evolutionarily Significant Units (ESUs) of Salmon and Steelhead (*Oncorhynchus* spp.) in Washington, Oregon and Idaho," (50 CFR 226.212)	Prohibits actions by federal agencies that are likely to jeopardize the continued existence of listed species or result in the destruction or adverse modification of habitat critical to them. Also prohibits the taking of any endangered species.	100-FR-3 groundwater discharges into the Hanford Reach of the Columbia River, which contains the Upper Columbia River spring-run Chinook salmon and the steelhead, which are endangered. The spring-run Chinook salmon do not spawn in the Hanford Reach but use it as a migration corridor. Steelhead spawning has been observed in the Hanford Reach. The bull trout is listed as a threatened species but is not considered a resident species and is rarely observed in the Hanford Reach.	100-FR-3. Remediation actions will be managed to avoid jeopardy and/or adversely affect a listed species or critical habitat.
***Migratory Bird Treaty Act of 1918* (16 USC 703–712; Ch. 128; July 13, 1918; 40 Stat. 755), as amended**			
Migratory Bird Treaty Act of 1918 (16 USC 703–712) "General Provisions" (50 CFR 10) "Migratory Bird Permits" (50 CFR 21)	Protects all migratory bird species and prevents "take" of protected migratory birds, their young, or their eggs." Federal agencies are required to avoid or minimize impacts to migratory bird resources, restore or enhance their habitat and prevent or abate its detrimental alteration.	Migratory birds utilize 100-IU-2 and 100-IU-6.	100-IU-2 and 100-IU-6. Remedial actions will require mitigation measures to deter nesting by migratory birds on, around, or within remedial action site and methods to identify and protect occupied bird nests in a manner that complies with requirements.
"Powers and Duties," "Habitat Buffer Zone for Bald Eagles—Rules" (RCW 77.12.655); "Permanent Regulations," "Bald Eagle Protection Rules" (WAC 232-12-292)			
Bald and Golden Eagle Protection Act of 1940 (16 USC 668) "Eagle Permits" (50 CFR 22)	Protects eagle habitat to maintain eagle populations so the species is not classified as threatened, endangered, or sensitive in Washington State.	Bald eagles nest, feed, and overwinter along the shores of the Columbia River.	100-IU-2 and 100-IU-6. Remedial actions will be performed in a way to protect bald eagle habitat.

Table A-1. Applicable or Relevant and Appropriate Requirements

Regulatory Citation	Description of Regulatory Requirement	Rationale for Including	Application

ACM = asbestos-containing material
ALARA = as low as reasonably achievable
ARAR = applicable or relevant and appropriate requirement
BACT = best available control technology
CFR = *Code of Federal Regulations*
MCL = maximum contaminant level
MCLG = maximum contaminant level goal
MNA = monitored natural attenuation
NESHAP = "National Emission Standards for Hazardous Air Pollutants"
OU = operable unit
PCB = polychlorinated biphenyl
RCW = *Revised Code of Washington*
RTD = removal, treatment (as required), and disposal
TAP = toxic air pollutant
WAC = *Washington Administrative Code*

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Rev. 0

Remedial Design Report/ Remedial Action Work Plan Addendum for 100-FR-1, 100-FR-2, 100-IU-2, and 100-IU-6 Soils

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

DOE/RL-2014-44-ADD1
Rev. 0

Remedial Design Report/ Remedial Action Work Plan Addendum for 100-FR-1, 100-FR-2, 100-IU-2, and 100-IU-6 Soils

Date Published
August 2015

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

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Terms

ACM	asbestos-containing material
AOC	area of contamination
ALARA	as low as reasonably achievable
ARAR	applicable or relevant and appropriate requirement
bgs	below ground surface
BMP	best management practice
CERCLA	*Comprehensive Environmental Response, Compensation, and Liability Act of 1980*
CFR	*Code of Federal Regulations*
CTA	container transfer area
CVP	cleanup verification package
DOE	U.S. Department of Energy
DOE-RL	U.S. Department of Energy, Richland Operations Office
DOT	U.S. Department of Transportation
EPA	U.S. Environmental Protection Agency
ERDF	Environmental Restoration Disposal Facility
ETF	Effluent Treatment Facility
FS	feasibility study
IC	institutional control
IH	industrial hygiene
LDR	land disposal restricted
MTCA	"Model Toxics Control Act – Cleanup"
NCP	"National Oil and Hazardous Substances Contingency Plan"
NESHAP	"National Emission Standards for Hazardous Air Pollutants"
OU	operable unit
PAH	polycyclic aromatic hydrocarbon
PCB	polychlorinated biphenyl
PPE	personal protective equipment
RAO	remedial action objective

RAWP	remedial action work plan
RCBRA	river corridor baseline risk assessment
RCRA	*Resource Conservation and Recovery Act of 1976*
RDR	remedial design report
RESRAD	RESidual RADioactivity
RI	remedial investigation
ROD	record of decision
RTD	remove, treat, and dispose
SAP	sampling and analysis plan
SNF	spent nuclear fuel
SPA	staging pile area
STOMP	Subsurface Transport Over Multiple Phases
TRU	transuranic
Tri-Party Agreement	*Hanford Federal Facility Agreement and Consent Order*
USC	*United States Code*
WAC	*Washington Administrative Code*

1 Introduction

The *Record of Decision for the Hanford 100 Area Superfund Site, 100-FR-1, 100-FR-2, 100-FR-3, 100-IU-2, and 100-IU-6 Operable Units* (hereafter referred to as the 100-F/IU Area ROD) (EPA 2014) defines selected remedies for the listed operable units (OUs) of the Hanford Site (referred to collectively as the 100-F/IU Area). In general, these selected remedies consist of three categories:

- Remove, treat, and dispose (RTD) remediation for waste sites in the 100-IU-2 and 100-IU-6 OUs.
- Monitored natural attenuation for contaminated groundwater in the 100-FR-3 OU.
- Institutional controls (ICs) to protect the integrity of response actions and minimize exposure to contamination in soil and groundwater until such contamination is at levels that allow for unlimited use and unrestricted exposure (as defined in the *Integrated Remedial Design/Remedial Action Work Plan for 100-F/IU*, hereafter referred to as the Integrated RDR/RAWP [DOE/RL-2014-44]) . This includes general ICs as well as specific ICs for individual waste sites in the 100-FR-1, 100-FR-2, 100-IU-2, and 100-IU-6 OUs.

The Integrated RDR/RAWP (DOE/RL-2014-44) addresses overarching common elements and integration considerations for these three categories. This addendum supplements the Integrated RDR/RAWP in addressing implementation requirements specific to the soil remedy of RTD for waste sites in the 100-FR-1, 100-FR-2, 100-IU-2, and 100-IU-6 OUs, as well as certain IC components.

The OUs that comprise the 100-F/IU Area are depicted in Figure 1-1. The 100-FR-1 and 100-FR-2 OUs are associated with past activities at the 100-F Reactor Area. Waste sites in these OUs are generally related to the operational and waste management processes for former reactor operations and the associated experimental animal farm. These waste sites were primarily remediated under interim actions, and the associated area has been restored. The 100-IU-2 and 100-IU-6 OUs include the waste sites within the areas between and outside the reactor areas within the River Corridor. Waste sites in these OUs are predominantly related to nonradiological operations such as construction activities and general purpose disposal. Many of the waste sites in these OUs have been previously remediated under interim actions, but several waste sites remain to be remediated.

Waste site remedial actions have been ongoing in the 100-F/IU Area since 1996 under three interim action RODs:

- *Interim Action Record of Decision for the 100-BC-1, 100-DR-1, and 100-HR-1 Operable Units, Hanford Site, Benton County, Washington* (EPA 1995) and the associated *Amendment to the Interim Action Record of Decision for the 100-BC-1, 100-DR-1, and 100-HR-1 Operable Units* (EPA 1997);
- *Interim Action Record of Decision for the 100-BC-1, 100-BC-2, 100-DR-1, 100-DR-2, 100-FR-1, 100-FR-2, 100-HR-1, 100-HR-2, 100-KR-1, 100-KR-2, 100-IU-2, 100-IU-6, and 200-CW-3 Operable Units, Hanford Site, Benton County, Washington* (EPA 1999); and
- *Record of Decision for the 100-BC-1, 100-BC-2, 100-DR-1, 100-DR-2, 100-FR-2, 100-HR-2, and 100-KR-2 Operable Units, Hanford Site (100 Area Burial Grounds), Benton County, Washington* (EPA 2000).

These previous and ongoing remediation activities have been performed in accordance with the applicable revision of DOE/RL-96-17, *Remedial Design Report/Remedial Action Work Plan for the 100 Area* (hereafter referred to as the interim action RDR/RAWP). The interim actions have established much of

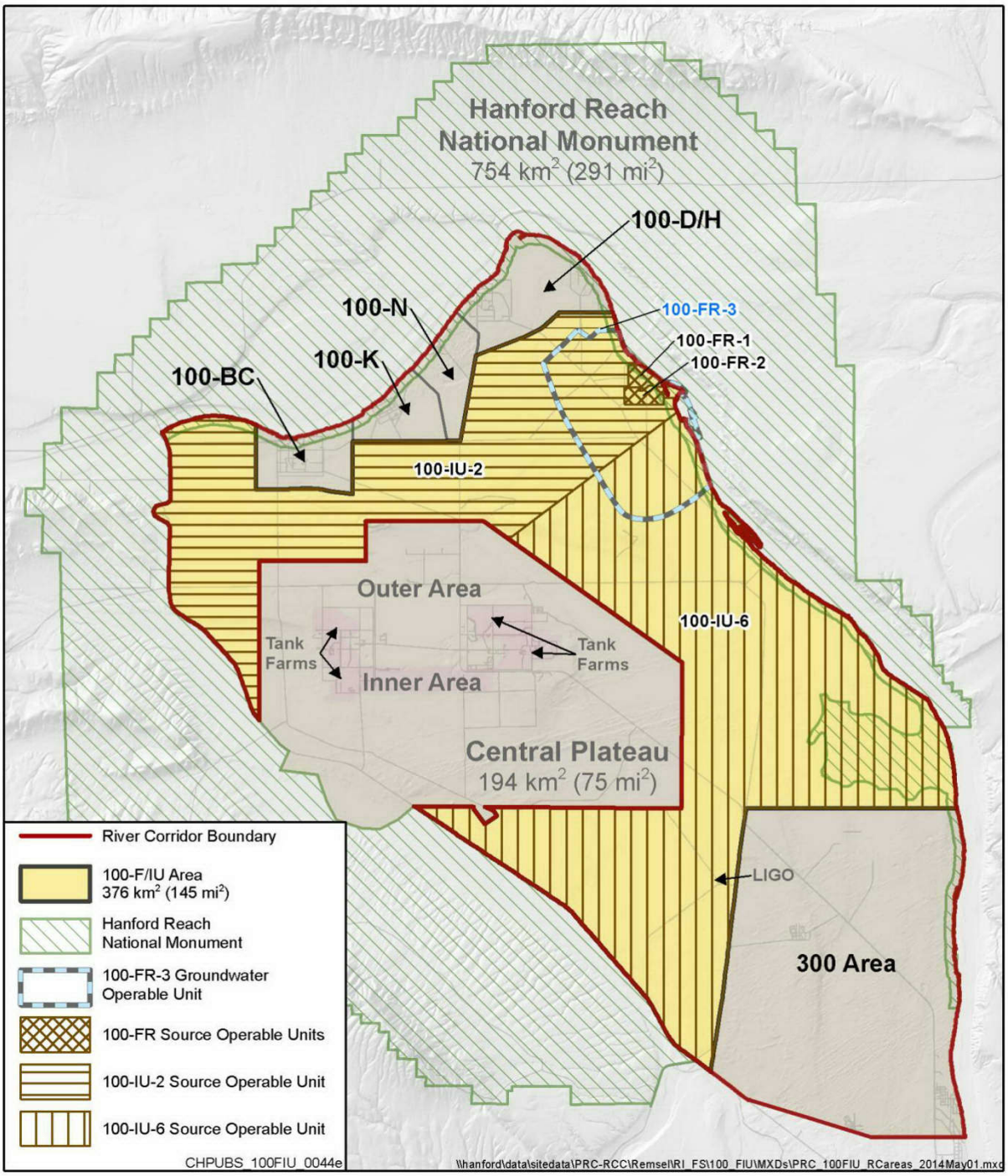

Figure 1-1. 100-F/IU Area Operable Units within the River Corridor

the document and process framework needed to successfully implement the scope of the 100-F/IU ROD. Upon approval, this addendum and the Integrated RDR/RAWP supersede the interim action RDR/RAWP for the 100-F/IU Area, but remedial designs, plans, and other regulatory agreements approved under interim actions shall remain in effect except where this addendum explicitly describes otherwise. Existing

lower tier documents that reference the interim action RDR/RAWP may continue to be used with the understanding that these references are superseded by this approved addendum and the associated Integrated RDR/RAWP (DOE/RL-2014-44). The interim action RDR/RAWP will continue to be applicable for other source OUs in the 100 Area for which a final action ROD has not yet been issued.

1.1 Purpose

The primary purpose of this addendum is to provide the RDR/RAWP to describe the design and implementation of the remedial action process required for RTD of 100-F/IU Area waste sites by the 100-F/IU Area ROD. In addition, this document addresses the requirements for completion of the remedial action process and the closeout/verification process for these waste sites in accordance with the 100-F/IU ROD. The contents of this document will be reviewed and revised as appropriate to reflect changes to the design and work plans for remedial action. In the meantime, any adjustments will be documented in the unit manager's meeting minutes and/or via change notices, as necessary.

1.2 Scope

This addendum supplements the Integrated RDR/RAWP to provide the RDR and RAWP for RTD of 100-F/IU Area waste sites. The *Hanford Federal Facility Agreement and Consent Order* (Tri-Party Agreement) (Ecology et al. 1989) lists the RDR and the RAWP as two separate documents. However, this document streamlines the requirements; the RDR and RAWP are combined to cover both the remedial designs and remedial actions.

1.2.1 Remedy Components and Waste Sites

This addendum addresses the following components of the 100-F/IU ROD:

- Removal of contaminated soil and associated debris from waste sites
- Treatment, as necessary, to meet waste acceptance criteria at an acceptable disposal facility
- Disposal of contaminated materials at the Hanford Site's Environmental Restoration Disposal Facility (ERDF) or other disposal facilities approved in advance by the U.S. Environmental Protection Agency (EPA)
- Backfilling and recontouring of excavated areas followed by planting with native vegetation
- ICs associated with access for active remediation areas.

The waste sites with a selected RTD remedy in the 100-F/IU Area ROD are identified in Table 1-1. If additional waste sites that may require remediation are identified beyond those listed in the table, they will be discussed with the U.S. Department of Energy, Richland Operations Office (DOE-RL) and the EPA for appropriate disposition. Summary information for all 100-FR-1, 100-FR-2, 100-IU-2, and 100-IU-6 waste sites is provided in Appendix A. Some of the waste sites identified in Table 1-1 have already been addressed and reclassified under interim actions. Activities for these waste sites may be limited to verification that the interim actions taken remain protective under the 100-F/IU ROD requirements without further remedial action, and associated documentation that these sites meet the 100-F/IU ROD requirements.

Table 1-1. Waste Sites Addressed by this Remedial Design Report/ Remedial Action Work Plan

Selected Remedy	Waste Site
RTD to residential cleanup levels	600-20, 600-279, 600-293, 600-294, 600-298:1, 600-298:2, 600-298:3, 600-298:4, 600-298:5, 600-298:6, 600-298:7, 600-298:8, 600-299:1, 600-299:2, 600-299:3, 600-299:4, 600-299:5, 600-299:6, 600-300:1, 600-300:2, 600-300:3, 600-300:4, 600-300:5, 600-300:6, 600-300:7, 600-300:8, 600-300:9, 600-300:10, 600-300:11, 600-300:12, 600-301, 600-303, 600-316:1, 600-316:2, 600-316:3, 600-316:4, 600-316:5, 600-316:6, 600-318:1, 600-318:2, 600-318:3, 600-318:4, 600-318:5, 600-320:1, 600-320:2, 600-320:3, 600-320:4, 600-320:5, 600-320:6, 600-320:7, 600-320:8, 600-320:9, 600-321:1, 600-321:2, 600-321:3, 600-321:4, 600-326:1, 600-326:2, 600-328, 600-329, 600-331, 600-332, 600-334:2, 600-349, 600-356, 600-358, 600-368, 600-369:1, 600-369:2, 600-369:3, 600-369:4, 600-369:5, 600-369:6, 600-369:7, 600-369:8, 600-370, 600-371, 600-372:1, 600-372:2, 600-373, 600-374, 600-375:1, 600-375:2, 600-375:3, 600-375:4, 600-375:5, 600-376:1, 600-376:2, 600-377, 600-378, 600-379

RTD = remove, treat, dispose

Buildings (including the 105-F Reactor Safe Storage Enclosure) are not part of the 100-F/IU Area ROD. Contaminated buildings have been demolished and removed in accordance with *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA) action memoranda (EPA and DOE 1997 and Ecology et al. 1998). Potential releases from those buildings may have resulted in waste sites that have been previously addressed or are within the scope of this document.

1.2.2 Waste Sites Containing Principal Threat Waste

Principal threat wastes are those source materials considered to be highly toxic and/or highly mobile that generally cannot be reliably contained and/or would present a significant risk to human health and/or the environment should exposure occur. Principal threat wastes associated with the 100-F/IU Area have already been removed through previous cleanup actions, and no further specific consideration is given in this document.

1.3 Report Organization

The essential elements of this RDR/RAWP are present in Sections 1.0 through 5.0, which comprise the main body of the report. The appendices present additional information and guidance. The contents of each section are briefly described below:

- Section 1.0, “Introduction,” presents the purpose, scope, and this overview of the report’s organization. Additional introductory and background information can be found in the integrated RDR/RAWP.
- Section 2.0, “Basis for Remedial Action,” presents the objectives, cleanup levels, cleanup verification approach, and applicable or relevant and appropriate requirements (ARARs).

- Section 3.0, "Remedial Action Design and Planning," presents the design and remediation planning components and process.
- Section 4.0, "Remedial Action Management and Approach" presents the details for field-implementation of the selected remedy and ICs specific to waste site remediation.
- Section 5.0, "Waste Management Plan," describes waste storage, transportation, packaging, handling, labeling, and disposal as applicable to waste streams for each waste site.
- Section 6.0, "References," contains all reference information used for the main body of the report.
- Appendix A, "Waste Site Information," presents a general description and status of all 100-FR-1, 100-FR-2, 100-IU-2, and 100-IU-6 waste sites.
- Appendix B, "Guidance for Cleanup Verification Packages," presents a detailed description of the cleanup verification process to aid in development and review of cleanup verification packages (CVPs).
- Appendix C, "Cleanup Levels," presents a summary of the development of the contaminant-specific numerical cleanup values.

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2 Basis for Remedial Action

The 100-F/IU Area ROD (EPA 2014) selected remedial action for specific waste sites based on a determination that remaining unremediated sites present an unacceptable risk to human health and the environment. The Integrated RDR/RAWP (DOE/RL-2014-44) provides the associated remedial action objectives (RAOs), which provide a narrative statement of the extent to which cleanup is necessary under the ROD. This chapter then provides the associated analyte-specific soil cleanup levels and requirements for their application, as well as the ARARs for 100-F/IU Area remedial action.

2.1 Cleanup Levels

DOE's reasonably anticipated future use for the 100-F/IU Area is conservation and preservation. The U.S. Environmental Protection Agency and the Washington State Department of Ecology believe that other uses, including residential use, are reasonably anticipated future land use. To achieve RAOs, numerical cleanup levels for residential land use were calculated during the 100-F/IU Area remedial investigation/feasibility study (RI/FS) (DOE/RL-2010-98, *Remedial Investigation/Feasibility Study for the 100-FR-1, 100-FR-2, 100-FR-3, 100-IU-2, and 100-IU-6 Operable Units*) and promulgated by the 100-F/IU Area ROD (EPA 2014). These cleanup levels also allow for conservation and preservation uses.

Soil cleanup levels for direct contact human health receptors were developed using standard approaches, consistent with state and federal guidance. Direct contact cleanup levels for nonradionuclides are based on risk calculations provided in the Washington State's "Model Toxics Control Act – Cleanup" (MTCA) procedures. Direct contact cleanup levels for radionuclides are calculated based on an excess lifetime cancer risk of $1x10^{-4}$ or a radiological dose of 15 mrem/yr. For each radionuclide, the lower of the risk or dose-based calculations is used as the cleanup level.

Soil cleanup levels for groundwater and surface water protection were also developed based on current state and federal guidance and, consistent with guidance, incorporate site-specific data from the 100-F/IU Area. Soil cleanup levels are described below based on a residential scenario with irrigation. Irrigation provides an increased amount of water to the soil, and a relatively high 72 mm/yr of water is assumed to reach groundwater. The irrigated residential scenario is used to identify the potential for groundwater and surface water contamination to occur from waste sites due to higher groundwater recharge rates associated with the irrigation of crops and was used to develop the residential cleanup levels.

Cleanup levels are calculated for single contaminants. For sites with multiple residual contaminants, risks from individual contaminants will be added and evaluated (as described in Section 2.2.2) to ensure that the waste site meets total risk limits as specified in CERCLA and the "National Oil and Hazardous Substances Contingency Plan" (NCP) (40 *Code of Federal Regulations* [CFR] 300). When a groundwater protection cleanup level is exceeded, site-specific information will be evaluated to determine if remediation has achieved the RAOs.

The *River Corridor Baseline Risk Assessment* (RCBRA) (DOE/RL-2007-21) and the RI/FS report (DOE/RL-2010-98) evaluated ecological risks at interim remediated waste sites with upland habitats for potential ecological risks. The RI/FS used information from the RCBRA and from other sources to evaluate the risk to populations and communities of ecological receptors, and determined that interim remedial actions that achieved interim action ROD cleanup levels for protection of human health were also protective of ecological receptors and there was no ecological risk at remediated waste sites within the 100-F/IU Area. Further, the 100-F/IU Area RI/FS report (DOE/RL-2010-98) concluded that there were no contaminants of ecological concern or ecological risk to populations and communities due to the

100-F/IU Area waste sites in riparian, near-shore, and river environments. These conclusions considered the size of waste sites relative to ecological receptor home ranges. The 100-F/IU Area ROD (EPA 2014) then determined that, for 100-F/IU Area waste sites that have not been remediated under interim actions, residual contamination will not be sufficient to adversely impact populations and communities of ecological receptors once human health cleanup levels are achieved. As such, no further evaluation of ecological risks will be performed for individual waste sites addressed under this RDR/RAWP.

The cleanup levels for a residential land-use scenario are included in Appendix C, Table C-1 for radiological and nonradiological constituents. The methodology used to arrive at these values is summarized in Appendix C of this document and in the 100-F/IU Area ROD (EPA 2014). For the purpose of using the RESidual RADioactivity (RESRAD) dose model, unrestricted future use in the 100-F/IU Area is represented by an individual resident in a rural-residential setting. This resident is assumed to consume and irrigate crops raised in a backyard garden, consume animal products (e.g., meat and milk) from locally raised livestock or meat from game animals (including fish), and live in a residence on the waste site. The exposure pathways considered in estimating dose from radionuclides in soil are inhalation; soil ingestion; ingestion of crops, meat, fish, drinking water, and milk; and external gamma exposure. Based on EPA guidance, this individual is conservatively assumed to spend 60% of his/her lifetime (15 hr/day, 350 days/yr) indoors on site and 12% of their time (3 hr/day, 350 days/yr) outdoors on site. The assumptions used for the unrestricted land-use scenario are also described in Appendix C of this document.

Soil cleanup levels for nonradionuclides were calculated using the MTCA Method B equations provided by *Washington Administrative Code* (WAC) 173-340-740(3) for carcinogens and noncarcinogens. For both carcinogens and noncarcinogens, the calculations assume that a resident with an average body weight of 16 kg (35 lb) over the period of exposure ingests soil at a rate of 200 mg/day (73 g/yr), with a frequency of contact of 100% and a gastrointestinal absorption rate of 100%. For individual nonradionuclide carcinogenic chemicals, the calculation is based on achieving an excess lifetime cancer risk goal of $1x10^{-6}$ for an exposure duration of 6 years and a lifetime of 75 years. For noncarcinogens, the calculation is based on achieving a hazard quotient of 1.

Soil cleanup levels for the protection of groundwater and surface water are based on site-specific data for the 100-F/IU Area and current federal drinking water standards and state water quality standards (EPA 2014). Contaminant-specific soil cleanup levels for the protection of groundwater and surface water were calculated based on site-specific data and specific parameters using the Subsurface Transport Over Multiple Phases (STOMP) code with a one-dimensional model. For highly mobile contaminants (retardation coefficient < 2), the model assumes the entire vadose zone from ground surface to groundwater is contaminated. For less mobile contaminants (retardation coefficient ≥ 2), the model assumes the top 70% is contaminated and the bottom 30% is not contaminated. Based on this model, no soil cleanup level for groundwater or river protection is calculated for some contaminants because they are calculated to not reach the groundwater within 1,000 years at levels that contaminate groundwater above drinking water standards (or would contaminate the river above surface water standards).

For the residential land-use scenario, it is assumed that the period of analysis for evaluation of site risks and groundwater protection is 1,000 years, and direct exposure of onsite residents to residual contamination to a depth of 4.6 m (15 ft) may occur (this represents a reasonable estimate of the soil depth that could be excavated and distributed at the soil surface as a result of site development activities).

2.2 Application of Cleanup Levels

2.2.1 Cleanup Levels Based on Vadose Zone Depth

For soil cleanup levels based on human exposure via direct contact or other exposure pathways where contact with the soil is required to complete the pathway, the point of compliance shall be established in the soils throughout the site from the ground surface to 4.6 m (15 ft) below the ground surface per WAC 173-340-740(6)(d). This represents a reasonable estimate of the depth of soil that could be excavated and distributed at the soil surface as a result of site development activities. Soils and materials 4.6 m (15 ft) or more below ground surface are referred to as being in the deep zone whereas the materials above 4.6 m (15 ft) below ground surface (bgs) are referred to as being in the shallow zone. The direct exposure cleanup levels are applicable to the ground surface and soils or materials within the shallow zone. Groundwater protection and river protection cleanup levels are applicable to soils in both the shallow and the deep zones. However, if a site will meet the direct exposure cleanup criteria throughout the site excavation, it is appropriate to handle the entire site as a shallow zone decision unit regardless of the depth of the excavation. This may be advantageous for site closeout because a site that meets the more restrictive shallow zone criteria will not have a requirement for deep zone ICs.

The RAOs call for prevention of human exposure to the upper 4.6 m (15 ft) of soil, structures, or debris with contaminants of concern at concentrations above cleanup levels and management of contaminated soils below 4.6 m (15 ft). Generally, this would entail RTD of soils below 4.6 m (15 ft) exceeding cleanup levels in Table C-1 for groundwater and river protection for waste sites in the scope of this addendum. It is anticipated that (under limited circumstances) factors such as nature and form of contaminated material, implementability, cost, volume, and impacts to ecological and cultural resources may be used to evaluate the extent of excavation at depths greater than 4.6 m (15 ft). Appropriate remedy selection change documentation (e.g., a memorandum-to-file, explanation of significant differences, or ROD amendment, based on the nature of the exception) will be prepared and public involvement will be provided for, if necessary. Regardless of these factors, protection of groundwater and the Columbia River must be achieved for any contamination left below 4.6 m (15 ft) (i.e., alternative remedial measures must be evaluated).

The soil cleanup levels apply to soil and structures (including pipelines and debris). Cleanup levels do not apply to constituents that are an integral part of manufactured structures. Application of soil cleanup levels to sediment and scale within pipelines and similar structures may be over-conservative, depending on site-specific conditions. Where there are exceedances of cleanup levels in sediment/scale data, but not in corresponding underlying soil, alternative demonstrations of RAO attainment may be used with EPA approval. For example, the EPA may approve use of a matrix-correction approach to adjust contaminant concentrations to consider a combined scale and pipeline wall matrix. The EPA may also approve qualitative demonstrations of protectiveness based on site-specific considerations.

2.2.2 Multiple Contaminant Concentrations

Cumulative effects associated with the presence of multiple radionuclide or nonradionuclide contaminants at waste sites must be evaluated to ensure that the waste site meets total risk limits as specified in CERCLA, the NCP, and MTCA. The following standards must be met for cumulative effects of multiple contaminants:

- Total excess cancer risk from all nonradionuclide constituents must not exceed 1×10^{-5}.
- Total of all toxicity hazard quotients for nonradionuclide constituents must be a hazard index of less than 1.

- Cumulative risk of all radionuclides must not exceed the CERCLA risk range of 10^{-4} to 10^{-6} or a radiological dose of 15 mrem/yr, where that limitation is more conservative.
- Summation of the predicted groundwater dose from all beta- and photon-emitting radionuclides must be less than 4 mrem/yr.

The 2007 MTCA cleanup regulation, WAC 173-340-708(8)(e), provides a method to determine compliance with cleanup levels for mixtures of carcinogenic polycyclic aromatic hydrocarbons (PAHs). Mixtures of carcinogenic PAHs are considered as a single hazardous substance, and the cleanup levels established for benzo(a)pyrene are used as the cleanup levels for mixtures of carcinogenic PAHs. Cleanup verification samples are analyzed to determine the concentration of each carcinogenic PAH listed in Table 2-1 (from Table 708-2 of the 2007 MTCA cleanup regulation). Following the guidelines of Appendix B, statistical values representing the PAH COC concentrations for each decision unit are calculated or the maximum detected value is selected when the COC is detected in fewer than 50% of the samples (and for focused samples). The selected value for each PAH is multiplied by the corresponding toxicity equivalency factor in Table 2-1 to obtain the toxic equivalent concentration of benzo(a)pyrene for that carcinogenic PAH. The toxic equivalent concentrations of all the carcinogenic PAHs are added to obtain the total toxic equivalent concentration of benzo(a)pyrene for the decision unit. This value is compared against the cleanup level for benzo(a)pyrene from Table C-1 to determine compliance. The results of this determination are included in the waste site CVP as described in Appendix B.

2.2.3 Discovery of Additional Contaminants

Contaminants of concern were selected in the 100-F/IU Area ROD (EPA 2014) based on review of available characterization data, waste site history and processes, and characterization of analogous waste sites, and are listed in Appendix C (Table C-1). In the event that contaminants are discovered during remediation for which cleanup levels were not established in the ROD, the information will be presented to the DOE and EPA project managers for determination of a path forward.

Table 2-1. Toxic Equivalency Factors for Carcinogenic Polyaromatic Hydrocarbons [a]

CAS Number	Carcinogenic Polyaromatic Hydrocarbons	Toxic Equivalency Factors
50-32-08	Benzo(a)pyrene	1
56-55-3	Benzo(a)anthracene	0.1
205-99-2	Benzo(b)fluoranthene	0.1
207-08-9	Benzo(k)fluoranthene	0.1
218-01-9	Chrysene	0.01
53-70-3	Dibenz(a,h)anthracene	0.1
193-39-5	Indeno(1,2,3-cd)pyrene	0.1

a. From WAC 173-340-708(8)(e), Table 708-2.

CAS = Chemical Abstract Services

2.3 Verification of Waste Site Cleanup

Appendix B provides guidance for the process by which CVPs are prepared and reviewed. The purpose of the CVP is to document that the relevant waste site has been remediated in accordance with the applicable ROD and that the RAOs under the applicable land-use scenario have been achieved. Site-specific data evaluations are presented in the CVP to demonstrate that the waste site, following remediation, does not pose an unacceptable risk to human health and is protective of groundwater and the river.

The primary determination of the successful completion of remediation is the comparison of analysis of residual COC concentrations against cleanup levels in appropriate tables. In addition, site-specific factors such as the concentration of the contaminants at depth, the type of waste site (solid or liquid), and calculations of residual site risks are used to verify that remaining concentrations of contaminants are protective of direct exposure and groundwater and the Columbia River (see Appendix B). Development of a site-specific contaminant distribution model may be necessary to more accurately describe actual site conditions and show that contaminant concentrations decrease with soil depth. Use of analogous sites and process knowledge, or a test pit or borehole, may be needed to establish the distribution of contaminants with respect to soil depth. A site-specific contaminant distribution model, using actual field data, will more accurately predict potential impacts of vadose zone soil contaminants on groundwater and the river. The model information will be used to determine if the residual concentrations of contaminants in the unsaturated vadose zone are protective of groundwater and the river, or if further excavation of remaining contamination in the unsaturated vadose zone is required. Results will be documented in the CVP.

2.4 Applicable or Relevant and Appropriate Requirements

The NCP (40 CFR 300) and the 100-F/IU Area ROD require that the remedial actions comply with ARARs established in the ROD. The purpose of this section is to summarize how each of the ARARs identified in the ROD will be met during remedial action.

Activities associated with the remedial action for the source area waste sites covered under the ROD are expected to occur on-site, as that term is defined under the NCP. As a result, the remedial actions described in this document must meet the substantive, but not administrative, requirements of the ARARs established in the ROD. In the event that any portion of the remediation work occurs at an offsite location (e.g., waste treatment at an offsite facility), the work is required to comply with all applicable requirements. The sites addressed by the 100-F/IU Area ROD and ERDF are reasonably close to one another, and the wastes meeting the ERDF waste acceptance criteria (WCH-191) are compatible for the selected disposal approach. Therefore, the waste sites and ERDF are considered to be a single site for response purposes.

If any requirement that might be an ARAR for the remedial action is promulgated subsequent to issuance of the 100-F/IU Area ROD, the DOE and EPA will review the requirement and determine if compliance with the new requirement is necessary to ensure that the remedy is protective of human health and the environment, in accordance with 40 CFR 300.430(f). If necessary to ensure protection of human health and the environment, the selected remedy will be revised to incorporate the newly promulgated ARAR.

2.4.1 Chemical-Specific ARARs

Chemical-specific ARARs are typically health- or risk-based regulatory values or methodologies that are applied to site-specific media and used to establish cleanup criteria. Chemical-specific ARARs for source waste site remedial action selected in the ROD are as follows:

- **WAC 173-340-740, "Unrestricted Land Use Soil Cleanup Standards":** Establishes methodology for calculating soil cleanup levels based on unrestricted land use (WAC 173-340-740(3)); adjustments to calculated cleanup levels to take into account cumulative effects of multiple contaminants and exposure pathways, adjustments based on state and federal law, and adjustments in consideration of natural background levels and practical quantitation limits (WAC 173-340-740(5)); points of compliance where cleanup levels must be attained (WAC 173-340-740(6)); and monitoring protocols for sampling, analysis, and statistical methods used to determine compliance (WAC 173-340-740(7)). Soil cleanup levels for unrestricted land use have been selected in the ROD. Sampling and analysis requirements and locations will be addressed in accordance with a sampling and analysis plan (SAP) for waste sites undergoing remediation; considerations for cumulative effects of multiple contaminants will be documented in closeout documentation as described in Appendix B.

- **WAC 173-340-747, "Deriving Soil Concentrations for Groundwater Protection":** Establishes methodology for determining soil concentrations that will not cause contamination of groundwater at levels that exceed groundwater cleanup levels under WAC 173-340-720. Soil cleanup levels to ensure protection of groundwater have been selected in the ROD, using alternative fate and transport modeling as allowed in WAC 173-340-747(8).

- **WAC 246-247-035(1)(a)(ii), "National Standards Adopted by Reference for Sources of Radionuclide Emissions" (adopting by reference 40 CFR 61.92):** Requires that airborne emissions from all combined operations at the Hanford Site not exceed 10 mrem/yr effective dose equivalent to any member of the public. For source waste site remedial actions, standard construction techniques such as use of water spray to control fugitive emissions of radioactively contaminated dust and particles will be used to meet this ARAR.

2.4.2 Action-Specific ARARs

Action-specific ARARs typically are technology- or activity-based requirements or limitations triggered by a particular type of action such as excavation, transport, and/or disposal of hazardous waste. Action-specific ARARs for source waste site remedial action selected in the ROD are as follows:

- **WAC 173-400-040, "General Standards for Maximum Emissions":** All sources and emission units are required to meet the general emission standards unless a specific source standard is available. General standards apply to visible emissions, particulate fallout, fugitive emissions, odors, emissions detrimental to health and property, sulfur dioxide, and fugitive dust. Remedial actions will be conducted in a manner to ensure compliance with substantive provisions of these standards. In particular, compliance with these requirements will be achieved by the use of fixatives and water sprays to control emissions of contaminated dust and particulates.

- **WAC 173-400-075, "Emission Standards for Sources Emitting Hazardous Air Pollutants":** This section identifies emission standards for hazardous air pollutants from various sources and adopts, by reference, "National Emission Standards for Hazardous Air Pollutants" (NESHAP), 40 CFR 61. These sources are, for the most part, industry specific and not expected to be encountered or implemented as part of 100-F/IU Area source waste site remediation, with the exception of standards

for asbestos emissions (discussed under the ARAR entry for 40 CFR 61 Subpart M) and radionuclide emissions (discussed under the ARAR entry for WAC 246-247).

- **WAC 173-460, "Controls for New Sources of Toxic Air Pollutants":** These requirements are considered applicable if a treatment technology that involves toxic air pollutant emissions is necessary during implementation of the source waste site remedial action. No treatment requirements have been identified at this time for 100-F/IU Area source unit waste sites that would be required to meet the substantive requirements of WAC 173-460. Treatment of some waste encountered during the remedial action may be required to meet the ERDF waste acceptance criteria. In most cases, the type of treatment anticipated would consist of solidification/stabilization techniques, and the provisions of WAC 173-460 would not be an ARAR. If the need for any treatment technology with toxic air pollutant emissions potentially subject to WAC 173-460 is identified, DOE will notify the EPA and an evaluation of WAC 173-460 requirements will be conducted.

- **WAC 173-480, "Ambient Air Quality Standards and Emission Limits for Radionuclides"; WAC 246-247, "Radiation Protection – Air Emissions":** These standards specify that airborne radionuclide may not exceed 10 mrem/yr to the whole body of any member of the public (WAC 173-480-040/WAC 246-247-035). The radionuclide emission standard applies to fugitive, diffuse, and point-source air emissions generated during excavation or treatment of source waste site contaminated soil within the 100-IU-2 and 100-IU-6 OUs. Compliance with the standard is determined on a Hanford Site-wide basis and is documented in the annual radionuclide air emissions report for the Hanford Site. WAC 173-480-050 requires that all emission units make every reasonable effort to maintain radioactive materials in effluents to unrestricted areas to levels that are as low as reasonably achievable (ALARA). WAC 173-480-060 and WAC 246-247-040(3) require the application of best available radionuclide control technology to control radioactive air emissions for new emission units; WAC 246-247-040(4) requires use of ALARA-based control technology for existing emission units. WAC 246-247-075 and WAC 173-480-070 establish monitoring, testing, and quality assurance requirements for emissions of radioactive material; WAC 246-247-035(1)(a)(i) and (ii) require determination of compliance with numerical limits in accordance with NESHAP emission tests. 100-F/IU Area remediation activities associated with radionuclides are required to meet all these standards, including associated design, work practices, and/or air emissions controls. Monitoring, testing, and quality assurance requirements will be defined in an air monitoring plan to be approved by the lead regulatory agency. Standard construction techniques such as using water spray to control fugitive emissions of contaminated dust and particulates will be used to meet emission standards of WAC 173-480 and WAC 246-247 when excavating source waste sites.

- **40 CFR 61 Subpart M, "National Emission Standard for Asbestos":** 40 CFR 61.140 and 61.145 define regulated asbestos-containing material (ACM) and regulated removal and handling requirements, and specify sampling, inspection, handling, and disposal requirements for regulated sources having the potential to emit asbestos. No visible emissions are allowing during handling, packaging, and transport of ACM. 40 CFR 61.150 identifies requirements for the removal and disposal of asbestos from demolition and renovation activities, and also specifies no visible emissions. Buried ACM may be encountered during excavation of source waste sites and on pipelines or other structures excavated as part of remedial action within the 100-IU-2 and 100-IU-6 OUs. ACM associated with remedial actions will be handled consistent with the applicable or relevant requirements of 40 CFR 61.140, 40 CFR 61.145, and 40 CFR 61.150.

- **40 CFR 761, "Polychlorinated Biphenyls (PCBs) Manufacturing, Processing, Distribution in Commerce, and Use Prohibitions":** 40 CFR 761.50(b)(1), (2), (3), (4), and (7) and (c) establish general requirements for the storage and disposal of polychlorinated biphenyl (PCB) wastes including liquid PCB wastes, PCB items, PCB remediation waste, PCB bulk product wastes, and PCB/radioactive wastes at concentrations exceeding 50 ppm PCBs. Specific handling and disposal requirements are established for PCB liquids, articles, and PCB containers in 40 CFR 761.60(a), (b), and (c), respectively. PCB remediation waste requirements are established in 40 CFR 761.61. Substantive requirements of these provisions would generally be applicable to PCB wastes encountered during remedial action for source waste sites. Remedial action will comply with these requirements through adherence to waste management procedures (see Chapter 5) and receiving facility waste acceptance criteria (e.g., WCH-191, *Environmental Restoration Disposal Facility Waste Acceptance Criteria*).

- **40 CFR 265.554, "Staging Piles":** Establishes substantive standards for temporary storage of solid, nonflowing hazardous remediation waste in staging piles. Hazardous remediation waste from the 100-IU-2 or 100-IU-6 OUs stored in staging piles shall be managed in accordance with Section 5.4.3.

- **WAC 173-303, "Dangerous Waste Regulations":** WAC 173-303 establishes a variety of substantive requirements applicable to generation, storage, treatment, and disposal of materials designated as dangerous waste. Dangerous waste associated with remedial actions in the 100-F/IU Area will comply with substantive provisions of the identified requirements through adherence to waste management procedures (see Chapter 5) and, for disposal, the receiving facility's waste acceptance criteria (e.g., WCH-191, *Environmental Restoration Disposal Facility Waste Acceptance Criteria*.) Specific provisions of WAC 173-303 identified in the ROD as ARARs are as follows:

  - **WAC 173-303-016, "Identifying Solid Waste," and WAC 173-303–017, "Recycling Processes Involving Solid Waste":** These sections establish criteria for identifying materials that are and are not solid wastes, including materials that are or are not solid wastes when recycled in certain ways.

  - **WAC 173-303-070, "Designation of Dangerous Waste":** Establishes the method for determining if a solid waste is regulated as a dangerous waste.

  - **WAC 173-303-077, "Requirements for Universal Waste":** This section exempts universal waste (i.e., certain batteries, mercury-containing equipment, and lamps) from most of the requirements of WAC 173-303 in lieu of alternative, less stringent management requirements.

  - **WAC 173-303-120, "Recycled, Reclaimed, and Recovered Wastes":** Describes requirements for persons who recycle materials that are solid and dangerous wastes. Certain recyclable materials, including scrap metal, spent refrigerants, spent antifreeze, and lead acid batteries, are subject to less stringent standards under WAC 173-303-120 when being recycled. WAC 173-303-120(5) provides for the recycling of used oil.

  - **WAC 173-303-140, "Land Disposal Restrictions":** Establishes treatment requirements and prohibitions for land disposal of dangerous waste. Provisions incorporate treatment standards for federal *Resource Conservation and Recovery Act of 1976* (RCRA) hazardous or mixed (hazardous and radioactive) wastes, in addition to establishing requirements for land disposal of certain state-only (nonfederally regulated) dangerous waste.

- **WAC 173-303-170, "Requirements for Generators of Dangerous Waste":** Establishes requirements for generators of solid waste, including requirements to determine if the waste is regulated as a dangerous waste; requirements for generators who accumulate dangerous waste on site in tanks, containers, or containment buildings for a period of 90 days or less; and requirements for generators who treat waste in onsite containers, tanks, or containment buildings within 90 days of waste generation.
- **WAC 173-303-200, "Accumulating Dangerous Waste On-Site":** Establishes requirements for accumulating dangerous waste on site in containers, tank systems, or containment buildings. Invokes various substantive standards for management of dangerous waste in containers and tanks. Container waste storage exceeding 90 days would be subject to the substantive requirements of WAC 173-303-630.
- **WAC 173-303-630, "Use and Management of Containers":** Establishes substantive requirements for management of containers holding dangerous waste, including requirements for maintaining containers in good condition, identifying container contents, using containers that are compatible with stored waste, keeping containers closed when not adding or removing waste, maintaining adequate aisle space, providing secondary containment for containers of liquid dangerous waste, and standards for storage of containers holding ignitable or reactive waste and incompatible wastes.
- **WAC 173-303-64620(4), "Requirements" (corrective action):** Requires corrective action for releases of dangerous waste and dangerous constituents and establishes minimum standards for implementing actions. Corrective action performed under CERCLA authority must be consistent with these standards. The process, selected action, and implementation of the remedial action for the 100-IU-2 and 100-IU-6 OUs satisfy this requirement.

- **WAC 173-350, "Solid Waste Handling Standards":** These regulations establish minimum standards for the proper handling and disposal of nondangerous, nonradioactive solid waste. Performance standards of WAC 173-350-040 require that solid waste facilities be designed, constructed, operated, and closed in a manner that does not pose a threat to human health or the environment, and that comply with other applicable environmental laws. WAC 173-350-300 establishes requirements for onsite storage of solid waste in containers and for collection and transportation in a manner that avoids littering or releases. Remedial action will comply with these requirements through adherence to the waste management procedures in Chapter 5.

2.4.3 Location-Specific ARARs

Location-specific ARARs are restrictions or requirements placed on hazardous substance concentrations or remedial actions based on the specific location of the substance or action. The location-specific ARARs established in the ROD are discussed below.

- **36 CFR 65, "National Historic Landmarks Program," 36 CFR 800, "Protection of Historic Properties,":** These provisions require that federal agencies consider the impacts of their actions on cultural properties through identification and evaluation. Potential adverse effects are to be avoided or mitigated. Historical and cultural reviews have been performed to identify cultural and historic sites within the 100-IU-2 and 100-IU-6 OUs. Additional reviews will be done, if necessary, at remedial action areas. Remedial actions will be performed in a manner to avoid or mitigate impacts on identified cultural properties, and to minimize harm to any National Historic Landmarks.

- **43 CFR 10, "Native American Graves Protection and Repatriation Regulations":** These provide requirements for federal agency responsibilities for discovery, protection, and appropriate disposition of human remains, associated and unassociated funerary objects, sacred objects, and items of cultural patrimony. Remedial activities in the 100-IU-2 and 100-IU-6 OUs will be conducted in a manner to identify, protect, and provide for appropriate disposition of covered human remains, objects, and items. In the event of a discovery of covered items, Native American Tribal consultation will be conducted.

- **"Archaeological and Historic Preservation Act of 1974," 16 USC §469a-1 through 469a-2d:** Requires that Federal projects do not cause the loss of archaeological or historic data through preservation; it does not require protection of the actual waste site or facility. Remediation activities in the 100-IU-2 and 100-IU-6 OUs will prevent irreparable loss of significant scientific, prehistoric, or archeological data through preservation.

- ***Migratory Bird Treaty Act of 1918*:** These requirements are applicable to the protection of migratory bird species associated with the 100-F/IU Area, including upland species and waterfowl. "Taking" of protected migratory birds, their young, or their eggs is prohibited. Federal agencies are required to avoid or minimize impacts to migratory bird resources, restore or enhance their habitat, and prevent or abate detrimental alteration. 100-F/IU Areas remedial actions will require mitigation measures to deter nesting by migratory birds on, around, or within remedial action sites, and methods to identify and protect occupied bird nests.

- **"Bald and Golden Eagle Protection Act," 16 USC §668, and 50 CFR 22:** Requires protection of eagle habitat to maintain eagle populations so the species is not classified as threatened, endangered, or sensitive. Bald eagles nest, feed, and overwinter along the shores of the Columbia River. Remedial actions in the 100-IU-2 and 100-IU-6 OUs will be performed in a way to protect bald eagle habitat.

3 Remedial Action Design and Planning

This chapter describes the framework for remedial action designs and other associated planning documents. Due to interim actions in the 100 Areas, many of the components described in this chapter have already been completed and implemented in ongoing waste site remediation.

3.1 Remedial Action Planning

The remedial action schedules for cleanup of the Hanford Site are driven by a set of milestones that have been established as part of the Tri-Party Agreement (Ecology et al. 1989), and which may be renegotiated as remediation proceeds. Scheduled future milestones associated with cleanup of the OUs associated with the 100-F/IU Area under the interim action ROD are summarized in Table 3-1, and may be renegotiated to align with the 100-F/IU Area ROD in accordance with the Tri-Party Agreement. Milestones presented are based on previous Tri-Party agreements for the interim action ROD and do not reflect schedule changes associated with the 100-F/IU Area ROD.

Cost estimates for remediation of remaining waste sites were prepared as part of the 100-F/IU Area RI/FS (DOE/RL-2010-98) and were subsequently carried forward into the 100-F/IU Area ROD (EPA 2014). The estimates were prepared with an accuracy of -30% to +50% to support evaluation of remedial alternatives and selection of a remedy. Cost estimates are updated based on design work. In accordance with CERCLA requirements, an explanation of significant differences will be pursued by the Tri-Parties if remediation costs change significantly from those identified in the ROD (generally more than -30% to +50%).

3.1.1 Detailed Remediation Planning

Project schedules are developed in accordance with the procedures of the performing contractor at several different levels consistent with the project work breakdown structure. The work breakdown structure-based schedules promote complete and consistent compliance with DOE O 413.3, *Program and Project Management for the Acquisition of Capital Assets,* and cost and schedule control systems criteria. Large-scale (multi-year) projects encompassing multiple smaller projects (e.g., each waste site remediation can be considered a single project, while the entire project is to remediate all waste sites) are generally planned and scheduled using a phased approach. Near-term (less than 1 year) work is usually planned and scheduled at a detail activity level using logic ties to establish and maintain a true critical-path schedule. Logic-driven, critical-path schedules, commonly referred to as the critical-path method, are used to manage and control the daily progress of the work and provide early warning of problem areas. Forecast planning and scheduling (1 to 2 years) can be performed at the task-package level, and long-range planning and scheduling (greater than 2 years) is performed at the work package or cost account levels. Planning elements at the work package level include, but are not limited to or bound by, remedial design, procurement, remedial actions, and site closures.

Some of the tiered planning documentation (e.g., remedial designs) may require approval by the lead regulatory agency, if requested. When reviews are required, DOE shall provide the documentation to the lead regulatory agency for review and approval. Summary briefings and discussions may be held at unit manager's meetings or other forums, as agreed. Issues will be identified and resolved in a timely manner to prevent or minimize impacts to schedules, including those for procurement. Specific processes for remedial design reviews and approvals are provided in Section 3.2.

Table 3-1. Summary of Tri-Party Agreement Milestones for 100-IU-2 and 100-IU-6 Waste Site Remediation[a]

Milestone	Description	Due Date/ Complete Date
M-016-149	Complete 100-IU-2/6 interim response actions for the following waste sites: 600-293, 600-294, 600-298, 600-299, 600-300, 600-301, 600-303, 600-305, 600-309, 600-310, 600-313, 600-316, 600-318, 600-319, 600-320, 600-321, 600-328, 600-329, 600-331, 600-332, 600-334, 600-326, 600-349, 600-358, 600-368, 600-369, 600-370, 600-371, 600-372, 600-373, 600-374, 600-375, 600-376, 600-377, 600-378, and 600-379.	March 31, 2016
M-016-00A	Complete all response actions for the 100 Area units (except groundwater actions that are covered under Major Milestone M-016-00 and 100-K Area response actions addressed in M-016-00C) by the specified due date as approved in a RDR/RAWP. Completion of response actions is defined as the completion of the ROD or action memorandum requirements in accordance with an approved RDR/RAWP or removal action work plan and EPA and/or Ecology approval of waste site reclassification forms.	March 31, 2017

a. The Tri-Party Agreement milestones presented in Table 3-1 address the selected remedy and schedule previously established in consideration of the interim action RODs for the 100 Area. These milestones may be renegotiated in accordance with the Tri-Party Agreement to align with the requirements of the 100-F/IU Area ROD.

Ecology = Washington Department of Ecology

EPA = U.S. Environmental Protection Agency

RDR/RAWP = remedial design report/remedial action work plan

ROD = Record of Decision

3.1.1.1 Remedial Action Design

Remedial designs are prepared by the remediation contractor and include all design work, project plans, project procedures, remediation cost estimating, drawings, and specifications required to perform the remediation. Project plans, procedures, and work packages will define the data-gathering requirements to ensure worker health and safety and to eventually prove the waste sites meet remediation goals and standards. Project procedures will define the "how to" of obtaining data and controlling the site activities. Planning documentation is discussed further in Section 3.3. Scope of work, design drawings, and specifications will also provide the necessary technical tools to procure subcontractors, as needed.

3.1.1.2 Remedial Actions

Remedial action includes implementing the remedial design and project plans. The implementation will include, but not limited to, subcontractor oversight, excavation, material handling, waste treatment,

analytical system operations, worker health and safety, radiological controls, data gathering, and overall daily conduct of operations. Subcontractor oversight occurs through administration of subcontract documents. Project specifications and procedures define the "how to" of excavation, material handling, analytical system operation, data gathering, and overall daily conduct of operations. Appropriate worker health and safety and radiological control requirements are included in site health and safety plans, permits, and job hazard analyses included in work packages.

3.1.1.3 Site Verification and Closeout

Site verification and closeout includes, but is not limited to, data collection (including samples and photographs), data evaluation, data interpretation, preparation of documentation, and EPA approval that the RAOs have been met via waste site reclassification or other documentation.

3.2 Remedial Action Design

Remedial action design includes all design work, project plans, project procedures, remediation cost estimates, drawings, and specifications required to perform the remedial action. Project plans will define the data-gathering requirements to ensure worker health and safety and to eventually prove that the waste sites meet remediation goals and standards. Project procedures and work packages define the "how to" of obtaining data and controlling the site activities. DOE shall provide the remedial action designs to the lead regulatory agency for review and approval, if requested. Summary briefings and discussions may be held at unit manager's meetings or other forums, as agreed. Issues will be identified and resolved in a timely manner to prevent or minimize impacts to schedules for issuing requests for proposals. Remedial action designs that were prepared and initiated or approved under the interim action ROD, and where the remedy selected in the 100-F/IU Area ROD has not significantly changed the designed work, will not require new review and approval.

The following process will be followed to implement the remedial action design review and approval process and may be modified at the 100 Area unit manager's meeting or via other documentation (e.g., Tri-Party Agreement change notice):

- When requested, DOE shall provide the draft remedial design package and design schedule to the lead regulatory agency at the unit manager's meetings, or deliver to the local field office.
- The lead regulatory agency shall provide notice to DOE in a timely manner, if approval is warranted, usually within 3 to 5 days.
- The lead regulatory agency review period is generally 2 weeks. If additional review time is necessary, the review period can be increased up to 4 weeks. If more than 4 weeks is required due to the complexity of the project, DOE and the lead regulatory agency shall agree to the review period, as necessary. To minimize impacts to the schedule, additional review time should be communicated early in the process.
- Review comments and issues shall be identified and resolved in a timely manner. Review comments and issues, including responses or resolutions, shall be documented in the unit manager's meetings, letters, or other forums, as agreed.
- DOE shall provide a copy of the final remedial design package, with comments incorporated, to the lead regulatory agency at the unit manager's meetings, deliver to the local field office, or otherwise transmit.

- A documented approval should be communicated to DOE by the lead regulatory agency within a reasonable time frame. The approval should reference the specific design and indicate that approval by the lead regulatory agency is warranted.

3.3 Other Remedial Action Planning Documents

Additional planning documentation for remedial action includes work packages and procedures, the SAP, health and safety plan(s), ecological and cultural resource reviews, air monitoring plans, technical performance specifications, and safety analysis/hazard classifications. Many of these planning documents have previously been prepared and issued under the interim action RDR/RAWP. As described in the following subsections, the existing documents may continue to be used under this RDR/RAWP, with the understanding that references to the interim action RDR/RAWP are superseded by this approved addendum and the associated Integrated RDR/RAWP (DOE/RL-2014-44).

3.3.1 Work Packages and Procedures

Work packages and procedures are used to provide guidance to site workers during field work execution. They define the scope, operations, progression of field work, personnel control requirements, radiological posting requirements, and analytical system guidance. Work packages and procedures are developed by multi-disciplinary involvement following a graded approach. The personnel responsible for compliance with this RDR/RAWP are included in the development process for work packages to ensure that applicable requirements are incorporated or addressed. The site superintendent (or other site contractor responsible party) must then execute field operations in compliance with these work packages.

3.3.2 Sampling and Analysis Plan

The SAP provides direction for sampling efforts to support excavation guidance, waste characterization, worker health and safety, and site closure for 100-F/IU Area waste site remediation. The SAP includes quality assurance project plans that define the strategy to control the quality and reliability of the analytical data and establish associated protocols for data management. The field analytical team must perform all sampling and analysis efforts in compliance with the applicable SAP and any site-specific sampling instructions or agreements developed in accordance with that SAP. The *100 Area Remedial Action Sampling and Analysis Plan* (DOE/RL-96-22) remains in effect for 100-F/IU Area remedial actions. New or revised SAPs are provided by DOE to the EPA for review and approval.

3.3.3 Health and Safety Plan

Health and safety plans for waste site remediation within the 100 Area have been developed to provide direction for general site health and safety measures associated with the remedial action scope. All remedial action contractor project personnel will be trained on the applicable health and safety plan. Job hazard analyses are developed for task-specific controls and are included in work packages.

3.3.4 Ecological and Cultural Resource Reviews

Prior to remedial action or the construction of support areas, cultural and ecological resource reviews are conducted to determine if the proposed activities in these areas will impact natural or cultural resources. The first line of action is to avoid or minimize impacts by siting activities in areas with the least potential for impact to significant resources. When impacts to natural or cultural resources are unavoidable, the project is given recommendations to minimize impacts. Additional mitigation may be required if criterion for a threshold area of disturbance or habitat quality is met.

3.3.5 Air Monitoring Plan

The substantive requirements applicable to radioactive air emissions resulting from remediation activities are to quantify potential emissions, monitor the emissions, and identify and employ best available radionuclide control technology. Exemption from these requirements may be requested if the potential-to-emit for the activity or emission unit would result in a total effective dose equivalent of less than 0.1 mrem/yr. Implementation of these elements fulfills the ARARs identified in Section 2.4. The use of best available radionuclide control technology includes, but is not limited to, dust suppression (e.g., water, water sprays, fixatives) and the use of other standard engineering controls (e.g., high-efficiency particulate air filter vacuum cleaners). Air monitoring plans incorporating these components are provided to the lead regulatory agency for approval.

3.4 Technical Performance Specifications

Technical performance specifications are prepared as needed to support remedial actions. Remediation of these sites requires soil removal, segregation, storage, transportation, disposal, and backfilling. Technical performance specifications may include the following areas:

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

Each technical specification establishes quality and workmanship requirements and defines how quality is measured.

3.5 Safety Analysis/Emergency Preparedness

Hazards associated with the proposed remedial actions addressed in this document are examined based on anticipated inventories of radioactive and/or hazardous materials and appropriate controls identified, and the hazard categorization is documented as warranted. Hazard categorization documentation, as well as analysis of radioisotopes and hazardous material for emergency response planning for waste sites requiring remediation, will be prepared before initiating excavation operations.

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4 Remedial Action Management and Approach

The Integrated RDR/RAWP (DOE/RL-2014-44) identifies the overall remedial action management and approach for implementation of the 100-F/IU Area ROD (EPA 2014). This chapter describes the components of the project team, change management approach, remedial action operations, and waste site closure processes specific to RTD at 100-IU-2 and 100-IU-6 waste sites.

4.1 Project Team

The project team for soil remediation consists of the lead agency (DOE), the lead regulatory agency (EPA), and DOE-RL's selected contractor(s). The contractor project managers are responsible for leading project teams in remedial action implementation. The project teams contain the personnel necessary to perform the remedial actions in a safe, efficient, and compliant manner.

4.2 Remedial Action Change Management

Change management will be performed as described in the Integrated RDR/RAWP (DOE/RL-2014-44). The contractor project manager is responsible for tracking all changes and obtaining appropriate reviews by staff for changes affecting 100-F/IU Area waste site remediation. The project manager will discuss the proposed change with DOE-RL, and DOE-RL will then discuss the type of change that is necessary with the EPA. As the lead regulatory agency, the EPA is responsible to determine the significance of the change.

4.3 Remedial Action Operations

The components of the selected remedy addressed by this addendum are identified in Section 1.2.1. This section describes general mobilization and RTD operations for waste sites. This section also identifies ICs associated with remedial action operations.

4.3.1 Mobilization and Site Preparation

Mobilization and site preparation include the following activities that are necessary to prepare the site for excavation:

- Establishing site utility services as required.
- Constructing necessary roads, field support facilities, container survey stations, and decontamination stations. Hanford Site roadways are constructed of existing site materials, except the surface course, which is imported. Field support facilities may include restrooms, changing facilities, lunchrooms, and construction offices; multiple facility support areas may be used for remediation of 100-IU-2 and 100-IU-6 waste sites.
- Stripping the existing vegetation and debris. Stripping removes surface and near-surface materials (including vegetation and roots, cobbles, and boulders) that may be stockpiled (where practicable) and used later as a top dressing and planting medium for revegetation. For sites where topsoils contain hazardous debris material or do not meet cleanup levels, the material is not stockpiled for reuse. In these cases, stripping may still be performed, with resulting material managed for disposal as waste, or surface material may be removed as part of general excavation activities without a discrete surface-stripping effort.

- Removing overburden material. Clean overburden and layback soils may be segregated and stockpiled on site for later use as backfill material.
- Removing slabs and foundations of demolished buildings, when necessary for access to underlying soil.

4.3.2 Remove, Treat, and Dispose

This subsection addresses activities specific to RTD remediation of waste sites. During all aspects of RTD, dust control will be maintained on the haul roads, at the excavation site, on overburden stockpiles, and in the staging pile areas (SPAs). Use of water for dust control at the excavation site will be minimized. Soil fixatives (e.g., soil cement) will be applied during periods of extended inactivity and/or when potential concerns arise about health issues or the spread of contamination.

Under the RTD process, contaminated soils and engineered structures containing contamination (e.g., pipelines) with COCs exceeding cleanup levels will be remediated up to 4.6 m (15 ft) bgs to meet cleanup levels for direct exposure, groundwater, and surface water protection as identified in Chapter 2. Remediation will continue below 4.6 m (15 ft) bgs where site COC concentrations exceed cleanup levels for groundwater and surface water protection. Site-specific modeling and consideration may be used to demonstrate protectiveness for COC concentrations at greater than 4.6 m (15 ft) bgs nominally above cleanup levels.

Engineered structures at waste sites identified for RTD, including pipelines, may be left in place if it can be demonstrated that residual contamination is not present or is present at residual concentrations that achieve RAOs. The cleanup levels do not apply to chemicals that are an integral part of manufactured structures, and site-specific consideration may be given for applying cleanup levels to sediment/scales within pipelines or other structures. When asbestos in nonfriable form (e.g., asbestos in the pipe matrix, asbestos impregnated in tar paper-wrapped water pipes) is encountered in the shallow zone, as in pipelines, and no other CERCLA hazardous waste is associated with the pipelines other than asbestos in nonfriable form, remediation of such pipelines is not required (DOE-RL et al. 2005c).

4.3.2.1 Excavation

Excavation involves removing clean and contaminated soil, debris, and anomalous waste present within the site boundaries. For dump sites with subsurface debris, materials will be excavated with standard construction equipment, sorting as necessary to remove anomalous material and large debris. Excavated materials may be stockpiled and staged in an approved SPA for subsequent load-out or may be loaded directly into waste transportation containers/vehicles at the excavation site.

In excavation areas where there are large quantities of observed lead-containing materials (e.g., lead bricks, lead slag) intermixed with the soil, observation, sorting, and radiological surveys (as necessary) for removal of the large materials and non-lead anomalous materials will be performed. The remaining materials may then be identified as meeting the RCRA definition of "soil" per 40 CFR 268.2 and considered hazardous/dangerous due to lead contamination. In such cases, the soil will be sampled in accordance with the SAP and transported to the ERDF or other approved facility for treatment (stabilization) and subsequent disposal.

Material from waste site areas that are not subsurface dump sites or burial grounds (e.g., pipelines or soil-staining sites) where anomalous material is not encountered does not require mechanical sorting. This material may be directly loaded into containers after enough information is gathered to characterize the waste.

Sluicing (use of water) is not an acceptable excavation method. Selection of the excavation/sorting method will be made by remedial action project management, and the method may be changed to another approved method based on the type of material being excavated. Alternate excavation/sorting methods (e.g., vacuum systems, metal detectors) may be proposed by the project on a case-by-case basis and implemented with concurrence from the DOE and EPA project representatives. During the excavation process, care will be taken to prevent the breakage or puncture of unopened or sealed cans, jars, and containers.

Material that has been excavated will be directed in one of the following ways.

- Radiologically contaminated material that is above cleanup levels and within the ERDF waste acceptance criteria (WCH-191) will be loaded into plastic-lined roll-off containers on project haul trucks at the excavation site. ACM will be double-bagged or put into roll-off containers that are double-lined. The loaded containers will be covered (i.e., by folding and securing the liner over the load) and surveyed prior to being transported to a container transfer area (CTA) using the project haul trucks. If radiological contamination is found on a container exterior, the container will be decontaminated using standard equipment and techniques. In the unlikely event that a container cannot be decontaminated using standard methods, advanced techniques, such as those described in Section 4.3.2.6, will be implemented as necessary. Released containers will be offloaded and staged in the CTA until applicable shipping papers (e.g., a waste tracking form) are completed. When the shipping papers have been completed, ERDF transport vehicles will enter the CTA, pick up the full containers, and haul them to the ERDF.

- Nonradiologically contaminated material above cleanup levels and within ERDF waste acceptance criteria (WCH-191) may be loaded into plastic-lined or unlined roll-off containers as described above or may be direct-loaded into material handling vehicles (e.g., dump trucks) for transportation to ERDF. ACM will be double-bagged or put into roll-off containers that are double-lined.

- Anomalous waste (e.g., drums, intact containers, or unknown materials) and/or above-cleanup-level material that is not within ERDF waste acceptance criteria (WCH-191) will be set aside within the area of contamination (AOC) or within a designated SPA for further characterization and final dispositioning. Waste that is subsequently identified for ERDF disposal or staging will be directed as described previously, with the exception that drummed waste may be transported in standard ERDF containers or by other means such as flatbed trailers or cargo vans. Excavated material that must be sent to facilities other than ERDF for treatment and/or disposal will be stockpiled or drummed and staged within the AOC, within designated SPAs, or within a container storage area until loaded for offsite shipment. Identification of an appropriate treatment and/or disposal facility and arrangements for loading and transporting excavated material to facilities other than ERDF will be made on a case-by-case basis by project waste management personnel. Prior to shipment, an offsite acceptability determination in accordance with 40 CFR 300.440 must be obtained from the EPA for receipt, storage, treatment, and disposal of CERCLA waste at the identified treatment/disposal facility.

- Land disposal restricted (LDR) waste or containers of LDR waste that are not within the ERDF waste acceptance criteria may need repackaging or treatment to comply with the ERDF waste acceptance criteria (WCH-191). LDR waste that has been placed into a container will not be placed back into the AOC (i.e., on the land), except by EPA approval. Land disposal restricted waste may be removed from a container and placed directly into another container, even within the designated AOC boundary, as long as no land placement occurs. Containerized LDR waste that needs to be placed on the ground for treatment or repackaging will be done within an SPA or as otherwise approved by the EPA.

- Material that is free of anomalous waste and below cleanup levels may be stockpiled on site for use as backfill material.
- In certain situations, soil may be placed over material excavated within a waste site or discovered within a staging pile as a temporary measure. Such action may be undertaken to minimize an imminent threat to workers (e.g., a high-dose item is uncovered, and a temporary soil cover is appropriate to control worker exposure). Temporary covering with soil may also be undertaken to prevent windborne dispersal of excavated material or highly contaminated soil and to maintain segregation from other waste site materials. These temporary measures may be undertaken while plans are developed for safe re-excavation and removal of waste site materials. In these instances lead regulator notification will be made.
- Non-LDR material that has been packaged may be returned to an excavation area or SPA in situations where the dose rates, contamination levels, free liquids, or other abnormalities have subsequently been determined to exceed normal transport requirements. In these situations, when repackaging is necessary, the previously excavated material will be reloaded into the transportation container. Notification to the lead regulatory agency is generally not required for these actions. The exception is LDR waste, which shall be managed in accordance with the fourth bullet above.
- An approved LDR treatment method for radioactively contaminated cadmium-, silver-, and mercury-containing batteries allows for macroencapsulation prior to disposal. However, lead-acid batteries are not covered by this standard and require initial treatment (draining corrosive liquids, treating separately prior to disposal) (DOE-RL et al. 2005b).
- While not anticipated for 100-IU-2 and 100-IU-6 waste sites, if suspect spent nuclear fuel (SNF) is discovered, it must be managed as SNF and is not eligible for disposal in ERDF. Shielded bunkers will be used for interim storage of the SNF with minimum specifications of (1) a 1.8-m (6-ft)-tall security fence, and (2) a bunker constructed of concrete shielding blocks including a heavy metal lid or concrete shielding block cover. Spent nuclear fuel will be characterized for shipment to the Canister Storage Building facility until an offsite storage or disposal facility authorized to manage SNF becomes available (DOE-RL et al. 2005b).
- While not anticipated for 100-IU-2 and 100-IU-6 waste sites, if transuranic (TRU) waste material is discovered, it must be identified as either contact-handled TRU waste or remote-handled TRU waste and managed in accordance with the waste acceptance criteria of the receiving facility (WCH-126, *600 Area Remediation Design Solution Waste Packaging, Transportation, and Disposal Requirements*).

All material being transported from the excavation site is covered, contained, or has moisture content adequate for inhibiting dust without being covered or contained during transport and disposal. The moisture content of bulk contaminated material destined for ERDF disposal will be in accordance with ERDF waste acceptance criteria (WCH-191).

Excavated material will be surveyed and characterized as necessary for appropriate disposition prior to undertaking disposal of materials. When excavation of a waste site is complete, exposed dig faces will be evaluated to verify that remedial action goals have been met. When cleanup levels have been met and backfill concurrence is obtained from the lead regulatory agency, site backfill will be authorized. Approval of a waste site reclassification form constitutes approval for backfill, or the lead regulatory agency may approve backfill in advance. (Note: Unless specified otherwise, the term "backfill" as used in this document refers to filling in and/or recontouring the excavation once post-waste site remediation sampling has demonstrated that cleanup levels have been met.) Clean backfill material is obtained from

clean material storage areas, approved/clean rubble, and local borrow sites. Excavations are backfilled as described in Section 4.4.4.

4.3.2.2 Material Handling and Transportation

All contaminated materials (including excavated soils, debris, disposable protective clothing, air filters, and trash) require proper packaging, handling, and transportation in accordance with the waste management plan provided in Chapter 5. Contaminated bulk materials will be transported to disposal using approved vehicles/containers. Drummed waste may either be loaded into standard ERDF containers or be transported by other means such as flatbed tractor-trailer units or cargo vans.

Containers will be transported from the remediation site to the ERDF over existing Hanford Site roadways. Each shipment of soil/debris transported to the ERDF will be referenced to a waste profile that is intended to provide an upper bound on the concentrations of contaminant materials found at the site. The waste profile is in effect until the characteristics of the excavation site have changed significantly. Empty containers returning from the ERDF will be removed from the ERDF tractor trailers in the CTA and rolled onto project haul trucks for refilling. The CTA helps to maintain a continuous flow of materials through the transportation system by allowing excavation to continue for a limited time if the trucks running to the ERDF are not operating, or it allows ERDF trucks to continue to run for a limited time if the excavators are not operating.

The containers are inspected for the presence of water prior to placing a liner or waste into the container. When water is found in a container with an estimated volume of 151 L (40 gal) or less (less than a depth of 1.27 cm [0.5 in.] in the bottom of the container), the water may be used as an aid for dust suppression in an adjacent excavation or staging pile, or absorbent materials may be used in the container. When water is found in the container with an estimated volume greater than 151 L (40 gal), lead regulatory agency approval is necessary to use the water as an aid for dust suppression.

An alternative to transporting loaded containers from the excavation area to the CTA, then from the CTA to ERDF, is to load excavated material directly into material handling vehicles. These vehicles then proceed directly to ERDF and the CTA is not used. The advantages of this method are that material handling vehicles can transport larger quantities and duplicate handling of excavated material is eliminated. Excavated material must not be radiologically contaminated and must meet the conditions of the applicable waste shipping and receiving plan.

Transportation and handling for offsite treatment and/or disposal of contaminated material will be coordinated on a case-by-case basis. All offsite shipments will be conducted using equipment and methods that are compliant with applicable U.S. Department of Transportation (DOT) regulations and DOE/RL-2001-36, *Hanford Sitewide Transportation Safety Document*.

4.3.2.3 Soil and Debris Characterization

Soil and debris characterization will be based on the observational approach and performed in accordance with the SAP. This approach relies on available historical information and limited field investigations combined with a "characterize-and-remediate-in-one-step" methodology. The latter methodology consists of the use of field screening instrumentation (e.g., radiological survey instruments), visual evaluation of waste forms encountered during remediation, and in-process analytical sampling. These elements are used together and in consideration of waste site-specific information to characterize waste as remediation proceeds. Remediation continues until a combination of field screening results, sampling results, and/or observed absence of waste debris provides initial indication that cleanup goals have been achieved. Site-specific verification is performed as described in Section 4.4.

4.3.2.4 Decontamination

Radiological decontamination, when necessary to support excavation activities, will generally be performed using dry methods (e.g., wiping and high-efficiency particulate air-filtered vacuum cleaners) to the extent possible. When the use of wet methods (e.g., pressure washers and steam cleaners) is required to achieve decontamination objectives and the associated water or cleaning solutions are not collected, work will be conducted by trained site workers in accordance with the best management practices (BMPs) described below. Other decontamination, when necessary, will generally be performed using wet methods in accordance with the following BMPs.

General BMPs. These apply to all equipment cleaning/decontamination activities within a waste site:

- Decontamination activities are typically performed within active excavation areas of the AOC.
- The amount of water used to clean equipment will be minimized.
- Only raw or potable water will be used.
- Soaps, detergents, or other cleaning agents that would be regulated as a hazardous waste will not be added to wash water.
- Pressure washing will normally use cold water (hot water may be used to avoid icing).
- Steam cleaning will be used only after other methods prove to be ineffective.
- Decontamination practices will be documented in the daily log.
- Personnel responsible for equipment decontamination will be trained to this best management practice.

BMPs for Sites where remediation is ongoing. These apply to equipment being washed and/or decontaminated within sites that have ongoing remediation, or at a decontamination area established outside of the waste sites.

- Equipment washing/decontamination will be located in areas with ongoing waste removal or in a centralized area that supports multiple remedial actions.
- Spent wash water and associated contamination will be kept within active areas of the AOC or within the decontamination area if located outside of the AOC.
- Pre- and post-washing/decontamination contaminant surveys are not required.
- The project may opt to collect wash water for reuse in the excavation or to be sent for treatment.

BMPs for sites where remediation is complete. These apply to equipment being washed and/or decontaminated where cleanup levels are anticipated to have been achieved and further active remediation is not expected.

- At the "completion" of excavation activities at a site, the project may opt to transport the equipment to a nearby site that is being remediated (by excavation) to perform equipment washing/decontamination (as described above), or to utilize a defined decontamination area.
- A pre- and post-survey will be performed on the washing/decontamination area to assess and remediate (if required) areas affected by the activity. When the washing/decontamination is set up in

an area of a site that has apparently attained the cleanup levels, sampling of the area may be performed in accordance with the SAP, at the discretion of the lead regulatory agency.

- The project may also opt to perform other methods of equipment washing and/or decontamination for a completed site (e.g., wrap the equipment for transfer to a decontamination pad, provide for a temporary facility at the site to collect wash water, fix the contamination to the equipment).

4.3.3 Implementation of Institutional Controls for Waste Site Remediation

ICs are required before, during, and after the active phase of remedial action implementation where ICs are necessary to protect human health and the environment. ICs are used to control access to residual contamination in soil above standards for unlimited use and unrestricted exposure. ICs are required during remedial action and after cleanup is complete, or until the site meets the requirements for unlimited use and unrestricted exposure (as defined in the Integrated RDR/RAWP (DOE-RL-2014-44)).

The Integrated RDR/RAWP (DOE/RL-2014-44) provides general description of the ICs specified under the 100-F/IU Area ROD (EPA 2014). Details for implementation are described in DOE/RL-2001-41, *Sitewide Institutional Controls Plan for Hanford CERCLA Response Actions and RCRA Corrective Actions* (as revised). Under the 100-F/IU Area ROD, 15 previously remediated 100-FR-1 and 100-FR-2 sites were identified that require ICs to prevent inadvertent exposure to residual contamination in the deep zone. While not anticipated, additional 100-IU-2 and 100-IU-6 sites requiring similar post-remediation ICs may be identified through the course of remediation. Such ICs may be conservatively applied where deep zone areas cannot be demonstrated to be protective of shallow zone criteria, as described in Chapter 2. The 100-F/IU Area ROD also identifies one 100-FR-1 waste site where ICs are required to prohibit irrigation. This type of IC is not anticipated for any remaining 100-IU-2 or 100-IU-6 waste sites under the scope of this addendum. Implementation of ICs for the 16 waste sites identified in the ROD and any additional sites that may be identified is addressed under the *Sitewide Institutional Controls Plan for Hanford CERCLA Response Actions and RCRA Corrective Actions*, and is not addressed further in this addendum. Implementation of the ROD requirement to provide signage and access control for waste sites with contamination above cleanup levels is described below.

- Signage is posted and will be maintained at various locations around the perimeter of the Hanford Site, and one additional sign is located along the Columbia River at the 100-F Reactor Area. The sign set consists of one each in English and Spanish. The sign posted along the river is located so that the distance for viewing from the river is approximately 150 m (500 ft). The English language sign reads as follows:

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

  The Spanish language sign reads as follows:

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

General site access to the Hanford Site is restricted, and security badges must be worn by employees, contractors, and visitors. Before receiving a badge, personnel must receive the level of training required to access the site or perform work or be appropriately escorted.

4.4 Site Verification and Closeout

Site verification and closeout includes sample collection, demonstration of attainment of RAOs, cleanup documentation, site closure, and site release, as summarized in the following subsections.

4.4.1 Verification Sample Collection

Verification samples of the residual soil from within the excavated site, any clean soil stockpiles intended for use as backfill material, and residual soil from SPAs (if applicable) will be collected in accordance with the applicable SAP, as described in Section 3.3.2, including site-specific work instructions or other documented agreements for verification sample collection. Results from the verification samples will be used to demonstrate attainment of the RAOs.

4.4.2 Attainment of Remedial Action Objectives

The general approach for verifying attainment of RAOs involves the following steps:

- Performing data verification and validation
- Calculating summary statistics appropriate to the verification data set
- Evaluating summary statistics against the appropriate cleanup levels
- If needed, modeling exposure and risk to future site inhabitants
- If needed, modeling future impacts to groundwater and the Columbia River.

A detailed description of the process for verifying attainment of the RAOs is provided in Appendix B of this document.

4.4.3 Attainment of Remedial Action Objectives in Orchard Areas

Some 100-F/IU Area waste sites are co-located within the estimated seven square miles of pre-Manhattan era orchard lands at the Hanford Site. The soils within these orchard lands are expected to contain residual lead and arsenic as a result of past pesticide use for the orchards. Such pesticide contamination is being addressed as the separate 100-OL-1 OU that is not within the scope of the 100-F/IU Area ROD, the Integrated RDR/RAWP, and this soil addendum. Co-located lead and arsenic contaminated soils will be addressed per the following protocol for the purposes of 100-F/IU waste site remediation and reclassification:

- If lead and/or arsenic concentrations in the top 1 m (3.3 ft) of a waste site exceed background, and evidence such as review of historical photographs and maps indicates that the site could be affected by former orchard pesticide use, it will be assumed that the lead and arsenic concentrations are the result of pesticide use. Such lead and arsenic concentrations may be remediated incidentally where present with other COCs above cleanup levels, but will not be considered in evaluations for waste site reclassification.

- If lead and/or arsenic concentrations exceed background, but not cleanup levels, below 1 m (3.3 ft) depth, and evidence indicates that the site could be affected by former orchard pesticide use, it will be assumed that the lead and arsenic concentrations are the result of pesticide use. Such lead and arsenic concentrations may be remediated incidentally where present with other COCs above cleanup levels, but will not be considered in evaluations for waste site reclassification.

- If lead and/or arsenic concentrations exceed cleanup levels below 1 m (3.3 ft) depth, and other COCs are not present above cleanup levels, a path forward will be developed with the lead regulatory agency. This may include further evaluation and/or remediation. For waste sites where fill material was placed over the surface following historic pesticide applications, the depth of the fill will be considered additively with the 1 m (3.3 ft) depth in evaluating lead and arsenic concentrations.

4.4.4 CERCLA Cleanup Documentation

Subsequent to determining that the RAOs have been attained, waste site reclassification documentation will be prepared, typically including a supporting CVP or other closeout documentation. The waste site reclassification documentation will document the remedial action process, verification sampling results (if applicable), and attainment of the RAOs under the appropriate land use at a site; and will support the eventual removal of the OU from the National Priorities List. Waste site reclassification documentation may be prepared for groups of sites or individual sites, as needed, in accordance with the guidance provided in Appendix B. Closeout documentation may also be used to support other CERCLA closeout documentation (e.g., remedial action reports, construction completion reports, and National Priorities List deletion packages).

4.4.5 Backfill, Recontour, and Revegetation

Once attainment of the RAOs under the appropriate land use has been verified, the site will be recontoured and/or backfilled and revegetated. A general recontour/backfill design will be developed based on the final excavated site and surrounding area topography, as well as the amount of stockpiled overburden/below-cleanup-level material that has been released for use as backfill material. As needed, additional backfill material may be transported to the excavated site from approved Hanford Site borrow areas.

Revegetation is performed after backfill to minimize runoff and erosion effects, as well as to restrict the spread of noxious weeds. Revegetation is generally performed between November and January, as the local shrub-steppe ecosystem receives its primary precipitation during this season, maximizing the potential for reestablishing vegetation. Restoration planning and scheduling also considers other project activities in the area.

The methods used for revegetation will reflect what is feasible and appropriate on a site-by-site basis. Native plant species will be selected based on availability and appropriateness for the structure of the soils to be revegetated. In some areas, shrubs such as sagebrush, bitterbrush, and hopsage may be planted as tubelings to provide habitat and structure for nesting wildlife. Native grasses that are adapted to the site conditions will be planted to provide an understory. Dry seed should be incorporated into the soil by mechanical means.

Any areas that have been excessively compacted may be loosened by ripping the soil with heavy equipment. Linear rip lines should be smoothed prior to revegetation. Based on site-specific conditions, fertilizer and/or straw mulch may be applied to support revegetation. Where used, straw applications should be mechanically crimped into the soil to prevent wind loss.

Representative revegetated areas will be monitored for 5 years following planting. Monitoring will be conducted using methods such as those from *Steppe Vegetation of Washington* (Daubenmire 1970) to estimate percent canopy cover and frequency of occurrence for each species. Additional plantings, fertilization, and/or soil amendment may be performed, as appropriate. The vegetative cover and composition at each site following a revegetation effort will be site specific, and different locations may

not be comparable. Several factors, including seedbed, moisture regime, and topographic features, influence native plant community establishment and success.

4.4.6 Site Release

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

Where deed notices or other ICs are used in accordance with the 100-F/IU Area ROD (EPA 2014), DOE will not allow activities that would interfere with the remedial action prior to EPA approval. In addition, DOE will take necessary measures, such as filing deed notices in appropriate county offices and enforcing such land-use limitations through contractual mechanisms, to ensure the continuation of these restrictions prior to any transfer or lease of the property to any private party in accordance with the statutory requirements of Section 120(h) of CERCLA and the regulatory requirements of 40 CFR 373. A copy of any restriction notification will be given to any prospective purchaser/transferee before any transfer or lease by DOE. The DOE will provide the EPA with written verification that these restrictions are in place. In addition, unless and until cleanup levels that would support unlimited use and unrestricted exposure are attained (as defined in the Integrated RDR/RAWP (DOE/RL-2014-44)), a reevaluation of the remedial action will occur as part of the CERCLA 5-year review. For more information on requirements applicable to ICs, refer to the Integrated RDR/RAWP (DOE/RL-2014-44) and the 100-F/IU Area ROD (EPA 2014).

5 Waste Management Plan

This waste management plan describes the activities for the management and disposal of waste associated with remedial action for 100-IU-2 and 100-IU-6 waste sites. Waste management activities will be performed in accordance with the applicable ARARs identified in Section 2.4. The requirements specified by the ARARs and other applicable guidance and procedures will address waste storage, transportation, packaging, handling, labeling, and disposal as they specifically apply to waste streams from each waste site.

5.1 Projected Waste Streams

Various waste streams are anticipated during waste site remediation. Each waste stream will require specific processing and disposal. Similar types of waste will be managed uniformly. Assignment of waste to the appropriate waste stream depends on knowing the designation of the waste and appropriate disposal facility. Waste streams may include, but are not limited to, the following:

- Nonhazardous, nondangerous miscellaneous solid waste
  - Filter paper, wipes, personal protective equipment (PPE), cloth, plastic, equipment, tools, pumps, wire, metal and plastic piping, and materials from cleanup of unplanned releases
  - "Demolition waste" consisting of solid, largely inert waste resulting from the demolition or razing of buildings, roads, or other man-made structures
- Mixed waste (i.e., waste that is both low-level radioactive waste and hazardous waste)
- Liquids, including liquids from unplanned releases (i.e., spills), decontamination/cleaning fluids, and unknown liquid encountered in pipelines or other waste site features
- Used oil and hydraulic fluids
- Returned sample waste associated with these waste sites
- Nonradioactive waste (e.g., asbestos, and chemically contaminated soils)
- Hazardous or dangerous waste.

Spent nuclear fuel has previously been encountered in the 100-FR-2 OU, but is not anticipated to be encountered during 100-IU-2 and 100-IU-6 waste site remediation.

5.1.1 Waste Characterization, Designation, and Disposal

Miscellaneous solid waste and demolition debris that has contacted contaminated media, and/or is designated as contaminated by process knowledge or other information, may be disposed of at ERDF as described below. Waste will be characterized and designated in accordance with requirements of the receiving facility and in accordance with the applicable SAP. The sorting process is observational and is performed to identify nonconforming waste forms. Waste will be designated using process knowledge, historical analytical data, engineering calculations, and/or analyses of samples identified in the referenced documents or SAPs, as appropriate. Anomalous wastes are defined as waste materials that must be separated from other waste streams because they may require special handling and/or treatment prior to disposal. This anomalous material may or may not require additional characterization prior to disposal. Every effort will be made to minimize waste volume for disposal at ERDF through recycling and reuse, as appropriate.

ERDF is the preferred disposal location, provided that the waste acceptance criteria (WCH-191) are met. As necessary, waste will be stored within the AOC, in an on-site container storage area, in staging piles, or at ERDF as described in the following subsections.

Miscellaneous solid waste or demolition debris that is nondangerous and has been radiologically released may be disposed of at an offsite permitted disposal facility or a limited purpose inert landfill, or recycled, as appropriate. On a case-by-case basis, and as allowed by the lead regulatory agency, such waste forms may be used as waste site backfill provided that general size and/or placement requirements are met. These case-by-case agreements will be documented in Unit Manager Meetings or other forums agreed to by the lead regulatory agency. Uncontaminated soils will be placed on the ground near the point of origin. Waste handling and disposal options are further described in in Section 5.2.

Small volumes of liquid that have been solidified may also be disposed of at ERDF if the waste meets ERDF waste acceptance criteria. Liquid waste that does not meet the ERDF acceptance criteria will be shipped to the Effluent Treatment Facility (ETF) or an appropriate offsite facility. Offsite facilities that receive contaminated waste must be deemed acceptable by the EPA in accordance with 40 CFR 300.440. The ETF is an approved noncontiguous onsite facility pursuant to CERCLA Section 104(d)(4) used to store and treat liquid waste generated from removal actions, provided the waste acceptance criteria are met.

Used nonradioactive oil will be sent offsite for recycling or disposal. Spent or unusable chemicals/reagents may also be generated during field sampling and analysis and would require disposal based on the designation.

Three categories of waste exist from a designation standpoint:

1. Wastes that do not require additional characterization or special handling include untreated wastes and/or process soil that may be designated without characterization, and do not require special handling for human exposure or waste acceptance.

2. Wastes that do not require additional characterization, but do require special handling are untreated wastes that may be designated without characterization, but do require special handling for human exposure or waste acceptance. Waste types in this category include, but are not limited to, lead bricks, friable ACM, and high-dose components that do not contain dangerous/hazardous materials.

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

Wastes will be designated for disposition based on historical data, process knowledge, engineering calculations, sampling and analysis, or combinations thereof. Each of these methods and their applications are described summarily below. This is presented for information purposes only, and the generator is responsible for proper waste designation.

- Historical data (e.g., analytical results) may be used to designate waste forms that have previously been characterized. Previous and current remediation projects have designated significant quantities of buried solid waste. The waste forms in this category are readily identified and are known for their hazardous material content.

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

Elemental lead debris, paint debris, and lead acid batteries are other examples where designation will be based on process knowledge.

- Engineering calculations may be performed to estimate the weight or volume of a hazardous waste in a certain matrix (e.g., calculating lead-based paint content on pump housings).
- Field screening and/or analytical sampling will be used for designation of wastes when the above-mentioned methods are not appropriate or available. Sampling and analysis is required for liquids and most of the anomalous waste forms. Where sampling is needed, historical data, process knowledge, and/or engineering calculations may be used to reduce the suite of analyses required. All sampling activities supporting waste designation will be performed in accordance with the SAP.

Figures 5-1 and 5-2 provide logic flow diagrams for disposition of soil and anomalous waste forms, respectively.

5.2 Waste Stream-Specific Management

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

5.2.1 Miscellaneous Solid Wastes

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

5.2.2 Low-Level Radioactive Waste

Low-level radioactive waste, including soil, concrete, debris, and structures, will be removed during excavation. Plastic, paper, and other compactible waste will also be generated as part of the remediation activities. Debris that has contacted contaminated media may be disposed at the ERDF if the waste acceptance criteria (WCH-191) can be met. If the waste acceptance criteria cannot be met, the waste will be shipped to an appropriate offsite facility, depending on the waste designation. Offsite facilities that receive contaminated waste must be deemed acceptable by the EPA in accordance with 40 CFR 300.440. Material that can be radiologically released may be disposed in an onsite inert landfill if the waste meets the criteria for being "inert," or recycled, as appropriate.

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

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

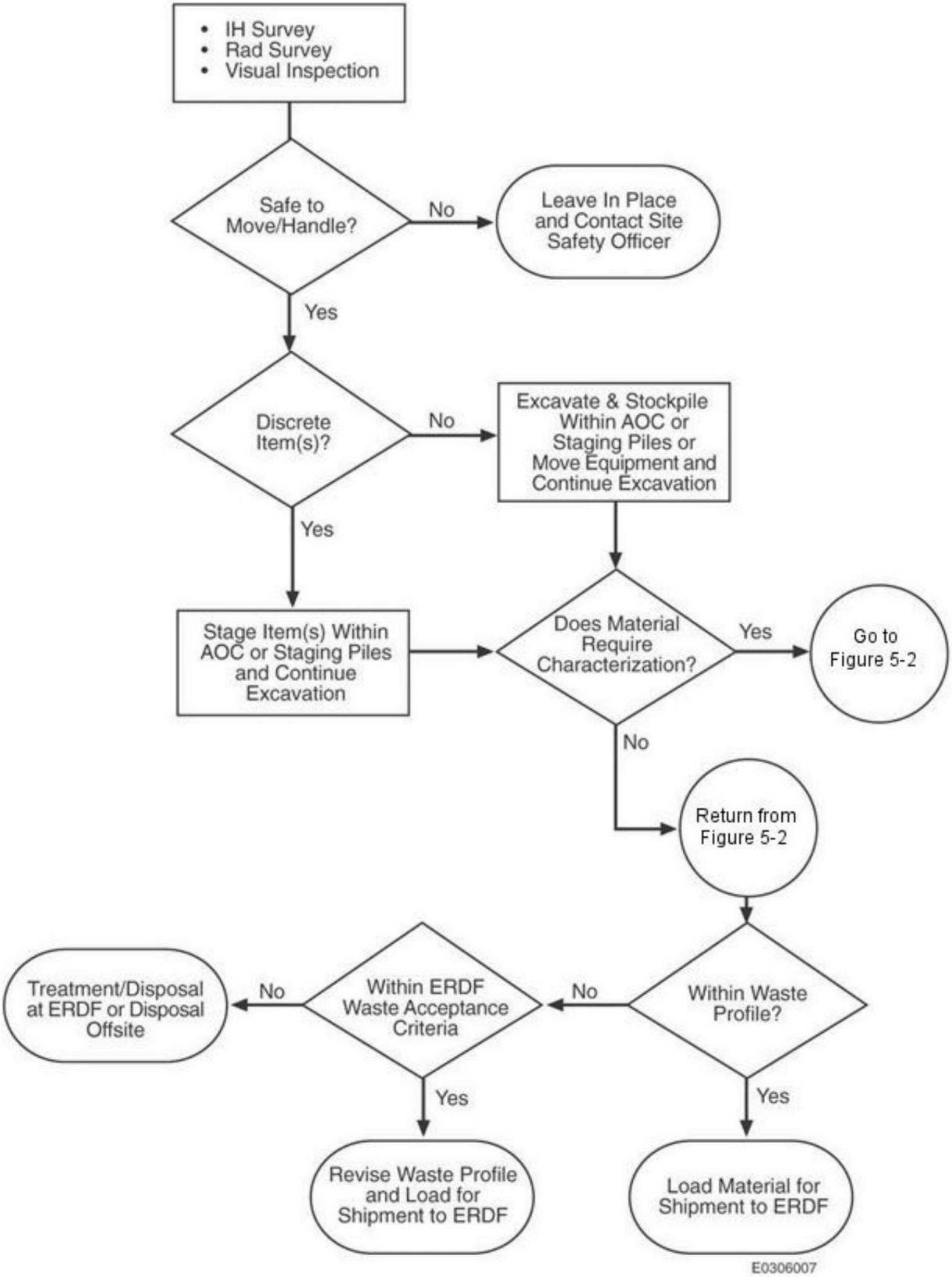

Figure 5-1. Logic Flow Diagram for Disposition of Buried Waste and Co-Mingled Soil

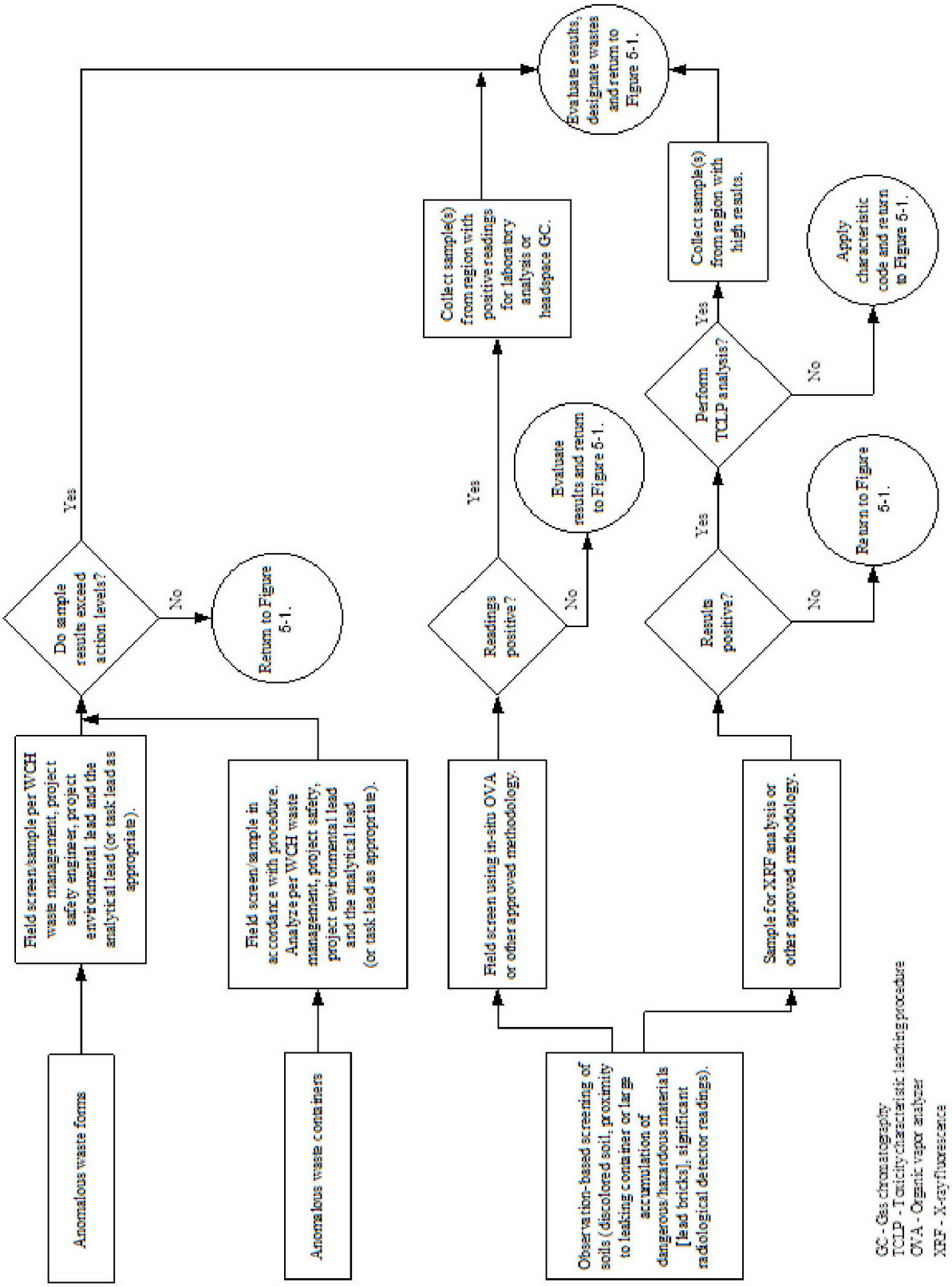

Figure 5-2. Logic Flow Diagram for Disposition of Anomalous Waste Forms

5.2.4 Liquid

5.2.4.1 Liquids from Unplanned Releases

If a release occurs, the notification of contractor spill release support is required. The reporting requirements will be met as prescribed by DOE O 232.1A, *Occurrence Reporting and Processing Operations*. The contractor point of contact will determine the actions required to address the spill and determine if the lead regulatory agency needs to be notified.

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

1. The spill occurred from equipment supporting the CERCLA activity.
2. The waste meets the ERDF waste acceptance criteria (WCH-191).
3. The spill occurred within the CERCLA OU boundary or onsite area.

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

Liquid that is not treated to meet the ERDF acceptance criteria will be shipped to the ETF or an appropriate offsite facility. The ETF is an approved noncontiguous onsite facility pursuant to CERCLA Section 104(d)(4) used to store and treat liquid waste generated from remedial actions, provided the waste acceptance criteria can be met.

5.2.4.2 Decontamination Fluids

Decontamination fluids (i.e., water and/or nonhazardous cleaning solutions) from cleaning equipment and tools used in the OU may be discharged to the ground in accordance with Section 4.3.2. If decontamination fluids are collected and contain contaminant levels above those listed in WAC 173-200 or groundwater cleanup standards in WAC 173-340-720, they may be designated and transported to the ETF or other facility authorized by the lead regulatory agency, or may be used as dust suppressant following approval by the lead regulatory agency. Small volumes of nondangerous decontamination fluids may be stabilized to eliminate free liquids and then disposed to the ERDF if the waste acceptance criteria can be met.

5.2.4.3 Liquid Remaining in Pipes

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

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

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

5.2.5 Used Oil and Hydraulic Fluids

Used oil and hydraulic fluids generated during operation of machinery at the waste sites will be radiologically released and sent offsite for recycling or disposal, as appropriate, or may be stabilized in accordance with ERDF waste acceptance criteria (WCH-191) and disposed to ERDF if the fluid contacted contaminated media associated with the waste site.

5.2.6 Returned Sample Waste

Screening and analysis of both solid and liquid samples may be conducted at the waste sites, offsite or onsite laboratories, and/or an onsite radiological counting facility. These samples are authorized to be returned to the OU. Unused samples and associated laboratory waste from offsite analyses will be managed by the applicable laboratory in accordance with contract specifications. Waste from field screening and onsite laboratories will be managed depending on whether it has been altered by analysis. Altered samples will be contained and disposed at the ETF, ERDF, or other appropriate facilities as authorized by the lead regulatory agency, depending on waste designation. Unaltered liquid waste generated during sample screening and analysis may be discharged to the ground near the point of generation, if contaminant concentrations are below levels listed in WAC 173-200, or below groundwater cleanup standards in WAC 173-340-720, or be disposed at the ETF, ERDF, or other appropriate facilities if it is above these criteria. Some liquids may be neutralized and/or stabilized to meet the disposal facility's waste acceptance criteria. Pursuant 40 CFR 300.440, remedial project manager approval is required before returning unused samples or waste from onsite or offsite laboratories. Approval of this RDR/RAWP constitutes remedial project manager approval for shipment of offsite and onsite laboratory sample waste back to the waste site of origin.

5.2.7 Radiological Counting Facility Sample Wastes

Samples from CERCLA activities may be analyzed in a radiological counting facility (currently located in the 300 Area). Counting capabilities include, but are not limited to, liquid scintillation, gross alpha/beta gamma, gamma ray spectroscopy, and alpha spectroscopy. This facility will be operated as a CERCLA facility to support counting of CERCLA samples from the Hanford Site. Various types of sample media will be prepared and counted such as smears, swipes, air filters, soil, liquids, and miscellaneous waste streams (e.g., concrete, cloth). Sample preparation activities prior to sample counting will typically involve physical processes (e.g., mounting of air filters and smears on planchets) prior to counting rather than radiochemistry.

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

Sample counting wastes, including any associated secondary waste, may routinely be sent back to the operable unit of origin for disposition. Alternatively, sample counting waste may be sent directly to

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

Disposal of CERCLA waste at any disposal facility other than ERDF requires EPA approval in accordance with 40 CFR 330.440. Disposal of material containing no or de minimis levels of CERCLA hazardous substances would not require an offsite acceptability determination per 40 CFR 300.440 and may be disposed at a non-CERCLA disposal facility.

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

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

5.3 Waste Handling, Packaging, and Labeling

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

Waste moved outside of the AOC must meet all substantive requirements of WAC 173-303 and DOT requirements, as appropriate. In addition, PCB wastes will be managed in accordance with substantive provisions of 40 CFR 761, and asbestos waste will be managed in accordance with 40 CFR 61. Waste will be packaged, marked, and labeled in accordance with ARARs. If waste is determined to be SNF or TRU waste, it will be packaged in accordance with the appropriate criteria as determined at the time of shipment to an approved facility. If disposed at ERDF, wastes from the 100-F/IU waste sites must meet the ERDF waste acceptance criteria (WCH-191), which prohibits disposal of SNF, TRU, and high-level wastes.

5.4 Storage

In general, waste unearthed in support of this RDR/RAWP will be disposed at the ERDF or other approved onsite or offsite facility. As necessary, waste will be stored within the AOC, in onsite container storage areas, in staging piles, or at the ERDF as described in the following subsections. In addition, in accordance with CERCLA Section 104(d)(4), where two or more noncontiguous facilities are reasonably related on the basis of geography, or on the basis of the threat or potential threat to the public health or welfare or the environment, the EPA may, at their discretion, treat these related facilities as one for purposes of implementing CERCLA response actions. EPA approval to allow movement of waste between noncontiguous onsite areas may be granted via e-mail and document in Unit Manager Meeting minutes.

5.4.1 Area of Contamination

Waste that is excavated and held (i.e., not immediately transported to the ERDF) for further analysis, treatment, or any other reason will be typically managed within the AOC. The AOC approach was discussed in the NCP (55 FR 8666) with regard to remedial actions under CERCLA. The guidance states that the AOC can be equated to a RCRA landfill where movement within the area would not be considered land disposal and would not trigger the requirements of Subtitle C, such as 90-day storage or LDRs. Any movement of soil outside of the AOC but within the CERCLA onsite area will trigger compliance with all ARARs, such as RCRA provisions for management of dangerous waste. The AOC for each waste site will be delineated in the project drawings and are considered part of this RDR/RAWP. These drawings may be provided to the lead regulatory agency upon request.

5.4.2 Container Storage Areas

Items that are not amenable to storage within the AOC and that can readily and safely be removed (e.g., bagged PPE and sample returns) may be managed outside of the AOC within container storage areas. Container storage will also be used for ancillary waste generated in support of the remedial action (e.g., spill cleanup material). Substantive requirements of 40 CFR 264 Subpart I and WAC 173-303-630 must be met for container storage areas storing regulated dangerous waste. Upon completion of use, all dangerous waste and residues will be removed or decontaminated, including any contaminated soil.

5.4.3 Staging Piles

As an alternative to storage within the AOC or in containers, waste that is not immediately transported to the ERDF or other EPA-approved disposal facility may be stored in staging piles. The staging piles must be operated in accordance with the standards and design criteria prescribed in 40 CFR 264.554, paragraphs (d) through (k). General requirements for the staging piles include the following.

- Staging piles are used only during remedial operations for temporary storage at a facility and must be located within the contiguous property where the wastes to be managed in the staging piles originated.
- Staging piles cannot be used for flowing (i.e., liquid) waste storage.
- The SPA must be designed to prevent or minimize releases of hazardous wastes and hazardous constituents into the environment and minimize or adequately control cross-media transfer. To protect human health and the environment, this can include installation of berms, dust control practices, or using plastic liners/covers, as appropriate. A release of a hazardous substance outside the SPA confines and into the underlying soil or ambient air will be considered a release into the environment, and immediate notification under CERCLA will be pursued in accordance with 40 CFR 302, if the quantity involved exceeds a reportable quantity over a 24-hour period, and/or in accordance with other regulation(s), as applicable. However, if hazardous substances are discovered within the confines of an approved staging pile, it is not considered a release (DOE-RL et al. 2005a).
- The staging pile must not operate for more than 2 years (measured from the first time remediation waste is placed into the pile), except when the EPA grants an operating term extension. A record of the date when remediation waste was first placed in the staging pile must be maintained until final closeout of the site is achieved.
- Ignitable or reactive waste must not be placed in a staging pile unless it has been treated or mixed before being placed in the pile so that the waste no longer meets the definition of ignitable or reactive

waste, or the waste is managed in order to protect it from exposure to any material or condition that may cause it to ignite or react.

- Incompatible wastes may not be placed in the same staging pile, unless the requirements in 40 CFR 264.17(b) have been met. The incompatible materials must be separated or they must be protected from each other with a dike, berm, wall, or other device. Remediation waste may not be piled on the same base where incompatible wastes or materials were previously piled, unless the base has been decontaminated sufficiently to comply with 40 CFR 264.17(b).
- Within 180 days after the operating term of the SPA located in a previously uncontaminated area expires, the SPA must be closed in accordance with 40 CFR 264.258(a) and 40 CFR 264.111, or 40 CFR 265.258(a) and 40 CFR 265.111. This includes removing all remediation waste, contaminated containment system components, contaminated structures and equipment, and leachate.

Approval of this RDR/RAWP by the EPA constitutes general authorization to operate staging piles during remediation of the 100-F/IU Area. Specific SPA locations will be identified on project drawings and approved by the EPA in unit manager's meetings or other documented means of communication. A map outlining the AOC and any SPAs will be posted at the field construction offices and will be updated in the field, as needed. Field operation of staging piles within the referenced regulatory provisions will be accomplished through the following controls:

- The SPA will be surrounded with a minimum of a 15-cm (6-in.) berm to control run-on/runoff prior to use.
- Dust control practices will be deployed consistent with soil piles managed in the AOC, including the use of crusting agents, as necessary, to minimize migration/leaching or contaminants into underlying soil.
- Surveys of the SPA will be performed prior to waste placement to ensure no cross-media transfer or staging of waste on previously contaminated areas. A staging pile shall be remediated within 180 days after the operating period per 40 CFR 264.554(j) and (k).
- Gross sorting of waste will be performed within the AOC to identify and remove drums or other containers from the bulk soil prior to moving the soil to the staging piles. Additional sorting may be required on bulk soil prior to moving the soil to the SPA. Any dangerous or unknown waste identified will be packaged and managed appropriately (drums) within the SPA and within close proximity to the specific staging pile. Drums will be properly labeled, managed, and inspected weekly, or as described in project waste management procedures.

Once characterization and designation of the material is completed, the waste will be loaded into containers for transport to the ERDF or shipped on site or off site for treatment and/or disposal, as appropriate. To close out the SPAs after the waste has been removed, samples of the residual soil will be collected in accordance with the applicable SAP; specific sampling details may be presented in a site-specific sampling instruction prepared in accordance with the SAP. The sample results will be evaluated against cleanup levels as described in Chapter 2 to demonstrate closeout.

5.4.4 Environmental Restoration Disposal Facility Drummed Waste Staging Area

On a case-by-case basis, a staging area may be available at the ERDF for wastes from the 100 Area remedial action sites that require special handling and/or treatment not currently available, such as thermal treatment of a mixed radioactive/dangerous waste. Waste will be characterized at the site prior to

transport to the ERDF staging area. All waste sent to the ERDF staging area will be stored in accordance with requirements prescribed by the ERDF ROD amendment (EPA 2002) and implementing documents.

5.5 Waste Transportation

Packaging, marking, and labeling for transportation will be in accordance with DOT 49 CFR requirements, ARARs, and procedures, as appropriate. With appropriate documentation (e.g., safety analysis report for packaging or risk-based exemption), packaging exceptions to DOT requirements that provide an equivalent degree of safety during transportation may be used for waste shipments. Coordination and preparation of these documents will be approved by the DOE-RL. ERDF roll-off-type containers will be used for most bulk wastes. Drummed waste may either be loaded into standard ERDF containers or be transported by other means such as flatbed tractor-trailer units or cargo vans. Containers will be sealed and shipped to the identified disposal facility as quickly as economically feasible. Waste will be transported in accordance with WAC 173-303, DOT regulations, and DOE/RL-2001-36, *Hanford Sitewide Transportation Safety Document*, as appropriate.

5.6 Waste Treatment

When necessary, treatment is one of the selected remedy elements for the 100-F/IU Area waste sites. Treatment may be conducted at the site, at ERDF (in special cases), or at an EPA-approved offsite facility. If LDR wastes are encountered, the requirements of 40 CFR 268 will be applied, unless a treatability variance is approved by the EPA. Offsite treatment must be performed at a facility approved by the EPA in accordance with 40 CFR 300.440. Return of treated waste from offsite treatment facilities for disposal at ERDF will require additional authorization from DOE-RL.

Treatment will be required for LDR material unless a treatability variance or ARAR waiver is requested by DOE-RL and approved by the lead regulatory agency. If LDR wastes are encountered, the requirements of 40 CFR 268 and WAC 173-303-140 will be applied. Should LDR material be encountered, it will be temporarily stored within the AOC, in a container storage area, or in staging piles and disposed in accordance with applicable regulations. If treatment is required to address LDR wastes, DOE-RL will obtain regulatory agency approval. An approved LDR treatment method for radioactively contaminated cadmium-, silver-, and mercury-containing batteries allows for macroencapsulation prior to disposal. However, lead-acid batteries are not covered by this standard and require initial treatment (draining corrosive liquids, treating separately prior to disposal) (DOE-RL et al. 2005b).

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Appendix A

100-F/IU Area Waste Site Information

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A1. 100-F/IU Area Waste Site Summary

Summary information for all waste sites associated with the 100-FR-1, 100-FR-2, 100-IU-2, and 100-IU-6 Operable Units as of September 1, 2014, is presented in this appendix as Tables A-1 and A-2. This information includes the decision identified for applicable sites under the *Record of Decision for the Hanford 100 Area Superfund Site, 100-FR-1, 100-FR-2, 100-FR-3, 100-IU-2, and 100-IU-6 Operable Units* (100-F/IU Area ROD) (EPA 2014), as well as their dispositioning under earlier RODs (EPA 1997, 1999, and 2000b). If a site was not previously included in a ROD, that status is also noted.

The 100-F/IU Area ROD was developed concurrently with ongoing remedial actions; as a result, multiple 100-IU-2 and 100-IU-6 waste sites and/or subsites remediated or evaluated under the *Interim Action Record of Decision for the 100-BC-1, 100-BC-2, 100-DR-1, 100-DR-2, 100-FR-1, 100-FR-2, 100-HR-1, 100-HR-2, 100-KR-1, 100-KR-2, 100-IU-2, 100-IU-6, and 200-CW-3 Operable Units* (Remaining Sites ROD) (EPA 1999) were not quantitatively evaluated in development of the 100-F/IU Area ROD. These sites therefore require a remediation decision under the 100-F/IU Area ROD, which is reflected in Table A-2. However, further activities for these waste sites may be limited to verification and associated documentation that interim actions taken remain protective under the 100-F/IU Area ROD requirements.

Many 100-F/IU waste sites were remediated using a "plug-in" approach under the Remaining Sites ROD (EPA 1999) and were documented in Explanations of Significant Difference (ESDs) (EPA 2000a, 2004, and 2009). The 2009 ESD (EPA 2009) also included a change in the way plug-in waste sites were reported. The new provision authorized that future plug-in sites would be documented in annual "Fact Sheets" included in the Tri-Party Agreement Administrative Record. Fact sheets were published annually in 2011, 2012, and 2013 by the U.S. Department of Energy to identify such sites. Waste sites that were added in this manner are documented in the following references:

- *Fact Sheet: 100 Area "Plug-In" and Candidate Sites for Fiscal Year 2010 - Annual Listing of Waste Sites Plugged into the Remove, Treat and Dispose Remedy in the 1999 Interim Action Record of Decision for the 100 Area* (DOE-RL 2011)
- *Fact Sheet: 100 Area "Plug-In" and Candidate Sites for Fiscal Year 2011 - Annual Listing of Waste Sites Plugged into the Remove, Treat and Dispose Remedy in the 1999 Interim Action Record of Decision for the 100 Area* (DOE-RL 2012)
- *Fact Sheet: 100 Area "Plug-In" and Candidate Sites for Calendar Year 2012 - Annual Listing of Waste Sites Plugged into the Remove, Treat and Dispose Remedy in the 1999 Interim Action Record of Decision for the 100 Area* (DOE-RL 2013).

Information related to current site knowledge and status was also compiled from the following summary resources:

- Waste Information Data System (WIDS)
- Stewardship Information System (SIS)
- DOE/RL-2010-98, *Remedial Investigation/Feasibility Study for the 100-FR-1, 100-FR-2, 100-FR-3, 100-IU-2, and 100-IU-6 Operable Units*
- OSR-2009-002, *100-F/IU-2/IU-6 Area – Segment 1 Orphan Sites Evaluation Report*
- OSR-2010-0001, *100-F/IU-2/IU-6 Area - Segment 2 Orphan Sites Evaluation Report*
- OSR-2010-0004, *100-F/IU-2/IU-6 Area - Segment 3 Orphan Sites Evaluation Report*

- OSR-2011-0001, *100-F/IU-2/IU-6 Area - Segment 4 Orphan Sites Evaluation Report*
- OSR-2011-0002, *100-F/IU-2/IU-6 Area - Segment 5 Orphan Sites Evaluation Report*.

Table A-1. 100-FR-1 and 100-FR-2 Waste Site Information

Site Name	Site Information	Site Status
100-F-2, Strontium Garden	This site is a former ecological study garden used for growing cereal grains, alfalfa, and other crops in soils containing strontium-90 and cesium-137.	RTD Waste site; Remaining Sites ROD (EPA 1999). Remediated and interim closed out per CVP-2001-00001. 100-F/IU Area ROD100-F/IU Area ROD (EPA 2014), no additional action.
100-F-4, 108-F Building 12-Inch French Drain	This site was a 0.3-m (12-in.)-diameter vertical vitrified clay pipe adjacent to the former 108-F Building that was removed during D&D of the building.	Candidate waste site; Remaining Sites ROD (EPA 1999). Remediated and interim closed out per CVP-2002-00001. 100-F/IU Area ROD (EPA 2014), no additional action.
100-F-7, Underground Fuel Tank	This site contained an underground 3,785-L (1,000-gal) fuel oil tank that supplied oil to the 1705-F Laboratory Building Heater Room. The laboratory was decommissioned and demolished in 1975. The former location of the fuel oil tank was excavated with the 100-F-33 fish ponds in 2005 and nothing was found.	Candidate waste site; Remaining Sites ROD (EPA 1999). Reclassified to no action per WSRF 2004-124. 100-F/IU Area ROD (EPA 2014), no additional action.
100-F-9, French Drain	This site was a 91-cm (36-in.)-diameter vertical concrete pipe at the east end of the 105-F Reactor Building storage room that was believed to have been removed during D&D activities for interim safe storage of the building from 1998 to 2003. A test pit at the former location of the french drain found no residual contamination.	Candidate waste site; Remaining Sites ROD (EPA 1999). Reclassified to no action per WSRF 2004-125. 100-F/IU Area ROD (EPA 2014), no additional action.
100-F-10, French Drain	This site was a 91-cm (36-in.)-diameter concrete pipe buried to unknown depth at the east end of the 105-F storage room. The french drain was removed during excavation of the 100-F-19:2 pipelines and its institutional controls status is included with the pipelines.	Candidate waste site; Remaining Sites ROD (EPA 1999). Remediated and interim closed out per CVP-2003-00017. 100-F/IU Area ROD (EPA 2014), excavation restrictions.
100-F-11, 108-F Building 18-Inch French Drain	This site was a 0.5-m (18-in.)-diameter vertical concrete pipe (length unknown) adjacent to the northwest corner of the electrical substation on the west wall of 108-F Building. Removed during D&D of the 108-F Building.	Candidate waste site; Remaining Sites ROD (EPA 1999). Remediated and interim closed out per CVP-2002-00001. 100-F/IU Area ROD (EPA 2014), no additional action.
100-F-12, 36-Inch French Drain at 105-F Building	This site was a 91-cm (36-in.)-diameter vertical concrete pipe of unknown length with a steel lid. Located at northeast corner of the 105-F Reactor.	Candidate waste site; Remaining Sites ROD (EPA 1999). Reclassified to no action per WSRF 2004-126. 100-F/IU Area ROD (EPA 2014), no additional action.
100-F-14, Vent Pipe	This site was a steel vent pipe extending above grade. The above-grade portion was 10 cm (4 in.) in diameter with a 90-degree bend at the top.	Candidate waste site; Remaining Sites ROD (EPA 1999). Site was reclassified to no action per WSRF 2004-127. 100-F/IU Area ROD (EPA 2014), no additional action.

Table A-1. 100-FR-1 and 100-FR-2 Waste Site Information

Site Name	Site Information	Site Status
100-F-15, 108-F Building French Drain	This site was a 1.2-m (36-in.)-diameter gravel-filled vertical concrete pipe extending to an unknown depth located adjacent to the east wall of the 108-F Building. This french drain was removed during D&D of the 108-F Building.	RTD Waste site; ROD Amendment (EPA 1997). Remediated and interim closed out per CVP-2002-00001. 100-F/IU Area ROD (EPA 2014), no additional action.
100-F-16, 108-F Building French Drain	This site was a 0.8-m (30-in.)-diameter vertical steel pipe of unknown length adjacent to the 108-F Building, which was removed during D&D of the 108-F Building.	Candidate waste site; Remaining Sites ROD (EPA 1999). Remediated and interim closed out per CVP-2002-00001. 100-F/IU Area ROD (EPA 2014), no additional action.
100-F-18, Condensate Drain	This site was a 91-cm (36-in.)-diameter vertical steel pipe located near the northwest corner of the 105-F Reactor Building adjacent to the north wall of the fan house. It was removed during D&D activities for interim safe storage of the building from 1998 to 2003.	Candidate waste site; Remaining Sites ROD (EPA 1999). Reclassified to no action per WSRF 2004-137. 100-F/IU Area ROD (EPA 2014), no additional action.
100-F-19, Process Effluent Pipelines. Subsites 1-3.	Numerous underground pipelines radioactively and/or chemically contaminated. These include process sewer lines, process effluent pipelines to and from the retention basins, and numerous others left in place upon D&D activities. Consists of three subsites: (1) north group, (2) south group, and (3) west group.	RTD Waste site; ROD Amendment (EPA 1997). Remediated and interim closed out per CVP-2001-00002 and CVP-2001-00003. 100-F/IU Area ROD (EPA 2014), excavation restrictions.
100-F-20, PNNL Parallel Pits	This site was two earthen pits or trenches, believed to have been used to dispose of both radioactive and nonradioactive material from the experimental animal farm.	RTD Waste site; Burial Grounds ROD (EPA 2000). Remediated and interim closed out per CVP-2006-00009 and WSRF 2006-060. 100-F/IU Area ROD (EPA 2014), no additional action.
100-F-23, 141-C Drywell	This site was a french drain that received liquid waste from animal pens and 141-C Building research laboratories.	Candidate waste site; Remaining Sites ROD (EPA 1999). Remediated and interim closed out per CVP-2003-00011. 100-F/IU Area ROD (EPA 2014), no additional action.
100-F-24, 145-F Drywell	This site was a french drain that received waste from the 145-F Animal Monitoring Laboratory.	Candidate waste site; Remaining Sites ROD (EPA 1999). Remediated and interim closed out per CVP-2003-00012. 100-F/IU Area ROD (EPA 2014), no additional action.
100-F-25, 146-F Drywells	This site was french drains that received waste from the 146-F and 146-FR Buildings.	Candidate waste site; Remaining Sites ROD (EPA 1999). Remediated and interim closed out per CVP-2003-00010. 100-F/IU Area ROD (EPA 2014), no additional action.

Table A-1. 100-FR-1 and 100-FR-2 Waste Site Information

Site Name	Site Information	Site Status
100-F-26, Underground Pipelines. Subsites 1-16.	100-F Water treatment facility underground pipelines; process sewer. Consists of 16 subsites as follows: 100-F-26:1, North Process Sewer Collection Pipelines. Reclassified to no action per WSRF 2005-008. 100-F-26:2, Water Pipelines to Aquatic Biology & Strontium Gardens; no action. WSRF 2005-005. 100-F-26:3, 184-F Powerhouse Pipelines; reclassified to no action per WSRF 2004-118. 100-F-26:4, South Process Pipelines. remediated and interim closed out per WSRF 2007-035. 100-F-26:5, 190-F Bypass Process Sewer Pipelines. Reclassified to no action per WSRF 2005-007. 100-F-26:6, 190-F Reservoir Pipelines. Reclassified to no action per WSRF 2004-119. 100-F-26:7, Sodium Dichromate and Sodium Silicate Pipelines; interim closed out after additional remediation per WSRF 2011-088. 100-F-26:8, 1607-F1 Sanitary Sewer Pipelines; remediated and interim closed out per WSRF 2005-004. 100-F-26:9, 1607-F2 Sanitary Sewer Pipelines; remediated and interim closed out per WSRF 2008-029. 100-F-26:10, 1607-F3 Sanitary Sewer Pipelines; remediated and interim closed out per WSRF 2007-028. 100-F-26:11, 1607-F4 Sanitary Sewer Pipelines. Reclassified to no action per WSRF 2005-003. 100-F-26:12, Main Process Sewer; remediated and interim closed out per WSRF 2007-034. 100-F-26:13, 108-F Drain Pipelines; remediated and interim closed out per WSRF 2005-011. 100-F-26:14, 116-F-5 Influent Pipelines; remediated and interim closed out per WSRF 2007-029. 100-F-26:15, Miscellaneous Pipelines associated with 1608-F Sump; remediated and interim closed out per WSRF 2007-031. 100-F-26:16, Reactor Cooling Water Pipelines. Reclassified to no action per WSRF 2004-120.	Candidate waste site; Remaining Sites ESD (EPA 2004). See subsite details. 100-F/IU Area ROD (EPA 2014), no additional action.

Table A-1. 100-FR-1 and 100-FR-2 Waste Site Information

Site Name	Site Information	Site Status
100-F-29, Process Sewer Pipeline	This site consisted of contaminated pipelines that existed at the 100-F Experimental Animal Farm.	Candidate waste site; Remaining Sites ROD (EPA 1999). Remediated and interim closed out per CVP-2001-00003. 100-F/IU Area ROD (EPA 2014), Excavation restrictions.
100-F-31, 144-F Sanitary Sewer System	This site consisted of a septic tank and drain field that supported the 144-F Building.	Candidate waste site; Remaining Sites ROD (EPA 1999). Remediated and interim closed out per WSRF 2006-033. 100-F/IU Area ROD (EPA 2014), no additional action.
100-F-33, 146-F Aquatic Biology Fish Ponds	The fish ponds were constructed of unlined reinforced concrete and used to support testing on fish using varying mixtures of river and reactor effluent water.	Candidate waste site; Remaining Sites ROD (EPA 1999). Remediated and interim closed out per WSRF 2006-021. 100-F/IU Area ROD (EPA 2014), no additional action.
100-F-34, Biology Facility French Drain	This site was a french drain that supported the 1705-F Experimental Gardens. Co-located with the 100-F-19:1 pipeline subsite.	Candidate waste site; Remaining Sites ROD (EPA 1999). Remediated and interim closed out per CVP-2001-00002. 100-F/IU Area ROD (EPA 2014), Excavation restrictions.
100-F-35, Soil Contamination Area	Soil contamination area inside the 105-F Reactor exclusion area identified in 1997 when survey instruments detected elevated readings over an area measuring approximately 3 by 3 m (10 by 10 ft). The contamination was believed to have been spillage from a container storing soil excavated from the 116-F-4 Pluto Crib.	RTD Waste site; Remaining Sites ESD (EPA 2009). Remediated and interim closed out per CVP-2002-00007. 100-F/IU Area ROD (EPA 2014), no additional action.
100-F-36, 108-F Chemical Pumphouse	This site was the 108-F Chemical Pumphouse, but was remodeled to be the Biological Laboratory for plant and animal experiments, then decontaminated and demolished.	Candidate waste site; Remaining Sites ESD (EPA 2004). Reclassified to no action per WSFR 2007-002. 100-F/IU Area ROD (EPA 2014), no additional action.
100-F-37, French Drain	This site consisted of an abandoned french drain near hydrant F-2.	Candidate waste site; Remaining Sites ESD (EPA 2004). Reclassified to no action per WSFR 2004-095. 100-F/IU Area ROD (EPA 2014), no additional action.
100-F-38, Yellow-Stained Soil	This site consisted of yellow-stained soil near hydrant F-2 and the 100-F-37 waste site.	Candidate waste site; Remaining Sites ESD (EPA 2004). Remediated and interim closed out per WSFR 2004-093. 100-F/IU Area ROD (EPA 2014), no additional action.
100-F-39, 100-F River Effluent Pipelines	This site consisted of two 108-cm (42-in.)-diameter pipelines that discharged reactor cooling water effluent from the 105-F Reactor into the main channel of the Columbia River via the 116-F-8 Outfall.	. No prior ROD. 100-F/IU Area ROD (EPA 2014), no additional action.

Table A-1. 100-FR-1 and 100-FR-2 Waste Site Information

Site Name	Site Information	Site Status
100-F-42, 1904-F Spillway	This site consisted of a reinforced concrete flume that extended from the 116-F-8 Outfall to the Columbia River shoreline.	RTD Waste site; Remaining Sites ESD (EPA 2009). Remediated and interim closed out per WSRF 2006-045. 100-F/IU Area ROD (EPA 2014), no additional action.
100-F-43, PNL Outfall Spillway	This site consisted of a reinforced concrete flume that extended from the 116-F-16 Outfall to the Columbia River shoreline.	RTD Waste site; Remaining Sites ESD (EPA 2009). Remediated and interim closed out per WSRF 2006-046. 100-F/IU Area ROD (EPA 2014), no additional action.
100-F-44, 100-F Miscellaneous Pipelines. Subsites 1-10.	This site consisted of a compilation of pipeline segments not previously addressed in any closure documents. Subsites are 100-F-44:1, Pipeline Near 182-F Reservoir; no action per WSRF 2007-005. 100-F-44:2, Pipeline Near 108-F Building; no action per WSRF 2007-006. 100-F-44:3, 1607-F3 Sewer System Pipeline; rejected per WSRF 2007-010. 100-F-44:4, Pipeline in Silica Gel Pit; no action per WSRF 2008-030. 100-F-44:5, Process Sewer Pipeline; no action per WSRF 2008-016. 100-F-44:6, 189-F Refrigeration Pipeline; rejected per WSRF 2007-007. 100-F-44:7, 1717-F Blowdown Pipeline; rejected per WSRF 2007-012. 100-F-44:8, 1717-F Fuel Oil Supply and Return Pipelines. Interim closed out, WSRF 2011-043. 100-F-44:9, 105-F Process Sewer Pipelines. Interim closed out, WSRF 2011-061. 100-F-44:10, 141-C Sewer Pipeline; rejected per WSRF 2007-011.	Candidate waste site; Remaining Sites ESD (EPA 2009). See subsite details. 100-F/IU Area ROD (EPA 2014), no additional action.
100-F-45, Buried Effluent Pipelines	The site consisted of a piece of pipeline that was buried in the river bank after it floated loose from the river effluent pipeline.	RTD Waste site; Remaining Sites ESD (EPA 2009). Interim closed out per WSRF 2011-084. 100-F/IU Area ROD (EPA 2014), no additional action.
100-F-46, French Drain	This site consisted of the 119-F french drain, a gravel-filled vertical pipe, and the pipeline from the 119-F Stack Sampling Building to the french drain.	No prior ROD. Reclassified to no action per WSRF 2008-021. 100-F/IU Area ROD (EPA 2014), no additional action.
100-F-47, 151-F Substation	The substation consisted of a fenced, gravel-bed yard measuring 92.4 m (303 ft) by 137.2 m (450 ft), with the 151-F Switch House along the eastern fence line. A railroad spur entered the yard from the south and paralleled the east fence line.	RTD Waste site; Remaining Sites ESD (EPA 2009). Interim closed out per WSRF 2011-086. 100-F/IU Area ROD (EPA 2014), no additional action. 12/15/2011.

Table A-1. 100-FR-1 and 100-FR-2 Waste Site Information

Site Name	Site Information	Site Status
100-F-48, 184-F Coal Pit Debris	The site consisted of an area of debris that was identified in an aerial photograph and a historical literature search.	RTD Waste site; Remaining Sites ESD (EPA 2009). Interim closed out per WSRF 2011-093. 100-F/IU Area ROD (EPA 2014), no additional action.
100-F-49, 1716-F Maintenance Garage Lubrication Pit	The site consists of components of the 1716-F Maintenance Garage, including the foundation, the lubrication pit, and the contaminated drain(s).	RTD Waste site; Remaining Sites ESD (EPA 2009). Interim closed out per WSRF 2011-089. 100-F/IU Area ROD (EPA 2014), no additional action.
100-F-50, 100-F Railroad French Drain	The site consists of a french drain between two sets of railroad tracks at the first junction in the south center of the 100-F Area.	No prior ROD. Reclassified to no action per WSRF 2007-001. 100-F/IU Area ROD (EPA 2014), no additional action.
100-F-51, 146-F Fish Laboratory Soil	The site is the soil under and around the former 146-F Fish Laboratory. WSRF 2011-085, 9/26/2011.	RTD Waste site; Remaining Sites ESD (EPA 2009). Interim closed out per WSRF 2011-085. 100-F/IU Area ROD (EPA 2014), no additional action.
100-F-52, 146-FR Radioecology/Aquatic Laboratory Soil	The site consists of the soil under and around the former 146-FR Radioecology and Aquatic Biology Laboratory.	No prior ROD. Reclassified to no action per WSRF 2008-022. 100-F/IU Area ROD (EPA 2014), no additional action.
100-F-53, 108-F Septic System	The site potentially consists of pipelines, a septic tank, the drain field, and any contaminated soil around them.	Candidate waste site; Remaining Sites ESD (EPA 2009). Reclassified to no action per WSRF 2008-019. 100-F/IU Area ROD (EPA 2014), no additional action.
100-F-54, Animal Farm Pastures	This site consists of the remaining soil associated with the former pastures that were used to hold contaminated animals.	No prior ROD. Reclassified to no action per WSRF 2008-015. 100-F/IU Area ROD (EPA 2014), no additional action.
100-F-55, Contaminated Ash Layer at 1607-F7	The site consists of a contaminated layer of ash located in a trench near the 1607-F7 area.	RTD Waste site; Remaining Sites ESD (EPA 2009). Interim closed out per WSRF 2011-083. 100-F/IU Area ROD (EPA 2014), no additional action.
100-F-56, 100-F Surface Debris/Stains. Subsites 1-2.	The site consists of scattered surface debris located throughout the 100-F Area. 100-F-56:1, 100-FGarnet Sand Areas; interim closed out, WSRF 2011-094, 12/15/2011. 100-F-56:2, Surface Debris Areas. Interim closed out. WSRF 2011-040. 6/2/2011.	RTD Waste site; Remaining Sites ESD (EPA 2009). See subsites. 100-F/IU Area ROD (EPA 2014), no additional action.

Table A-1. 100-FR-1 and 100-FR-2 Waste Site Information

Site Name	Site Information	Site Status
100-F-57, 190-F Process Water Pump House Debris. Subsites 1-2.	The site consists of the remaining foundation of the demolished 190-F Process Water Pump House. 100-F-57:1; Eastern portion of 190-F Bldg. Interim closed out per WSRF 2012-010 4/10/2012. 100-F-57:2; Western portion of 190-F Bldg. Interim closed out per WSRF 2012-058, 8/23/2012.	RTD Waste site; Remaining Sites ESD (EPA 2009). See subsites. 100-F/IU Area ROD (EPA 2014), no additional action.
100-F-58, 100-F Surface Debris Potentially Containing Asbestos.	This site contained potential asbestos-contaminated waste that was collected from several locations in the 100-F Area where it had been discarded or abandoned.	RTD Waste site; 100 Area Fact Sheet (DOE-RL 2011). Interim closed out per WSRF 2011-033. 100-F/IU Area ROD (EPA 2014), no additional action.
100-F-59, Riparian Zone Contamination Originating from Waste Site 128-F-2.	This site is a nonradiological waste site created after the remediation of the 128-F-2 Burn Pit. It has two riparian areas known to contain contaminants above soil remedial action goals. The first riparian area, located adjacent to the Columbia River, was remediated, as part of 128-F-2, to an elevation below the ordinary high water mark of the river. The second riparian area, located east and southeast of the 128-F-2 waste site and below the ordinary high water mark, was not remediated.	No prior ROD. WIDS and SIS Accepted site. Deferred to 100 Area final ROD. 100-F/IU Area ROD (EPA 2014), no additional action.
100-F-60, 100F Cast Iron Pipe	This site was a piece of 10-cm (4-in.)-diameter cast iron pipe found during confirmatory sampling of test pit 19 for the 100-F-26:9 pipelines.	RTD Waste site; 100 Area Fact Sheet (DOE-RL 2011). Interim closed out per WSRF 2010-034. 100-F/IU Area ROD (EPA 2014), no additional action.
100-F-61, Stained Soil near 100-F-12.	This site was an area of stained soil discovered in 2004 during confirmatory sampling of the 100-F-12 french drain. Analysis of a soil sample indicated several constituents with chemical concentrations above remedial action goals.	RTD Waste site; 100 Area Fact Sheet (DOE-RL 2011). Interim closed out per WSRF 2011-103. 100-F/IU Area ROD (EPA 2014), no additional action.
100-F-62, Animal Farm Septic Pipelines.	This site was effluent piping from the 141-M Building to the 1607-F7 septic tank and drain field, and effluent piping from the 144-F Building to the 100-F-31 septic tank and drain field in the 100-F Experimental Animal Farm.	RTD Waste site; 100 Area Fact Sheet (DOE-RL 2011). Interim closed out per WSRF 2011-104. 100-F/IU Area ROD (EPA 2014), no additional action.
100-F-63, Animal Farm Radioactive Effluent Pipelines.	This site included the radioactive effluent pipelines and process sewers at the north end of the 100-F Experimental Animal Farm.	RTD Waste site; 100 Area Fact Sheet (DOE-RL 2011). Interim closed out per WSRF 2011-0977. 100-F/IU Area ROD (EPA 2014), no additional action.

Table A-1. 100-FR-1 and 100-FR-2 Waste Site Information

Site Name	Site Information	Site Status
100-F-64, Stained Soil Near 1713-FA.	This site consisted of red and yellow stained soil along railroad tracks near the 1713-FA Building with elevated concentrations of lead.	RTD Waste site; 100 Area Fact Sheet (DOE-RL 2012). Interim closed out per WSRF 2011 119. 100-F/IU Area ROD (EPA 2014), no additional action.
100-F-65, Green Stained Soil Near RR Tracks.	This site consisted of green stained soil along the railroad tracks immediately west of the 190-F Building. Remediated as part of the 100-F-57:2 waste site.	RTD Waste site; 100 Area Fact Sheet (DOE-RL 2012). Interim closed out per WSRF 2012-059. 100-F/IU Area ROD (EPA 2014), no additional action.
116-F-1, Lewis Canal, Process Effluent Disposal Trench.	This site was an unlined trench 914 m (3,000 ft) long by 12 m (40 ft) wide by 3 m (10 ft) deep that received reactor cooling water (process effluent) from the 105-F Reactor, 190-F Building, and 116-F-14 Retention Basin, plus decontamination wastes from the 189-F Building.	RTD Waste site; ROD Amendment (EPA 1997). Remediated and interim closed out per CVP-2002-00009. 100-F/IU Area ROD (EPA 2014), no additional action.
116-F-2, 107-F Liquid Waste Disposal Trench	This site was an open liquid waste trench used for intermittent disposal of reactor cooling water (process effluent) from 1950 to 1965.	RTD Waste site; ROD Amendment (EPA 1997). Remediated and interim closed out per CVP-2001-00005. 100-F/IU Area ROD (EPA 2014), excavation restrictions.
116-F-3, 105-F Storage Basin Trench	This site was a trench that received reactor cooling water (process effluent) during a 1947 fuel element rupture occurrence. In 1951, the trench received sludge from the 105-F Fuel Storage Basin.	RTD Waste site; ROD Amendment (EPA 1997). Remediated and interim closed out per CVP-2002-00008. 100-F/IU Area ROD (EPA 2014), no additional action.
116-F-4, Pluto Crib	This site was a wooden crib that received liquid waste from the105-F Reactor during fuel ruptures between 1950 and 1952.	RTD Waste site; ROD Amendment (EPA 1997). Remediated and interim closed out per CVP-2001-00006. 100-F/IU Area ROD (EPA 2014), no additional action.
116-F-5, Ball Washer Crib	This site was a wood structure located in the transfer basin area of the 105-F Reactor Building that received decontamination wastes from the 105-F Reactor ball washer assembly.	RTD Waste site; ROD Amendment (EPA 1997). Remediated and interim closed out per CVP-2001-00007. 100-F/IU Area ROD (EPA 2014), no additional action.
116-F-6, Liquid Waste Disposal Trench	This site was an open excavation used to receive reactor cooling water (process effluent) during maintenance shutdowns of the 105-F Reactor.	RTD Waste site; ROD Amendment (EPA 1997). Remediated and interim closed out per CVP-2002-00010. 100-F/IU Area ROD (EPA 2014), excavation restrictions.

Table A-1. 100-FR-1 and 100-FR-2 Waste Site Information

Site Name	Site Information	Site Status
116-F-7, 117-F Crib and Pipeline. Subsites 1-2.	This site consisted of a crib, and pipeline that have been filled with gravel and covered with clean soil. The pipeline originated at the 117-F Filter Building (132-F-5) and terminated at the crib site.	Candidate waste site; Remaining Sites ROD (EPA 1999). Subsites reclassified to no action per WSRFs 2004-128 and 2005-044. 100-F/IU Area ROD (EPA 2014), no additional action.
116-F-8, 1904-F Outfall Structure	Located on the bank of the Columbia River, this site served as a weir box for 105-F Reactor coolant water ducted to the river via the 100-F-42 Spillway to provide overflow capability in case the outfall lines became plugged.	RTD Waste site; Remaining Sites ROD (EPA 1999). Remediated and interim closed out per WSRF 2006-038. 100-F/IU Area ROD (EPA 2014), no additional action.
116-F-9, PNL Animal Waste Leach Trench	This site was a leaching trench that received waste water from the cleaning of animal pens in the experimental animal farms.	RTD Waste site; ROD Amendment (EPA 1997). Remediated and interim closed out per CVP-2001-00008. 100-F/IU Area ROD (EPA 2014), excavation restrictions.
116-F-10, 105-F Dummy Decontamination French Drain	This site consisted of a vitrified clay pipe placed in the ground vertically and used to dispose of fluid from decontamination of dummy fuel element spacers and other reactor hardware.	RTD Waste site; ROD Amendment (EPA 1997). Remediated and interim closed out per CVP-2003-00003. 100-F/IU Area ROD (EPA 2014), no additional action.
116-F-11, Cushion Corridor French Drain	This site was a french drain that received liquid decontamination waste from the cushion corridor area of the reactor.	RTD Waste site; ROD Amendment (EPA 1997). Remediated and interim closed out per CVP-2001-00003. 100-F/IU Area ROD (EPA 2014), no additional action.
116-F-12, 148-F French Drain	This site was a french drain that received effluent pump priming water from the 148-F Pumphouse during 1944-1964. Co-located with the 100-F-19:1 pipeline subsite.	Candidate waste site; Remaining Sites ROD (EPA 1999). Remediated and interim closed out per CVP-2001-00002. 100-F/IU Area ROD (EPA 2014), excavation restrictions.
116-F-14, 107-F Retention Basins	This site was a concrete-lined, open-top reservoir designed to retain reactor cooling water prior to discharge to the Columbia River.	RTD Waste site; ROD Amendment (EPA 1997). Remediated and interim closed out per CVP-2001-00009. 100-F/IU Area ROD (EPA 2014), excavation restrictions.
116-F-15, 108-F Radiation Crib	This site was a floor drain and sump that emptied into a trench beneath the floor of the 108-F Building.	RTD Waste site; Remaining Sites ROD (EPA 1999). Remediated and interim closed out per WSRF 2007-003. 100-F/IU Area ROD (EPA 2014), no additional action.

Table A-1. 100-FR-1 and 100-FR-2 Waste Site Information

Site Name	Site Information	Site Status
116-F-16, PNL Outfall Structure	Located on the bank of the Columbia River, this site served as a concrete weir box that carried experimental animal farm wastes to the river.	RTD Waste site; Remaining Sites ROD (EPA 1999). Remediated and interim closed out per WSRF 2006-039. 100-F/IU Area ROD (EPA 2014), no additional action.
118-F-1, Burial Ground	This site was a solid waste burial ground that received radioactive material and reactor components from the 100-F Reactor from 1954-1965. Site contained two north/south trenches.	RTD Waste site; Burial Grounds ROD (EPA 2000). Remediated and interim closed out per CVP-2007-00001. 100-F/IU Area ROD (EPA 2014), no additional action.
118-F-2, Burial Ground	This site received solid waste from the 100-F Reactor and biology facilities from 1945 to 1965.	RTD Waste site; Burial Grounds ROD (EPA 2000). Remediated and interim closed out per CVP-2007-00002. 100-F/IU Area ROD (EPA 2014), no additional action.
118-F-3, Minor Construction Burial Ground	This solid waste site received irradiated reactor parts from the 100-F Reactor during the 3X Project in 1952. Waste was primarily vertical safety rod thimbles and step plugs.	RTD Waste site; Burial Grounds ROD (EPA 2000). Remediated and interim closed out per CVP-2006-00008. 100-F/IU Area ROD (EPA 2014), no additional action.
118-F-4, 115-F Pit	This site was a small unlined disposal pit used to receive silica gel from the 115-F drying towers.	Candidate waste site; Remaining Sites ROD (EPA 1999). Reclassified to no action per WSRF 2004-129. 100-F/IU Area ROD (EPA 2014), no additional action.
118-F-5, PNL Sawdust Pit	This site received sawdust containing strontium-90 and plutonium-239 from the animal pens at the Experimental Animal Farm from 1954-1975. Materials were placed in paper boxes or 250-L (55-gal) metal drums for burial.	RTD Waste site; Burial Grounds ROD (EPA 2000). Remediated and interim closed out per CVP-2007-00003. 100-F/IU Area ROD (EPA 2014), no additional action.
118-F-6, PNL Solid Waste Burial Ground	This site received biological waste from animal research studies from 1965-1973. During remediation, a single railroad tank car containing burned animal carcasses was found buried in the easternmost trench, as predicted by geophysical investigations. Informational samples and strontium-90 assays were taken of groundwater in trench 4, which was excavated to 6.5 m (21 ft) below ground surface.	RTD Waste site; Burial Grounds ROD (EPA 2000). Remediated and interim closed out per CVP-2008-00001. 100-F/IU Area ROD (EPA 2014), excavation restrictions.
118-F-7 Misc. Hardware Storage Vault	This site was a below ground concrete vault south of the 105-F Reactor building that was used from 1945 to 1965 for temporary storage of contaminated reactor parts and mixed wastes.	RTD Waste site; Burial Grounds ROD (EPA 2000). Remediated and interim closed out per CVP-2006-00007. WSRF 2008-018. 100-F/IU Area ROD (EPA 2014), no additional action.

Table A-1. 100-FR-1 and 100-FR-2 Waste Site Information

Site Name	Site Information	Site Status
118-F-8, 105-F Reactor Building Subsites 1-4.	This site is an inactive plutonium production reactor that operated from 1944 to 1965 and was placed in Interim Safe Storage in 2003. The site includes: 118-F-8:1: 105-F Reactor Ancillary Support Areas, Below-Grade Structures, and Underlying Soils;	Action memorandum (EPA 1998). 118-F-8:1, Remediated and interim closed out per CVP-2003-00017. 100-F/IU Area ROD (EPA 2014), no additional action.
	118-F-8:3: 105-F Fuel Storage Basin and Underlying Soils; and	118-F-8:3, Remediated and interim closed out per CVP-2003-00017. 100-F/IU Area ROD (EPA 2014), excavation restrictions.
	118-F-8:4: 105-F Fuel Storage Basin West Side Adjacent and Side Slope Soils.	118-F-8:4, Remediated and interim closed out per CVP-2007-00004. 100-F/IU Area ROD (EPA 2014), excavation restrictions.
120-F-1, Glass Dump	This was a dump site containing surface litter consisting of numerous fluorescent tubes, light bulbs, vacuum tubes, broken tools, small batteries, chemical bottles, and laboratory apparatus.	RTD Waste site; Remaining Sites ROD (EPA 1999). Remediated and interim closed out per WSRF 2008-028. 100-F/IU Area ROD (EPA 2014), no additional action.
126-F-1, Ash Pit	This was a solid waste site that received coal ash from the 184-F coal-fired steam plant. The site became radioactively contaminated due to leakage from the 105-F Reactor process effluent disposal system.	RTD Waste site; ROD Amendment (EPA 1997). Remediated and interim closed out per CVP-2002-00004. 100-F/IU Area ROD (EPA 2014), no additional action.
126-F-2, 183-F Clearwells	Reinforced concrete water storage basins designed to store river water being processed for reactor coolant. Operated from 1945 to 1965.	Candidate waste site; Remaining Sites ROD (EPA 1999). Remediated and interim closed out per WSRF 2006-017. 100-F/IU Area ROD (EPA 2014), no additional action.
128-F-1, Burning Pit	Burning pit that operated from 1945 to 1965. Waste included nonradioactive, combustible materials such as paint waste, office waste, and chemical solvents.	Candidate waste site; Remaining Sites ROD (EPA 1999). Reclassified to no action per WSRF 2003-035. 100-F/IU Area ROD (EPA 2014), no additional action.
128-F-2, Burning Pit	Site is an irregularly-shaped depression located on the river bank used for burning of nonhazardous office waste, vegetation, paint, solvents, and other combustibles.	Candidate waste site; Remaining Sites ROD (EPA 1999). Remediated and interim closed out per WSRF 2008-031. 100-F/IU Area ROD (EPA 2014), no additional action.
128-F-3, PNL Burn Pit	Shallow pit used for burning materials from the Experimental Animal Farm. Pit currently filled with coal ash.	Candidate waste site; Remaining Sites ROD (EPA 1999). Remediated and interim closed out per WSRF 2006-042. 100-F/IU Area ROD (EPA 2014), no additional action.

Table A-1. 100-FR-1 and 100-FR-2 Waste Site Information

Site Name	Site Information	Site Status
132-F-1, Chronic Feeding Barn	Site was a concrete block building with concrete animal pens that was used as the main housing facility for sheep and other livestock used in radiological dose studies.	Candidate waste site; Remaining Sites ROD (EPA 1999). Remediated and interim closed out per WSRF 2006-029. 100-F/IU Area ROD (EPA 2014), no additional action.
132-F-3, Gas Recirculation Facility	Single-story concrete building that housed the reactor inert gas processing and recirculation system.	Candidate waste site; Remaining Sites ROD (EPA 1999). Reclassified to no action per WSRF 2003-025. 100-F/IU Area ROD (EPA 2014), no additional action.
132-F-4, 116-F Reactor Stack. Subsites 1-2.	Site contains concrete rubble from demolition of the 105-F (116-F) Reactor Stack. The stack was used to exhaust confinement air from the work areas of the 105-F Reactor Building from 1944-1965 and was demolished in 1983. The stack and its foundation were demolished with explosives and buried in a trench. Site consists of two subsites: (1) 116-F Reactor Stack, and (2) Reactor Stack Base Burial Site.	Candidate waste site; Remaining Sites ROD (EPA 1999). 132-F-4:1, reclassified to no action per WSRF 2003-023. 100-F/IU Area ROD (EPA 2014), no additional action. 132-F-4:2, reclassified to no action per WSRF 2005-043. 100-F/IU Area ROD (EPA 2014), no additional action.
132-F-5, 117-F Filter Building	Building received exhaust fan discharge through an inlet duct from the 105-F Reactor and discharged filtered air through a duct and out the 116-F stack.	Candidate waste site; Remaining Sites ROD (EPA 1999). Reclassified to no action per WSRF 2003-029. 100-F/IU Area ROD (EPA 2014), no additional action.
132-F-6, 1608-F Waste Water Pumping Station	Former concrete building that housed a water pumping station that operated from 1944-1965 and was demolished in situ in 1987. Received waste water from reactor drains and sumps and combined these wastes with reactor effluent.	Candidate waste site; Remaining Sites ROD (EPA 1999). Reclassified to no action per WSRF 2003-032. 100-F/IU Area ROD (EPA 2014), no additional action.
141-C, Animal Barn	Site was the location of the large animal barn and biology laboratory, and also referred to as the hog barn.	Candidate waste site; Remaining Sites ROD (EPA 1999). Remediated and interim closed out per WSRF 2006-027. 100-F/IU Area ROD (EPA 2014), no additional action.
182-F, Reservoir	Received raw water from the Columbia River for input to the reactor cooling water system. Operated 1945-1965.	Candidate waste site; Remaining Sites ROD (EPA 1999). Remediated and interim closed out per WSRF 2005-025. 100-F/IU Area ROD (EPA 2014), no additional action.
600-351, Stained Soil Areas Outside of 100-F Area	This site contained two stained soil areas outside of 100-F Area hiving stained, crusted soil and no vegetation.	RTD Waste site; 100 Area Fact Sheet (DOE-RL 2012). Interim closed out per WSRF 2011-087. 100-F/IU Area ROD (EPA 2014), no additional action.

Table A-1. 100-FR-1 and 100-FR-2 Waste Site Information

Site Name	Site Information	Site Status
1607-F1, 124-F-1 Septic Tank and Drainfield	Concrete septic tank with a 125-person capacity, a vitrified pipe tile field, and associated piping. Received sanitary sewage from the 1701-F badge house, 1709-F Fire Station, and 1720-F administrative office and change room.	Candidate waste site; Remaining Sites ROD (EPA 1999). Remediated and interim closed out per WSRF 2004-130. 100-F/IU Area ROD (EPA 2014), no additional action.
1607-F2, Septic System	Site included a septic tank, drainfield, and associated piping that received sanitary wastes from the 184-F, 185-F, 190-F, and 1700 Admin. Services Building. Site operated from 1944 to 1988.	RTD Waste site; Remaining Sites ROD (EPA 1999). Remediated and interim closed out per CVP-2002-00005. 100-F/IU Area ROD (EPA 2014), no additional action.
1607-F3, 124-F-3 Septic System	Site included a 41-person capacity concrete tank with vitrified pipe tile field. It operated from 1944 to 1965. It received sanitary sewage from 182-F Pump Station, 183-F Water Treatment Plant, and 151-F Substation. Arsenic-lead site.	Candidate waste site; Remaining Sites ROD (EPA 1999). Remediated and interim closed out per WSRF 2006-047. 100-F/IU Area ROD (EPA 2014), no additional action.
1607-F4, Septic System	Site included a 6-person capacity concrete tank, vitrified pipe tile field, and associated piping. It operated from 1944 to 1965 and received sanitary sewage from the 115-F Gas Recirculation Building.	Candidate waste site; Remaining Sites ROD (EPA 1999). Remediated and interim closed out per WSRF 2004-131. 100-F/IU Area ROD (EPA 2014), no additional action.
1607-F5, Septic System	Site included a 6-person capacity concrete tank with vitrified pipe tile field. It operated from 1944 to 1965 and received sanitary sewage from the 181-F Pump house.	Candidate waste site; Remaining Sites ROD (EPA 1999). Remediated and interim closed out per WSRF 2006-043. 100-F/IU Area ROD (EPA 2014), no additional action.
1607-F6, Septic System	Site included three tanks, a tile field, and associated pipelines. It operated from 1945 to 1975 and received sanitary wastes from the 1705-F, 146-F, and 146-FR Animal Farm Buildings.	RTD Waste site; Remaining Sites ROD (EPA 1999). Remediated and interim closed out per CVP-2001-00010. 100-F/IU Area ROD (EPA 2014), no additional action.
1607-F7, Septic System	Site included a septic tank, drainfield, and associated piping that received sanitary sewage from the 141-M Building.	Candidate waste site; Remaining Sites ROD (EPA 1999). Remediated and interim closed out per WSRF 2006-040. 100-F/IU Area ROD (EPA 2014), no additional action.
UPR-100-F-1, Sewer Line Leak	Spill of 64,352 L (17,000 gal) of animal pens wash water occurred when a process sewer line from the 141-C Hog Barn plugged and overflowed adjacent to the building in 1971.	Candidate waste site; Remaining Sites ROD (EPA 1999). Remediated and interim closed out per CVP-2001-00003. 100-F/IU Area ROD (EPA 2014), no additional action.

Table A-1. 100-FR-1 and 100-FR-2 Waste Site Information

Site Name	Site Information	Site Status
UPR-100-F-2, Basin Leak Ditch (100-F-3)	Ditch formed by overflow of the north end of the 107-F Retention Basin during 1955 and enlarged by repeated overflows from an effluent line manhole north of the basin. Ditch ran northeast to the Columbia River	RTD Waste site; ROD Amendment (EPA 1997). Remediated and interim closed out per CVP-2001-00011. 100-F/IU Area ROD (EPA 2014), no additional action.
UPR-100-F-3, Mercury Spill	Mercury spilled on the floor of the former 146-FR Fish Lab. All material was "squeegeed" out the door of the building and was reported to have been cleaned up and removed.	Candidate waste site; Remaining Sites ROD (EPA 1999). Remediated and interim closed out per CVP-2003-00010. 100-F/IU Area ROD (EPA 2014), no additional action.

CVP = cleanup verification package
D&D = decontamination and decommissioning
ESD = explanation of significant differences
ROD = record of decision
RTD = remove-treat-dispose
SIS = Stewardship Information System
UPR = unplanned release
WIDS = Waste Information Data System
WSRF = waste site reclassification form

Table A-2. 100-IU-2 and 100-IU-6 Waste Site Information

Site Name	Site Information	Site Status
600-3, Hanford Townsite Dumping Area and Paint Pit 100-IU-6	Site consisted of a shallow trench that appeared to be an old borrow pit approximately 37 x 27 x 1.2 m (120 x 90 x 4 ft) and a dumping area spread over an area about 280 x 490 m (925 x 1,600 ft). Waste included dried paint and paint cans, roofing paper, possible asbestos-containing material, steel, aluminum, burnt wood, etc.	Candidate waste site; Remaining Sites ROD (EPA 1999). Interim closed out per WSRF 2011-072, CCN 161468. 100-F/IU Area ROD (EPA 2014), no additional action.
600-5, Waste Oil Dump, Asphalt Heliport 100-IU-2	Site consisted of a circular asphalt or heavy oil area 4.6 m (15 ft) in diameter and an asphalt or heavy oil ditch 7.6 m (25 ft) long, 38 cm (15 in.) wide, and 2.5 cm (1 in.) deep. Also located at this site was a metal flag and steel pipe.	Candidate waste site; Remaining Sites ROD (EPA 1999). Interim closed out per WSRF 2010-087. 100-F/IU Area ROD (EPA 2014), no additional action.
600-20, 100-IU-6, Tank Cleaning Site; 615 Hot Mix Plant. 100-IU-6	The site was the remaining components of a hot mix asphalt batch plant that included two large asphalt tanks, valve pits, piping, asphalt spills, and assorted debris. Waste asphalt, dumped in solid and liquid form, was prevalent at the site, as was other construction and equipment debris.	Candidate waste site. 100 Area Fact Sheet (DOE-RL 2013). (Remediation pending: 8/27/14) 100-F/IU Area ROD (EPA 2014), RTD to cleanup levels.
600-23, Dumping Area Within Gravel Pit #11 100-IU-6	Site was an area of buried debris inside a large gravel pit.	RTD Waste site; Remaining Sites, 100-IU-6 ESD (EPA 2000a). Remediated and interim closed out per CVP-2001-00020. 100-F/IU Area ROD (EPA 2014), no additional action.
600-52, White Bluffs Surface Basin 100-IU-2	Site was a depression in the ground that may have received discharges from the 600-106 Pickling Acid Crib.	Candidate waste site; Remaining Sites ROD (EPA 1999). Site was reclassified to no action per WSRF 2003-028. 100-F/IU Area ROD (EPA 2014), no additional action.
600-98, East White Bluffs City Landfills 100-IU-2	Site consisted of two unlined pre-Hanford landfills.	Candidate waste site; Remaining Sites ROD (EPA 1999). Reclassified to no action per WSRF 2004-098. 100-F/IU Area ROD (EPA 2014), no additional action.
600-99, JA Jones #2 100-IU-2	Site contained minor construction equipment used by the J.A. Jones Construction Company and included wood scraps, concrete, and some metallic waste.	Candidate waste site; Remaining Sites ROD (EPA 1999). Reclassified to no action per WSRF 2003-037. 100-F/IU Area ROD (EPA 2014), no additional action.
600-100, White Bluffs Landfill 100-IU-2	Site is an unlined depression that received industrial, commercial, domestic, and farm waste.	Candidate waste site; Remaining Sites ROD (EPA 1999). Interim closed out per WSRF 2010-082. 100-F/IU Area ROD (EPA 2014), no additional action.

Table A-2. 100-IU-2 and 100-IU-6 Waste Site Information

Site Name	Site Information	Site Status
600-107, Cribs at 213-J&K Storage Facility 100-IU-6	Site consisted of two small cribs located in the 213-J and 213-K Storage Vault Facility.	Candidate waste site; Remaining Sites ROD (EPA 1999). Reclassified to no action per WSRF 2003-033. 100-F/IU Area ROD (EPA 2014), no additional action.
600-108, 213-K Vault (with 600-257, 213-J Vault) 100-IU-6	This waste site consisted of the 213-K Storage Vault only, which was one of two parallel, reinforced concrete, earth-covered storage facilities. Originally built to store containers of processed plutonium product; later used to store soil samples and contaminated equipment.	Candidate waste site; Remaining Sites ROD (EPA 1999). Interim closed out per WSRF 2011-051. 100-F/IU Area ROD (EPA 2014), no additional action.
600-109, HTCL, Hanford Trailer Camp Landfill 100-IU-6	This site was located within a gravel pit and consisted of scattered debris and typical domestic and construction waste that were used during construction of the Hanford Site facilities. This is an arsenic-lead contamination site.	Candidate waste site; Remaining Sites ROD (EPA 1999). Interim closed out per WSRF 2010-075. 100-F/IU Area ROD (EPA 2014), no additional action.
600-110, HTL, Hanford Townsite Landfill. 100-IU-6	This site consisted of an unlined excavated area used for pre-Hanford dumping of industrial and domestic waste. The site was backfilled for use in the Hanford Construction Camp.	Candidate waste site; Remaining Sites ROD (EPA 1999). Reclassified to no action per WSRF 2004-062. 100-F/IU Area ROD (EPA 2014), no additional action.
600-111, P-11 Critical Mass Laboratory Crib 100-IU-6	This site was the location of a demolished facility and crib with subsurface radiological contamination. Facilities were called the P-11 Critical Mass Laboratory and included the 120 and 123 Buildings.	Candidate waste site; Remaining Sites ROD (EPA 1999). Remediated and interim closed out per WSRF 2004-065. 100-F/IU Area ROD (EPA 2014), no additional action.
600-120, White Bluffs Spare Parts Burn Pit 100-IU-2	This site was a burn pit that was used for industrial and commercial wastes. The site appears to have been backfilled with coal ash.	Candidate waste site; Remaining Sites ROD (EPA 1999). Interim closed out per WSRF 2010-063. 100-F/IU Area ROD (EPA 2014), no additional action.
600-124, White Bluffs Burn Site and Paint Disposal Area 100-IU-2	The site was an area with evidence of burning and paint disposal. Possible asbestos-containing material was scattered about.	Candidate waste site; Remaining Sites ROD (EPA 1999). Remediated and interim closed out per WSRF 2010-094. 100-F/IU Area ROD (EPA 2014), no additional action.
600-125, White Bluffs Waste Disposal Trench 1 100-IU-2	This site was a sandy depression with wood, ceramic, and metal debris on the surface.	Candidate waste site; Remaining Sites ROD (EPA 1999). Interim closed out per WSRF 2010-088. 100-F/IU Area ROD (EPA 2014), no additional action.
600-127, White Bluffs Fuel Storage Area 100-IU-2	This site was two loading docks and a rectangular area surrounded by a low soil berm.	Candidate waste site; Remaining Sites ROD (EPA 1999). Interim closed out per WSRF 2004-064. 100-F/IU Area ROD (EPA 2014), no additional action.

Table A-2. 100-IU-2 and 100-IU-6 Waste Site Information

Site Name	Site Information	Site Status
600-128, White Bluffs Oil and Oil Filter Dump Site 100-IU-2	This site was a pre-Hanford, White Bluffs Community oil dump area that included canister-type oil filters.	Candidate waste site; Remaining Sites ROD (EPA 1999). Remediated and interim closed out per WSRF 2003-039. 100-F/IU Area ROD (EPA 2014), no additional action.
600-129, White Bluffs Community Dump Site 100-IU-2	This site was a pre-Hanford, White Bluffs Community dump site of miscellaneous debris and trash.	Candidate waste site; Remaining Sites ROD (EPA 1999). Remediated and interim closed out per WSRF 2004-136. 100-F/IU Area ROD (EPA 2014), no additional action.
600-131, White Bluffs Special Fabrication Shops 100-IU-2	This site included the remnants of the Special Fabrication Shop and Warehouse, boiler house, loading dock/well, and a water station.	Candidate waste site; Remaining Sites ROD (EPA 1999). Remediated and interim closed out per WSRF 2003-045. 100-F/IU Area ROD (EPA 2014), no additional action.
600-132, Construction Contractor Shop Landfill 100-IU-2	This site was a large, open borrow pit, with access ramps for trucks, ridges in the bottom where scraped, and piles of soil near the edges. Miscellaneous trash was scattered about the site.	Candidate waste site; Remaining Sites ROD (EPA 1999). Remediated and interim closed out per WSRF 2003-040. 100-F/IU Area ROD (EPA 2014), no additional action.
600-139, White Bluffs Automotive Repair Shop 100-IU-2	This site was an area thought to be associated with an automotive repair shop, due to type of surface debris: battery caps, engine gaskets, dumped waste oil, and fragments of tail lights.	Candidate waste site; Remaining Sites ROD (EPA 1999). Remediated and interim closed out per WSRF 2003-041. 100-F/IU Area ROD (EPA 2014), no additional action.
600-146, Steel Structure on Northwest Side of Gable Mountain 100-IU-6	The site included a steel structure constructed of steel "I" beams and "L" beams. The structure appeared to be lying in a horizontal position. Debris observed lying around the structure included stainless steel pipe, metal rings, metal boxes, empty cans, and wood.	RTD Waste site; Remaining Sites ESD (EPA 2009). Interim closed out per WSRF 2010-045. 100-F/IU Area ROD (EPA 2014), no additional action.
600-149, Small Arms Range. Subsites 1-2. 100-IU-6	The site was a practice range for rifles, shotguns, machine guns, hand grenades, smoke bombs, and other small arms. 600-149:1; range house building, well pumphouse, and four firing ranges. 600-149:2; berm located behind pistol/rifle range area.	RTD Waste site; 100 Area Remaining Sites ROD (EPA 1999). See Subsites. 600-149:1; Interim closed out per WSRF 2011-028. 600-149:2; Remediated and interim closed out per WSRF 2008-049. 100-F/IU Area ROD (EPA 2014), no additional action.
600-176, White Bluffs Paint Disposal Area 100-IU-2	The site was a dumping area where excess paint materials were disposed of by pouring them on the ground. The paint spills and chips were scattered over a large area.	Candidate waste site. 100 Area Remaining Sites ROD (EPA 1999). Remediated and interim closed out per WSRF 2011-029. 100-F/IU Area ROD (EPA 2014), no additional action.

Table A-2. 100-IU-2 and 100-IU-6 Waste Site Information

Site Name	Site Information	Site Status
600-178, 213-J and 213-K Guard House Toilet Pit 100-IU-6	The site was a toilet pit opening within a concrete pad that was the remains of a guard house. No evidence of a sewage distribution system (septic tank) was found.	RTD Waste site; Remaining Sites ESD (EPA 2009). Interim closed out per WSRF 2011-057. 100-F/IU Area ROD (EPA 2014), no additional action.
600-181, White Bluffs Oil Dump 100-IU-2	This site was an oil dumping area with an asphalt-like surface.	Candidate waste site. 100 Area Remaining Sites ROD (EPA 1999). Remediated and interim closed out per WSRF 2003-048. 100-F/IU Area ROD (EPA 2014), no additional action.
600-182, White Bluffs Asbestos Pipe Lagging and Excess Piping 100-IU-2	This site consisted of excess piping materials and an area of highly degraded piping insulation that appeared to be made of asbestos or a similar material.	RTD Waste site; Remaining Sites ESD (EPA 2009). Interim closed out per WSRF 2010-089. 100-F/IU Area ROD (EPA 2014), no additional action.
600-186, Hanford Construction Camp Septic Tanks and Sewage 100-IU-6	The waste site included all of the septic tanks as well as the sewage treatment plants at the Hanford Construction Camp.	Candidate waste site; Remaining Sites ESD (EPA 2009). Interim closed out per WSRF 2011-069, CCN 161467. 100-F/IU Area ROD (EPA 2014), no additional action.
600-188, White Bluffs Waste Disposal Trench 2 100-IU-2	This site was an open trench with industrial waste filling about one-third of it. There was evidence of chemical or oil dumping as well as empty 208-L (55-gal) drums.	Candidate waste site; Remaining Sites ROD (EPA 1999). Interim closed out per WSRF 2010-090. 100-F/IU Area ROD (EPA 2014), no additional action.
600-190, White Bluffs Tar/Paint Disposal Area 100-IU-2	This site was an area where tar and/or paints appeared to have been dumped.	Candidate waste site. 100 Area Remaining Sites ROD (EPA 1999). Remediated and interim closed out per WSRF 2003-047. 100-F/IU Area ROD (EPA 2014), no additional action.
600-191, White Bluffs Community Dump Site 2 100-IU-2	This site was a pre-Hanford, White Bluffs Community dump site of miscellaneous debris and trash.	RTD Waste site; Remaining Sites ESD (EPA 2009). Remediated and interim closed out per WSRF 2004-136. 100-F/IU Area ROD (EPA 2014), no additional action.
600-201, White Bluffs Paint and Disposal Site 100-IU-2	This site contained miscellaneous trash and debris including paint, glass, metal shavings, metal parts, and army-green canvas material.	Candidate waste site. 100 Area Remaining Sites ROD (EPA 1999). Reclassified to no action per WSRF 2003-038. 100-F/IU Area ROD (EPA 2014), no additional action.

Table A-2. 100-IU-2 and 100-IU-6 Waste Site Information

Site Name	Site Information	Site Status
600-202, Four Burn and Burial Pits at Hanford Townsite 100-IU-6	This site included four burn and burial pits located close together and arranged to form a triangle. The waste included miscellaneous trash such as glass, china, bottles, kitchen materials, and a broken toilet bowl.	Candidate waste site; Remaining Sites ROD (EPA 1999). Interim closed out per WSRF 2011-030. 100-F/IU Area ROD (EPA 2014), no additional action.
600-204, Hanford Townsite Burn and Burial Trench 100-IU-6	This site was a long, narrow trench that was used for dumping and burning trash.	Candidate waste site. 100 Area Remaining Sites ROD (EPA 1999). Remediated and interim closed out per WSRF 2003-043. 100-F/IU Area ROD (EPA 2014), no additional action.
600-205, Hanford Townsite Landfill 2 100-IU-6	This site was a large area that appeared to have been used as a dumping area for domestic waste for the Hanford townsite community.	Candidate waste site. 100 Area Remaining Sites ROD (EPA 1999). Interim closed out per WSRF 2011-031. 100-F/IU Area ROD (EPA 2014), no additional action.
600-208, Hanford Construction Camp Boiler House Ponds 100-IU-6	This site consisted of 18 liquid disposal ponds that supported the boiler houses used for heating in the Hanford construction camp.	Candidate waste site. 100 Area Remaining Sites ROD (EPA 1999). Reclassified to no action per WSRF 2004-096. 100-F/IU Area ROD (EPA 2014), no additional action.
600-235, Lead-Sheathed Telephone Cables 100-IU-6	Lead-Sheathed Telephone Cables in all areas of the Hanford Site.	No prior ROD. No Action per WSRF 2001-091. 100-F/IU Area ROD (EPA 2014), no additional action.
600-239, Debris in Pit 16 100-IU-6	The site contained several large wooden beams, pallets, steel pipe, plates, and rubber tires. Miscellaneous Restoration was performed in 2012 to remove debris.	No prior ROD. No Action per WSRF 2001-017. 100-F/IU Area ROD (EPA 2014), no additional action.
600-257, 213-J Vault; with 600-108, 213-K Vault 100-IU-6	These waste sites consisted of the 213-K and 213-J vaults; two parallel, reinforced concrete, earth-covered storage facilities. Originally built to store containers of processed plutonium product; later used to store soil samples and contaminated equipment.	Candidate waste site. 100 Area Remaining Sites ROD (EPA 1999). Interim closed out per WSRF 2011-051. 100-F/IU Area ROD (EPA 2014), no additional action.
600-279, Vegetation-Free Area Between White Bluffs and 100-F Area. 100-IU-2	The site was a large area with no vegetation covered with ash and bits of burned debris related to a pre-Manhattan Engineering District orchard. The area is located in the corner of a large orchard visible in 1941 and 1948 aerial photographs.	RTD Waste site; 100 Area Fact Sheet (DOE-RL 2013). Interim closed out per WSRF 2013-134. 100-F/IU Area ROD (EPA 2014), RTD to cleanup levels.
600-280, Hardened Tar Site 100-IU-6	The site is a 10- x 6-m area where tar was dumped.	RTD Waste site; Remaining Sites ESD (EPA 2009). Interim closed out per WSRF 2011-014. 100-F/IU Area ROD (EPA 2014), no additional action.

Table A-2. 100-IU-2 and 100-IU-6 Waste Site Information

Site Name	Site Information	Site Status
600-293, Service Station #1	This site was the former location of a service station that supported the White Bluffs Central Shops.	Candidate waste site; Remaining Sites ESD (EPA 2009). Interim closed out per WSRF 2013-120. 100-F/IU Area ROD (EPA 2014), RTD to cleanup levels.
600-294, Service Station #2	This site was the former location of a service station north of Federal Avenue and west of Gasoline Alley that was demolished and buried in place in 1975.	Candidate waste site; Remaining Sites ESD (EPA 2009). Interim closed out per WSRF 2013-132. 100-F/IU Area ROD (EPA 2014), RTD to cleanup levels.
600-295, Paint Shop 100-IU-2	This site was the location of a former paint shop building.	Candidate waste site; Remaining Sites ESD (EPA 2009). Interim closed out per WSRF 2011-007. 100-F/IU Area ROD (EPA 2014), no additional action.
600-296, Fire Department Septic System 100-IU-2	This site consisted of multiple locations of former fire station septic systems.	Candidate waste site; Remaining Sites ESD (EPA 2009). No action per WSRF 2011-015. 100-F/IU Area ROD (EPA 2014), no additional action.
600-297, Imhoff Tank 100-IU-2	This site consisted of an Imhoff tank located south of Federal Avenue, and west of the Chicago Milwaukee Railroad that supported former facilities in the vicinity and is associated with the 600-106 filter bed.	Candidate waste site; Remaining Sites ESD (EPA 2009). Interim closed out per WSRF 2011-006. 100-F/IU Area ROD (EPA 2014), no additional action.
600-298, Stained/Burned Soil Areas. Subsites 1-8. 100-IU-2	This site consisted of multiple surface-stained and burned soil areas containing debris.	RTD Waste site; Remaining Sites ESD (EPA 2009). Subsites 1-8 were interim closed out per WSRF 2013-040. 100-F/IU Area ROD (EPA 2014), RTD to cleanup levels.
600-299, Battery areas. Subsites 1-6 100-IU-2	This site consisted of multiple areas with batteries at the ground surface, surface debris, and stained soil. This is an arsenic-lead contamination site.	RTD Waste site; Remaining Sites ESD (EPA 2009). Subsites 1-6 were interim closed out per WSRF 2013-041. 100-F/IU Area ROD (EPA 2014), RTD to cleanup levels.
600-300, Miscellaneous Debris. Subsites 1-12. 100-IU-2	This site consisted of miscellaneous debris areas with containers of paint, tar, petroleum products, and unknown substances. This is an arsenic-lead contamination site.	RTD Waste site; Remaining Sites ESD (EPA 2009). Subsites 1-12 were interim closed out per WSRF 2013-042. 100-F/IU Area ROD (EPA 2014), RTD to cleanup levels.
600-301, White Bluffs Sanitary Sewer Pipelines 100-IU-2	This site consisted of miles of sanitary sewer pipelines associated with the White Bluffs townsite.	Candidate waste site; Remaining Sites ESD (EPA 2009). Interim closed out per WSRF 2013-129. 100-F/IU Area ROD (EPA 2014), RTD to cleanup levels.

Table A-2. 100-IU-2 and 100-IU-6 Waste Site Information

Site Name	Site Information	Site Status
600-302, French Drain and Vent Pipe 100-IU-2	This site was a 1-m-diameter drain with an associated vent pipe.	Candidate waste site; Remaining Sites ESD (EPA 2009). No Action per WSRF 2010-095. 100-F/IU Area ROD (EPA 2014), no additional action.
600-303, Vertical Pipes 100-IU-2	This site consisted of four vertical pipes sticking out of the ground in a 3- x 3-m area adjacent to a concrete foundation of a former building.	Candidate waste site; Remaining Sites ESD (EPA 2009). Interim closed out per WSRF 2013-046. 100-F/IU Area ROD (EPA 2014), RTD to cleanup levels.
600-305, Areas with suspect asbestos-containing material Subsites 1-5 100-IU-2	This site consisted of suspect asbestos-containing material areas.	RTD Waste site; Remaining Sites ESD (EPA 2009). Subsites 1-5 were interim closed out per WSRF 2012-070. 100-F/IU Area ROD (EPA 2014), no additional action.
600-306, Burn site #1 100-IU-2	This site was a burned surface debris area, approximately 9 x 9 m in area.	RTD Waste site; Remaining Sites ESD (EPA 2009). Interim closed out per WSRF 2012-031. 100-F/IU Area ROD (EPA 2014), no additional action.
600-307, Burn site #2 100-IU-2	This site was a burned surface debris area, approximately 4 x 4 m in area.	RTD Waste site; Remaining Sites ESD (EPA 2009). Interim closed out per WSRF 2012-032. 100-F/IU Area ROD (EPA 2014), no additional action.
600-308, Garnet Sand 100-IU-2	This site was a surface garnet sand area, approximately 6 x 6 m in area.	RTD Waste site; Remaining Sites ESD (EPA 2009). Interim closed out per WSRF 2012-060. 100-F/IU Area ROD (EPA 2014), no additional action.
600-309, Burn Site #3 100-IU-2	This site was an area of burned and dumped debris from pre-Hanford and Hanford disposal activities. The site was approximately 30 x 20 m in area.	RTD Waste site; Remaining Sites ESD (EPA 2009). Interim closed out per WSRF 2012-040. 100-F/IU Area ROD (EPA 2014), no additional action.
600-310, Burn Site #4 100-IU-2	This site was a burned area of glass cinders and metal slag, approximately 7 x 17 m in area.	RTD Waste site; Remaining Sites ESD (EPA 2009). Interim closed out per WSRF 2012-041. 100-F/IU Area ROD (EPA 2014), no additional action.
600-311, Burn Site #5 100-IU-2	This site was a burned surface debris area, approximately 2 x 2 m in area.	RTD Waste site; Remaining Sites ESD (EPA 2009). Interim closed out per WSRF 2012-042. 100-F/IU Area ROD (EPA 2014), no additional action.

Table A-2. 100-IU-2 and 100-IU-6 Waste Site Information

Site Name	Site Information	Site Status
600-312, Burn Site #6 100-IU-2	This site was a burned surface debris area, approximately 2 x 2 m in area.	RTD Waste site; Remaining Sites ESD (EPA 2009). Interim closed out per WSRF 2012-043. 100-F/IU Area ROD (EPA 2014), no additional action.
600-313, Oil stained or Burn Area 100-IU-6	This site consisted of an oil-stained or burned area approximately 3 m in diameter.	RTD Waste site; Remaining Sites ESD (EPA 2009). Interim closed out per WSRF 2012-044. 100-F/IU Area ROD (EPA 2014), no additional action.
600-314, Telecommunication Components. Subsites 1-5 100-IU-6	This site consisted of multiple areas with single components of telecommunication equipment with dimensions of 41 x 23 cm. Also includes a single 3-m-diameter area with battery debris.	RTD Waste site; Remaining Sites ESD (EPA 2009). Subsites 1-5 were Interim closed out per WSRF 2012-045. 100-F/IU Area ROD (EPA 2014), no additional action.
600-315, Black Granular Stain 100-IU-6	This site was a 4-m-diameter black granular stain.	Candidate waste site; Remaining Sites ESD (EPA 2009). No Action per WSRF 2011-024. 100-F/IU Area ROD (EPA 2014), no additional action.
600-316, Dry cell Batteries. Subsites 1-6 100-IU-6	This site consisted of multiple areas with dry cell battery debris and mixed farmstead debris.	RTD Waste site; Remaining Sites ESD (EPA 2009). Subsites 1-6 were interim closed out per WSRF 2013-034. 100-F/IU Area ROD (EPA 2014), RTD to cleanup levels.
600-317, Batteries/burn Area 100-IU-6	This site consisted of scattered debris areas with battery debris and burned debris, approximately 15 x 7 m in area.	RTD Waste site; Remaining Sites ESD (EPA 2009). Interim closed out per WSRF 2012-046. 100-F/IU Area ROD (EPA 2014), no additional action.
600-318, Wet cell battery Areas. Subsites 1-5. 100-IU-6	This site consisted of multiple areas with battery and automotive shop debris.	RTD Waste site; Remaining Sites ESD (EPA 2009). Subsites 1-5 were Interim Closed Out per WSRF 2013-035. 100-F/IU Area ROD (EPA 2014), RTD to cleanup levels.
600-319, Miscellaneous Debris Areas. Subsites 1-3. 100-IU-6	This site consisted of multiple areas with debris, including areas with potential paint and solvent-related waste.	RTD Waste site; Remaining Sites ESD (EPA 2009). Subsites 1-3 were interim closed out per WSRF 2012-071. 100-F/IU Area ROD (EPA 2014), no additional action.
600-320, Oil Stain Areas. Subsites 1-9. 100-IU-6	This site consisted of multiple surface oil stains and oil dump areas with oil filters and tar. This is an arsenic-lead contamination site.	RTD Waste site; Remaining Sites ESD (EPA 2009). Subsites 1-9 were interim closed out per WSRF 2012-047. 100-F/IU Area ROD (EPA 2014), RTD to cleanup levels.

Table A-2. 100-IU-2 and 100-IU-6 Waste Site Information

Site Name	Site Information	Site Status
600-321, Suspect Asbestos Areas. Subsites 1-4. 100-IU-6	This site consisted of multiple areas with suspect asbestos-containing material on the ground surface.	RTD Waste site; Remaining Sites ESD (EPA 2009). Subsites 1-4 were interim closed out per WSRF 2013-047. 100-F/IU Area ROD (EPA 2014), RTD to cleanup levels.
600-322, Rail Spur Pipe 100-IU-6	This site was an 8-in.-diameter carbon steel drain pipe under a railroad spur.	Candidate waste site; Remaining Sites ESD (EPA 2009). No Action per WSRF 2011-011. 100-F/IU Area ROD (EPA 2014), no additional action.
600-323, Bermed Area 100-IU-6	This site consisted of an area of bermed cinders with dimensions of approximately 30 x 30 m and 0.5 m high. EPA 2009. Candidate Site. No action per WSRF 2011-009, 4/26/11.	Candidate waste site; Remaining Sites ESD (EPA 2009). No Action per WSRF 2011-009. 100-F/IU Area ROD (EPA 2014), no additional action.
600-324, Burned Debris Area 100-IU-6	This site consisted of an area of burned debris on a 7- x 9-m concrete pad.	RTD Waste site; Remaining Sites ESD (EPA 2009). Interim closed out per WSRF 2012-048. 100-F/IU Area ROD (EPA 2014), no additional action.
600-325, Areas of Burned Roofing. Subsites 1-2. 100-IU-6	This site consisted of two areas with dimensions of approximately 5 m in diameter and 5 x 20 m with burned roofing material.	RTD Waste site; Remaining Sites ESD (EPA 2009). Subsites 1-2 were interim closed out per WSRF 2012-033. 100-F/IU Area ROD (EPA 2014), no additional action.
600-326, Odorous Black Material. Subsites 1-2. 100-IU-6	This site consisted of surface stained areas measuring 2 x 4 m with gray suspect insulation material. Also a 6-m-diameter area with black material.	Candidate waste site; Remaining Sites ESD (EPA 2009). 100-F/IU Area ROD (EPA 2014), RTD to cleanup levels.
600-327, Suspect Dichromate Facility 100-IU-6	This site was a 6- x 10-m depression with water pipe stub at north end.	Candidate waste site; Remaining Sites ESD (EPA 2009). No Action per WSRF 2011-010. 100-F/IU Area ROD (EPA 2014), no additional action.
600-328, Lead slag area	This site was a 1- x 2-m area with suspect lead slag, stained soil, and stressed vegetation.	RTD Waste site; Remaining Sites ESD (EPA 2009). Interim closed out per WSRF 2013-054. 100-F/IU Area ROD (EPA 2014), RTD to cleanup levels.
600-329, Concrete Outfall Structure	This site is a concrete structure, possibly a waste water outfall to the Columbia River.	Candidate waste site; Remaining Sites ESD (EPA 2009). 100-F/IU Area ROD (EPA 2014), RTD to cleanup levels.

Table A-2. 100-IU-2 and 100-IU-6 Waste Site Information

Site Name	Site Information	Site Status
600-331, Lime Sulfur Barrel Site	This site was an arsenic-lead contamination site approximately 3 m in diameter. This is the location of a pre-Hanford lime-sulfur barrel that deteriorated and collapsed, spilling its contents of arsenic-lead pesticide onto the soil.	Candidate waste site; Remaining Sites ESD (EPA 2009). (Pending interim closed out per WSRF 2013-114; 9/16/14) 100-F/IU Area ROD (EPA 2014), RTD to cleanup levels.
600-332, Gable Mt. Firing Range Septic System	This site was the location of a septic system for the small arms firing range. The septic tank was approximately 1.2 x 2.1 x 0.9 m but had been previously removed.	Candidate waste site; Remaining Sites ESD (EPA 2009). 100-F/IU Area ROD (EPA 2014), RTD to cleanup levels.
600-334, CMX Building. Subsites 1-2. 100-IU-6	This site was the former location of the 145 Building CMX/Process Water Development Semi-Works. Site dimensions are approximately 57 x 96 m. 600-334:1 CMX Building & Surface Anomalies. No action per WSRF 2011-002. 600-334:2 Burn Area Near CMX Bldg	Candidate waste site; Remaining Sites ESD (EPA 2009). See subsites. 600-334:1: 100-F/IU Area ROD (EPA 2014), no additional action. 600-334:2: 100-F/IU Area ROD (EPA 2014), RTD to cleanup levels.
600-341, Inter-Areas Battery Remnant Areas. Subsites 1-2. 100-IU-2	This site consisted of areas of soil with dry cell battery remnants and debris. 600-341:1; Inter Areas Battery Remnant Area #1A; interim closed out per WSRF 2010-053. 600-341:2; Inter Areas Battery Remnant Area #1B; interim closed out per WSRF 2010-066.	RTD Waste site; 100 Area Fact Sheet (DOE-RL 2011). Interim closed out (See subsites). 100-F/IU Area ROD (EPA 2014), no additional action.
600-342, Inter Areas Contaminated Clothing Area Near Susie Junction 100-IU-2	Disposal area of discarded radiological protective clothing near Susie Junction.	RTD Waste site; 100 Area Fact Sheet (DOE-RL 2011). Interim closed out per WSRF 2010-008. 100-F/IU Area ROD (EPA 2014), no additional action.
600-343, Inter Areas Burn Site #1 100-IU-2	This site consisted of residual ash from burned material and discarded asphalt in an excavated trench.	RTD Waste site; 100 Area Fact Sheet (DOE-RL 2011). Interim closed out per WSRF 2010-052. 100-F/IU Area ROD (EPA 2014), no additional action.
600-344, Inter Areas Stain Area #1 100-IU-2	This site consisted of a stained soil area with discarded pre-Hanford metal container lids.	RTD Waste site; 100 Area Fact Sheet (DOE-RL 2011). Interim closed out per WSRF 2010-067. 100-F/IU Area ROD (EPA 2014), no additional action.
600-345, 100-BC Vicinity Oil Stain and Filter Area 100-IU-2	This site was a stained soil area with discarded oil filters.	RTD Waste site; 100 Area Fact Sheet (DOE-RL 2011). Interim closed out per WSRF 2010-068. 100-F/IU Area ROD (EPA 2014), no additional action.

Table A-2. 100-IU-2 and 100-IU-6 Waste Site Information

Site Name	Site Information	Site Status
600-346, 100-BC Vicinity ash and Debris Area 100-IU-2	This site consisted of several small fly ash dump areas with metal debris.	RTD Waste site; 100 Area Fact Sheet (DOE-RL 2011). Interim closed out per WSRF 2010-055. 100-F/IU Area ROD (EPA 2014), no additional action.
600-349, Unexploded Ordnance (UXO) outside of 600-149 100-IU-6	This site consisted of potential Unexploded Ordnance (UXO) in an area outside of the 600-149 small arms range.	Candidate waste site; 100 Area Fact Sheet (DOE-RL 2011). 100-F/IU Area ROD (EPA 2014), RTD to cleanup levels.
600-350, PNL Dirt Mounds/Water Catchment Experiment. 100-IU-6	This site consisted of two separate fenced areas containing linear soil mounds.	RTD Waste site; 100 Area Fact Sheet (DOE-RL 2011). Remediated and Interim closed out per WSRF 2011-073. 100-F/IU Area ROD (EPA 2014), no additional action.
600-356, Tar Deposit West of Susie Junction 100-IU-6	This site consisted of two areas of pebbles and rocks northwest of Susie Junction with visible dark staining.	RTD Waste site; 100 Area Fact Sheet (DOE-RL 2013). Remediated and Interim closed out per WSRF 2014-053. 100-F/IU Area ROD (EPA 2014), RTD to cleanup levels.
600-358, Scattered Waste Areas in Vicinity of Gable Mtn Firing Range 100-IU-6	The site consisted of scattered CERCLA regulated debris identified during the UXO characterization and clearance of the 600-149 firing range.	Candidate waste site; 100 Area Fact Sheet (DOE-RL 2012). 100-F/IU Area ROD (EPA 2014), RTD to cleanup levels.
600-368, Segment 4 Stained Soil #1 100-IU-6	This site consisted of a 15-m^2 (157-ft^2) area covered with green granules.	Candidate waste site. 100 Area Fact Sheet (DOE-RL 2012). Interim closed out per WSRF 2013-083. 100-F/IU Area ROD (EPA 2014), RTD to cleanup levels.
600-369, Segment 4 Bare/Crusted Soil Areas. Subsites 1-8. 100-IU-6	This site consisted of eight debris and burn pit areas that were devoid of vegetation near the Leazer Spur. This is an arsenic-lead contamination site.	Candidate waste site. 100 Area Fact Sheet (DOE-RL 2012). Subsites 1-8 were interim closed out per WSRF 2013-090. 100-F/IU Area ROD (EPA 2014), RTD to cleanup levels.
600-370, Segment 4 Bare Ground & Crusted Soil Areas. 100-IU-2	This site consisted of a large disturbed area with multiple burn sites, burn remnants, transite, insulators, wood, and concrete debris.	Candidate waste site. 100 Area Fact Sheet (DOE-RL 2012). Interim closed out per WSRF 2013-084. 100-F/IU Area ROD (EPA 2014), RTD to cleanup levels.
600-371, Segment 4 Chalky Material Area 100-IU-2	This site consisted of multiple locations having a white chalky substance that resembled either grout or bentonite.	Candidate waste site. 100 Area Fact Sheet (DOE-RL 2012). Interim closed out per WSRF 2013-085. 100-F/IU Area ROD (EPA 2014), RTD to cleanup levels.
600-372, Segment 4 Oil Stain and Filter Area #1. Subsites 1-2. 100-IU-2	This site consisted of two areas with a discarded oil filter that were devoid of vegetation.	Candidate waste site. 100 Area Fact Sheet (DOE-RL 2012). Subsites 1-2 were Interim closed out per WSRF 2013-091. 100-F/IU Area ROD (EPA 2014), RTD to cleanup levels.

Table A-2. 100-IU-2 and 100-IU-6 Waste Site Information

Site Name	Site Information	Site Status
600-373, Segment 4 Bare Ground & White Stained Area 100-IU-2	This site consisted of a 28-m^2 (303-ft^2) area devoid of vegetation and covered by a white stain and crusted soil/glass debris.	Candidate waste site. 100 Area Fact Sheet (DOE-RL 2012). Interim closed out per WSRF 2013-086. 100-F/IU Area ROD (EPA 2014), RTD to cleanup levels.
600-374, Segment 4 Drum Remnant Area 100-IU-2	This site consisted of an empty 208-L (55-gal) drum (crushed) surrounded by a small area devoid of vegetation.	Candidate waste site. 100 Area Fact Sheet (DOE-RL 2012). Interim closed out per WSRF 2013-087. 100-F/IU Area ROD (EPA 2014), RTD to cleanup levels.
600-375, Segment 4 Dry Cell Battery Debris Areas Subsites 1-5. 100-IU-2	This site consisted of five locations that have dry cell battery debris and stained soil.	Candidate waste site. 100 Area Fact Sheet (DOE-RL 2012). Subsites 1-5 were interim closed out per WSRF 2013-092. 100-F/IU Area ROD (EPA 2014), RTD to cleanup levels.
600-376, Segment 4 Stained Soil #2. Subsites 1-2. 100-IU-2	This site consisted of two stained soil areas with patches of bare ground and dried yellow material on the surface.	Candidate waste site. 100 Area Fact Sheet (DOE-RL 2012). Subsites 1-2 were interim closed out per WSRF 2013-093. 100-F/IU Area ROD (EPA 2014), RTD to cleanup levels.
600-377, Segment 4 Oil Stain & Filer Area #2 100-IU-6	This site consisted of a 3-m^2 (32-ft^2) area devoid of vegetation and containing multiple filters.	Candidate waste site. 100 Area Fact Sheet (DOE-RL 2012). Interim closed out per WSRF 2013-088. 100-F/IU Area ROD (EPA 2014), RTD to cleanup levels.
600-378, Telephone Exchange Emergency Gen Bldg Underground Fuel Tank 100-IU-6	This site is the historical location of a 379-L (100-gal) underground storage tank used to store fuel for the 506 telephone exchange emergency generator building (508 Building).	Candidate waste site. 100 Area Fact Sheet (DOE-RL 2012). Interim closed out per WSRF 2014-051. 100-F/IU Area ROD (EPA 2014), RTD to cleanup levels.
600-379, Segment 4 Burn Area #1 100-IU-6	This site consisted of a burn area with visible remnants.	Candidate waste site. 100 Area Fact Sheet (DOE-RL 2012). Interim closed out per WSRF 2013-089. 100-F/IU Area ROD (EPA 2014), RTD to cleanup levels.
628-1, White Bluffs Burn Pit 100-IU-2	This site was a triangle-shaped area covered with sand and gravel and possibly used as a burn pit.	Candidate waste site. 100 Area Remaining Sites ROD (EPA 1999). Remediated and interim closed out per WSRF 2003-046. 100-F/IU Area ROD (EPA 2014), no additional action.
JA Jones 1, J.A. Jones Co. Construction Dumping Pit #1 100-IU-6	This site was a trench used by the J.A. Jones Company for the disposal of miscellaneous debris, construction waste, and paint products.	RTD Waste site; Remaining Sites, 100-IU-6 ESD (EPA 2000a). Remediated and interim closed out per CVP-2001-00019. 100-F/IU Area ROD (EPA 2014), no additional action.

Table A-2. 100-IU-2 and 100-IU-6 Waste Site Information

Site Name	Site Information	Site Status
UPR-600-11, Contaminated Soil Dumped at J.A. Jones Pit #1 100-IU-6	This site was an area within the J.A. Jones Pit #1 where contaminated material was mistakenly disposed. The contaminated material was removed in 1980.	No prior ROD. Remediated and interim closed out per WSRF 98-215. 100-F/IU Area ROD (EPA 2014), no additional action.
UPR-600-16, Fire and Contamination Spread at P-11 (600-111) 100-IU-6	The area is currently a flat, featureless field that has been sown with rye grass. The results of an extensive radiological survey of the surface soil and confirmatory and verification sampling of the associated 600-111 waste site in 2008 showed that no residual contaminant concentrations are present at the site.	Candidate waste site. 100 Area Remaining Sites ROD (EPA 1999). Interim closed out per WSRF 2008-045. 100-F/IU Area ROD (EPA 2014), no additional action.

CVP = cleanup verification package
ESD = explanation of significant differences
ROD = record of decision
RTD = remove-treat-dispose
UPR = unplanned release
WSRF = waste site reclassification form

A2. References

CVP-2001-00001, *Cleanup Verification Package for the 100-F-2 Strontium Garden,* Bechtel Hanford, Inc., Richland, Washington.

CVP-2001-00002, *Cleanup Verification Package for the 100-F-19:1 and 100-F-19:3 Reactor Cooling Water Effluent Pipelines, 100-F-34 Biology Facility French Drain, and 116-F-12 French Drain*, Bechtel Hanford, Inc., Richland, Washington.

CVP-2001-00003, *Cleanup Verification Package for the 100-F-19:2 Reactor Cooling Water Effluent Pipelines, 116-F-11 Cushion Corridor French Drain, UPR-100-F-1 Sewer Line Leak, and 100-F-29 Experimental Animal Farm Process Sewer Pipelines*, Bechtel Hanford, Inc., Richland, Washington.

CVP-2001-00005, *Cleanup Verification Package for the 116-F-2, 107-F Liquid Waste Disposal Trench*, Bechtel Hanford, Inc., Richland, Washington.

CVP-2001-00006, *Cleanup Verification Package for the 116-F-4 Pluto Crib*, Bechtel Hanford, Inc., Richland, Washington.

CVP-2001-00007, *Cleanup Verification Package for the 116-F-5 Ball Washer Crib*, Bechtel Hanford, Inc., Richland, Washington.

CVP-2001-00008, *Cleanup Verification Package for the 116-F-9 Animal Waste Leaching Trench*, Bechtel Hanford, Inc., Richland, Washington.

CVP-2001-00009, *Cleanup Verification Package for the 116-F-14 Retention Basin*, Bechtel Hanford, Inc., Richland, Washington.

CVP-2001-00010, *Cleanup Verification Package for the 1607-F6 Septic System and Pipelines*, Bechtel Hanford, Inc., Richland, Washington.

CVP-2001-00011, *Cleanup Verification Package for the UPR-100-F-2 (100-F-3) Basin Leak Ditch*, Bechtel Hanford, Inc., Richland, Washington.

CVP-2001-00019, *Cleanup Verification Package for the JA Jones 1 Site*, Bechtel Hanford, Inc., Richland, Washington.

CVP-2001-00020, *Cleanup Verification Package for the 600-23Dumping Area,* Bechtel Hanford, Inc., Richland, Washington.

CVP-2002-00001, *Cleanup Verification Package for the 100-F-4, 100-F-11, 100-F-15, and 100-F-16 French Drains*, Bechtel Hanford, Inc., Richland, Washington.

CVP-2002-00004, *Cleanup Verification Package for the 126-F-1, 184-F Powerhouse Ash Pit,* Bechtel Hanford, Inc., Richland, Washington.

CVP-2002-00005, *Cleanup Verification Package for the 1607-F2 Septic System,* Bechtel Hanford, Inc., Richland, Washington.

CVP-2002-00007, *Cleanup Verification Package for the 100-F-35 Soil Contamination Site*, Bechtel Hanford, Inc., Richland, Washington.

CVP-2002-00008, *Cleanup Verification Package for the 116-F-3 Fuel Storage Basin Trench*, Bechtel Hanford, Inc., Richland, Washington.

CVP-2002-00009, *Cleanup Verification Package for the 116-F-1 Lewis Canal*, Bechtel Hanford, Inc., Richland, Washington.

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Appendix B

Guidance for Preparation of Cleanup Verification Packages

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B1. Purpose

The purpose of this appendix is to provide guidance to assist both authors and readers of documents for final closeout of waste sites in accordance with the *Record of Decision for the Hanford 100 Area Superfund Site, 100-FR-1, 100-FR-2, 100-FR-3, 100-IU-2, and 100-IU-6 Operable Units* (100-F/IU Area ROD) (EPA 2014), and the TPA-MP-14 procedure in RL-TPA-90-0001, *Tri-Party Agreement Handbook Management Procedures*. The waste site reclassification form (WSRF) is the documentation of approval of the lead agencies for individual waste site reclassification. The WSRF may be incorporated within a larger document for format and presentation purposes, but the document is considered to be a supporting attachment. For previous interim and final waste site reclassifications in the 100 Areas, cleanup verification packages (CVPs) were written to reclassify radioactive liquid effluent sites and burial grounds while remaining sites verification packages were written to reclassify sites termed "candidate sites" or "remaining sites." Under the 100-F/IU Area ROD, CVPs will be used as the primary supporting document for waste site reclassification. A CVP is not required if appropriate reclassification bases can be provided in a stand-alone WSRF or via supporting attachments other than a CVP. Projects will use this appendix as guidance for preparing final reclassification documentation.

B2. Objective

The overall objective of the CVPs under the 100-F/IU Area ROD (EPA 2014) is to demonstrate that the relevant waste sites have been remediated and may be reclassified to a final status. The 100-F/IU Area ROD provides the U.S. Department of Energy, Richland Operations Office, with the authority and guidelines to conduct continuing remedial actions at waste sites in the 100-F/IU Area and to propose waste sites for final reclassification. The 100-F/IU Area ROD specifies the remedial action objectives (RAOs), and associated cleanup levels that define the extent to which the waste sites require cleanup to protect human health and the environment.

B3. Scope

The scope of this guidance is intended for the CVPs for the 100-F/IU Area waste sites addressed by this remedial design report/remedial action work plan (RDR/RAWP), but equivalent processes are expected to be used for waste sites throughout the 100 and 300 Areas. This is a guidance document, not a requirements document, and deviations from the guidance are acceptable.

The following are potential examples where it may be appropriate to deviate from this guidance:

- For multiple sites that were remediated or determined not to require remediation and received associated interim reclassification prior to issuance of the 100-F/IU Area ROD, but did not receive quantitative evaluation during development of the ROD. The remedy selected for these sites was remove, treat, and dispose to preserve the intent of the interim action remedy being implemented during ROD development. Because CVPs and remaining sites verification packages have already been written under interim actions for these sites, additional final reclassification supporting documentation may be limited to numerical demonstration that the interim action activities remain protective under the cleanup levels of the 100-F/IU Area ROD.
- For sites that are identified for "no additional action" under the 100-F/IU Area ROD, final WSRFs may be prepared with no further explanation or supporting documentation.
- For small sites with limited analytical data sets, the lead agencies may agree to attach the analytic data and/or a simple comparison table to the TPA-MP-14 WSRF (RL-TPA-90-0001) with a location

map and a brief description of the action(s) performed. No other effort may be needed for reclassification or cleanup verification of such waste sites.

- Site-specific guidance from the lead agencies may specifically provide an alternate method for a portion of the CVP or for an entire CVP. This site-specific guidance should be documented and specifically noted in the CVP as approved by the lead agencies.
- Continuing process improvements may require deviation from this guidance in an effort to improve the closeout documents. These process changes will be incorporated into this appendix during future revisions of this document. Material process changes and decision-maker concurrence with material CVP changes will be documented in meeting minutes, in Tri-Party Agreement Change Notices, or by chronicling other correspondence.

The remainder of this guidance describes the typical steps involved in the preparation of the CVP closeout documents.

B4. Cleanup Verification Packages

B4.1 Executive Summary

The executive summary restates (at a higher level) the contents of the CVP. This includes a table documenting the achievement of cleanup levels and RAOs for the given waste site. Table B-1 is provided as an example.

Table B-1. Summary of Attainment of Remedial Action Objectives

Regulatory Requirement	Remedial Action Goals	Results	Remedial Action Objectives Attained?
Direct Exposure – Radionuclides	Attain radionuclide total excess cancer risk of <1 x 10^{-4} over 1,000 years.	**Example Language:** *Radionuclides were not COCs for this waste site.* **Or:** *Maximum radionuclide excess cancer risk estimated using a sum of fractions evaluation is 1.22 x* 10^{-5}. **Or:** *Site-specific radionuclide excess cancer risk calculated by RESRAD is 1.1* x 10^{-6}.	*NA* *Yes* *Yes*
Direct Exposure – Nonradionuclides	Attain individual COC cleanup levels.	**Example Language:** *All individual COC concentrations are below the cleanup levels.*	*Yes*
Meet Nonradionuclide Risk Requirements	Attain a hazard quotient of <1 for all individual noncarcinogens.	**Example Language:** *The hazard quotients for individual nonradionuclide COCs in the shallow zone and overburden are less than 1.*	*Yes*
	Attain a cumulative hazard quotient of <1 for noncarcinogens.	**Example Language:** *The cumulative hazard quotient (enter value) is less than 1 for the shallow zone and overburden.*	*Yes*
	Attain an excess cancer risk of <1 x 10^{-6} for individual carcinogens.	**Example Language:** *Excess cancer risk values for individual nonradionuclide COCs are less than 1 x* 10^{-6}.	*Yes*

Table B-1. Summary of Attainment of Remedial Action Objectives

Regulatory Requirement	Remedial Action Goals	Results	Remedial Action Objectives Attained?
	Attain a total excess cancer risk of <1 x 10^{-5} for carcinogens.	**Example Language:** *Total excess cancer risk (enter value) is less than 1 x 10^{-5}.*	*Yes*
Groundwater/ River Protection – Radionuclides	Attain single radionuclide COC groundwater and river protection cleanup levels.	**Example Language:** *Radionuclides were not COCs for this waste site.* **Or:** *Residual concentrations of radionuclide COCs meet soil cleanup levels for the protection of groundwater and the Columbia River* [c]*.*	*NA* *Yes*
	Attain National Primary Drinking Water Standards: 4 mrem/yr (beta/gamma) dose rate to target receptor/organs. [a]	**Example Language:** *Radionuclides were not COCs for this waste site.* **Or:** *Compliance is demonstrated by individual components meeting cleanup levels. (If these are not attained, see Section C.5.2.)*	*NA* *Yes*
	Meet drinking water MCL for alpha emitters.	**Example Language:** *Radionuclides were not COCs for this waste site.* **Or:** *There are no alpha-emitting COCs for this site.* **Or:** *No alpha-emitting COCs are predicted to migrate to groundwater within 1,000 years.*	*NA* *NA* *Yes*
	Meet total uranium drinking water standard of 30 µg/L MCL (40 CFR 141.66). [a]	**Example Language:** *Uranium was not a COC for this waste site.*	*NA*
Groundwater/ River Protection – Nonradionuclides	Attain individual nonradionuclide groundwater and river cleanup levels.	**Example Language:** *Residual concentrations of COCs meet soil cleanup levels for the protection of groundwater and the Columbia River.* [b]	*Yes*

Example Footnotes:

a "National Primary Drinking Water Regulations" (40 *Code of Federal Regulations* 141.66).

b Under the 100-F/IU ROD, exceedance of cleanup levels for direct exposure or groundwater and river protection are expected to seldom occur but would trigger evaluation based on the likelihood of a threat to human health that could include additional cleanup, a site-specific risk analysis, or other actions.

COC = contaminant of concern

MCL = maximum contaminant level

NA = not applicable

RESRAD = RESidual RADioactivity dose model

The WSRFs may be prepared for individual waste sites or for groups of sites, and are prepared in accordance with TPA-MP-14. The WSRF may be incorporated within the CVP document, or the CVP may be presented as an attachment to the WSRF, but the WSRF serves as the documentation of approval of the lead agencies for waste site reclassification. There is no further, separate approval of the CVP. A sample WSRF is provided below.

WASTE SITE RECLASSIFICATION FORM

Operable Unit: 100-IU-6 **Control No.:** [Obtained from WIDS]

Waste Site Code(s)/Subsite Code(s): [WIDS Number and Site Name]

Reclassification Category: Interim ☐ Final ☒

Reclassification Status: Closed Out ☒ No Action ☐ Rejected ☐
RCRA Postclosure ☐ Consolidated ☐ None ☐

Approvals Needed: DOE ☒ Ecology ☐ EPA ☒

Description of current waste site condition:

The [WIDS Number and Site Name] waste site is located within the 100-IU-6 Operable Unit and is identified as a waste site requiring remediation in the *Record of Decision for the Hanford 100 Area Superfund Site, 100-FR-1, 100-FR-2, 100-FR-3, 100-IU-2, and 100-IU-6 Operable Units* (100-F/IU Area ROD). The [WIDS Number] waste site consisted of contaminated soils associated with [XXX].

Remediation of the [WIDS Number] waste site was conducted between [Dates]. Approximately [XXX] bank cubic meters (BCM) ([XXX] bank cubic yards [BCY]) of soil, rock, building debris, and piping were removed from the excavation and disposed to the Environmental Restoration Disposal Facility (ERDF).

The selected remedy involved (1) excavating the site to the extent required to meet specified soil cleanup levels, (2) disposing of contaminated excavation materials at ERDF, (3) demonstrating through verification sampling that cleanup goals have been achieved, and (4) proposing the site for reclassification as Final Closed Out.

Basis for reclassification:

Following remediation, verification sampling for the [WIDS Number] waste site was conducted on [Dates]. The sample results were evaluated in comparison to the cleanup levels and remedial action objectives (RAOs) from the 100-F/IU Area ROD and DOE/RL-2014-44-ADD1, *Remedial Design Report/Remedial Action Work Plan Addendum for 100-FR-1, 100-FR-2, 100-IU-2, and 100-IU-6 Soils,* (100-F/IU Area RDR/RAWP Soils Addendum), Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. In accordance with this evaluation, the verification sampling results support a reclassification of the [WIDS Number] waste site to Final Closed Out. The current site conditions achieve the cleanup levels and RAOs established by the 100-F/IU Area ROD and the 100-F/IU Area RDR/RAWP Soils Addendum. Contamination did not extend into the deep zone; therefore, institutional controls to restrict uncontrolled drilling or excavation into the deep zone are not required. The basis for reclassification is described in detail in the *Cleanup Verification Package for the* [WIDS Number and Site Name] (attached).

Regulator comments:

WASTE SITE RECLASSIFICATION FORM

Operable Unit: 100-IU-6 **Control No.:** [Obtained from WIDS]

Waste Site Code(s)/Subsite Code(s): [WIDS Number and Site Name]

Waste Site Controls:

Engineered Controls: ☐ Yes ☒ No Institutional Controls: ☐ Yes ☒ No O&M Requirements: ☐ Yes ☒ No

If any of the Waste Site Controls are checked Yes, specify control requirements including reference to the Record of Decision, TSD Closure Letter, or other relevant documents:

No additional controls are required.

DOE Project Director (printed)	Signature	Date
N/A Ecology Project Manager (printed)	Signature	Date
EPA Project Manager (printed)	Signature	Date

B4.2 Statement of Protectiveness

This section is a paragraph stating that the waste site attains RAOs of the 100-F/IU ROD and discussing the pertinent future land use for the area. Whether or not institutional controls are necessary is explained. The discussion in this paragraph and the discussion in the Executive Summary should be essentially the same.

B4.3 Site Description and Background

The site history, waste disposal history, site physical dimensions, and location are summarized in this section of the CVP, and a figure(s) showing the vicinity map and/or site plan are provided.

B4.4 Characterization Sampling Activities (If Applicable)

Characterization sampling prior to remediation is appropriate if the location, nature, and potential contamination are not well known. The purpose of this section is to summarize results of such sampling

activities (if any) performed for waste sites. The type of information to be provided would include objectives and dates of site visits, dates of sampling, participation by the U.S. Department of Energy, Richland Operations Office or regulatory agencies, and any findings or determinations (e.g., nature and extent of contamination, visible description of staining, waste form) that resulted from the site visit.

B4.4.1 Geophysical Investigations

This section describes geophysical surveys performed at the site including figures showing possible nature and extent of below-ground features.

B4.4.2 Sample Design for Characterization Screening

The purpose of this section is to summarize the site-specific work instruction or other documentation/processes leading to sampling (e.g., a phased approach using focused sampling). This section typically includes a figure showing locations of samples and a sample summary table similar to Table B-2 with a discussion of the contaminants of concern (COCs), providing an explanation of how they were derived (e.g., based on professional judgment, process knowledge, waste characterization, analogous site information, visible inspection of waste forms).

B4.4.3 Characterization Sample Results

The purpose of this section is to describe the results of sampling activities. Analytical data from sampling are typically provided in an appendix to the CVP.

Table B-2. Sample Summary

Sample Location	Sample Media	Sample Number	WSP Coordinate Locations	Depth (m bgs)	Sample Analysis
Example Information					
Septic tank	*Septic tank contents*	*J01XN2*	*N 147917 E 580875*	*3*	*GEA, gross alpha, gross beta, ICP metals, PCB, pesticides, mercury, SVOA*
		J01XN6			*Hexavalent chromium*
Duplicate septic tank samples	*Septic tank contents*	*J01XN3*	*N 147917 E 580875*	*3*	*GEA, gross alpha, gross beta, ICP metals, PCB, pesticides, mercury, SVOA*
		J01XN7			*Hexavalent chromium*
Ash located east of septic tank	*Ash*	*J01XN1*	*N 147917 E 580882*	*0.5*	*ICP metals, PCB, pesticides, mercury, SVOA*
		J01XN5			*Hexavalent chromium*

Table B-2. Sample Summary

Sample Location	Sample Media	Sample Number	WSP Coordinate Locations	Depth (m bgs)	Sample Analysis
Equipment blank	*Silica sand*	*J01XN4*	*NA*	*NA*	*ICP metals, mercury, SVOA, PCB, pesticides*

Source: Field Sampling, Logbook [XXX]. Reference, [XXX]

bgs = below ground surface

GEA = gamma energy analysis

ICP = inductively coupled plasma

NA = not applicable

PCB = polychlorinated biphenyl

SVOA= semivolatile organic analysis

WSP = Washington State Plane

B4.5 Remedial Action Summary

A description of the excavation and disposal activities for remedial action is given in this section, which may include figures of pre- and post-remediation topographic contours. Appropriate information includes the dates of waste site excavation, description (and photographs if applicable) of materials excavated, disposal location of waste material, general excavation dimensions and elevations, locations of overburden and staging piles (if applicable), and amount of material disposed from the site. Pre- and post-remediation photographs and site maps showing pre-remediation Waste Information Data System boundaries compared to post-remediation site boundaries may be provided. Maps showing post-remediation site contours should be provided if available. Waste volumes provided are for a general sense of scale only.

Additionally, the CVP will discuss significant materials that may have been left at the site (if any) and what significant materials were removed. A summary of field screening or in-process sampling activities (if applicable) that guided remedial actions is also included.

B4.6 Verification Sampling Activities

This section describes the information used to develop the sampling designs for cleanup verification sampling, including reference to appropriate documents and dates of sampling.

B4.6.1 Contaminants of Concern for Verification Sampling

Waste site COCs identified for cleanup verification, typically via a site-specific verification sampling instruction, are listed in this section. The rationale or basis for the final site COC list is discussed in this section.

B4.6.2 Verification Sample Design

A brief explanation regarding the remedial excavation decision units and cleanup verification sampling is included in this section. Statistical sample designs for cleanup verification sampling of waste sites are

typically developed in a site-specific work instruction using Visual Sample Plan[1] (VSP) software. However, a statistical sample design may not be appropriate for all waste sites, and an exclusively focused sampling approach may be used with agreement from the lead agency and lead regulatory agency. Focused sampling may also be used in combination with statistical sampling approaches.

The description of the verification sample design typically includes information pertaining to the location, individual Hanford Environmental Information System (HEIS) sample numbers, Washington State Plane coordinates, and analytical methods requested for all samples collected. This information is typically presented in a table with an accompanying figure showing the sample locations overlain on a map of the area including the remediation footprint of the waste site(s).

For soil cleanup levels based on human exposure via direct contact or other exposure pathways where contact with the soil is required to complete the pathway, the point of compliance shall be established in the soils throughout the site from the ground surface to 4.6 m (15 ft) below ground surface (bgs) per *Washington Administrative Code* (WAC) 173-340-740(6)(d) (Ecology 2007). This represents a reasonable estimate of the depth of soil that could be excavated and distributed at the soil surface as a result of site development activities. Soils and materials 4.6 m (15 ft) bgs or more, within the unsaturated zone, are referred to as being in the deep zone, whereas the materials above 4.6 m (15 ft) bgs are referred to as being in the shallow zone. The direct exposure cleanup levels are applicable to the ground surface and soils or materials within the shallow zone. Groundwater protection and river protection cleanup levels are applicable to soils in both the shallow and the deep zones. However, if a site will meet the direct exposure cleanup criteria throughout the site excavation, it is acceptable to handle the entire site as a shallow zone decision unit regardless of the depth of the excavation. This may be advantageous for site closeout because a site that meets the more restrictive shallow zone criteria will not have a requirement for deep zone ICs. A discussion regarding the rationale for decision unit selection is given as part of development of a site-specific sampling approach in accordance with the applicable SAP. Decision units may be identified based on depth, spatial, and/or process history considerations.

Sampling dates and the number of samples collected per decision unit are also discussed in this section. If any focused sampling was conducted, a summary of this activity and its rationale is also included.

B4.7 Verification Sampling Results

The verification samples collected are submitted to offsite laboratories certified to perform the requisite analyses using U.S. Environmental Protection Agency (EPA)-approved analytical methods. The laboratory-reported analysis data from the sampling are verified and validated for use in the statistical calculations (as appropriate) and are included in appendices to the CVP.

The primary statistical calculation to support cleanup verification is the 95% upper confidence limit (UCL) on the arithmetic mean of the data. All UCL calculations are performed with EPA's ProUCL software[2]. The 95% UCL values for detected COCs in statistical data sets are calculated for each decision unit according to the following:

- If there are five or more detections of a given COC within a data set, and the COC is detected in 25% or more of the total samples, a UCL is calculated. A detection in either or both of the primary/duplicate sample pair is considered a single detection.

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[1] Visual Sample Plan is a site map-based user-interface statistical sample design program. **Reference:** PNNL-19915, 2010, *Visual Sample Plan 6.0 User's Guide*, available at http://vsp.pnnl.gov/documentation.stm, Pacific Northwest National Laboratory, Richland, Washington.

[2] ProUCL may be downloaded at http://www.epa.gov/osp/hstl/tsc/software.htm.

- If there are less than five detections of a given COC within a data set, a UCL is not calculated and the maximum concentration is used. A detection in either or both of the primary/duplicate sample pair is considered a single detection.
- If a given COC within a data set is detected in five or more samples, but is detected in 25% or less of the total samples, a UCL is not calculated and the maximum concentration is used. A detection in either or both of the primary/duplicate sample pair is considered a single detection.
- If there are no detections of a COC within a data set, then there is no calculation or further evaluation performed for the COC.

For the statistical evaluation of primary/duplicate sample pairs, the following is applied to determine the value to be used in the UCL calculation:

- If detections are reported for both the primary and duplicate, the maximum concentration is used.
- If one detection and one nondetection are reported, the detected concentration is used.
- If both the primary and duplicate are reported as nondetects, the higher detection limit is used (as a nondetect within ProUCL).

The statistical values represent the COC concentrations for each decision unit (e.g., overburden, shallow zone, or deep zone soils). All UCL calculations are performed with EPA's ProUCL software. For sample results that are nondetects (i.e., a "U" is included with the data flags), the full reported minimum detectable activity (radionuclides) or practical quantitation limit (nonradionuclides) value is used as the concentration. Data are then identified as detected (1) or nondetected (0) in the ProUCL data input. In cases that ProUCL output identifies more than one potential UCL for a given data set, the UCL with the highest value is chosen. ProUCL cannot compute UCLs for data sets with less than five results; therefore, analysis of any statistical data sets with less than five results will be determined in consultation with the lead regulatory agency. The 95% UCL calculation brief is included in an appendix to the CVP.

For focused sampling, no statistical evaluation is performed and the maximum detected value is used for comparison with the cleanup levels.

Comparisons of quantified COC results against the cleanup levels for the waste site are summarized in appropriate tables. Comparison to statistical contaminant concentrations and comparisons to focused sampling results are presented in separate tables. Contaminants that were not detected by laboratory analysis are excluded from these tables. Calculated cleanup levels are not presented in the Ecology Cleanup Levels and Risk Calculations database or other reference databases for calcium, magnesium, potassium, silicon, and sodium. The EPA's *Risk Assessment Guidance for Superfund* (EPA 1989) recommends that aluminum and iron not be considered in site risk evaluations. Therefore, aluminum, calcium, iron, magnesium, potassium, silicon, and sodium are not considered COCs and are not included in tables for comparison to cleanup levels even though results for these constituents are routinely provided by the laboratories. Where asbestos is identified as a site COC, verification of cleanup completion may be based on visual identification of no residual asbestos-containing material by a certified asbestos inspector and should be described in the CVP.

Contaminants of concern were selected in the 100-F/IU Area ROD based upon the *Remedial Investigation/Feasibility Study for the 100-FR-1, 100-FR-2, 100-FR-3, 100-IU-2, and 100-IU-6 Operable Units* (DOE/RL-2010-98), which included a risk assessment. In the event that contaminants are discovered during remediation for which cleanup levels were not established in the ROD, the information

will be presented to the U.S. Department of Energy and EPA project managers for determination of a path forward.

Potassium-40, radium-226, radium-228, thorium-228, and thorium-232 may be detected in waste site samples, but are excluded from evaluation in these tables because these isotopes are not related to the operational history of the Hanford Site. The thorium and radium detected in environmental samples are associated with background quantities of uranium naturally present in soil.

The laboratory-reported data results for all constituents are stored in a project-specific database prior to archival in HEIS and are included as an attachment to the 95% UCL calculation.

B4.8 Verification Sample Data Evaluation

This section describes the evaluation of the sampling data in terms of comparison to the cleanup levels, the radionuclide risk requirements, and the nonradionuclide risk requirements. Ideally, evaluation of the results listed in the tables reporting the sample results indicates that all COCs were quantified below cleanup levels. In this case, residual concentrations of site COCs are protective in relation to the requirements for direct exposure and groundwater and river protection.

B4.8.1 Comparison of Sample Data to the Cleanup Levels

Typically, evaluation of the results from verification sampling at a waste site against the cleanup levels in Appendix C, Table C-1 will indicate that all COCs are quantified below the cleanup levels. Exceedance of cleanup levels for direct exposure or groundwater and river protection would trigger additional cleanup, a site-specific risk analysis, or other evaluation based on the likelihood of a threat to human health. Soil cleanup levels selected to be protective of groundwater and the river were calculated as described in Section 8.2 of the 100-F/IU Area ROD (EPA 2014). This included an assumed groundwater recharge rate of 72 mm/yr, representing an irrigated condition.

Per the Model Toxics Control Act (MTCA) Cleanup Regulation (Ecology 2007), WAC 173-340-708(8), compliance with cleanup levels for mixtures of carcinogenic polycyclic aromatic hydrocarbons (carcinogenic PAHs) is determined by considering mixtures of carcinogenic PAHs as a single hazardous substance and using the cleanup levels established for benzo(a)pyrene as the cleanup level for mixtures of carcinogenic PAHs. Statistical values representing the PAH COC concentrations for each decision unit are determined per the guidelines in Section B.4.6, or the maximum result is used for focused samples. The selected value for each PAH is multiplied by the corresponding toxicity equivalency factor as shown in Table B-3b to obtain the toxic equivalent concentration of benzo(a)pyrene for that carcinogenic PAH. The toxic equivalent concentrations of all the carcinogenic PAHs are added to obtain the total toxic equivalent concentration of benzo(a)pyrene for the decision unit. This value is compared against the cleanup level for benzo(a)pyrene from Table C-1 to determine compliance. The result of the determination of the total toxic equivalent concentration of benzo(a)pyrene is shown in Table B-3a and is included in Table B-3b.

Table B-3a. Toxic Equivalent Concentrations of Benzo(a)Pyrene [a]

Carcinogenic Polyaromatic Hydrocarbons	Maximum or Statistical Result (mg/kg)	Toxic Equivalency Factors (Unitless)	Toxic Equivalency BAP Concentration (mg/kg)
Benzo[a]pyrene	*0.005*	1	*0.005*
Benzo[a]anthracene	*0.005*	0.1	*0.0005*
Benzo[b]fluoranthene	*0.004*	0.1	*0.0004*
Benzo[k]fluoranthene	*0.0076*	0.1	*0.00076*
Chrysene	*0.06*	0.01	*0.0006*
Dibenz[a,h]anthracene	*0.024*	0.1	*0.0024*
Indeno[1,2,3-cd]pyrene	*0.04*	0.1	*0.004*
Total Toxic Equivalency Concentration of Benzo(a)pyrene			*0.01366*

a From WAC 173-340-708(8)(e), Table 708-2 (Ecology 2007).

BAP = benzo(a)pyrene

An example table showing the comparison of the statistical or maximum results as determined in the 95% UCL calculation to the direct exposure cleanup levels and groundwater and river protection cleanup levels is shown in Table B-3b. Ecological risk evaluations have concluded that remedial actions that achieve cleanup levels to protect human health are also protective of ecological receptors, as described in Section 2.4.4 of the RDR/RAWP. No further evaluation or screening of potential ecological risk is performed in CVPs.

Table B-3b. Example Comparison of Statistical Contaminant of Concern Concentrations to Cleanup Levels[a]

COC	Maximum or Statistical Result [b] (pCi/g)	Radionuclide Shallow Zone Cleanup Levels (pCi/g)	Radionuclide Groundwater and River Protection Cleanup Levels (pCi/g)	Does the Statistical Result Exceed Cleanup Levels? [c]
Example Residential Results:				
Cesium-137	*0.036*	*4.4*	*NA*	*No*
Strontium-90	*0.49*	*2.3*	*NA*	*No*
COC	**Maximum or Statistical Result[b] (mg/kg)**	**Nonradionuclide Direct Exposure Cleanup Levels (mg/kg)**	**Nonradionuclide Groundwater and River Protection Cleanup Levels (mg/kg)**	**Does the Statistical Result Exceed Cleanup Levels?[c]**
Example Residential Results:				
Arsenic	*3.5 (<BG)*	*20*	*20*	*No*

Table B-3b. Example Comparison of Statistical Contaminant of Concern Concentrations to Cleanup Levels[a]

Chromium (hexavalent)	*0.6*	*240*	*2.0*	*No*
Mercury	*0.03*	*24*	*NA*	*No*
COC	**Maximum or Statistical Result[b] (mg/kg)**	**Nonradionuclide Direct Exposure Cleanup Levels (mg/kg)**	**Nonradionuclide Groundwater and River Protection Cleanup Levels (mg/kg)**	**Does the Statistical Result Exceed Cleanup Levels?[c]**
Benzo(a)pyrene TEC	*0.01366[d]*	*0.14*	*NA*	*No*

Example Footnotes:

a Cleanup Levels obtained from Appendix C, Table C-1 of this document.

b Background (BG) values are available from ECF-HANFORD-11-0038, *Soil Background for Interim Use at the Hanford Site*.

c Under the 100-F/IU Area ROD, exceedance of cleanup levels for direct exposure or groundwater and river protection are expected to seldom occur but would trigger evaluation based on the likelihood of a threat to human health that could include additional cleanup, a site-specific risk analysis, or other actions.

d Evaluation of the compliance of benzo(a)pyrene with cleanup levels includes the toxic equivalency concentrations of the carcinogenic PAHs in Tables 2-1 and B-3a.

BG = background
COC = contaminant of concern
WAC = *Washington Administrative Code*
RDL = required detection limit
TEC = toxic equivalency concentration
NA = not available; no cleanup level calculated

While not identified as COCs, the analytes in Table B-3c were detected above background levels in the example cleanup verification samples. These detections were below risk-based cleanup levels calculated during development of the 100-F/IU Area ROD. Therefore, these constituents do not warrant consideration as COCs. Data for all analytes are included in the appendices.

Table B-3c. Example Detected Waste Site Analytes Not Identified as COCs

Anthracene	Dibenz(a,h)anthracene	Nickel
Benzo(a)anthracene	Phenanthrene	Zinc
Benzo(b)fluoranthene	Copper	

B4.8.2 Evaluation of Attainment of Radionuclide and Nonradionuclide Risk Requirements

This section discusses how the verification sampling data are used in demonstrating attainment of radionuclide and nonradionuclide risk requirements.

B4.8.2.1 Radionuclide Evaluation of Risk and Dose

In addition to meeting the radionuclide cleanup levels of Table C-1, the residual soil radionuclide activities must also meet the risk and radiological dose standards of 40 CFR 300 for direct exposure and 40 *Code of Federal Regulations* (CFR) 141 for protection of groundwater. The individual radionuclide cleanup verification statistical or focused data values may be entered into the RESidual RADioactivity (RESRAD) computer code (current version 6.5 [ANL 2009]) to predict the direct exposure cancer risk and the impact on groundwater and the river from residual radionuclide activities. General RESRAD input parameters for evaluation of carcinogenic risk per the 100-F/IU ROD are presented in Appendix C.

Separate RESRAD runs are performed for separate decision units of a waste site area (e.g., the excavation footprint, overburden, and staging pile areas). Per Section 7.1.2 of the 100-F/IU Area ROD, the cancer risk limit for soil radionuclide cleanup levels was set at a $1x10^{-4}$ risk limit or 15 mrem/yr for isotopes where the latter is more conservative. Soil radionuclide cleanup levels must also meet the multi-contaminant total cancer risk limit of $1x10^{-4}$.

The "National Oil and Hazardous Substances Pollution Contingency Plan" (40 CFR 300.430) establishes that CERCLA cleanups should generally achieve a level of residual risk of 10^{-4} to 10^{-6}. However, EPA guidance states that the upper boundary of the risk range is not a discrete line at 10^{-4} and a specific risk estimate around 10^{-4} may be considered acceptable, if justified based on site-specific conditions. If this circumstance occurs appropriate discussion shall be presented in the CVP. The results of the RESRAD radionuclide cancer risk predictions for the all-pathways scenarios for the units of the waste site area are typically presented as excess lifetime cancer risk (ELCR) versus time (years). These ELCR determinations represent the cancer risk contributions from soils at relevant time periods. Because of radioactive decay, the risk usually decreases over time and the maximum predicted ELCR occurs at the present time. However, there may be instances where radionuclides decay to more radioactive daughter products causing risk to increase over time. All ELCR predictions must be less than the individual and total cancer risk limit of $1x10^{-4}$ to meet the cleanup levels. The RESRAD computations are shown in detail in calculation briefs presented in an appendix to the CVP. A figure may be provided to illustrate excess lifetime cancer risk as predicted using the RESRAD model.

Alternatively, for waste sites with few radionuclide COCs at concentrations well below the individual radionuclide cleanup levels, Table B-4 provides a typical comparison of the shallow zone (including overburden) radionuclide cleanup verification statistically quantified values to direct exposure single radionuclide $1x10^{-4}$ cancer risk values using a sum of fractions evaluation. The columns on the left side of Table B-4 are the COCs and the statistical values, corrected for background, as appropriate. Uranium background is subtracted from the analyses for all soil samples but background for other radionuclides is only subtracted from the overburden soil analysis. This accounts for anthropogenic and naturally occurring radionuclide background in surface soils. Only uranium background concentrations are accounted for in shallow and deep zone soils by subtracting uranium isotope concentrations from the statistical values or maximum values. The fourth column presents the single radionuclide $1x10^{-4}$ cancer risk equivalence activity, and the last two columns present the statistical values divided by the cancer risk equivalence activity. In the Table B-4 example, the total predicted radionuclide cancer risk based on sum-of-fractions determination is less than $1x10^{-4}$ so no further evaluation is necessary. However, if the sum-of-fractions determination is greater than $1x10^{-4}$, further evaluation using RESRAD with site-specific input parameters or further cleanup is necessary.

Table B-4. Example Sum-of-Fractions Evaluation of Radionuclide Direct Exposure Risk

COCs	Statistical Values (pCi/g)		Activity Equivalent to $1x10^{-4}$ cancer risk [a] (pCi/g)	Fraction	
	Shallow Zone	Overburden		Shallow Zone	Overburden
Example Results:					
Cesium-137	0.044 (ND)	0 (<BG) (ND)	4.4	0.010	0
Cobalt-60	0.047 (ND)	0.049 (ND)	1.4	0.034	0.035
Europium-152	0.100 (ND)	0.15 (ND)	3.3	0.030	0.045
Europium-154	0.14 (ND)	0.14 (ND)	3	0.047	0.047

Table B-4. Example Sum-of-Fractions Evaluation of Radionuclide Direct Exposure Risk

COCs	Statistical Values (pCi/g)		Activity Equivalent to $1x10^{-4}$ cancer risk [a] (pCi/g)	Fraction	
	Shallow Zone	Overburden		Shallow Zone	Overburden
Sum of Fractions				0.121	0.127
Cancer Risk				1.21×10^{-5}	1.27×10^{-5}

Example Footnotes:

a Single radionuclide $1x10^{-4}$ cancer risk equivalence values are presented in Table C-1 of Appendix C and in Table 5 of the 100-F/IU Area ROD (EPA 2014).

COC = contaminant of concern

ND = not detected (in all samples in the data set)

B4.8.2.2 Nonradionuclides Evaluation of Risk Standards

The comparison tables, using Table B-3b as an example, provide a comparison of the nonradionuclide cleanup verification maximum or statistical values to the direct exposure, groundwater protection, and river protection cleanup levels.

Attainment of Nonradionuclide Noncarcinogenic and Carcinogenic Risk Standards

For COCs with noncarcinogenic effects, WAC 173-340 specifies the evaluation of the hazard quotient, which is given as daily intake divided by a reference dose (WAC 173-340-200). Hazard quotients for individual noncarcinogenic nonradionuclides for residential land use are calculated by rearranging Equation 740-1 of WAC 173-340 (2007) as shown in Table C-2a. Similarly, the cancer risks for individual carcinogenic nonradionuclides for residential land use are calculated by rearranging Equation 740-2 of WAC 173-340 (2007), as shown in Table C-2b.

Calculation and application of hazard quotient and cancer risk under WAC 173-340 (2007) is discussed further in Table C-2 of Appendix C. Values for the reference doses (RfDs) and cancer potency factors (CPFs) for use in calculating the hazard quotient and cancer risk are provided in Table C-3.

Individual hazard quotients and the sum of individual hazard quotients for a waste site must be less than 1.0. For cumulative carcinogenic COCs, the cumulative excess cancer risk must be less than $1x10^{-5}$. For multiple carcinogenic COCs, the risks of the individual COCs (described above) are summed. If no risk associated with a single COC exceeds $1x10^{-6}$ for residential land use, and if the sum of the individual COC risk values do not exceed $1x10^{-5}$, then the carcinogenic risk requirements have been met.

Typically, the results of evaluation of the attainment of noncarcinogenic and carcinogenic individual and cumulative risk standards are presented in a calculation brief that is included in an appendix to the CVP.

Site-Specific Evaluation of Attainment of Nonradionuclide Noncarcinogenic and Carcinogenic Risk Standards

For instances where the conservative approach does not result in a determination that the sum of individual noncarcinogenic hazard quotients is less than 1.0 or that the individual or cumulative carcinogenic risks are less than $1x10^{-6}$ and $1x10^{-5}$, respectively, site-specific risk evaluations may be performed. The noncarcinogenic hazard quotient calculation may use an occupancy factor in

Equations 740-1 and 740-2 from WAC 173-340-740(3) to account for the amount of time individuals may actually spend on a waste site. For small waste sites (less than 1,000 m^2), a site-specific calculation may be performed utilizing an area factor to account for the size of the waste site and, hence, the daily intake.

B4.8.3 Groundwater Cleanup Levels Attained

The groundwater cleanup levels are applicable to all decision units (e.g., shallow zone, deep zone, and overburden). Soil cleanup levels for radionuclides and nonradionuclides for the protection of groundwater and the river are summarized in Table C-1 of Appendix C. These were calculated during development of the 100-F/IU Area ROD (EPA 2014) based on site-specific data and specific parameters using the STOMP (Subsurface Transport Over Multiple Phases) code. Exceedance of cleanup levels for groundwater and river protection is expected to seldom occur but would trigger evaluation based on the likelihood of a threat to human health that could include additional cleanup, a site-specific risk analysis, or other actions.

B4.8.3.1 Radionuclide Groundwater Cleanup Levels Attained

Attainment of soil cleanup levels for protection of groundwater is determined by comparison to Table C-1 standards. If radionuclide soil cleanup levels for protection of groundwater in Table C-1 are exceeded, it is appropriate to perform a site-specific RESRAD evaluation as described in Section C.5.2 of Appendix C to determine if residual soil concentrations may actually be protective of groundwater. Comparison of peak radionuclide concentrations predicted by a site-specific RESRAD evaluation against the groundwater cleanup levels is presented in a table similar to Table B-5.

Table B-5. Example RESRAD Predicted Peak Radionuclide Groundwater Concentrations Compared to Cleanup Levels

Radionuclide	Peak Concentration (pCi/L)	Cleanup Level (pCi/L)	Cleanup Level Attained? (Yes/No)
Example Language:			
Tritium	*18,500*	*20,000*	*Yes*

B4.8.3.2 Nonradionuclide Groundwater Protection Cleanup Levels Attained

Comparison table(s), such as Table B-3b, provide a tool for evaluation of the nonradionuclide cleanup verification data against the groundwater and river protection cleanup levels. Soil cleanup levels protective of groundwater and the river were calculated as described in Section 8.2 of the 100-F/IU Area ROD (EPA 2014). Parameters specific to a residential land-use scenario were used in the STOMP model to perform these calculations. Under the 100-F/IU ROD, exceedance of cleanup levels for direct exposure or groundwater and river protection would trigger additional evaluation based on risk to human health that could induce additional cleanup, a site-specific risk analysis, or other actions.

B4.9 Data Quality Assessment Process

The data quality assessment (DQA) has been integrated into the CVP and is presented here as a subsection. The DQA is very briefly summarized in the body of the CVP, with the detailed DQA (as represented in the following sections) placed in an appendix to the CVP. The DQA process involves evaluation of data to determine if the data are of the right type, quality, and quantity to support the

intended use (EPA 2000). The DQA process completes the data life cycle (i.e., planning, implementation, and assessment) that was initiated by the data quality objective process.

The DQA process is not intended to be a definitive analysis of a project or problem, but instead provides an assessment of the reasonableness of the data that have been generated (EPA 2000). The DQA focuses on the laboratory data, statistical error tolerances, and the overall data quality objectives, specifically by addressing the question, "Are the data of the right type, quality, and quantity to support their intended use?" The intended use of the data is to make the appropriate decision regarding whether the site meets the RAOs as defined by the cleanup levels. The site closeout or cleanup decision rules are the cleanup levels. Completion of a CVP following this guidance inherently is the functional equivalent of performing a DQA for a waste site.

The DQA need not be performed on field screening data if the field screening data are not used in decisions regarding the rejection of the null hypothesis (a decision that the site is "clean"). Therefore, field decisions that the site is "dirty" will be made based on the field screening data with the understanding that the decision to remediate a site determined to be contaminated based on field readings may not be within error tolerances. This is a project risk management decision and is deemed as an acceptable risk by project decision makers.

After sampling is completed, sample data packages are validated, including review of the following items, as appropriate, for each analytical method:

- Sample holding times
- Method blanks
- Matrix spike recovery
- Surrogate recovery
- Matrix spike/matrix spike duplicate results
- Sample replicates
- Associated batch laboratory control sample results
- Data package completeness.

For CVPs and related documents (e.g., leachability study reports, data summary reports), all laboratory-applied "J" flags on radionuclide results will be deleted. A footnote will be included in the radionuclide data summary tables indicating that, because of laboratory reporting conventions, these results may have a nonrelevant "J" qualifier in the HEIS database and/or in the analytical report.

Where the "J" qualifier is applied through the validation process, the qualifier will not be deleted and the traditional "estimated" footnote will be presented. The footnote will also direct the reader to the DQA section of the document. The DQA section provides additional discussion regarding the reasons why the "J" qualifier was applied during validation and also discusses the usability of the data.

Data qualified as not detected (i.e., "U") indicate that the appropriate analysis was performed but that the analyte was not detected. The concentration associated with "U" qualified data represents the practical quantitation limit (PQL). The analyte may or may not exist in the sample at concentrations below the PQL.

Data qualified as rejected (i.e., "R") indicate that the data are not useable due to a major quality assurance/quality control deficiency. All other qualified results are considered accurate within the standard errors associated with environmental samples and the individual analytical methods performed.

The adequacy of laboratory quality assurance/quality control is evaluated as a subset of the PARCC parameters (i.e., precision, accuracy, representativeness, completeness, and comparability) in the applicable SAP. This evaluation is presented in a validation report that is prepared by a third-party contractor, who determines whether the laboratory met the required target detection limits of precision, accuracy, and completeness.

Reported analytical detection levels are compared to the specified detection limits in the SAP. The data validation notes any analyses in which the PQL or minimal detectable activity was above the SAP-specified required quantitation limits (RQLs). The RQLs are based on optimal conditions. Interferences and different matrices may significantly affect the PQLs. Practical quantitation limits that exceed the specified RQLs do not necessarily invalidate the data for decision-making purposes; however, the exceedances need to be evaluated on a case-by-case basis within the DQA.

An evaluation of the matrix spike/matrix spike duplicate samples and the associated percent recoveries and relative percent differences is also performed. Acceptable limits are presented in the SAP. However, it should be noted that the matrices of environmental samples are not homogenous. The natural heterogeneities in the matrices can cause significant variability in the percent recovery and relative percent difference calculations, which can exceed the limits presented in the SAP. Exceedances observed in the data set need to be evaluated on a case-by-case basis to determine if there is any indication that the analytical system or methodology is at fault.

B4.10 Summary for Waste Site Reclassification

The purpose of this section is to provide a statement that the given waste site has been evaluated in accordance with the 100-F/IU Area ROD and that the results of the verification sampling support a reclassification (in accordance with the TPA-MP-14 process [RL-TPA-90-0001]) of the given waste site to “final closed out” or “final no action.”

When field screening or sampling results indicate that residual concentrations of contaminants at the site meet the cleanup levels for direct exposure, groundwater protection, and river protection without remediation, “final no action" is the appropriate reclassification status. Per the conceptual site model, waste site contamination does not extend into deep zone soils if it is not found in the shallow zone. Hence, sampling activities are normally not required for deep zone soils, and institutional controls to prevent uncontrolled drilling or excavation into the deep zone are generally not required.

When a waste site has been remediated in accordance with the 100-F/IU Area ROD or other decision documents, this is stated and the applicable version of the RDR/RAWP is cited. The amount of material for disposal at the Environmental Restoration Disposal Facility is noted for a general sense of magnitude. Sampling conducted to verify the completeness of remediation is briefly discussed and analytical results for the waste site shown to meet the cleanup objectives for direct exposure and groundwater and river protection are noted. Accordingly, it is stated that waste site reclassification to "final closed out" is supported for the waste site. The maximum depth of the waste site excavation area is identified as necessary to describe potential deep zone considerations and the possible need for institutional controls to prevent future intrusion into deep zone contamination. However, if deep zone areas can be demonstrated to meet the more restrictive shallow zone cleanup criteria, then institutional controls to prevent uncontrolled drilling or excavation into the deep zone may not be required.

B5. References

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Appendix C

Development of Cleanup Levels and Summary of RESRAD Methodology

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C1. Introduction

As described in the *Record of Decision for the Hanford 100 Area Superfund Site, 100-FR-1, 100-FR-2, 100-FR-3, 100-IU-2, and 100-IU-6 Operable Units* (100-F/IU Area ROD) (EPA 2014), cleanup levels have been developed for each media and/or exposure pathway to provide protection of human health and the environment and comply with applicable or relevant and appropriate requirements (ARARs).

Soil cleanup levels for contaminants of concern (COCs) were developed based on direct human contact as well as groundwater and surface water protection and are summarized in Tables 5 and 6 of the 100-F/IU Area ROD (EPA 2014). Cleanup levels from this ROD are summarized in Table C-1 of this appendix. These cleanup levels apply to soil and engineered structures that include pipelines and debris. The cleanup levels do not apply to chemicals that are an integral part of manufactured structures, and site-specific consideration may be given for applying cleanup levels to sediment/scales within pipelines or other structures. The need for remedial action is based on the existence of soil contamination. Direct contact cleanup levels for nonradionuclides are based on current Washington State Department of Ecology 2007 standards at *Washington Administrative Code* (WAC) 173-340. The direct contact soil cleanup levels for radionuclides were set at either the risk-based level of $1x10^{-4}$ cancer risk or the radiation dose limit of 15 mrem/yr that was used in the interim action RODs, whichever is lower.

The objective of this appendix is to document the development of cleanup levels for nonradionuclide and radionuclide COCs that are protective of human health and the environment. Impacts to human health are addressed by evaluation of direct contact/exposure and groundwater/Columbia River pathways.
The cleanup levels for comparison against residual soil contamination concentrations and evaluation of site risk are contained in the 100-F/IU Area ROD (EPA 2014) based on development during the *Remedial Investigation/Feasibility Study for the 100-FR-1, 100-FR-2, 100-FR-3, 100-IU-2, and 100-IU-6 Operable Units* (100-F/IU Area RI/FS) (DOE/RL-2010-98) and are summarized in the following sections.

Cleanup levels are developed for waste site COCs to attain acceptable levels of human health risk and to protect groundwater and the Columbia River. Because of uncertainty with the nature and extent of contamination, the cleanup levels are evaluated as if exposure comes from individual constituents and cleanup levels are set at acceptable risk levels for exposure to individual constituents. For sites with multiple residual contaminants, risks from individual contaminants will be added and evaluated to ensure that the waste site meets total risk limits as specified in the 100-F/IU Area ROD (EPA 2014). When a groundwater protection cleanup level is exceeded, site-specific information will be evaluated to determine if remediation has achieved the remedial action objectives of the 100-F/IU Area ROD.

C2. Nonradionuclide Cleanup Levels

Numeric cleanup levels, expressed in terms of concentration (mg/kg), were developed for 100-F/IU Area nonradionuclide COCs using the version of WAC 173-340 (Ecology 2007) that was in effect at the time the 100-F/IU Area ROD (EPA 2014) was approved. Soil residential cleanup levels for nonradionuclides were calculated using the WAC 173-340-740 chemical standards for unrestricted use for all COCs using a hazard index of one and a cancer risk of $1x10^{-6}$.

Table C-1. Soil Cleanup Level Summary from the 100-F/IU Area Record of Decision

Contaminant	Direct Exposure	Protection of Groundwater and the River			Source [a]
		100-FR-1 & 100-FR-2	100-IU-2	100-IU-6	
Radionuclides	**(pCi/g)**	**(pCi/g)**	**(pCi/g)**	**(pCi/g)**	
Cesium-137	4.4	--	--	--	ROD
Cobalt-60	1.4	--	--	--	ROD
Europium-152	3.3	--	--	--	ROD
Europium-154	3.0	--	--	--	ROD
Nickel-63	608	--	--	--	ROD
Strontium-90	2.3	24,600	64,200	104,000	ROD
Metals	**(mg/kg)**	**(mg/kg)**	**(mg/kg)**	**(mg/kg)**	
Arsenic	20	--	--	--	ROD
Chromium VI	240	2.0	2.0	2.0	ROD
Lead	250	--	--	--	ROD
Mercury	24	--	--	--	ROD
Inorganics and TPH	**(mg/kg)**	**(mg/kg)**	**(mg/kg)**	**(mg/kg)**	
Nitrate	568,000	1,790	6,360	11,300	ROD
TPH – Diesel Range	2,000	2,000	2,000	2,000	ROD
TPH – Motor Oil	2,000	2,000	2,000	2,000	ROD
Organic Compounds	**(mg/kg)**	**(mg/kg)**	**(mg/kg)**	**(mg/kg)**	
Benzo(a)pyrene	0.14	--	--	--	ROD
PCB Aroclor-1254	0.5	--	--	--	ROD
PCB Aroclor-1260	0.5	--	--	--	ROD

-- = Not available; no cleanup level calculated (contaminant is not predicted to reach groundwater).

a Cleanup levels in this table are obtained from Section 8.2 of the 100-F/IU Area ROD. Geotechnical parameters specific to the area associated with different operable units were used in STOMP modeling calculations. Under the 100-F/IU Area ROD, exceedance of cleanup levels for direct exposure or groundwater and river protection are expected to seldom occur but would trigger evaluation based on the likelihood of a threat to human health that could include additional cleanup, a site-specific risk analysis, or other actions.

PCB = polychlorinated biphenyl
ROD = Record of Decision
STOMP = Subsurface Transport Over Multiple Phases
TPH = total petroleum hydrocarbons

The direct exposure cleanup levels tabulated in Table C-1 apply to the upper 4.6 m (15 ft) of the soil column per WAC 173-340-740(6)(d) and represent concentrations for individual COCs that will be protective of human health from direct contact with contaminated waste for a residential land-use scenario. WAC 173-340 also specifies the evaluation of hazard quotients and excess carcinogenic risk. These parameters can be derived by rearranging Equations 740-1 and 740-2 of WAC 173-340, as shown in Tables C-2a and C-2b, respectively. Values for the reference doses (RfDs) and cancer potency factors (CPFs) that were in use at the time the 100-F/IU Area ROD (EPA 2014) was approved are provided in Table C-3. Institutional controls to prevent deep excavation or well drilling will be considered if the applicable direct exposure cleanup levels are not attained in the soil below 4.6 m (15 ft) in depth.

C3. Groundwater and River Protection Cleanup Levels for Radionuclide and Nonradionuclide Contaminants In Soil

Soil cleanup levels for radionuclide and nonradionuclide COCs for the protection of groundwater and surface water are summarized in Table C-1. These were calculated as described in the 100-F/IU Area ROD (EPA 2014) based on site-specific data and specific parameters using the STOMP (Subsurface Transport Over Multiple Phases) code with a one-dimensional model for all contaminants. For highly mobile contaminants (retardation coefficient <2), the model assumes the entire vadose zone from ground surface to groundwater is contaminated. For less mobile contaminants (retardation coefficient e 2), the model assumes the top 70% is contaminated and the bottom 30% is not contaminated. A groundwater recharge rate of approximately 72 mm/yr was used, representing an irrigated condition. Based on this model, no soil cleanup level for groundwater or river protection is calculated for some contaminants because the contaminant is calculated to not reach the groundwater within 1,000 years.

Exceedance of cleanup levels for groundwater and river protection is expected to seldom occur but would trigger evaluation based on the likelihood of a threat to human health that could include additional cleanup, a site-specific risk analysis, or other actions. Site-specific evaluation of the attainment of National Primary Drinking Water Standards for radionuclides is described in Section C5.2 of this appendix.

C4. Radionuclide Cleanup Levels

Cleanup levels for radionuclide COCs are summarized in Table C-1 of this appendix. Soil radionuclide cleanup levels are based upon determinations of individual radionuclide activities that will be protective of a direct exposure carcinogenic risk limit of $1x10^{-4}$, or a 15 mrem/yr radiological dose limit for isotopes where that is more conservative. The RESidual RADioactivity (RESRAD) model was selected by the Tri-Parties as the radionuclide risk and dose assessment model for generating cleanup levels for radionuclide contaminants in soil and for verifying that concentrations remaining after remedial action achieve cleanup levels to meet the cumulative carcinogenic risk limit of $1x10^{-4}$. The RESRAD model was developed by Argonne National Laboratory (ANL 2001, 2009) to implement U.S. Department of Energy (DOE) guidelines for residual radioactive material in soil. The most current version of RESRAD will be used for conducting radionuclide risk assessments.

Table C-2a. Parameters for Hazard Quotient for Residential Land Use

Rearrange Equation 740-1 of WAC 173-340 (2007)		
Hazard Quotient = (Concentration)*(SIR*AB1*EF*ED)/(RfD*ABW*UCF*AT)		
Hazard Quotient = (Concentration)*(Daily Intake Factor)/(RfD)		
Variable	Value	Description
SIR	200	mg/day, Soil Ingestion rate
AB1	1	unitless, Gastrointestinal absorption rate
EF	1	unitless, Exposure Frequency
ED	6	years, Exposure Duration
ABW	16	kg, Body weight (average)
UCF	1,000,000	mg/kg, Units conversion factor
AT	6	years, Averaging Time
RfD	(Variable)	Chemical Specific Reference Dose
Daily Intake Factor =	**1.25E-05**	**per day**

Table C-2b. Parameters for Excess Cancer Risk for Residential Land Use

Rearrange Equation 740-2 of WAC 173-340 (2007)		
Cancer Risk = (Concentration)*(CPF*SIR*AB1*EF*ED)/(ABW*UCF*AT)		
Cancer Risk = (Concentration)*(Daily Intake Factor)*(CPF)		
Variable	Value	Description
SIR	200	mg/day, Soil Ingestion rate
AB1	1	unitless, Gastrointestinal absorption rate
EF	1	unitless, Exposure Frequency
ED	6	years, Exposure Duration
ABW	16	kg, Body weight (average)
UCF	1,000,000	mg/kg, Units conversion factor
AT	75	years, Averaging Time
CPF	(Variable)	Chemical Specific Cancer Potency Factor
Daily Intake Factor =	**1.00E-06**	**per day**

Table C-3. Oral Reference Dose and Cancer Potency (Slope) Factors

Analyte	90th Percentile Background[a]	Oral Reference Dose (RfD)[b] (mg/kg-day)	Cancer Potency Factor (CPF)[b] $(mg/kg\text{-}day)^{-1}$
Metals			
Antimony	0.13	4.00E-04	--
Arsenic	6.5	3.00E-04	1.50E+00
Barium	132	2.00E-01	--
Beryllium	1.51	2.00E-03	--
Boron	3.9	2.00E-01	--
Cadmium	0.563	1.00E-01	--
Chromium, total	19	1.50E+00	--
Chromium VI	--	3.00E-03	--
Cobalt	16	3.00E-04	--
Copper	22	4.00E-02	--
Lead	10	NA	NA
Lithium	13.3	2.00E-03	--
Manganese	512	1.40E-01	--
Mercury	0.013	3.00E-04	--
Molybdenum	0.47	5.00E-03	--
Nickel	19.1	2.00E-02	--
Selenium	0.78	5.00E-03	--
Silver	0.17	5.00E-03	--
Strontium	--	6.00E-01	--
Tin	--	6.00E-01	--
Uranium	3.2	3.00E-03	--
Vanadium	85	5.00E-03	--
Zinc	68	3.00E-01	--
Inorganics			
Chloride	--	NA	NA
Cyanide	--	6.00E-04	--
Fluoride	2.8	6.00E-02	--
Nitrate	52	7.10E+00	--
Nitrite	--	1.00E-01	--

Table C-3. Oral Reference Dose and Cancer Potency (Slope) Factors

Analyte	90th Percentile Background[a]	Oral Reference Dose (RfD)[b] (mg/kg-day)	Cancer Potency Factor (CPF)[b] $(mg/kg\text{-}day)^{-1}$
Nitrogen in Nitrite and Nitrate	--	1.60E+00	--
Sulfate	--	NA	NA
Volatile Organic Compounds			
Acetone	--	9.00E-01	--
Benzene	--	4.00E-03	5.50E-02
Carbon tetrachloride	--	4.00E-03	7.00E-02
Chloroform	--	1.00E-02	3.10E-02
Dichloroethylene; 1,1- (dichloroethene)	--	5.00E-02	--
Dichloroethylene;1,2-, total	--	9.00E-03	--
Dichloroethylene;1,2-,cis	--	1.00E-02	--
Ethyl Acetate	--	9.00E-01	--
Hexachlorobutadiene	--	1.00E-03	7.80E-02
Hexachloroethane	--	1.00E-03	1.40E-02
Methyl Ethyl Ketone (2-butanone)	--	6.00E-01	--
Methyl Isobutyl Ketone (4-M,2-P)	--	8.00E-02	--
Methylene chloride	--	6.00E-02	7.50E-03
Tetrachloroethene	--	1.00E-02	5.40E-01
Toluene	--	8.00E-02	--
Trichloroethane;1,1,1-	--	2.00E+00	--
Trichloroethylene (Trichloroethene; TCE)	--	--	8.90E-02
Vinyl Chloride	--	3.00E-03	7.20E-01
Xylene	--	2.00E-01	--
Semivolatile Organic Compounds and Polycyclic Aromatic Hydrocarbons			
Acenaphthene	--	6.00E-02	--
Anthracene	--	3.00E-01	--
Benzo(a)anthracene	--	--	7.30E-01
Benzo(a)pyrene	--	--	7.30E+00
Benzo(b)fluoranthene	--	--	7.30E-01
Benzo(k)fluoranthene	--	--	7.30E-01

Table C-3. Oral Reference Dose and Cancer Potency (Slope) Factors

Analyte	90th Percentile Background[a]	Oral Reference Dose (RfD)[b] (mg/kg-day)	Cancer Potency Factor (CPF)[b] (mg/kg-day)$^{-1}$
Benzo(g,h,i)perylene	--	NA	NA
Bis(2-chloro-1-methylethyl) ether	--	4.00E-02	7.00E-02
Bis(2-chloroethoxy)methane	--	3.00E-03	--
Bis(2-chloroethyl) ether	--	NA	NA
Bis(2-ethylhexyl) phthalate	--	2.00E-02	1.40E-02
Bromophenylphenyl ether; 4-	--	NA	NA
Butylbenzylphthalate	--	2.00E-01	1.90E-03
Carbazole	--	--	2.00E-02
Chloro-3-methylphenol, 4-	--	1.00E-01	--
Chloroanilene; 4-	--	4.00E-03	2.00E-01
Chloronaphthalene; 2-	--	8.00E-02	--
Chlorophenol, 2-	--	5.00E-03	--
Chrysene	--	--	7.30E-02
Dibenz[a,h]anthracene	--	--	7.30E-01
Dibenzofuran	--	1.00E-03	--
Dichlorobenzene; 1,2-	--	9.00E-02	--
Dichlorobenzene; 1,3-	--	3.00E-02	--
Dichlorobenzene, 1,4-	--	7.00E-02	5.40E-03
Dichlorobenzidine; 3,3-	--	--	4.50E-01
Dichlorophenol; 2,4-	--	3.00E-03	--
Diethylphthalate	--	8.00E-01	--
Dimethylphthalate	--	1.00E+00	--
Dimethylphenol; 2,4-	--	2.00E-03	--
Di-n-butylphthalate	--	1.00E-01	--
Dinitro-2-methylphenol; 4,6-	--	1.00E-04	--
Dinitrophenol; 2,4-	--	2.00E-03	--
Dinitrotoluene, 2,4-	--	2.00E-03	3.10E-01
Dinitrotoluene; 2,6-	--	1.00E-03	--
Ethylene glycol	--	2.00E+00	--
Fluoranthene	--	4.00E-02	--

Table C-3. Oral Reference Dose and Cancer Potency (Slope) Factors

Analyte	90th Percentile Background[a]	Oral Reference Dose (RfD)[b] (mg/kg-day)	Cancer Potency Factor (CPF)[b] $(mg/kg\text{-}day)^{-1}$
Fluorene	--	4.00E-02	--
Hexachlorobenzene	--	8.00E-04	1.60E+00
Hexachlorobutadiene	--	1.00E-03	7.80E-02
Hexachlorocyclopentadiene	--	6.00E-03	--
Hexachloroethane	--	7.00E-04	4.00E-02
Indeno(1,2,3-cd)pyrene	--	--	7.30E-01
Isophorone	--	2.00E-01	0.00095
Methylnaphthalene, 2-	--	4.00E-03	--
Methylphenol; 2- (cresol;o-)	--	5.00E-02	--
Methylphenol; 4- (cresol;p-)	--	1.00E-01	--
Naphthalene	--	2.00E-02	--
Nitroaniline; 2-	--	1.00E-02	--
Nitroaniline; 3-	--	3.00E-04	2.10E-02
Nitroaniline; 4-	--	4.00E-03	2.00E-02
Nitrobenzene	--	2.00E-03	--
Nitrophenol; 4-	--	8.00E-03	--
Nitrosodi-n-dipropylamine, n-	--	--	7.00E+00
Nitrosodiphenylamine;N-	--	--	4.90E-03
Pentachlorophenol	--	3.00E-02	1.20E-01
Phenol	--	3.00E-01	--
Pyrene	--	3.00E-02	--
Tributyl Phosphate	--	1.00E-02	9.00E-03
Trichlorobenzene, 1,2,4-	--	1.00E-02	2.90E-02
Trichlorophenol; 2,4,5-	--	1.00E-01	--
Trichlorophenol; 2,4,6-	--	1.00E-03	1.10E-02
Pesticides and Polychlorinated Biphenyls			
Aldrin	--	3.00E-05	1.70E+01
BHC, Alpha-	--	8.00E-03	6.30E+00
BHC, beta	--	--	1.80E+00
BHC, gamma (Lindane)	--	3.00E-04	1.10E+00

Table C-3. Oral Reference Dose and Cancer Potency (Slope) Factors

Analyte	90th Percentile Background[a]	Oral Reference Dose (RfD)[b] (mg/kg-day)	Cancer Potency Factor (CPF)[b] $(mg/kg\text{-}day)^{-1}$
Chlordane	--	5.00E-04	3.50E-01
Dalapon	--	3.00E-02	--
Db; 2,4- [4-(2,4-dichlorophenoxy) butanoic acid]	--	8.0E-03	--
DDD, 4,4'-	--	--	2.40E-01
DDE, 4,4'-	--	--	3.40E-01
DDT, 4,4'-	--	--	3.40E-01
Dicambra	--	3.00E-02	--
Dichlorophenoxyacetic acid; 2,4-	--	1.00E-02	--
Dieldrin	--	5.00E-05	1.60E+01
Dinoseb (DNBP)	--	1.00E-03	--
Endosulfan (I, II, sulfate)	--	6.00E-03	--
Endrin (and ketone, aldehyde)	--	3.00E-04	--
Heptachlor	--	5.00E-04	4.50E+01
Heptachlor epoxide	--	1.30E-05	9.10E+00
Methoxychlor	--	5.00E-03	--
Polychlorinated biphenyls	--	--	2.00E+01
PCB Aroclor 1016	--	7.00E-05	7.00E-02
PCB Aroclor 1221	--	--	2.00E+00
PCB Aroclor 1232	--	--	2.00E+00
PCB Aroclor 1242	--	--	2.00E+00
PCB Aroclor 1248	--	--	2.00E+00
PCB Aroclor 1254	--	2.00E-05	2.00E+00
PCB Aroclor 1260	--	--	2.00E+00
Silvex (tp;2,4,5-)	--	8.00E-03	--
Toxaphene	--	--	1.10E+01
Trichlorophenoxyacetic acid;2,4,5-	--	1.00E-02	--

Table C-3. Oral Reference Dose and Cancer Potency (Slope) Factors

Analyte	90th Percentile Background[a]	Oral Reference Dose (RfD)[b] (mg/kg-day)	Cancer Potency Factor (CPF)[b] $(mg/kg\text{-}day)^{-1}$

a Background from ECF-HANFORD-11-0038,2012, *Soil Background for Interim Use at the Hanford Site*, Rev. 0, CH2M HILL Plateau Remediation Company, Richland, Washington.

b Oral reference dose and cancer potency factor values that were in use at the time the 100-F/IU Area ROD (EPA 2014) was approved are from Table G-12 of DOE/RL-2010-98, 2014, *Remedial Investigation/Feasibility Study for the 100-FR-1, 100-FR-2, 100-FR-3, 100-IU-2, and 100-IU-6 Operable Units, Addendum*.

Single radionuclide soil concentrations corresponding to a carcinogenic risk limit of $1x10^{-4}$ in a rural-residential scenario were calculated using RESRAD version 6.5 (ANL 2009) and the appropriate parameters from the 100-F/IU Area RI/FS report (DOE/RL-2010-98) and ECF-HANFORD-10-0429, *Documentation of Preliminary Remediation Goals (PRGs) for Radionuclides Using the IAROD Exposure Scenario for the 100 and 300 Area Remedial Investigation/Feasibility Study (RI/FS) Report*. Determinations of radionuclide cleanup levels to be protective of human health direct exposure carcinogenic risk are reported in the calculation brief and summarized in Table 5 of the 100-F/IU Area ROD (EPA 2014). These RESRAD input parameters are reproduced in this appendix as Table C-4.

Table C-4. RESRAD Residential Input Parameters for the100-F/IU Area

Category	Parameter	Units	User Input, Residential Scenario	Reference
Exposure pathways	External Gamma: Inhalation: Plant Ingestion: Meat Ingestion: Milk Ingestion: Aquatic Foods: Drinking Water: Soil Ingestion: Radon:	NA	Active Active Active Active Active Active Active Active Suppressed	WDOH/320-015
R011 – Contaminated Zone (CZ)	Area of CZ [a]	m^2	10,000 [a]	RESRAD default
	Thickness of CZ [a]	m	4.6 [a]	WDOH/320-015
	Length parallel to aquifer flow [a]	m	100 [a]	Square root of contaminated site area
	Radiation dose limit	mrem/yr	15	WDOH/320-015
	Elapsed time since waste placement	yr	0	RESRAD default
R012 – Principal Radionuclide Concentrations	All radionuclide contaminants of concern	pCi/g	Contaminant-specific	
R013 – Cover and CZ Hydrological Data	Cover depth [a]	m	0	RESRAD default
	Cover erosion rate	m/yr	Not Used	No cover
	Density OF CZ	g/cm^3	1.6	DOE/RL-90-07
	CZ erosion rate	m/yr	0.001	RESRAD default
	CZ total porosity	Unitless	0.4	WDOH/320-015
	CZ field capacity	Unitless	0.15	Same as SZ Field Capacity

Table C-4. RESRAD Residential Input Parameters for the100-F/IU Area

Category	Parameter	Units	User Input, Residential Scenario	Reference
	CZ hydraulic conductivity	m/yr	250	DOE/RL-96-11, DOE/RL-93-37
	CZ b parameter	Unitless	4.05	WDOH/320-015
	Humidity in air	g/cm^3	8	RESRAD default
	Evapotranspiration coefficient	Unitless	0.91	WDOH/320-015
	Wind speed	m/sec	3.4	PNNL-12087
	Precipitation	m/yr	0.16	DOE/RL-90-07
	Irrigation rate	m/yr	0.76	WDOH/320-015
	Irrigation mode	NA	Overhead	RESRAD default
	Runoff coefficient	Unitless	0.2	RESRAD default
	Watershed area for nearby stream or pond	m^2	1,000,000	RESRAD default
	Accuracy for water/soil computations	NA	0.001	RESRAD default
R014 – Saturated Zone (SZ) Hydrological Data	Density of SZ	g/cm^3	1.6	DOE/RL-90-07
	SZ total porosity	Unitless	0.4	WDOH/320-015
	SZ effective porosity	Unitless	0.25	ANL-EAIS-8, Table 3.2
	SZ field capacity	Unitless	0.15	ANL-EAIS-8, Equation 4.4
	SZ hydraulic conductivity	m/yr	5,530	DOE/RL-96-11, DOE/RL-93-37
	SZ hydraulic gradient	Unitless	0.00125	DOE/RL-96-11, DOE/RL-93-37
	SZ b parameter	Unitless	4.05	WDOH/320-015
	Water table drop rate	m/yr	0.001	RESRAD default
	Well pump intake depth below water table	m	4.6 (15 ft), typical RCRA well screen length	
	Nondispersion (ND) or mass balance (MB)	NA	ND	RESRAD default
	Well pumping rate	m^3/yr	250	RESRAD default
R015 – Uncontaminated and Unsaturated Strata Hydrological Data	Number of unsaturated strata [a]	Unitless	1 [a]	Site-specific
	Thickness [a]	m	12 [a]	Site-specific
	Soil density	g/cm^3	1.6	DOE/RL-90-07
	Total porosity	Unitless	0.4	WDOH/320-015
	Effective porosity	Unitless	0.25	ANL-EAIS-8, Table 3.2
	Field capacity	Unitless	0.15	ANL-EAIS-8, Equation 4.4
	Soil-specific b parameter	Unitless	4.05	WDOH/320-015
	Hydraulic conductivity	m/yr	250	DOE/RL-96-11
R016 – K_d for Individual Radionuclides	K_d for contaminated zone, uncontaminated zone, and saturated zone	mL/g	Contaminant-specific	DOE/RL-2010-98, Appendix F
	Saturated leach rate	yr^{-1}	Not used	Use Kd values
	Saturated solubility	g/mL	Not used	Use Kd values
R017 – Inhalation and External Gamma	Inhalation rate	m^3/yr	7,300	WDOH/320-015
	Mass loading for inhalation	g/m^3	0.0001	WDOH/320-015
	Exposure duration	yr	30	RESRAD Default
	Indoor dust filtration factor	Unitless	0.4	RESRAD Default

Table C-4. RESRAD Residential Input Parameters for the100-F/IU Area

Category	Parameter	Units	User Input, Residential Scenario	Reference
	External gamma shielding factor	Unitless	0.4	ECF-HANFORD--10-0429
	Indoor time fraction	Unitless	0.6	ECF-HANFORD--10-0429
	Outdoor time fraction	Unitless	0.12	ECF-HANFORD--10-0429
	Shape factor	NA	Circular unless otherwise specified	
R018 – Ingestion Pathway Data, Dietary Parameters	Fruits, vegetables, and grain consumption	kg/yr	110	WDOH/320-015
	Leafy vegetable consumption	kg/yr	2.7	WDOH/320-015
	Milk consumption	L/yr	100	WDOH/320-015
	Meat and poultry consumption	kg/yr	36	WDOH/320-015
	Fish consumption	kg/yr	19.7	WDOH/320-015
	Other seafood consumption	kg/yr	0.9	RESRAD Default
	Soil ingestion	g/yr	36.5	ECF-HANFORD--10-0429
	Drinking water intake	L/yr	730	WDOH/320-015
	Drinking water contamination fraction	Unitless	1	RESRAD Default
	Household water contamination fraction	Unitless	1	RESRAD Default
	Livestock water contamination fraction	Unitless	1	RESRAD Default
	Irrigation water contamination fraction	Unitless	1	RESRAD Default
	Aquatic food contamination fraction	Unitless	0.5	RESRAD Default
	Plant food contamination fraction	Unitless	-1 [b]	RESRAD Default
	Meat contamination fraction	Unitless	-1 [b]	RESRAD Default
	Milk contamination fraction	Unitless	-1 [b]	RESRAD Default
R019 – Ingestion Pathway Data, Nondietary	Livestock fodder intake for meat	kg/d	68	RESRAD Default
	Livestock fodder intake for milk	kg/d	55	RESRAD Default
	Livestock water intake for meat	L/d	50	RESRAD Default
	Livestock water intake for milk	L/d	160	RESRAD Default
	Livestock intake of soil	kg/d	0.5	RESRAD Default
	Mass loading for foliar deposition	g/m^3	0.0001	RESRAD Default
	Depth of soil mixing layer	m	0.15	RESRAD Default
	Depth of roots	m	0.9	RESRAD Default
	Groundwater fractional usage – drinking water	Unitless	1	RESRAD Default
	Groundwater fractional usage – household	Unitless	1	RESRAD Default
	Groundwater fractional usage – livestock water	Unitless	1	RESRAD Default
	Groundwater usage – irrigation	Unitless	1	RESRAD Default

Table C-4. RESRAD Residential Input Parameters for the100-F/IU Area

Category	Parameter	Units	User Input, Residential Scenario	Reference
R021 – Radon		NA	Not used	Radon is not a COPC

a The stated numeric values are only used when RESRAD is used to determine generic cleanup levels. Otherwise, site-specific input values for these parameters are determined on a site-by-site basis. All other values are fixed at the values shown unless modified with regulator approval.

b The default value of -1 specifies that the contaminated fraction of this input will be calculated from the appropriate area factor in RESRAD (for a waste site of less than the default of 10,000 m^2 RESRAD calculates and applies an area factor based on the actual waste site area). Setting the default value in this column to zero will turn off the pathways entirely.

COPC = contaminant of potential concern
CZ = contaminated zone
GW = groundwater
ND = nondetect
RCRA = *Resource Conservation and Recovery Act of 1976*
RESRAD = RESidual RADioactivity

C5. Using RESRAD for Waste Site Radionuclide Cleanup Verification

Where more than one radionuclide is detected and radionuclide cleanup levels in Table C-1 are not exceeded, a sum-of-fractions evaluation or a RESRAD evaluation must be performed to determine that the cumulative carcinogenic risk limit of $1x10^{-4}$ is not exceeded. The input parameters and assumptions used in RESRAD to generate the radionuclide direct exposure cleanup levels presented in this remedial design report/remedial action work plan are summarized in Table C-4. For the purpose of site cleanup verification, the RESRAD input values (e.g., the thickness of the contaminated zone, the thickness of the uncontaminated zone, and the size of the waste site) will be determined on a site-specific basis. RESRAD calculates all radionuclides in the decay chain (daughters) in calculating ingrowth and decay. It has not been determined if any daughters were present at the time of waste emplacement, but they would be insignificant dose contributors; therefore, estimated daughters are not included as input.

C5.1 Radionuclide Evaluation of Direct Exposure Risk

For waste sites with few radionuclide COCs, at concentrations all below the individual radionuclide cleanup levels, Table B-5 of Appendix B provides an example comparison of the shallow zone radionuclide cleanup verification data to direct exposure single radionuclide cancer risk values and the cumulative carcinogenic risk limit of $1x10^{-4}$ using a sum-of-fractions evaluation. Typically, this will be sufficient to demonstrate that direct exposure cumulative risk limitations are met. It is not necessary to perform a sum-of-fractions or RESRAD evaluation for a waste site or decision unit if there is only one detected radionuclide or if the residual concentrations of multiple radionuclide COCs are all below background or are less than one-tenth of the single radionuclide soil concentration equivalent to a $1x10^{-4}$ carcinogenic risk calculated by RESRAD.

If the sum-of-fractions evaluation indicates the cumulative carcinogenic risk limit of $1x10^{-4}$ is exceeded, a site-specific RESRAD evaluation should be performed. The general process is to first determine the nature and extent of site-specific residual contamination (concentrations, thickness, and area of actual radionuclide contamination). This information is input to the RESRAD model with the general parameters from Table C-4 to evaluate the direct exposure carcinogenic risk. No cover material is assumed to exist on top of the contaminated shallow zone unless existence of cover is explicitly stated. To perform the calculations, the parameters are entered into the RESRAD data menu, and appropriate

times for calculations are selected. Default times of 1, 3, 10, 30, 100, 300, and 1,000 years are used in a preliminary run to determine the year when the peak risk occurs from each radionuclide COC, pathway, and layer (e.g., shallow zone or deep zone).

The RESRAD software is run and the summary report and graphical output for radionuclide risk are accessed to determine the peak year(s) in 1,000 years. The summary report is accessed by viewing the file "summary.rep" in the RESRAD output. The graphical output for excess cancer risk of radionuclides is accessed by selecting:

Results: Standard Graphics

Type: Risk

Radionuclide: Individual

Pathways: Summed/External

If the peak year of the maximum risk for individual radionuclides indicated in the graphical output is not the same as the year of maximum dose/risk in the "Contaminated Zone and Total Dose Summary" of the summary report, then individual RESRAD runs should be performed for the individual radionuclides to find the individual years of peak dose/risk. The years of peak dose/risk are entered as calculation times in the RESRAD calculation, and the RESRAD software is rerun.

The health risk report ("intrisk/rep") is accessed and the "All Pathways" total risk for each year of the RESRAD evaluation is recorded in an appropriate table. The table is included with other site-specific detailed information in a calculation brief presented in the calculations appendix to the cleanup verification package (CVP). A figure or figures may be provided to illustrate excess lifetime cancer risk as predicted using the RESRAD model.

C5.2 Radionuclide Evaluation for Groundwater Protection

Attainment of soil cleanup levels for protection of groundwater is determined by comparison to Table C-1 standards. If radionuclide soil cleanup levels for protection of groundwater in Table C-1 are exceeded, it is appropriate to perform a site-specific RESRAD evaluation to determine if residual soil concentrations may actually be protective of groundwater. After remediation, residual radioactive and nonradioactive contaminants remaining in soil must be at such levels that concentrations of contaminants that could migrate through the soil column to groundwater do not exceed cleanup levels considered protective of groundwater in Table C-1. Protection of groundwater is intended to achieve cleanup levels derived from maximum contaminant levels (MCLs) promulgated under the federal National Primary Drinking Water Regulations (40 CFR 141).

C5.2.1 Attainment of Radionuclide MCLs

Separate MCLs exist for strontium-90, tritium (H-3), radium-226, and radium-228. The MCLs for strontium-90 and tritium are 8 pCi/L and 20,000 pCi/L, respectively (40 CFR 141.66). The MCL for combined radium-226 and radium-228 is 5 pCi/L (40 CFR 141.66). The MCL for technetium-99 is 900 pCi/L as obtained from the *Soil Screening Guidance for Radionuclides: User's Guide* (EPA 2000). The MCL for total uranium (as uranium metal) is established at 30 μg/L (40 CFR 141.66). The MCL for individual alpha-emitting radionuclides (excluding radon and uranium) is 15 pCi/L (40 CFR 141.66). However, per the STOMP model evaluation of transport to groundwater summarized in Table C-1, no alpha-emitting radionuclides are predicted to migrate to groundwater within 1,000 years, so residual soil concentrations of all alpha-emitting radionuclides are protective of groundwater and surface water.

To predict site-specific groundwater radionuclide activities, risk, and dose based on activities in soil, exposure pathways in the RESRAD input file for external gamma exposure, inhalation, soil ingestion, and radon are suppressed. Pathways for ingestion of plants, meat, milk, aquatic foods, and drinking water are active in the residential scenario. Appropriate site-specific input parameters including contaminated site dimensions and radionuclide activities in soil and their distribution coefficients (K_d values) are entered into the RESRAD data menu and default calculation times of 1, 3, 10, 30, 100, 300, and 1,000 years are used for the initial calculation. The concentration of uranium metal in mg/kg is entered for uranium-238 as pCi/g, and the predicted uranium-238 groundwater concentration (presented as pCi/L in the RESRAD output) is the uranium metal concentration in μg/L. The basic radiation dose limit of 4 mrem/yr is input for groundwater protection.

The RESRAD software is run and the concentration report and graphical output for radionuclides in drinking water are accessed to determine which radionuclides do or do not reach groundwater in 1,000 years. The concentration report is accessed by viewing the file "concent.rep" in the RESRAD output. The graphical output for concentration of radionuclides in drinking water is accessed in the RESRAD version 6.5 Graphics Display (ANL 2009) by selecting:

Type: Concentration

Radionuclide: Individual

Media (Pathways): Drinking Water

If the drinking water concentrations predicted in the concentration report and the graphical output displays zero for the full 1,000 years, the contaminants do not impact groundwater within 1,000 years. Typically, the graphical output may show that strontium-90, technetium-99, and tritium (H-3) are predicted to reach groundwater within 1,000 years. The years of the maximum groundwater concentrations for these radionuclides are obtained from the RESRAD summary report for radiological dose in the RESRAD output table headed "Summed Dose/Source Ratios and Single Radionuclide Soil Guidelines." The year of maximum groundwater concentration for each radionuclide is in the column headed by "tmin, years."

The year of maximum groundwater concentration for each radionuclide from the column headed by "tmin, years" is entered in the calculation times of the RESRAD inputs and the software is rerun. The concentration report and graphical output for radionuclides in drinking water are accessed to determine that the predicted years of maximum groundwater concentration are correct. If the predicted maximum groundwater (well water) concentrations in the concentration report, "concent.rep," for strontium-90, technetium-99, and tritium are less than their respective MCLs of 8 pCi/L, 900 pCi/L, and 20,000 pCi/L (and the predicted uranium-238 groundwater concentration [shown as pCi/L in the RESRAD output but read as μg/L] is less than the uranium metal MCL of 30 μg/L), residual soil concentrations of these constituents are predicted to be protective of groundwater and the river. The findings of the RESRAD evaluation are typically reported in a calculation brief included in the calculations appendix to the waste site CVP. If the groundwater concentrations predicted by RESRAD indicate that COCs impact groundwater, a table is provided in the calculation brief that shows the predicted peak concentration for each detected radionuclide COC and provides the individual MCLs for comparison, as shown in the Table C-5 example.

Table C-5. Example Peak Radionuclide Groundwater Concentrations Compared to Maximum Contaminant Levels

Radionuclide	Groundwater Peak Concentration (pCi/L)	Year of Peak Concentration (years)	Groundwater MCL (pCi/L)
Americium-241	0 [a]	NA	15
Carbon-14	(Site-specific)	(Site-specific)	2,000
Cobalt-60	(Site-specific)	(Site-specific)	100
Cesium-137	(Site-specific)	(Site-specific)	60
Europium-152	0 [a]	NA	200
Europium-154	0 [a]	NA	60
Europium-155	0 [a]	NA	600
Nickel-63	(Site-specific)	(Site-specific)	50
Plutonium-238	0 [a]	NA	15
Plutonium-239/240	0 [a]	NA	15
Strontium-90	(Site-specific)	(Site-specific)	8
Technetium-99	(Site-specific)	(Site-specific)	900
Tritium (H-3)	(Site-specific)	(Site-specific)	20,000

a Per the STOMP model evaluation of transport to groundwater summarized in Table C-1, no alpha-emitting radionuclides are predicted to migrate to groundwater within 1,000 years.

MCL = maximum contaminant level

C5.2.2 Attainment of 4 mrem/yr Drinking Water Radionuclide Dose Rate

The average annual activity of beta particle and photon radioactivity from man-made radionuclides in drinking water shall not produce an annual dose equivalent to the total body or any internal organ greater than 4 mrem/yr, per 40 CFR 141.66. To determine if any organ receives a dose of more than 4 mrem/yr, the dose to each organ is calculated for the radionuclide COCs that are predicted to migrate to groundwater. However, if only one radionuclide is predicted to reach groundwater and this radionuclide attains its MCL as discussed in Section C.5.2.1, it is not necessary to evaluate the attainment of the 4 mrem/yr drinking water dose rate.

An example of a calculation brief to determine attainment of MCLs and the maximum allowable drinking water dose of 4 mrem/yr for beta/gamma emitters can be found in Calculation No. 0100H-CA-V0087. The 4 mrem/yr equivalent concentration for each organ for each radionuclide is determined from the maximum permissible concentrations listed in Table 1 of NBS Handbook 69 (NBS 1963). The factor C4 (i.e., the concentration that will produce a dose of 4 mrem/yr to that organ) is calculated for each organ and radionuclide.

The C4 factors for the COCs are summarized in Table C-6.

Table C-6. Factors for Calculating Radionuclide-Specific Organ Doses Using Methodology Mandated by the Safe Drinking Water Act for Comparison to the 4 mrem/yr Standard for Beta and Gamma Emitters

Radionuclide	Organ	C_4 [a], 4 mrem/yr Equivalent Concentration (pCi/L)
Carbon-14	Total Body	9,000
	Bone	2,000
	Fat	2,000
Cobalt-60	GI(LLI)	100
	Total Body	900
	Liver	3,000
Cesium-137	Bone	80
	GI(LLI)	2,000
	Total Body	200
	Liver	60
Europium-152	Bone	30,000
	GI(LLI)	200
	Total Body	2E+05
	Liver	1E+05
Europium-154	Bone	5,000
	GI(LLI)	60
	Total Body	7E+04
	Liver	6E+04
Europium-155	Bone	1E+05
	GI(LLI)	600
	Total Body	9E+05
	Liver	6E+05
H-3 (Tritium)	Total Body	20,000
Nickel-63	Bone	50
	GI(LLI)	3,000
	Total Body	2,000
	Liver	600
Strontium-90	Bone	8
	GI(LLI)	100
	Total Body	8

a Calculated by methodology given in *National Interim Primary Drinking Water Regulations*, Appendix IV, "Dosimetric Calculations for Man-Made Radioactivity" (EPA 1997).

GI(LLI) = gastrointestinal tract-lower large intestine

The cumulative dose for each organ at time "t" needs to be calculated separately and using a sum-of-fractions equation, as shown in the formula below. If a radionuclide does not have a maximum permissible concentration for the organ of interest, the C4 factor for total body dose is used in the calculation. The calculations performed are documented in the comparison to drinking water standards calculation brief. The organs for which doses need to be computed are total body, bone, gastrointestinal tract-lower large intestine, and liver. The individual organ doses are summed and compared to 4 mrem/yr.

$$\text{Doseorgan x (t)} = [\text{ConcA(t)/C4A(x)} + \text{ConcB(t)/C4B(x)} + \ldots] \text{ x (4 mrem/yr)}$$

If the total dose for organ "x" is less than 4 mrem/yr, then the standard is met.

A figure may be provided in the CVP that shows the calculated dose to each organ from groundwater. An example of a calculation brief to determine attainment of MCLs and the maximum allowable drinking water dose of 4 mrem/yr for beta/gamma emitters can be found in Calculation No. 0100H-CA-V0087.

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DOE/RL-2014-44-ADD2
Revision 0

Remedial Design Report/Remedial Action Work Plan Addendum for the 100-F/IU Groundwater

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

U.S. DEPARTMENT OF ENERGY | Richland Operations Office

P.O. Box 550
Richland, Washington 99352

Approved for Public Release;
Further Dissemination Unlimited

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Revision 0

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Date Published
August 2015

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
By Ashley R Jenkins at 11:31 am, Aug 20, 2015

Release Approval | Date

Approved for Public Release;
Further Dissemination Unlimited

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Terms

100-AGWM	100 Area Groundwater Model
ARAR	applicable or relevant and appropriate requirement
AWLN	automated water level network
CERCLA	*Comprehensive Environmental Response, Compensation, and Liability Act of 1980*
COC	contaminant of concern
Cr(VI)	hexavalent chromium
CSM	conceptual site model
CY	calendar year
DO	dissolved oxygen
DOE	U.S. Department of Energy
DQO	data quality objective
DWS	drinking water standard
EPA	U.S. Environmental Protection Agency
HASP	health and safety plan
IC	institutional control
LCL	lower confidence limit
MNA	monitored natural attenuation
O&M	operations and maintenance
OU	operable unit
PPE	personal protective equipment
PQL	practical quantitation limit
PSQ	principal study question
QA	quality assurance
QC	quality control
RA	remedial action
RAO	remedial action objective
RAWP	remedial action work plan
RDR	remedial design report
ROD	record of decision
RI/FS	remedial investigation/feasibility study
SAP	sampling and analysis plan
TCE	trichloroethene
UCL	upper confidence limit
UU/UE	unlimited use/unrestricted exposure

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1 Introduction

The 100 Area (*Comprehensive Environmental Response, Compensation, and Liability Act of 1980* [CERCLA] site identification number WA38900900076) includes the River Corridor areas of the Hanford Site, in Benton County, Washington. The 100-FR-1, 100-FR-2, 100-FR-3, 100-IU-2, and 100-IU-6 Operable Units (OUs), hereinafter referred to as 100-F/IU, are part of the Hanford Site 100 Area. Within the 100 Areas, 100-F/IU has four source OUs (100-FR-1, 100-FR-2, 100-IU-2, and 100-IU-6) and a groundwater OU (100-FR-3) (Figure 1-1).

The remedial design report/remedial action work plan (RDR/RAWP) (DOE/RL-2014-44, *Integrated Remedial Design Report/Remedial Action Work Plan for 100-F/IU*), hereinafter called the Integrated RDR/RAWP, addresses all five OUs and is accompanied by two addenda. The two addenda correspond to the two distinct media (soil and groundwater).

DOE/RL-2014-44-ADD1, *Remedial Design Report/Remedial Action Work Plan Addendum for 100-FR-1, 100-FR-2, 100-IU-2, and 100-IU-6 Soils* (referred to as the Soil Addendum), describes the work elements, performance measurements, construction management and oversight, schedule, and costs specific to the removal, treatment (as required), and disposal remedy for waste sites associated with the 100-IU-2 and 100-IU-6 OUs.

This *RDR/RAWP Addendum for 100-FR-3 Groundwater* (referred to as the Groundwater Addendum) describes the design, work elements, construction management and oversight, schedule, and costs specific to the groundwater remedy, which is monitored natural attenuation (MNA) and institutional controls (ICs) to restrict well drilling and groundwater use. Performance monitoring will be implemented to evaluate progress of the MNA remedy and verify attainment of the remedial action objectives (RAOs) for groundwater. The remedial design approach, remedial action (RA) management approach, environmental management and controls, RA completion, and cost/schedule components of the groundwater remedy are presented in Chapters 3 through 7 of this Groundwater Addendum. The performance monitoring component of the MNA remedy is discussed in Chapter 3 of this Groundwater Addendum and presented in the 100-FR-3 Groundwater Sampling and Analysis Plan (SAP) in Appendix A.

1.1 Purpose

This Groundwater Addendum describes how the progress of MNA will be evaluated and final attainment of RAOs will be demonstrated. RAOs were identified in 2014 by the U.S. Environmental Protection Agency (EPA) and U.S. Department of Energy (DOE) in *Record of Decision Hanford 100 Area Superfund Site 100-FR-1, 100-FR-2, 100-FR-3, 100-IU-2, and 100-IU-6 Operable Units* (EPA and DOE, 2014), hereinafter called the 100-F/IU record of decision (ROD). This addendum is the companion document to the Soil Addendum (DOE/RL-2014-44-ADD1).

1.2 Scope

This Groundwater Addendum includes RAs that will be implemented to meet the requirements of the 100-F/IU ROD (EPA and DOE, 2014). Groundwater components discussed in this addendum for the 100-FR-3 OU are summarized in Table 1-1.

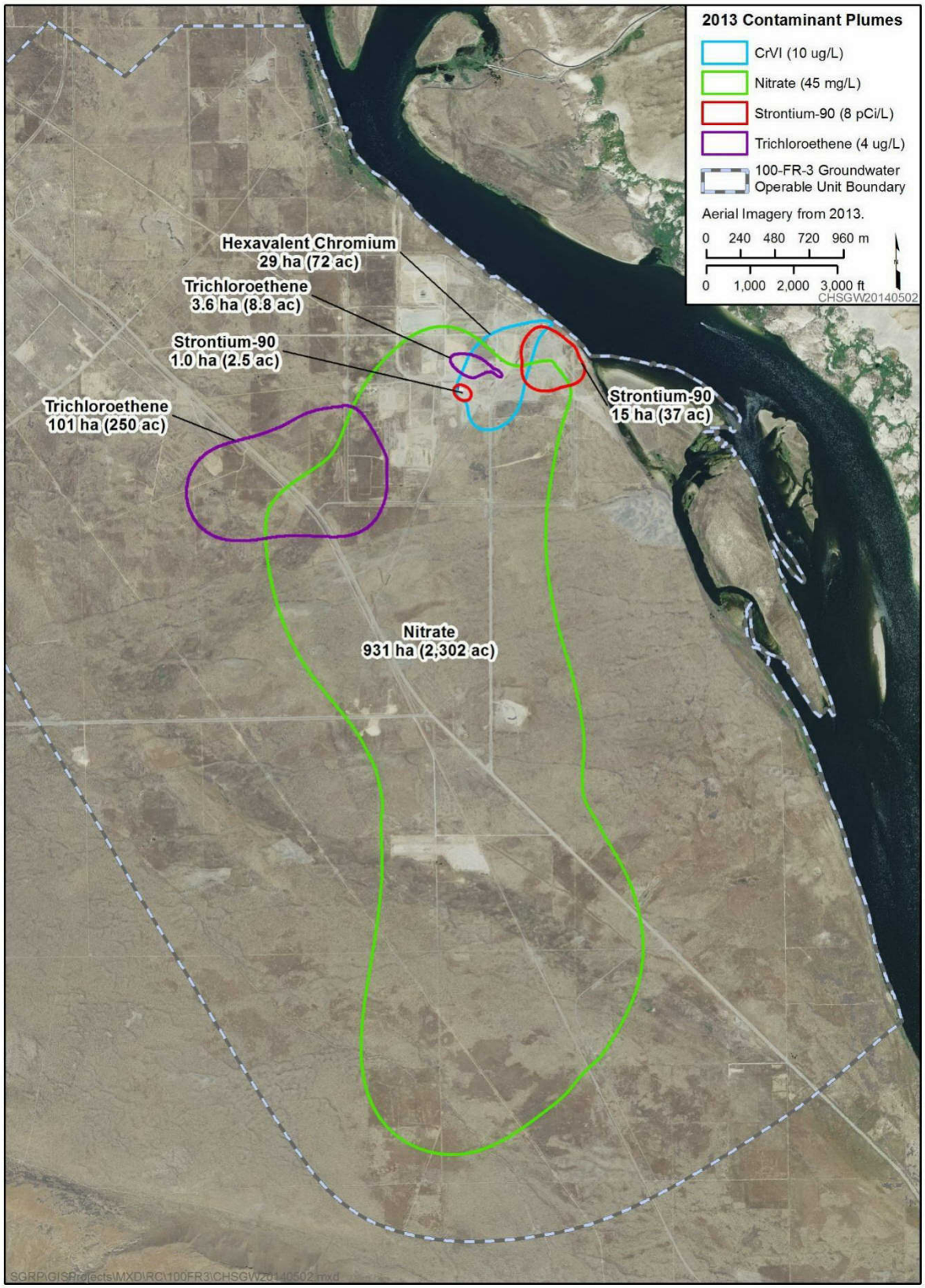

Figure 1-1. 100-FR-3 Operable Unit and 2013 Groundwater Plumes

Table 1-1. Major Components of the Selected Groundwater Remedy

100-FR-3 Operable Unit
Natural attenuation for Cr(VI), nitrate, strontium-90, and TCE in groundwater
Groundwater monitoring for Cr(VI), nitrate, strontium-90, and TCE in groundwater
Institutional controls*

* Institutional controls are implemented by DOE through DOE/RL-2001-41, *Sitewide Institutional Controls Plan for Hanford CERCLA Response Actions and RCRA Corrective Actions*. Details are described in Section 2.1.2 of DOE/RL-2014-44, *Integrated Remedial Design Report/Remedial Action Work Plan for 100-F/IU*.

Cr(VI) = hexavalent chromium
TCE = trichloroethene

MNA is a remedial strategy that monitors natural attenuation processes until cleanup levels are met. MNA measures and documents contaminant concentration reductions arising from various naturally occurring physical, chemical, and biological processes. The performance monitoring component of the MNA remedy includes installation of new monitoring wells, periodic sampling of new and existing monitoring wells, laboratory analysis, and data evaluation to assess and confirm the natural attenuation processes, rates of attenuation, and overall protectiveness. Well decommissioning will be performed when the RA is complete and may be performed when wells are determined to be no longer needed for any monitoring purpose.

ICs are required to control well drilling through excavation permits and restrict groundwater use until such time as groundwater achieves levels protective of unlimited use/unrestricted exposure (UU/UE). Groundwater use will be restricted through ICs to limited research purposes and for monitoring and treatment, as approved by EPA or the Washington State Department of Ecology.

Contaminated groundwater that migrates into 100-F/IU from other OUs is not part of the 100-FR-3 OU and is not addressed by the 100-F/IU ROD (EPA and DOE, 2014).

1.3 Site Description and Background

The site description and background for 100-F/IU is provided in the Section 1.3 of the Integrated RDR/RAWP (DOE/RL-2014-44).

1.3.1 Physical Setting

The physical setting for 100-F/IU is provided in the Integrated RDR/RAWP (DOE/RL-2014-44).

1.3.2 Nature and Extent of Contamination

The groundwater evaluation in DOE/RL-2010-98, *Remedial Investigation/Feasibility Study for the 100-FR-1, 100-FR-2, 100-FR-3, 100-IU-2 and 100-IU-6 Operable Units*, hereinafter called the 100-F/IU remedial investigation/feasibility study (RI/FS), compared exposure point concentrations for each contaminant to federal and state drinking water standards (DWSs) and Washington State groundwater cleanup levels. Contaminant concentrations in groundwater were also compared to surface water standards for protection of aquatic organisms because the groundwater discharges to the Columbia River. This comparison included state surface water quality standards for fresh water and federal ambient water quality criteria. The 100-F/IU RI/FS (DOE/RL-2010-98) identified nitrate, trichloroethene (TCE), strontium-90, and hexavalent chromium (Cr(VI)) as contaminants of concern (COCs).

Groundwater plume areas, where COC concentrations exceed federal or state DWSs or ambient water quality criteria, were identified based on calendar year (CY) 2013 groundwater monitoring results (DOE/RL-2014-32, *Hanford Site Groundwater Monitoring Report for 2013*). Groundwater within the

100-FR-3 OU contains nitrate at concentrations greater than the DWS[1] of 45,000 µg/L with an estimated nitrate plume area of 931 ha (2,302 ac) (Figure 1-1). A TCE plume at concentrations greater than the 4.0 µg/L 2007 WAC 173-340, "Model Toxics Control Act—Cleanup," level is approximately 105 ha (259 ac) (Figure 1-1). Strontium-90 was detected at concentrations above the 8 pCi/L DWS with an estimated plume area of 16 ha (40 ac) (Figure 1-1). Cr(VI) concentrations greater than the state surface water quality standard (WAC 173-201A, "Water Quality Standards for Surface Waters of the State of Washington") of 10 µg/L were identified in a plume area estimated at 29 ha (72 ac) (Figure 1-1). The CY 2013 groundwater monitoring results did not identify any Cr(VI) concentrations that exceeded the 2007 WAC 173-340-720, "Groundwater Cleanup Standards," level of 48 µg/L.

[1] Nitrate may be expressed as nitrate-nitrogen (NO_3-N) or nitrate (NO_3). The DWS for NO_3-N is 10,000 µg/L, and the mathematical equivalent value for NO_3 is 45,000 µg/L.

2 Basis for Remedial Action

The RA basis for the 100-FR-3 OU is described in the Integrated RDR/RAWP (DOE/RL-2014-44), which includes the selected remedy, RAOs, and applicable or relevant and appropriate requirements (ARARs). Cleanup levels for the 100-FR-3 OU COCs are presented in Table 2-1.

Table 2-1. Cleanup Levels for 100-FR-3 Operable Unit Contaminants of Concern

Contaminant of Concern	Cleanup Level	Units	Basis for Cleanup Level
Nitrate (as NO_3)	45,000	µg/L	DWS[a]
Trichloroethene	4	µg/L	WAC 173-340-720
Hexavalent Chromium[b]	10	µg/L	WAC 173-201A
	48	µg/L	WAC 173-340-720
Strontium-90	8	pCi/L	DWS
Media: Groundwater Operable Unit: 100-FR-3 Available Use: Drinking water and all other uses Controls to Ensure Restricted Use: Yes			

Note: Bases for these cleanup levels are risk limits and DWS applicable or relevant and appropriate requirements to protect drinking water uses, which also are protective of the river.

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

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

a. Nitrate may be expressed as nitrate-nitrogen (NO_3-N) or as nitrate (NO_3). The DWS for NO_3-N is 10,000 µg/L, and the mathematical equivalent value for nitrate (NO3) is 45,000 µg/L.

b. Cleanup levels for hexavalent chromium are 48 µg/L in the upland groundwater and 10 µg/L where groundwater discharges to surface water.DWS = drinking water standard

The following RAOs for the 100-FR-3 OU are identified in the 100-F/IU ROD (EPA and DOE, 2014):

- RAO 1—Prevent unacceptable risk to human health from ingestion of and incidental exposure to groundwater containing contaminant concentrations above federal and state standards and risk-based thresholds.
- RAO 2—Prevent unacceptable risk to human health and ecological receptors from groundwater discharges to surface water containing contaminant concentrations above federal and state standards and risk-based thresholds.
- RAO 7—Restore groundwater impacted from 100-FR-1, 100-FR-2, 100-IU-2, and 100-IU-6 releases to proposed cleanup levels, which include DWSs, within a time frame that is reasonable given the particular circumstances of the site.

Details of the specific remedial design approach for groundwater are described in Chapter 3.

MNA is the remedy for all COCs in the 100-FR-3 OU to reduce groundwater concentrations to less than cleanup levels. Overall plume behavior is controlled by a combination of the source strength (flux of contaminants into the groundwater) and the rate and capacity of attenuation in the groundwater. Without a

continuing source, the net plume response will be to diminish over time. The primary natural attenuation processes for COCs present in the 100-FR-3 OU include biodegradation and abiotic degradation, radioactive decay, dispersion, volatilization, and sorption. The estimated time frame required for COC concentrations to decrease to below the cleanup levels is presented in Table 2-2. These estimates were determined by computer modeling and are presented in the 100-F/IU RI/FS (DOE/RL-2010-98).

Table 2-2. Remedial Action Time Frame Estimates

Contaminant of Concern	Cleanup Level	Years[a]
Nitrate	45,000 µg/L	80
Trichloroethene	4 µg/L	50
Hexavalent Chromium[b]	10 µg/L	35
	48 µg/L	20
Strontium-90	8 pCi/L	150

a. The time frame required to attain the cleanup levels will vary in different areas of the contaminant of concern plume.

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

3 Remedial Design Approach

This chapter provides the remedial design approach for implementing the selected remedy of MNA for 100-FR-3 OU groundwater. The performance monitoring component of MNA includes periodic sampling, laboratory analysis, and data evaluation to assess the attenuation process and overall protectiveness. Performance monitoring results will be used to demonstrate that cleanup levels have been attained and the RA is complete. The two phases of MNA performance monitoring (remediation monitoring and attainment monitoring) are discussed in Section 3.1.1.

The performance monitoring design, including identification of monitoring networks, installation of new wells, periodic sampling, and laboratory analysis, is presented in this chapter. Data evaluation to assess the natural attenuation processes, rates of attenuation, and overall protectiveness during performance monitoring is presented in Chapter 6. ICs that are part of the remedy are described in Section 2.1.2 of the Integrated RDR/RAWP (DOE/RL-2014-44).

The companion documents associated with this Groundwater Addendum are summarized in Table 3-1. The Groundwater SAP, Waste Management Plan, and Operations and Maintenance (O&M) Plan are included as appendices to this document. Reporting of yearly performance monitoring results will be presented in the annual Hanford Site groundwater monitoring report (e.g., DOE/RL-2014-32).

Table 3-1. Companion Documents to Groundwater Addendum

Document Title	Purpose/Content	Document Status
Sampling and Analysis Plan	Describes well installation and sampling procedures, locations, parameters, and frequency of sampling for MNA performance monitoring	Included as Appendix A.
Operations and Maintenance Plan	Operations and maintenance activities including inspection, maintenance, and periodic replacement of monitoring wells	Included as Appendix B.
Waste Management Plan	Describes the waste management procedures	Included as Appendix C.
Performance Monitoring Reports	Evaluates performance monitoring results, progress toward attainment of cleanup levels, and cleanup level attainment calculations when applicable. Includes updates to groundwater flow and transport model and plume area determinations. Report schedule will support the CERCLA 5-year reviews for the Hanford Site.	Prepared as a separate report at 5-year frequencies during MNA. The first 5-year report is anticipated to be prepared in 2020 to support the 2016 to 2021 Hanford Site 5-year CERCLA review.
Phase 1 Well Report	Prepared after the first year of monitoring of Phase 1 wells. This report will summarize the findings from the Phase 1 well installation, updates to groundwater model and plumes, early water level measurement results, and recommendations for Phase 2 wells.	Preparation of report planned for fiscal year 2017 after all Phase 1 wells have completed the first year of performance monitoring.

Table 3-1. Companion Documents to Groundwater Addendum

Document Title	Purpose/Content	Document Status
Sitewide Institutional Controls Plan for Hanford CERCLA Response Actions and RCRA Corrective Actions (DOE/RL-2001-41)	Describes implementation and maintenance of ICs for the Hanford Site	Independent document identifying Hanford Site ICs, revised as needed

CERCLA = *Comprehensive Environmental Response, Compensation, and Liability Act of 1980*
IC = institutional control
MNA = monitored natural attenuation

3.1 Performance Monitoring Design Basis

This section discusses the approach for implementing and evaluating the MNA component of the 100-F/IU ROD (EPA and DOE, 2014).

3.1.1 Implementation Approach

The MNA remedy relies upon natural attenuation processes to reduce groundwater COC concentrations during the estimated time periods to concentrations less than the cleanup levels for 100-FR-3 OU groundwater. Natural attenuation processes include a variety of physical, chemical, or biological processes, which under favorable conditions, act without human intervention to reduce the mass, toxicity, mobility, volume, or concentration of contaminants in soil or groundwater.

MNA includes performance monitoring to assess the effectiveness of natural attenuation to meet cleanup levels. Performance monitoring will continue until COCs have attained the cleanup levels, and are expected to continue to meet cleanup levels, and EPA approves termination of the monitoring. The 100-FR-3 OU groundwater plumes are shown in Figure 1-1.

As discussed in OSWER 9355.0-129, *Guidance for Evaluating Completion of Groundwater Restoration Remedial Actions*, performance monitoring consists of two phases: remediation monitoring and attainment monitoring. The first phase (remediation monitoring) refers to the phase of the remedy where remedial activities are being implemented to reach groundwater cleanup levels. During this phase, groundwater sampling and monitoring data are collected to evaluate contaminant migration and changes in COC concentrations over time. Progress towards attaining the cleanup level is evaluated during the remediation phase on a well-by-well basis for each COC. Remediation monitoring for a specific monitoring well and COC is complete when the data evaluation demonstrates that the groundwater has reached the cleanup level. Some wells will monitor for multiple COCs. In these cases, conclusions may be made, at any time during groundwater remediation, to remove certain COCs from the monitoring program because the data indicate that they have met their cleanup level before other, more recalcitrant, COCs in the well (OSWER 9355.0-129).

The attainment monitoring phase occurs after the remediation monitoring phase is complete. Once the groundwater is observed to have reached the cleanup level, data are collected and evaluated to confirm that the attainment monitoring phase has been completed. The attainment monitoring phase at a monitoring well is complete when contaminant-specific data provide both of the following technical and scientific bases:

- The contaminant cleanup level for each COC has been met.

- Groundwater will continue to meet the contaminant cleanup level for each COC in the future (OSWER 9355.0-129).

3.1.2 Performance Monitoring Design Considerations

A site-specific data quality objective (DQO) process was performed to identify monitoring networks, frequency and timing of sample collection, data assessments, and progress evaluations required for the design of an effective performance monitoring and data evaluation program for 100-FR-3 OU groundwater. The following guidance documents were utilized during the DQO process:

- OSWER Directive 9200.4-17P, *Use of Monitored Natural Attenuation at Superfund, RCRA Corrective Action, and Underground Storage Tank Sites*
- OSWER Directive 9283.1-44, *Recommended Approach for Evaluating Completion of Groundwater Restoration Remedial Actions at a Groundwater Monitoring Well*
- OSWER 9355.0-129, *Guidance for Evaluating Completion of Groundwater Restoration Remedial Actions*
- EPA 230-R-92-014, *Methods for Evaluating The Attainment Of Cleanup Standards Volume 2: Ground Water*
- EPA/600/R-04/027, *Performance Monitoring of MNA Remedies for VOCs in Ground Water*
- EPA/600/R-07/139, *Monitored Natural Attenuation of Inorganic Contaminants in Ground Water Volume 1 – Technical Basis for Assessment*
- EPA/600/R-07/140, *Monitored Natural Attenuation of Inorganic Contaminants in Ground Water Volume 2 – Assessment for Non-Radionuclides Including Arsenic, Cadmium, Chromium, Copper, Lead, Nickel, Nitrate, Perchlorate, and Selenium*
- EPA/600/R-10/093, *Monitored Natural Attenuation of Inorganic Contaminants in Ground Water Volume 3 – Assessment for Radionuclides Including Tritium, Radon, Strontium, Technetium, Uranium, Iodine, Radium, Thorium, Cesium, and Plutonium-Americium*
- EPA 600/R-11/204, *An Approach for Evaluating the Progress of Natural Attenuation in Groundwater*

Guidance from the preceding documents was utilized to supplement the existing well locations and optimize a monitoring network designed to monitor changes in plume size, identify target zones for monitoring, refine the understanding of hydraulic gradients, and collect sufficient data to support decision making. The Groundwater SAP (Appendix A) presents the performance monitoring approach, including locations of new and existing monitoring wells, aquifer tubes, and a riverbank seep to be sampled, sampling frequency, and analytes. The DQO report (SGW-58291, *Data Quality Objectives for 100-FR-3 Monitored Natural Attenuation*) will be published in 2015 as a separate report. The report is included with Appendix A (Groundwater SAP) for convenience.

Groundwater monitoring will consist of sampling monitoring wells, aquifer tubes, and riverbank seeps for COCs, degradation products, and geochemical parameters to support the overall remedy performance evaluation. The geochemical groundwater parameters used for assessing MNA effectiveness include pH, dissolved oxygen (DO), specific conductance, temperature, and turbidity. Only monitoring well sample results will be used in determining compliance with cleanup levels.

Due to analytical uncertainties identified in the 100-F/IU RI/FS (DOE/RL-2010-98), sampling and analysis will also be conducted for antimony, cadmium, and cobalt to determine if these analytes are

below the action level. Degradation products of TCE are also identified for sampling. These chemicals include *cis*-1,2-dichloroethene and vinyl chloride.

The monitoring network locations and frequency of performance monitoring will vary, depending on the progress of MNA. As sample results demonstrate that the COC plumes decrease in area and/or migrate, monitoring locations will be evaluated and adjusted accordingly. Sample frequencies vary, depending on the monitoring stage. Initial remediation phase monitoring will be performed quarterly for all new wells during the first year of monitoring, followed by annual sampling in years 2 through 5. Existing wells will be sampled annually or, at specified locations, semiannually (two times per year) during the first 5 years of sample collection. Sampling frequencies are reduced to biennial sampling (one time every 2 years) after the first 5 years of sampling have established contaminant concentration trends.

3.2 Performance Monitoring Design Summary

The summary for the 100-FR-3 OU performance monitoring design describes the following elements:

- MNA overview
- Performance monitoring
- DQO outputs
- Remediation phase monitoring network and evaluation
- Attainment phase monitoring network and evaluation

MNA performance monitoring is achieved through establishing a monitoring network to produce data sufficient to evaluate the attenuation of COCs. The network design includes existing monitoring wells, aquifer tubes, and a riverbank seep. New monitoring wells are also included in the design.

3.2.1 Monitored Natural Attenuation of Groundwater

As part of the 100-F/IU RI/FS (DOE/RL-2010-98), an evaluation was performed to demonstrate that MNA was a viable remedy for the 100-FR-3 OU. The evaluation used a multiple lines of evidence approach that considered the occurrence, mechanisms, rates, and expected performance of natural attenuation processes in site conditions. MNA evaluation in the 100-F/IU RI/FS (DOE/RL-2010-98) demonstrated the following elements:

- Effective source control
- Clear and meaningful trend of decreasing contaminant mass and/or concentration over time at appropriate monitoring or sampling points
- Directly or indirectly, the type(s) of natural attenuation processes that are active at the site, and the rate at which such processes will reduce contaminant concentrations to required levels

Additional details of the MNA evaluation are presented in Appendix M of the 100-F/IU RI/FS (DOE/RL-2010-98).

3.2.2 Performance Monitoring

The MNA remedy includes performance monitoring to ensure the effectiveness of natural attenuation to meet cleanup levels. Performance monitoring will continue until COCs have attained cleanup levels, and are expected to continue to meet cleanup levels, and EPA approves termination of the monitoring. Groundwater plumes are shown in Figure 1-1. The Groundwater SAP (Appendix A) presents the performance monitoring approach, including locations of new and existing wells, aquifer tubes, and the riverbank seep within the monitoring network, sampling frequency, and analytes.

As the RA progresses, the extent of the contaminated aquifer is expected to change. The groundwater monitoring network will be evaluated during the RA to ensure adequate and accurate evaluation of contaminant concentrations and contaminated aquifer boundary changes over time.

Yearly performance monitoring sampling will be summarized and presented in the annual groundwater report (e.g., DOE/RL-2014-32). A separate report summarizing the Phase 1 well results, groundwater model updates, water level measurement results, network optimizations, and any Phase 2 well recommendations will be prepared after Phase 1 wells have completed the first year of performance monitoring. Comprehensive performance monitoring reports will be prepared at 5-year intervals to evaluate progress of the MNA remedy. Details on the analysis and reporting of results are presented in Section 3.3.

3.2.2.1 Principal Study Questions

A site-specific DQO process was performed to identify the data needs for performance monitoring. The following principal study questions (PSQs) were identified during the DQO (methods for use of monitoring results to evaluate PSQs are described in Chapter 6, and additional details on development of PSQs are described in the DQO report [SGW-58291], presented in the Groundwater SAP [Appendix A]):

- PSQ 1— Is natural attenuation of Cr(VI), nitrate, TCE, and strontium-90 in groundwater occurring as expected?
  - PSQ 1a—Are contaminant concentrations and plume area/mass decreasing?
  - PSQ 1b—Are rates of decline consistent with expectations?
  - PSQ 1c—Are there changes in environmental conditions that may reduce the efficacy of natural attenuation?
  - PSQ 1d—Are there unacceptable impacts to the Columbia River?
  - PSQ 1e—Is there evidence of new or continuing releases of contaminants to the environment that could impact the effectiveness of the natural attenuation remedy?
- PSQ 2—Are concentrations of antimony, cadmium, and cobalt below action levels?
- PSQ 3— Do new geologic and hydrogeologic data confirm the conceptual site model (CSM)?
- PSQ 4—Have RAOs been achieved?
  - PSQ 4a—Are concentrations of COCs below cleanup levels?
  - PSQ 4b—Will groundwater continue to meet the cleanup level in the future?

3.2.2.2 Decision Rules

The following decision rules requiring sampling and analysis were identified in the DQO (methods for use of the monitoring results to evaluate the decision rules are described in Chapter 6):

- Decision Rule No. 1—If the weight of evidence indicates that natural attenuation is occurring as expected, then continue MNA; otherwise, evaluate other options.
- Decision Rule No. 2—If monitoring indicates that concentrations of antimony, cadmium, and cobalt are not greater than the action level or practical quantitation limit (PQL), then discontinue monitoring; otherwise, perform risk assessment.

- Decision Rule No. 3—If new geologic and hydrogeologic data confirm the CSM, then retain the model; otherwise, update it.
- Decision Rule No. 4—If RAOs have been achieved for an individual COC, then proceed to attainment monitoring for that COC; otherwise, continue MNA.

3.2.3 Contaminants of Concern and Other Analytes

Sampling will include analyses for the following COCs at the respective plume locations: Cr(VI), nitrate, strontium-90, and TCE. Samples to monitor TCE attenuation will also include analysis for vinyl chloride and *cis*-1,2-dichloroethene, which are TCE degradation products. Field measurements, including specific conductance, pH, DO, turbidity, and temperature, will be collected during groundwater sample events. Sampling for antimony, cadmium, and cobalt will be conducted during the first 10 years of sampling at the monitoring wells identified in Table A-8 of the Groundwater SAP (Appendix A) to determine if these analytes are present below action levels.

3.2.4 Sample Frequency

The performance monitoring sample frequency is determined, based on the type of well and the expected variability of results. New wells will be sampled quarterly for 1 year to establish the baseline and seasonal variability. For existing wells and aquifer tubes, a minimum of annual sampling will be performed for the first 5 years to establish a new baseline. Selected existing wells, at locations where changes in water table are likely to affect concentrations, will be sampled semiannually at high and low river stage for the first 5 years.

The sampling frequency for the performance monitoring network will be evaluated after the initial 5 years of monitoring. After the first 5 years, it is anticipated that the sample frequency will be reduced to every 2 years (biennial). Biennial sampling will provide at least two sampling events for subsequent 5-year performance monitoring reports. During the 5 years of attainment monitoring, the sampling frequency may be quarterly for 2 years to detect seasonal variability and may be reduced to annual for the next 3 years.

Annual and biennial sampling events will be scheduled for fall when river stage is low (September or October). Semiannual wells (twice per year) will also be sampled at high river stage (mid-May through mid-July).

3.2.5 Performance Monitoring Network

The performance monitoring component includes identification of the groundwater monitoring network for each COC, installation of new wells, periodic sampling of new and existing wells, laboratory analysis, and periodic evaluation to assess the natural attenuation processes, rates of attenuation, and overall protectiveness.

Groundwater monitoring will be performed to document changes in contaminant concentrations and extent for all groundwater COCs. Monitoring networks for each COC were identified during the DQO process. Locations were identified to monitor COC concentrations, detect changes in plume areas, and refine the understanding of local hydraulic gradients. In total, 28 existing wells, 8 new Phase 1 wells, 6 aquifer tubes, and 1 riverbank seep were identified for analytical sampling, based on the DQO process. An additional four existing wells were identified for water level measures only. The locations of the monitoring network components are presented in the Groundwater SAP (Appendix A).

Information on hydraulic gradients will be obtained using an automated water level network (AWLN), encompassing 19 wells and the 100-F river gauge station. The information will provide refinements to the groundwater model and be utilized for natural attenuation evaluation. The AWLN will be operated for at

least the first 5 years of performance monitoring; then, continuation of AWLN monitoring will be re-evaluated. Manual water level measurements will also be obtained from other wells in the monitoring network at low, moderate, and high river stage periods during the first 10 years of performance monitoring.

As COC plumes decrease in size or migrate over time, adjustments to the monitoring network will be evaluated. Adjustments may include removing upgradient wells from the monitoring network. At a minimum, COC monitoring networks will be evaluated at 5-year intervals during the remedy.

3.2.5.1 New Groundwater Monitoring Wells

New groundwater monitoring wells will be installed to further define the natural attenuation processes and update the rates of attenuation that are occurring to reflect post-source remediation conditions. The need and location for new wells will be determined in two phases based on existing groundwater monitoring results and results from the first phase of new well installation. Based on the DQO process, a total of eight locations were identified for Phase 1 well installation.

A phased approach was implemented to site new wells required for performance monitoring at locations determined to most efficiently assess the effectiveness of the MNA remedy. Phase 1 wells were identified in the DQO process and Phase 2 new wells, if needed, will be determined after evaluation of data collected from all wells in the monitoring network. An evaluation of Phase 1 wells results will be reported after all wells have completed the first year of monitoring. The report will include recommendations for Phase 2 wells.

The eight wells identified for Phase 1, as well as any Phase 2 wells, will be drilled 3 m (10 ft) into the top of the Ringold upper mud unit.

3.2.5.2 Operations and Maintenance

Appendix B describes O&M activities associated with the monitoring network. Activities include inspection, maintenance, and periodic replacement of monitoring wells. The plan describes routine maintenance activities for the monitoring network. Any well maintenance activities that affect sample quality will be summarized in the annual groundwater report (e.g., DOE/RL-2014-32). Due to the long-term nature of MNA remedy for the 100-FR-3 OU COCs, roadway access and associated maintenance will be required to support sample collection through the performance monitoring period at the specified sample locations.

3.3 Performance Monitoring Analysis and Reporting

Yearly results of performance monitoring sampling will be summarized and presented in the annual groundwater report (e.g., DOE/RL-2014-32).

A separate report of the Phase 1 well results and any Phase 2 well recommendations will be prepared after all Phase 1 wells have completed the first year of performance monitoring. The report will summarize the findings from Phase 1 well installation, updates to the groundwater model projections and plumes, early water level measurement results, and optimizations for the monitoring network.

Comprehensive performance monitoring evaluation reports will be prepared at a 5-year frequency throughout the remedy. Progress evaluations, including any groundwater modeling updates, will be presented in the reports. PSQs and decision rules identified in the DQO will be evaluated in the reports, as described in Chapter 6. Evaluation of antimony, cadmium, and cobalt results, as well as any detections of TCE degradation products in excess of the required detection limit, will be included using methods addressed in Chapter 6. The initial 5-year performance monitoring report is anticipated to be prepared in

2020 to align with the 2016 to 2020 Hanford Site 5-year review period. Subsequent reports will be prepared at 5-year intervals.

3.3.1 Remediation Monitoring Progress Evaluation

During the remediation monitoring phase, natural attenuation rates for each COC will be calculated for the performance monitoring reports to evaluate the progress of the MNA remedy, relative to the expected time frames. Evaluations used to demonstrate attainment of the cleanup levels during the remediation monitoring phase will be performed with data from monitoring wells only. The description of methods used to determine COC attenuation rates and evaluate COC progress toward meeting the cleanup levels, and triggers for re-assessing MNA performance are presented in Chapter 6.

As discussed in OSWER 9355.0-129, the remediation phase at a monitoring well is completed when the data collected and evaluated from that well demonstrate that groundwater has reached cleanup levels for all COCs. OSWER 9355.0-129 specifies that, at any time during groundwater remediation, conclusions may be made to remove certain COCs from the monitoring program because the data indicate that they have met their cleanup level before other, more recalcitrant COCs, in the well. This conclusion will be documented in the monitoring report and used, in conjunction with the current well data at the time of RA completion, to make the conclusion that all COCs have reached their cleanup level.

Progress evaluations will be performed and documented in the 5-year performance monitoring reports through the remediation monitoring phase. When the progress evaluation demonstrates that concentrations of a COC have met the cleanup level at a specific well, attainment monitoring for that COC/well will begin. Depending on timing, a progress evaluation may be performed separately from the 5-year performance monitoring report if a given COC/well has met the cleanup level and is ready to enter the attainment monitoring phase. In this case, the evaluation will be included in the subsequent 5-year report. After the attainment monitoring results demonstrate that the COC/well has met the cleanup level, the well will be considered to have completed RA for that COC. Details of evaluations to be performed with monitoring data are presented in Section 6.4.

3.3.2 Suggested Format for MNA Performance Monitoring Report

A suggested outline for the 5-year performance monitoring report is presented in the following subsection. Sections of the outline are more applicable to the earlier years of monitoring. Not all sections of the suggested format may be applicable for a given performance period and may be omitted. Additional sections may be added, as needed.

The format of the MNA performance monitoring report may be used to report both remediation and attainment phase results.

3.3.2.1 MNA Performance Monitoring Report

1. Introduction
    - 1.1. Purpose
    - 1.2. Period of Performance
    - 1.3. Report Organization
2. Contaminant Monitoring
    - 2.1. Contaminant Monitoring Network and Parameters
        - 2.1.1. Installation of New Wells
        - 2.1.2. Well Maintenance and Repair
    - 2.2. Contaminant Monitoring Data
        - 2.2.1. Contaminants of Concern

2.2.2. Contaminant Degradation Products, Field Parameters, and Other Analytes
2.2.3. Analysis of Contaminant Monitoring Data
2.2.3.1. Plume Boundaries
2.2.3.2. Natural Attenuation Rate Determinations
2.2.3.3. Environmental Conditions Affecting Natural Attenuation
2.2.3.4. Contaminant Impacts to the Columbia River
2.2.3.5. New or Continuing Releases of COCs
2.2.3.6. Contaminant Degradation Products and Trace Metals
3. Hydraulic Gradients
3.1. AWLN Results
3.2. Manual Water Level Results
3.3. Seasonal Variation
3.4. Influence of Geology and Hydrogeology in Southern 100-FR-3 OU
4. Contaminant Transport Modeling
4.1. Contaminant Transport Parameters
4.2. Contaminant Transport Model Calibration
4.3. Predictive Contaminant Transport Simulations
5. Remediation Phase Monitoring Evaluation
5.1. Progress Toward Meeting RAOs
5.2. Evaluations for Contaminants of Concern at Individual Wells
5.2.1.Attenuation Rate Evaluation and Cleanup Level Attainment Estimate
5.2.2.Evaluation of Cleanup Level Attainment at Individual Wells
5.3. Contaminant Evaluation Throughout Plume
5.4. Updates to Monitoring Network
6. Attainment Phase Monitoring Evaluation
6.1. Evaluation of Cleanup Level Attainment at Individual Wells
6.2. Contaminant Evaluation Throughout Plume
6.3. Summary of Cleanup Level Attainment
7. Conclusions
7.1. Changes to the Site Conceptual Model
7.2. Remediation Monitoring Evaluation of PSQs and Decision Rules
7.2.1. PSQ #1a through 1e; Decision Rule #1
7.2.2. PSQ #2; Decision Rule #2
7.2.3. PSQ #3; Decision Rule #3
7.2.4. PSQ #4a and #4b; Decision Rule #4
8. Recommendations
9. References

3.3.3 Attainment Monitoring Evaluation

When the remediation monitoring progress evaluation demonstrates that COC concentrations have attained cleanup levels at a specific well, the attainment monitoring phase will commence for that specific COC/well. Attainment monitoring will be performed for 5 years for each COC/well. Attainment monitoring wells may be sampled quarterly for the first 2 years and may be reduced to annually for the remaining 3 years. If the results of attainment monitoring demonstrate that a COC/well has attained the cleanup level, using the methods presented in Section 6.4.2, then attainment monitoring for that COC/well will cease. However, additional monitoring may be performed, if needed, to support preparing plume maps and performance monitoring reports.

Some areas of the COC plume will attain the cleanup level more rapidly than other areas. Therefore, both remediation monitoring and attainment monitoring may be performed for the same COC at different wells during the same sample period.

Only monitoring well results will be used for demonstrating that a COC plume has attained the cleanup level. When attainment monitoring is completed at each well within the monitoring network, and COC concentrations have attained the cleanup level throughout the plume(s) and are expected to continue to meet the cleanup level, then the RA for that COC will be complete. The subsequent evaluation of cleanup level attainment and RA completion for that COC will be documented either in the next 5-year performance monitoring report or in the final RA report, whichever is appropriate. If attainment monitoring results for a given COC do not demonstrate that the cleanup level has been attained, then DOE and the regulators will evaluate the results and determine the path forward. When all COCs have completed attainment monitoring, data evaluations demonstrate attainment of the cleanup levels, and it is expected that groundwater will continue to meet the cleanup levels, then the RA will be complete and a final RA report for the 100-FR-3 OU will be prepared.

3.4 CERCLA 5 Year Review

In accordance with 40 CFR 300.430(f)(4)(ii), "National Oil and Hazardous Substances Pollution Contingency Plan," "Remedial Investigation/Feasibility Study and Selection of Remedy," DOE and EPA have agreed to conduct 5-year reviews for the 100 Area because the selected remedy will not achieve levels that allow for UU/UE within 5 years. Reviews are conducted 5 years after initiation of RA and every 5 years until cleanup levels established in the ROD (EPA and DOE, 2014) are attained. The reviews are conducted pursuant to CERCLA Section 121(c), "Cleanup Standards," and as provided in EPA 540-R-01-007, *Comprehensive Five-Year Review Guidance*.

The following three 5-year review reports for the Hanford Site have been completed (in 2001, 2006, and 2012, respectively):

- EPA, 2001, *USDOE Hanford Site First Five Year Review Report*
- DOE/RL-2006-20, *The Second CERCLA Five-Year Review Report for the Hanford Site*
- DOE/RL-2011-56, *Hanford Site Third CERCLA Five-Year Review Report*

Upcoming 5-year reviews will include the following time periods:

- Fourth 5-year review – 2011 through 2016
- Fifth 5-year review – 2016 through 2021

3.5 Final Remedial Action Report

This section describes the final RA closure report and provides a brief summary of typical report content.

A final RA report will be prepared to document cleanup activities that occurred and to demonstrate compliance with ROD requirements.

The final RA report will be prepared using the format provided in EPA 540-R-98-016, *Close Out Procedures for National Priorities List Sites*. The final RA report outline includes the following suggested primary sections:

1. Introduction
2. Summary of Site Conditions
3. Demonstration of Cleanup Activity Quality Assurance (QA)/Quality Control (QC)

4. Monitoring Results
5. Performance Standards and Construction QC
6. Summary of Operation and Maintenance
7. Summary of Remediation Costs
8. Protectiveness
9. Five-Year Review
10. References

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4 Remedial Action Management and Approach

The Integrated RDR/RAWP (DOE/RL-2014-44) presents a project team and change management approach associated with implementation of the selected remedies. For the groundwater remedy component, CH2M HILL Plateau Remediation Company is responsible for remedial design and RA activities associated with MNA and performance monitoring. RA work tasks specific to the groundwater remedy are described in Section 4.1.

4.1 Remedial Action Work Tasks

RA tasks associated with MNA and ICs are described in the following subsections.

4.1.1 Procurement and Construction

Performance monitoring activities include installation of new wells. Eight locations were identified for Phase 1 new well installation. Additional Phase 2 wells may be identified, depending on evaluation of Phase 1 results.

Procurement activities will include contracts for well drilling and construction, geophysical services, and analytical services. The work will be accomplished using the most efficient combination of onsite resources and service vendors.

Access to the new well locations may require construction of new access roads. The new roads will require maintenance through the monitoring period until the wells are decommissioned. Maintenance of existing roads to existing wells, and other locations within the identified monitoring network, will be required to provide access through the applicable monitoring periods until the wells are decommissioned.

An AWLN will be established and tracked at 19 wells and the 100-F river gauge station for at least the first 5 years of monitoring. The AWLN includes 7 new wells and 12 existing wells. Locations within the AWLN will be equipped, as required, for the automated measurements.

4.1.2 Rehabilitation of Old Wells and River Gauge Station Repairs

Several older wells with missing or unverified construction information were identified for potential use in the monitoring networks. These wells will be investigated to determine suitability in the monitoring network. Investigation includes a review of documentation, where available; camera surveys; borehole geophysics; and field inspections. Table A-10 of the Groundwater SAP (Appendix A) identifies the wells requiring investigation.

Several existing wells identified for use in the monitoring network extend deeper than the base of the unconfined aquifer. Grouting of these wells will be performed to allow sampling within the unconfined aquifer. Table A-10 of the Groundwater SAP (Appendix A) identifies the wells requiring rehabilitation.

Repairs will be made to the existing 100-F river gauge station on the Columbia River to allow safe access and use of station.

4.1.3 Implementation of Institutional Controls

ICs for the 100-FR-3 OU groundwater are presented in Section 2.1.2 of the Integrated RDR/RAWP (DOE/RL-2014-44). ICs to be implemented by DOE include administrative controls that control well drilling through excavation permits and restrict groundwater use until such time as the groundwater achieves levels protective of UU/UE where groundwater is above cleanup levels. These ICs are implemented through DOE/RL-2001-41, *Sitewide Institutional Controls Plan for Hanford CERCLA Response Actions and RCRA Corrective Actions*.

4.1.4 Project Status Reporting

Progress will be communicated in the Unit Managers Meetings, including sample and analysis results, operations, and general project status and timelines.

5 Environmental Management and Controls

This chapter describes the environmental management and controls associated with implementation of the 100-FR-3 OU remedy.

5.1 Air Emissions

Radiological and nonradiological air emissions associated with MNA of groundwater are not anticipated.

5.2 Reporting Requirements for Non-Routine Releases

40 CFR 302, "Designation, Reportable Quantities, and Notification," requires immediate notification to the National Response Center on discovery of a hazardous substance release into the environment in excess of a reportable quantity in a 24-hour period. 40 CFR 355, "Emergency Planning and Notification," requires immediate notification to the community emergency coordinator for the local emergency planning committee and to the State Emergency Response Commission for release of a reportable quantity of an extremely hazardous substance or a CERCLA hazardous substance in a 24 hour period, except for releases exempted from reporting under 40 CFR 355.31, "What Types of Releases are Exempt from the Emergency Release Notification Requirements of this Subpart?" The Hanford Site has comprehensive policies and procedures in place to report nonroutine releases to the environment; these procedures will be followed at the 100-FR-3 Groundwater OU.

5.3 Waste Management

The waste management plan for the RA is provided in Appendix C. The plan provides details on the specific requirements for waste identification, characterization, segregation, packaging, labeling, storage, and inspection for waste generation activities associated with the new well installation, sample collection, and well maintenance. The following projected waste streams are included in the waste management plan:

- Drill cuttings (both dry soil and saturated slurries)
- Purgewater generated during well or aquifer tube installation, development, testing, monitoring, maintenance, decommissioning, and decanting of saturated soils
- Decontamination fluids

Miscellaneous solid wastes may include, but are not limited to, the following:

- Filter paper, syringes, wipes, personal protective equipment (PPE), cloth, plastic, equipment, tools, pumps, wire, metal and plastic piping, and materials from cleanup of unplanned releases
- Decommissioning debris, such as concrete, wood, rebar, metal/plastic pipe and screens, wire, liners, bentonite/sand/gravel, equipment, pumps, and tanks
- Spent/excess chemicals/reagent and used oil

5.4 Cultural/Ecological Resources

Protection of cultural resources is addressed, in part, during the ARAR identification process based on CERCLA and 40 CFR 300, "National Oil and Hazardous Substances Pollution Contingency Plan." The lead and non-lead regulatory agencies identify ARARs for the release or RA at a CERCLA site (40 CFR 300.400[g], "General"). ARARs for the 100-F/IU RA are provided in Appendix A of the Integrated RDR/RAWP (DOE/RL-2014-44).

As identified in Appendix A of the Integrated RDR/RAWP (DOE/RL-2014-44), the following ARAR protects ecological resources for work within the 100-FR-3 OU:

- *Endangered Species Act of 1973*—100-FR-3 OU groundwater discharges into the Hanford Reach of the Columbia River contains three species listed as threatened or endangered. The spring-run Chinook salmon do not spawn in the Hanford Reach but use it as a migration corridor. Steelhead spawning has been observed in the Hanford Reach. The bull trout is not considered a resident species and is rarely observed in the Hanford Reach. Remediation actions and investigation activities will be managed to avoid jeopardy and/or adversely affect a listed species or critical habitat.

Ecological, cultural, historical, and Native American sites and artifacts will be protected, as identified in the Integrated RDR/RAWP (DOE/RL-2014-44), Appendix A ARARs. Prior to disturbing the earth (e.g., drilling and excavation), the DOE Richland Operations Office will initiate discussions with the affected parties, and an analysis of cultural and ecological resource impacts will be undertaken. This analysis will include an assessment of the resources present and a qualitative comparison to the risk posed by contaminants present in the OU.

A cultural resources review is part of work planning activities, and the project will involve cultural resources staff early in the planning stage to address potential concerns and consider the effects that the planned project activities could have.

5.5 Safety and Health Program

The remediation contractor's hazardous waste operations safety and health program was developed for employees involved in hazardous waste site activities. The program was developed to comply with the requirements of 29 CFR 1910.120, "Occupational Safety and Health Standards," "Hazardous Waste Operations and Emergency Response," and 10 CFR 835, "Occupational Radiation Protection," to ensure the safety and health of workers during hazardous waste operations.

The health and safety program was developed in accordance with the overall remediation contractor's health and safety program to define the chemical, radiological, and physical hazards and to specify the controls and requirements for day-to-day work activities on the overall Hanford Site. It also incorporates applicable core functions and guiding principles, outlined in the Integrated Safety Management System, and governs minimum personal training; control of industrial safety and radiological hazards; PPE; site control; and general emergency response to spills, fire, accidents, injury, and incident reporting.

Access and work activities will be controlled in accordance with approved work packages, as required by established internal work requirements and processes. The health and safety plan (HASP), which addresses the health and safety hazards of each phase of site operation, includes the requirements for hazardous waste operations and/or construction activities, as specified in 29 CFR 1910.120.

Project field staff will be required to comply with the HASP at all times. Unescorted site visitors are required to read and sign the HASP before entering the construction area and must have completed the required training outlined in the HASP. Escorted visitors are briefed on health and safety concerns and must be escorted by the site superintendent (or designee) at all times when they are in the construction area.

During operations and construction, emergency response for the 100-FR-3 OU remedial activities will be covered by the HASP. The HASP specifies primary emergency response actions for site personnel, area alarms, implementation of the emergency action plan and emergency equipment at the task site, emergency coordinators, emergency response procedures, and spill containment procedures.

5.6 Emergency Response

During construction and operations, emergency response for project activities will be covered by the project-specific HASP and related health and safety procedures and work instructions. The HASP, health and safety procedures, and work instructions contain primary emergency response actions for site personnel, area alarms, implementation of the emergency action plan, and emergency equipment at each task site, as well as emergency coordinators, emergency response procedures, and spill containment. A copy of the HASP will be kept in the construction field office. When emergencies arise that are beyond the limitations of the project-specific HASP, DOE-0223, *Emergency Plan Implementing Procedures*, will govern project staff response, as specified in the HASP.

5.7 Quality Assurance Program

Overall QA for the RDR/RAWP (DOE/RL-2014-44) will be planned and implemented in accordance with 10 CFR 830, "Nuclear Safety Management," Subpart A, "Quality Assurance Requirements"; EPA/240/B-01/003, *EPA Requirements for Quality Assurance Project Plans* (EPA QA/R-5); EPA/240/R-02/009, *Guidance for Quality Assurance Project Plans* (EPA QA/G-5); EPA/240/B-05/001, *Guidance on Quality Assurance for Environmental Technology Design, Construction, and Operation* (EPA QA/G-11); and SW-846, *Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, Third Edition; Final Update IV-B*. QA activities will use a graded approach, based on potential impact to the environment, safety, health, reliability, and continuity of operations. QA for groundwater monitoring will be discussed in the Groundwater SAP (Appendix A) and will comply with the following requirements:

- DOE/RL-96-68, Hanford Analytical Services Quality Assurance Requirements Document (HASQARD)
- DOE O 414.1D, *Quality Assurance*

The Groundwater SAP (Appendix A) contains a QA project plan, which establishes the quality requirements for environmental data collection, including planning, implementation, and assessment of sampling, field measurements, and laboratory analysis.

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6 Remedial Action Completion

This chapter describes the strategy that will be used to assess progress toward the attainment of RAOs and determine when site closure can be implemented. This discussion includes details of the methods that will be used to determine when remediation can end and demonstrate attainment of cleanup levels in groundwater. Methods to answer PSQs and address decision rules are also identified.

Objectives for groundwater cleanup are summarized in the RAOs discussed in Chapter 2. Cleanup levels for the 100-FR-3 OU COCs are presented in Table 2-1. The estimated time frame required for COC concentrations to reduce to levels below cleanup levels is presented in Table 2-2. RAOs will be achieved through MNA, while maintaining ICs to prevent groundwater use until cleanup levels are achieved.

6.1 Strategy for Completing Site Closure

General guidance and recommendations, as part of a general framework for the implementation of MNA, are discussed in EPA 600/R-11/204 and summarized in the following eight steps:

1. Demonstrate that natural attenuation is occurring according to expectations.
2. Detect changes in environmental conditions (e.g., hydrogeologic, geochemical, microbiological, or other changes) that may reduce the efficacy of any of the natural attenuation processes.
3. Identify any potentially toxic and/or mobile transformation products.
4. Verify that the plume(s) is not expanding downgradient, laterally, or vertically.
5. Verify that no unacceptable impact exists to downgradient receptors.
6. Detect new releases of contaminants to the environment that could impact the effectiveness of the natural attenuation remedy.
7. Demonstrate the efficacy of ICs that were put in place to protect potential receptors.
8. Verify attainment of RAOs.

Progress toward achieving RAOs in the 100-FR-3 OU will be evaluated based on a strategy employing multiple lines of evidence to address each of the steps of the framework for MNA implementation proposed by EPA 600/R-11/204 and answering PSQs presented in Chapter 3. The principal lines of evidence include the following:

- Monitoring and characterization to identify processes, evaluate current conditions, and determine rates of change in conditions
- Groundwater modeling to make projections
- Statistical analysis of both the monitoring data and groundwater model projections to assess conformance with expectations for ultimate attainment of and compliance with RAOs

The strategy for completing site closure is implemented in two phases: remediation monitoring phase and attainment monitoring phase. The remediation phase consists of three stages that are briefly described in Table 6-1, which also provides a general timeline for monitoring, analysis, and reporting activities. Table 6-2 relates PSQs and decision rules to EPA 600/R-11/204 and to evaluation methods discussed in this chapter.

Table 6-1. Stages of Remediation Phase Monitoring and Associated Activities

Stage	Duration	Actions
I	2 years	• Installation of new monitoring wells (Phase 1) • Commencement of performance monitoring sampling • Evaluation of MNA processes and associated indicators • Phase 1 well report to include year 1 monitoring results, model updates, and Phase 2 well recommendations • Reporting of performance monitoring sampling results in the annual groundwater report
II	3 years	• Model updates and historical/predictive simulations and statistical characterization of monitoring data • Identification and reduction of data gaps: new well installation (Phase 2), and data collection • MNA progress evaluation presented in the 5-year performance monitoring report: – Evaluate changes to the monitoring network – Evaluate need for continuing automated water level network – Evaluate PSQs and decision rules • Reporting of performance monitoring sampling results in the annual groundwater report
III	Ongoing	• Scheduled monitoring and analyses: – Reporting of performance monitoring sampling results in the annual groundwater report – Evaluation of any deviations from expectations • Comprehensive 5-year performance monitoring evaluation and reports: – Update statistical analyses and complete ongoing progress evaluations – Model updates, including use of historical data for model validation and calibration to improve model predictions – Model simulations to evaluate progress of MNA and project cleanup dates – Identification and reduction of data gaps – Evaluate PSQs and decision rules – If data suggest MNA objectives attained for any contaminant of concern/well combination: ▪ Confirm and document cleanup level attainment ▪ Evaluate monitoring network – Provide input to the Hanford Site *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* 5-year review

MNA = monitored natural attenuation

PSQ = principal study question

Remediation monitoring will continue as the COC concentration attenuates. Over time, new monitoring locations may be added to the network as a COC plume migrates away from the original network. New wells will undergo remediation and attainment monitoring and associated evaluations as prescribed for the initial network.

When remediation monitoring results of a specific COC/well combination demonstrate that the cleanup level has been met as described in Section 6.4.1, then the attainment monitoring phase will begin for that specific COC/well combination. As such, attainment monitoring will occur on a well-by-well basis throughout the attenuation period.

Because MNA is a passive system and no active systems are being employed at the site, OSWER Directive 9283.1-44 recommends that data used to evaluate completion of the remediation phase may also be used as part of the attainment phase evaluation. Assuming that the attainment monitoring evaluation shows that the COC has met the cleanup level and will continue to meet the cleanup level, as described in Section 6.4.2, then that COC/well combination may be removed from the monitoring network. When all wells monitoring a given COC have completed the attainment monitoring phase and successfully demonstrated cleanup level attainment, then the RA for that COC will be complete.

In the following sections, elements of the strategy for completing site closure will be presented in detail as they relate to each of the steps of the EPA framework for MNA implementation.

6.2 Monitoring Activities and Refinement of the Conceptual Site Model

Monitoring data from existing and new wells will be collected, compiled, reviewed, and evaluated to provide the basis for the following activities that will be performed as part of the remediation monitoring phase to refine the CSM and evaluate progress toward attainment of cleanup goals:

1. Documenting processes and associated indicators of MNA
2. Identifying geochemical indicators of MNA efficacy
3. Developing plume maps for each COC to delineate plume extents, evaluate spread of contamination, assess plume migration over time, and determine whether there are unacceptable impacts to the Columbia River
4. Mapping of water levels from manual measurements and AWLN continuous data and evaluating seasonal river stage variations, as well as data obtained during installation of new monitoring wells, to refine the CSM and determine changes in the distribution of hydraulic gradient magnitude and direction in the aquifer and assess factors that may impact plume migration
5. Monitoring aquifer tubes and a riverbank seep
6. Evaluating presence of trace metals (antimony, cadmium, and cobalt)
7. Evaluating IC efficacy

Details on implementation of these activities are provided in the following subsections.

6.2.1 Document Processes and Associated Indicators of MNA

The type(s) of natural attenuation processes that are active at the site, and the rate at which such processes will reduce contaminant concentrations to required levels, will be evaluated during the remediation monitoring phase based on the MNA evaluation presented in Appendix M of the 100-F/IU RI/FS (DOE/RL-2010-98).

Monitoring of COC concentrations and identified degradation products, per the identified sampling frequency, will provide necessary information to document these processes and evaluate MNA progress on the basis of those processes by assessing the COC concentration reduction trends.

Implementation of this activity answers PSQs 1a, 1b, and 4a and addresses *Step 1* of the EPA framework for MNA implementation, as part of demonstrating that natural attenuation is occurring according to expectations. It also addresses *Step 3* by identifying potential toxic and/or mobile transformation products.

6.2.2 Identify Geochemical Indicators of MNA Efficacy

Although it is not expected that geochemical conditions will significantly change in the future in 100-F/IU, it is unlikely that any such change would significantly alter the geochemical environment towards one that is less favorable to attenuation. This is because the environment is already fairly oxidizing, and any shift to more reducing conditions would only favor reductive degradation of COCs. During the remediation monitoring phase, monitoring of the geochemical environment will include sampling for and evaluating changes in specific conductance, pH, DO, turbidity, and temperature.

Implementation of this activity answers PSQ 1c and addresses *Step 2* of the EPA framework for MNA implementation.

6.2.3 Plume Mapping

Contaminant plume mapping will be performed annually during the initial years when annual monitoring samples are collected. Updated plume maps will then be generated when new results are available (based on the sampling frequency [e.g., biennial]) as well as to support the Phase 1 well report and 5-year performance monitoring reports. Plume mapping will follow the integrated numerical interpolation procedure implemented as part of the annual Hanford Site groundwater monitoring report (e.g., DOE/RL-2014-32). For each COC, the systematic plume mapping approach is based on implementing an integrated procedure of compiling and aggregating data sets in a comprehensive database, developing input files, and executing batch processes using the open source statistical computing/programming language R (The R Development Core Team, 2012, *The R Project for Statistical Computing*) to develop piece-wise continuous contaminant distributions.

The numerically interpolated piece-wise continuous COC distributions allow for estimating contaminant mass, plume center of mass, and spread of the contaminant across the plume area for each COC plume. As a result, the area and spread of contamination, as well as the migration of contamination, will be evaluated over time to monitor potential expansion of the contaminant. Plume mass may be determined, based on estimates of plume thickness and aquifer porosity. Estimates of area and mass answer PSQ 1a and address *Step 4* of the EPA framework for MNA implementation.

Evaluation of numerically interpolated COC distributions will assist in assessing uncertainties in plume spread and attenuation. Plume maps will also enhance understanding of potential COC migration toward the Columbia River and, when considered together with the distinct concentration measurements at each monitoring location along the shoreline, will assist in determining any unacceptable impacts to the Columbia River, thereby answering PSQ 1d and addressing *Step 5* of the EPA framework for MNA implementation.

Evaluation of monitoring data for plume maps would also reveal unexpected increases in COC contamination, which might indicate new or continuing releases of contaminants, answering PSQ 1e and addressing *Step 6* of the EPA framework for MNA implementation.

The updated COC plumes will also be used as initial conditions for the 100 Area Groundwater Model (100-AGWM) to validate previous predictions and update projections, as discussed in Section 6.3.

6.2.4 Water Level Mapping and Refining CSM

Mapping of groundwater level data will be performed using the methods detailed in SGW-42305, *Collection and Mapping of Water Levels to Assist in the Evaluation of Groundwater Pump-and-Treat Remedy Performance*. This methodology is routinely implemented for the purposes of the 100 Areas annual pump-and-treat operations report (e.g., DOE/RL-2014-25, *Calendar Year 2013 Annual Summary Report for the 100-HR-3 and 100-KR-4 Pump-and-Treat Operations, and 100-NR-2 Groundwater Remediation*), but it is also directly applicable to the evaluation of MNA remedy performance.

The groundwater level mapping method uses an extension of the hybrid universal kriging/analytic element method technique detailed in SGW-42305. First, hydraulic gradients are calculated for triangular elements developed from the network of monitoring wells. Next, groundwater elevation contours are constructed to depict the patterns of groundwater flow and corresponding directions of contaminant migration throughout the groundwater OU. The calculated hydraulic gradients and groundwater elevation contours together provide the basis for evaluating flow patterns and determining whether adverse conditions are being developed that could impact plume migration. Seasonal river stage variations will also be evaluated to determine their influence on flow patterns and the region of river-aquifer interaction where patterns of shoreline inundation vary extensively over the course of the year.

Data obtained during the installation of new monitoring wells will be evaluated to refine the CSM and further refine the representation of aquifer hydraulic parameters, with emphasis on aquifer transmissivity throughout the 100-FR-3 OU, particularly in the southern part of the groundwater OU. As described in Section A3.2.1.3 of the Groundwater SAP (Appendix A), the new well installation data will include the elevation of geologic contacts, transmissivity of unconfined aquifer, and water table elevation.
The refined CSM will improve the evaluation of the magnitude and direction of hydraulic gradients across the OU and the resulting flow patterns to determine the potential for plume migration toward downgradient potential receptors. The refined CSM will also be used to update the parameterization of the 100-AGWM, as discussed in Section 6.3.

Implementation of this activity responds to PSQs 1c and 3 and also addresses *Step 2* of the EPA framework for MNA implementation and, in particular, detection of any changes in hydrologic conditions that may reduce the efficacy of the natural attenuation processes.

6.2.5 Monitoring Aquifer Tubes and Riverbank Seep

A network of aquifer tubes and a natural riverbank seep will be monitored, as described in the Groundwater SAP (Appendix A). Concentration data for each of these sources will be used to support plume mapping and to confirm that there are no unacceptable impacts to the Columbia River, thereby answering PSQ 1d and addressing *Step 5* of the EPA framework for MNA implementation. Data from aquifer tubes and the seep will not be used to determine attainment of groundwater cleanup levels. However, if COC concentrations increase in aquifer tubes or the seep, the monitoring well network may be re-evaluated to determine if sufficient coverage exists.

6.2.6 Trace Metals

Antimony, cadmium, and cobalt will be analyzed at four monitoring wells identified in Table A-8 of the Groundwater SAP (Appendix A). The wells were chosen based on a review of the analytical data as detailed in the DQO summary report (SGW-58291), presented in Appendix A. After a sufficient number of data points have been collected, data will be evaluated using statistical methods described in

Section 6.4. If concentrations of any of these analytes exceed action levels or PQLs, a risk assessment will be performed. This activity answers PSQ 2.

6.2.7 Institutional Controls

ICs required for contaminated 100-FR-3 groundwater are implemented on a sitewide basis by DOE through DOE/RL-2001-41, as discussed in Section 4.1.3. DOE prepares an annual report on the effectiveness of ICs for the Hanford Site. Information from the annual IC reports will be used to evaluate the IC efficacy for the 100-FR-3 OU. Implementation of this activity addresses *Step 7* of the EPA framework for MNA implementation.

6.3 Groundwater Modeling

Groundwater flow and contaminant transport simulations will be performed for each COC using 100-AGWM, which is documented in SGW-46279, *Conceptual Framework and Numerical Implementation of 100 Areas Groundwater Flow and Transport Model*. 100-AGWM integrates site-specific features, events, and processes, including site geology, aquifer heterogeneity, natural recharge, anthropogenic water discharges, interim and final RAs (such as the pump-and-treat systems in other 100 Area groundwater OUs), together with the interaction between the aquifer and the Columbia River, while considering river bathymetry and time varying river stage conditions. As data from existing and new monitoring locations become available, 100-AGWM will be updated and refined, as necessary, to improve model calibration and the reliability of future projections simulated using the model.

100-AGWM will be used to project the time required to attain RAOs at individual monitoring locations (consistent with EPA guidance) and throughout the entire groundwater OU. Projections will be systematically updated, as new data and information become available, to refine the numerical representation of the CSM. Future projections made using the 100-AGWM will provide one basis for expectation of the rate-of-change in contaminant concentrations at individual monitoring locations, and throughout the entire groundwater OU, to supplement projections that are based upon direct analysis of the monitoring data. Projections made with 100-AGWM will be reported in terms of a best estimate, together with one or more measures of uncertainty that accompany the best estimate projection. Methods that may be used to describe and depict uncertainty in projected cleanup times are described in the following subsections.

Implementation of this activity answers PSQs 1a, 1b, 1d, 3, 4a, and 4b, and it addresses *Steps 1, 4, 5, and 8* of the EPA framework for MNA implementation.

6.3.1 Expectations and Rates-of-Change

As described in the 100-F/IU RI/FS (DOE/RL-2010-98), MNA is expected to achieve RAOs in the time frames set forth. For most COCs in most areas of the groundwater OU, contaminant concentrations exceed final cleanup standards by a factor of 2 to 5. As a result, attenuation rates required to achieve RAOs within the time frame detailed in the ROD (EPA and DOE, 2014) are relatively low, which means that the rates-of-change in contaminant concentrations due to natural attenuation processes will be quite small.

Since expected rates-of-change will be small, cleanup projections calculated in the years soon after commencement of the MNA remedy will likely be accompanied by more uncertainty, as depicted by wide confidence (prediction) intervals, than cleanup projections that are calculated as more data become available. Uncertainty in the cleanup projections is expected to narrow over time, as illustrated by narrowing confidence (prediction) intervals calculated about the best estimate projection, as the number of data points increases and knowledge of the attenuation processes and their rates increases.

This expectation of narrowing confidence (prediction) intervals reflecting increased data and knowledge over time is a common feature of long-term monitoring programs, including those accompanying MNA remedies, and will apply both to projections made using the 100-AGWM and projections made on the basis of regression analysis using the monitoring data (as described in Section 6.4). A consequence of this expectation is that it may require several reporting periods and review cycles for conclusive identification of trends at some locations and for some COCs throughout the groundwater OU. This expectation is one basis for using multiple lines of evidence to ensure that progress is being made toward attainment, and that any potential receptors are protected.

6.3.2 Uncertainty of Projected Cleanup Times

As data become available, the uncertainty in the projected time to achieve RAOs will be depicted using confidence (prediction) intervals constructed about a best estimate; this will be done for both projections made using the 100-AGWM and for projections based upon direct analysis of the monitoring data. When making projections on the basis of the monitoring data directly, these intervals will be computed from the results of regression analysis performed on the monitoring data. When making projections on the basis of modeling completed using 100-AGWM, intervals can be computed using one of the following methods:

- First order/second moment methods that are conceptually similar to the methods used to compute confidence intervals from sample data (USGS Techniques and Methods 6-E2, *OPR-PPR, a Computer Program for Assessing Data Importance to Model Predictions Using Linear Statistics*; Maskey and Guinot, 2003, "Improved first-order second moment method for uncertainty estimation in flood forecasting")
- Monte-Carlo techniques that create multiple realizations each constrained by historical data and process knowledge (USGS, 2010, *Approaches to Highly Parameterized Inversion: A Guide to Using PEST for Model-Parameter and Predictive-Uncertainty Analysis*)

In either case, the best estimate and confidence (prediction) intervals calculated using 100-AGWM can be compared with those calculated from the sample data obtained from individual wells.

6.4 Statistical Analysis

OSWER 9355.0-129 recommends evaluating COC concentration levels on a well-by-well basis, separately for each COC, to assess aquifer restoration. As discussed in OSWER Directive 9283.1-44, it may be appropriate to conclude that the remediation phase is complete at a monitoring well based on a nonstatistical or visual analysis of the data. Nonstatistical methods are appropriate if all results are less than the cleanup level and the quantitation limit is less than the cleanup level. If these conditions do not apply, COC concentrations will be evaluated on a well-by-well (i.e., intrawell) basis based on statistical analyses of monitoring data and supporting modeling projections.

The strategy for completing site closure is implemented in two phases: (a) the remediation monitoring phase and (b) the attainment monitoring phase. Certain key statistical tests, referred to as fundamental tests, will be applied during both the remediation and attainment monitoring phases to evaluate performance and determine whether additional actions are required, as detailed in Sections 6.4.1 through 6.4.4.

Attainment monitoring for each COC at each well will be undertaken when data demonstrate that concentrations of each COC have met the cleanup level. Data obtained during the remediation monitoring phase may also be employed in the attainment monitoring phase statistical tests to assess the status of attainment of remedial objectives (i.e., cleanup levels), which is consistent with the recommendations of OSWER Directive 9283.1-44.

Attainment of cleanup levels is a quantitative procedure, which is assessed through the application of appropriate statistical tests as detailed below. However, assessment of MNA performance and progress toward the attainment of cleanup levels during the remediation monitoring phase also requires qualitative interpretation of data, such as geochemical data, groundwater flow and contaminant migration rates and directions, and other factors, in addition to the application of statistical tests detailed in the following sections.

6.4.1 Remediation Monitoring Phase: Fundamental Tests

As recommended in OSWER Directive 9283.1-44, for each combination of COC and monitoring well, a statistical analysis of the groundwater water sample data set will be performed to evaluate if MNA progress is consistent with expectations and assess the attainment of cleanup levels. During the remediation monitoring phase, the fundament test is the *trend test*. The trend test evaluates the time-dependent sample concentrations for each COC at each well, using parametric or nonparametric methods: if a trend is identified, then the slope of the trend can be calculated, together with confidence limits around this slope.

During the remediation monitoring phase, the *mean test* will also be implemented in addition to the trend test. The mean test is based on calculating the mean contaminant concentration for the particular COC at the particular well, as well as upper confidence limits (UCLs) and lower confidence limits (LCLs) around the mean to account for variability around the true mean. Cleanup level attainment during remediation monitoring evaluation is determined by calculating the 95 percent UCL on the mean, as described in Section 6.4.3, and comparing to the cleanup level.

These statistical analyses will be used during the remediation monitoring phase to evaluate MNA progress toward, and attainment of, cleanup levels. The outcomes of the application of these tests provide the basis for MNA progress evaluation by considering the following:

- If the 95 percent UCL is at or below the cleanup level, then that COC/well combination has attained the cleanup level, and the remediation monitoring phase is complete for this COC/well combination. Attainment monitoring can commence.
- If the slope of the trend indicates that the mean and the LCL will fall below the cleanup level sooner than the estimated time frame presented in Table 2-2, MNA progress is on target to meet the cleanup goals.
- If the slope of the trend indicates that the mean and the UCL will fall below the cleanup level later than the estimated time frame presented in Table 2-2, but the LCL indicates cleanup levels will be met sooner than the estimated time frame, then the confidence interval must be narrowed.
- If the slope of the trend indicates that the mean and the LCL will fall below the cleanup level later than the estimated time frame presented in Table 2-2, then:
  - If the confidence interval is unacceptably large, the confidence interval must be further narrowed.
  - If the confidence interval is acceptable, further investigation is required to identify the cause.

Application of these tests during the remediation monitoring phase answers PSQs 1a, 1b, and 4a, and addresses *Step 1* of the EPA framework for MNA implementation, assisting in demonstrating that natural attenuation is occurring according to expectations. As applied to near-river wells, it answers PSQ 1d and addresses *Step 5* of the EPA framework for MNA implementation regarding unacceptable impacts to the Columbia River. Evaluation of monitoring data for trends may reveal unexpected increases in COC

contamination that may indicate new or continuing releases of contaminants that will require further investigation, answering PSQ 1e and addressing *Step 6* of the EPA framework for MNA implementation.

6.4.2 Attainment Monitoring Phase: Fundamental Tests

Similarly to the remediation monitoring phase, a statistical analysis of the groundwater sample data for each combination of COC and monitoring well will be performed during the attainment monitoring phase to evaluate whether the cleanup level has been attained for the particular COC/well combination. Attainment monitoring will be performed for 5 years for each COC/well combination. The attainment monitoring evaluation may include data used to evaluate remediation monitoring completion.

The 95 percent UCL on the mean will be determined, as described in Section 6.4.3, and used for comparison to the cleanup level. The fundamental test during the attainment monitoring phase comprises the following:

- If the 95 percent UCL is at or below the cleanup level,

  and

- The time-dependent slope of the trend is zero or statistically significantly negative,

  then

  It is appropriate to conclude that the attainment monitoring phase is complete and the cleanup level is attained for that COC/well combination.

Evaluation of cleanup level attainment will be performed on a well-by-well basis following the approach described above. Monitoring wells where it is determined that cleanup levels are attained will be removed from the monitoring network, unless monitoring is required for some other purpose.

Because the time frames for each of the COCs to meet the cleanup levels vary from 35 to 150 years, the RA for each COC will be completed at different times. RA completion for each COC plume and the entire 100-FR-3 OU is described in Section 6.7.

Application of these fundamental tests is the basis for verifying attainment of the remediation objectives, answering PSQ 4b and addressing *Step 8* of the EPA framework for MNA implementation. Similar tests will be applied to answer PSQ 2 regarding trace metals considering the action levels presented in Table A-4 in the Groundwater SAP (Appendix A).

6.4.3 Methods for Calculating Means and Confidence Levels

The 95 percent UCL calculated with ProUCL, Version 5.0.00 (EPA, 2013) will be used for comparison to cleanup levels. Updated versions of ProUCL will be used as they become available. ProUCL calculates an accurate 95 percent UCL considering data distribution, data set size, skewness of the data, and percentage of nondetects.

In some cases, ProUCL will suggest more than one UCL. Confidence levels on the mean value for a sample data set can be calculated using a wide variety of statistical methods, each of which relies upon a set of assumptions. For example, some methods for calculating confidence levels are strictly applicable only for certain sample data distributions, such as Gaussian (normal), or lognormal. Some confidence levels estimate methods are not suitable when there are a large number of nondetect (i.e., "censored") data. In the event that multiple UCLs are suggested by ProUCL, the sample data distribution may be tested and the most suitable of the suggested UCLs will be used in accordance to a sample data distribution.

The UCL suggested by ProUCL may correspond to a higher percentile UCL (e.g., 97.5 percent or 99 percent UCL), depending on the method selected for calculating the UCL and considering the sample size and its standard deviation. In these cases, the higher percentile UCL suggested by ProUCL will be used for comparison with the cleanup level.

6.4.4 Methods for Trend Testing and Slope Estimation

For each COC/well combination, the analysis of concentration trends is a fundamental element of both the remediation and attainment monitoring phases. In all cases, common nonparametric methods will be used to test for the presence of a trend, and to quantify the slope of the trend: these methods comprise the Mann-Kendall (standard or seasonal) trend test, which identifies the presence of a trend but does not quantify the slope, and the Theil-Sen trend estimator (standard or seasonal), which calculates the slope value. These tests are typically conducted on the logarithm of the concentration value, rather than the native concentration value.

These trend tests are strictly applicable in the case of a monotonic trend either in the entire data set or within seasonal subsets. In some instances, however, trends may not be monotonic either in the entire data set or within seasonal subsets; this occurs when changes in concentration are related to other factors, such as the impact of remediation or changes in groundwater levels. In such cases, the influence of these other factors may be incorporated in the trend estimation by presenting them as an independent variable using parametric multiple linear regression. Depending on the variability of COC concentrations at each monitoring well, global application of a single slope estimation technique or regression equation for every COC/well combination may result in the calculation of misleading trends and slopes. Therefore, the dependency of COC concentrations on river-stage variations and/or other hydrological factors will be evaluated in order to determine the most suitable methods for trend and slope estimation.

With regard to the selection of the number of samples required to estimate the slope, as presented in OSWER Directive 9200.4-17P, the first line of evidence regarding the use of MNA requires that, regression analysis provides rate constants for attenuation that provide a precise definition of a "clear and meaningful trend of decreasing contaminant concentration over time." In Wilson, 2008, "Extracting rate constants for MNA from long-term monitoring data," a "clear and meaningful trend" is defined as the first order rate constant for attenuation over time that is greater than zero at some predetermined level of confidence (Wilson, 2008, "Extracting rate constants for MNA from long-term monitoring data"). Although eight samples is an efficient criterion for a minimal data set to evaluate natural attenuation, Wilson concluded that, in examples that he presented, 8 sample dates would have failed to detect successful attenuation at 6 of 14 sites. Therefore, it may be necessary to gather more data to be able to clearly identify statistically significant attenuation, as short data sets can potentially lead to inaccurate projections of the true trend.

Finally, there are cases when a statistically significant rate of attenuation can be calculated based on short-term data, but rates calculated based on longer term data sets may not be statistically significant. It is therefore important to determine the appropriate data set to perform any statistical analysis in order to calculate meaningful attenuation rates and evaluate the efficacy of the natural attenuation processes. For that reason, pre-/post-source-removal trends will be analyzed to discern the right starting point in time to conduct the statistical analysis for the fundamental tests.

6.5 Indicators of Unacceptable Performance

Evaluation of the performance monitoring results will consider criteria that will indicate unacceptable performance of the remedy and that may trigger response actions. General conditions to be considered during data reviews and performance evaluations are discussed in OSWER Directive 9200.4-17P:

- Contaminant concentrations in soil or groundwater at specified locations exhibit an increasing trend not originally predicted during remedy selection.
- Near-source wells exhibit large concentration increases indicative of a new or renewed release.
- Contaminants are identified in monitoring wells located outside of the original plume boundary.
- Contaminant concentrations are not decreasing at a sufficiently rapid rate to meet the remediation objective.
- Changes in land and/or groundwater use will adversely affect the protectiveness of the MNA remedy.

As detailed in Section 6.3, it is expected that some performance evaluations, particularly in the early years of monitoring which will include data from new monitoring wells, may indicate variable attenuation rates and plume extents. Some of this variation may be attributable to sampling variability and seasonal fluctuation. However, this will be expected to diminish as the number of data increases. If evaluation of the sampling results indicate that any of the conditions persist over multiple review cycles, and are not attributable to other factors, then DOE and the regulators will evaluate the protectiveness of the remedy and, if the remedy is deemed not protective, determine a path forward.

6.6 Monitoring Optimization

The monitoring well network and sampling frequency will be optimized over time, as more data become available and conclusions from data evaluations are drawn. Analyses during the early stages of the remediation monitoring phase will focus on obtaining sufficient data to estimate trends within acceptable confidence intervals. Once sufficient data are available, attainment of the cleanup goals will be assessed for each COC/well combination over time.

The monitoring network will ultimately reduce as the plumes attenuate and individual wells attain the cleanup level for each COC. However, additional monitoring locations may be added to the monitoring network to track plumes that migrate off the initial network as they attenuate. Even after cleanup level attainment, sampling at monitoring locations may continue at reduced frequency for other purposes, such as preparing plume maps and supporting performance monitoring reports.

6.7 Remedial Action Completion

Completion of the 100-FR-3 OU MNA remedy will be demonstrated by attainment of the groundwater cleanup levels for each COC. During remediation monitoring, contaminant migration and changes in COC concentrations over time for each COC/well combination are evaluated, as described in Section 6.4.1. The time-dependent slope for the COC concentration at each well is determined to assess progress towards cleanup level attainment relative to expectations. Cleanup level attainment is determined on a well-by-well basis for each COC by calculating the 95 percent UCL on the mean and comparing the value to the cleanup level. When the evaluation demonstrates that a specific COC/well combination has attained the cleanup level, then attainment monitoring for that COC/well will commence.

Attainment monitoring results are evaluated on a well-by-well basis to verify COC attenuation, as described in Section 6.4.2. Evaluation consists of calculating the 95 percent UCL on the mean and determining the COC concentration trend slope. If the 95 percent UCL is at or below the cleanup level and the COC trend slope is zero or negative, then the specific COC/well combination is considered to have met the cleanup level and groundwater has completed attenuation in that monitoring area. No further monitoring is required for the COC/well combination, although additional sampling may be performed to support other purposes such as plume mapping. When attainment monitoring and subsequent data

evaluation are successfully completed at all wells monitored for a given COC, then the RA for that COC plume will be complete and no further monitoring for that COC is required.

Additional wells may be added to the monitoring network as COC plumes migrate. Over time, as groundwater COCs attenuate and evaluation of well data demonstrates attainment, the number of wells within the monitoring network will decrease until all wells have attained cleanup levels and RA is complete. The evaluation of cleanup level attainment on a well-by-well basis and eventual RA completion for each COC will be documented in the 5-year performance monitoring reports described in Section 3.3, as well as the final RA report. Any wells where COC attainment is achieved will be listed in a table in the applicable 5-year performance monitoring report with EPA concurrence on the report serving to document agreement that attainment was reached. EPA approval of termination of monitoring or other changes in monitoring will be documented by change notices or revisions to the Groundwater SAP (Appendix A).

Depending on timing, a progress evaluation may be performed separately from the 5-year performance monitoring report if a given COC/well has met the cleanup level and is ready to enter the attainment monitoring phase. In this case, the evaluation will be included in the subsequent 5-year report.

If attainment monitoring results for a given COC do not demonstrate that the cleanup levels have been attained, then DOE and the regulators will evaluate the results and determine the path forward.

The 100-FR-3 OU RA will be complete when all COC/well combinations have successfully completed attainment monitoring and demonstrated cleanup level attainment as described in this chapter.
The groundwater plumes are projected to attain the cleanup levels at time frames varying from 35 to 150 years, with strontium-90 requiring the longest attenuation period. Therefore, performance monitoring for Cr(VI), TCE, and nitrate will be completed with cleanup level attainment documented in 5-year performance monitoring reports prior to the strontium-90 attainment. When the well-by-well evaluation of the strontium-90 plume demonstrates attainment of the cleanup level, a final RA report for the 100-FR-3 OU will be prepared, as described in Section 3.5.

Table 6-2. Evaluation of Performance Monitoring Principal Study Questions and Corresponding Decision Rules with Crosswalk to Applicable EPA Guidance

Principal Study Question	Decision Rule	Evaluation Method	EPA Guidance (Section 6.1)
PSQ 1a. Are contaminant concentrations and plume area/mass decreasing?	Decision Rule 1. If the weight of evidence indicates that natural attenuation is occurring as expected then continue MNA; otherwise, evaluate other options.	Document processes and associated indicators of MNA (Sec. 6.2.1) Plume mapping (Sec. 6.2.3) Groundwater modeling (Sec. 6.3) Statistical analysis (Sec. 6.4)	Step 1: Demonstrate that natural attenuation is occurring according to expectations. Step 3: Identify any potentially toxic and/or mobile transformation products. Step 4: Verify the plume is not expanding downgradient, laterally or vertically.
PSQ 1b. Are rates of decline consistent with expectations?		Document processes and associated indicators of MNA (Sec. 6.2.1) Groundwater modeling (Sec. 6.3) Statistical analysis (Sec. 6.4)	Step 1: Demonstrate that natural attenuation is occurring according to expectations. Step 3: Identify any potentially toxic and/or mobile transformation products.
PSQ 1c. Are there changes in environmental conditions that may reduce the efficacy of natural attenuation?		Identify geochemical indicators of MNA efficacy (Sec. 6.2.2) Water level mapping and refining CSM (Sec. 6.2.4)	Step 2: Detect changes in environmental conditions that may reduce the efficacy of any of the natural attenuation processes.
PSQ 1d. Are there unacceptable impacts to the Columbia River?		Plume mapping (Sec. 6.2.3) Monitoring aquifer tubes and riverbank seep (Sec. 6.2.5) Groundwater modeling (Sec. 6.3) Statistical analysis (Sec. 6.4)	Step 5: Verify no unacceptable impact to downgradient receptors.
PSQ 1e. Is there evidence of new or continuing releases of contaminants to the environment that could impact the effectiveness of the natural attenuation remedy?		Plume mapping (Sec. 6.2.3)	Step 6: Detect new releases of contaminants to the environment that could impact effectiveness.
PSQ 2. Are concentrations of antimony, cadmium, and cobalt below action levels?	Decision Rule 2. If monitoring indicates concentrations are not greater than the action level or practical quantitation limit, then discontinue monitoring; otherwise, perform risk assessment.	Trace metals (Sec. 6.2.6) Attainment monitoring statistical analysis (Sec. 6.4.2)	Not in EPA guidance; required to resolve previous analytical uncertainty.

Table 6-2. Evaluation of Performance Monitoring Principal Study Questions and Corresponding Decision Rules with Crosswalk to Applicable EPA Guidance

Principal Study Question	Decision Rule	Evaluation Method	EPA Guidance (Section 6.1)
PSQ 3. Do new geologic and hydrogeologic data confirm the conceptual site model?	Decision Rule 3. If new geologic and hydrogeologic data confirm the conceptual site model, then retain the model; otherwise, update it.	Water level mapping and refining CSM (Sec. 6.2.4) Groundwater modeling (Sec. 6.3)	Step 1: Demonstrate that natural attenuation is occurring according to expectations. Step 2: Detect changes in environmental conditions that may reduce the efficacy of any of the natural attenuation processes. Step 4: Verify the plume is not expanding downgradient, laterally or vertically.
PSQ 4a. Are concentrations of COCs below cleanup levels?	Decision Rule 4. If RAO has been achieved for an individual COC, then proceed to attainment monitoring for that COC; otherwise, continue MNA.	Document processes and associated indicators of MNA (Sec. 6.2.1) Groundwater modeling (Sec. 6.3) Statistical analysis (Sec. 6.4)	Step 8: Verify attainment of the remediation objectives.
PSQ 4b. Will groundwater continue to meet the cleanup level in the future?		Groundwater modeling (Sec. 6.3)	
Not an identified PSQ; evaluated within EPA performance monitoring guidance	Not applicable.	Institutional controls (Sec. 6.2.8)	Step 7: Demonstrate the efficacy of institutional controls that were put in place to protect potential receptors.

AWLN = automated water level network
COC = contaminant of concern
CSM = conceptual site model
EPA = U.S. Environmental Protection Agency
MNA = monitored natural attenuation
PSQ = principal study question
RAO = remedial action objective

7 Cost and Schedule

The cost and schedule for the 100-FR-3 groundwater OU remedy components are presented in this chapter.

7.1 Cost Summary

The cost for the 100-FR-3 groundwater OU MNA is $19.5 million (Table 7-1) (ECE-100FR314-00007, *Environmental Cost Estimate for 100 F/IU RD/RAWP*). The costs for ICs restricting 100-FR-3 OU groundwater use are included in the overall 100-F/IU IC cost presented in the Integrated RDR/RAWP (DOE/RL-2014-44).

Performance monitoring includes periodic sampling and analysis from 28 existing monitoring wells, 8 new Phase 1 wells, 6 aquifer tubes, and 1 riverbank seep. An additional 6 Phase 2 wells may be identified for the monitoring network and are included in the cost estimate. For cost estimating purposes, new monitoring wells are assumed to be sampled quarterly for Year 1, annually for Years 2 through 5, and biennially thereafter. Existing monitoring wells, aquifer tubes, and the seep will be sampled annually for Years 1 through 5, and biennially thereafter.

Performance monitoring sampling results will be presented in the annual groundwater monitoring report (e.g., DOE/RL-2014-32). A separate report detailing Phase 1 well results, modeling updates, water level measurement results, and any Phase 2 well recommendations will be prepared after Phase 1 wells have completed the first year of performance monitoring. Detailed evaluation of the results and modeling updates will be presented in separate performance monitoring reports. The performance monitoring reports will be generated at 5-year frequencies to support the Hanford Site CERCLA 5-year review cycles.

Table 7-1. Summary of Costs for Monitored Natural Attenuation Remedy

Activity	Total Costs
Project Management	$3,366,932
Well Drilling (New and Replacement Wells)	$2,988,090
Well Rehabilitation, Upgrades to River Gauge Station, Automated Water Level Network, and Operations and Maintenance	$4,380,851
Performance Monitoring, Reporting, and Well Decommissioning	$8,811,823
Total Costs	**$19,547,696**

7.2 Schedule

Implementation of the 100-FR-3 OU performance monitoring will begin after approval of the Integrated RDR/RAWP (DOE/RL-2014-44), as shown in Figure 7-1. Installation of new monitoring wells is projected to be initiated immediately following RDR/RAWP approval and is anticipated to be completed 6 months after RDR/RAWP approval.

Data from the new and existing wells will be obtained in the first monitoring year; however, completion of quarterly sampling for all Phase 1 wells will extend into the next monitoring year. The first full year of

monitoring at Phase 1 wells will be completed 1 year from the final Phase 1 well acceptance date. A report detailing an initial evaluation of the monitoring program and recommendations of Phase 2 monitoring wells is projected to be completed 6 months after the first year of monitoring data is obtained for all Phase 1 wells. Additional Phase 2 monitoring wells, if required, will be completed within approximately 1 year after recommendation. Approval of cultural resource reviews for Phase 2 wells is estimated to take 6 months. Results from the monitoring network will be evaluated for changes to the sampling plan, including additional wells or aquifer tubes, after the first 5 years of monitoring. The first comprehensive 5-year performance monitoring report is anticipated to be prepared in 2020 to support the sitewide CERCLA 5-year review.

The duration of MNA performance monitoring is based on the 2011 model estimated time frame for each COC to achieve its cleanup level as described in the 100-F/IU RI/FS (DOE/RL-2010-98). The estimated time frames are rounded up to account for model uncertainties. The following time frames are estimated for each COC:

- Cr(VI) = 35 years (based on 10 μg/L cleanup level)
- Trichloroethene = 50 years
- Nitrate = 80 years
- Strontium-90 = 150 years

Estimated time frames will be refined and updated based on the performance monitoring reports. Once the cleanup level for each COC is achieved, 5 years of attainment monitoring will be performed at each well. The 5-year attainment monitoring period is not included in the time frame estimates for cleanup level attainment.

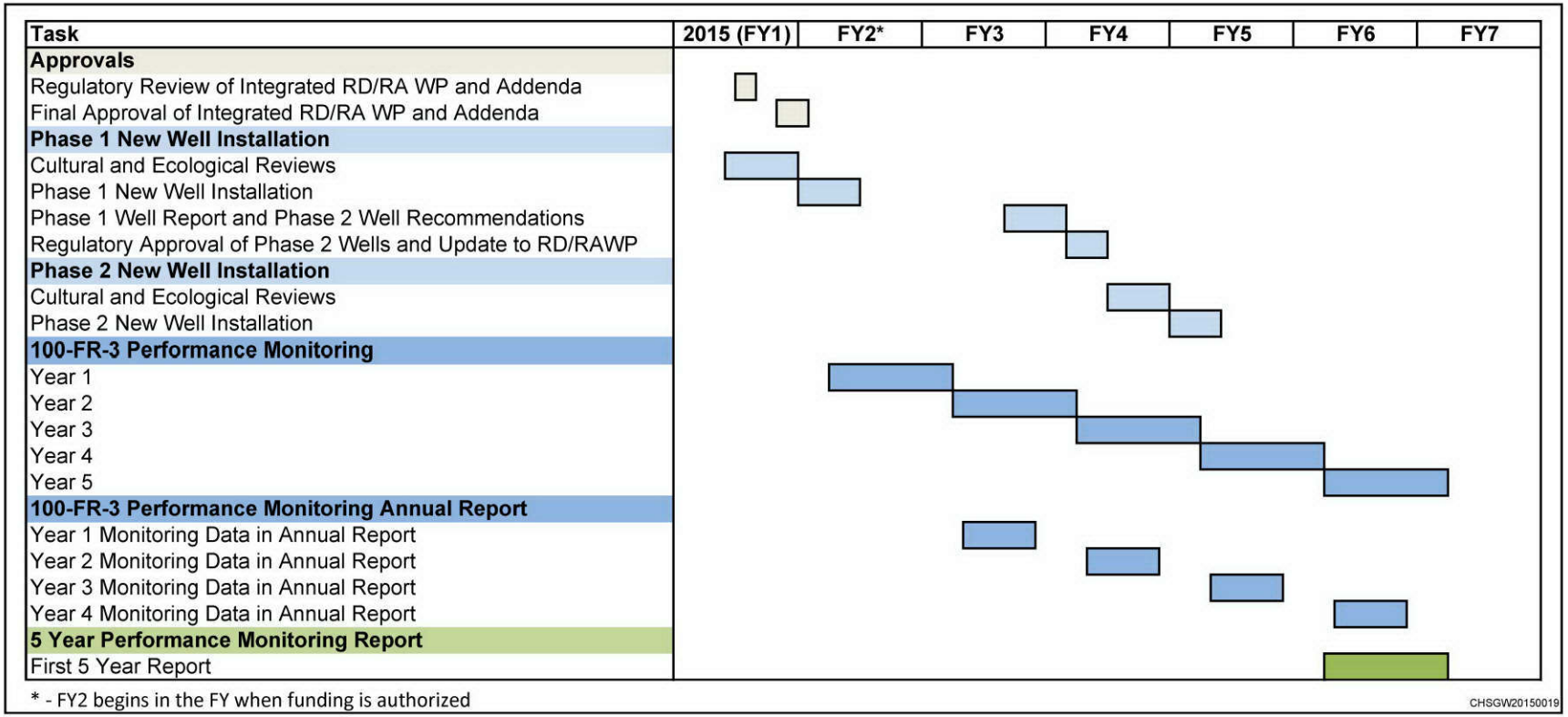

Figure 7-1. Schedule for 100-FR-3 Operable Unit Performance Monitoring Implementation

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Appendix A

100-FR-3 Groundwater Sampling and Analysis Plan

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Terms

ALARA	as low as reasonably achievable
ASTM	ASTM International, formerly American Society for Testing and Materials
AWLN	automated water level network
BTR	Buyer's Technical Representative
CFR	*Code of Federal Regulations*
COC	contaminant of concern
Cr(VI)	hexavalent chromium
DOE	U.S. Department of Energy
DOE-RL	U.S. Department of Energy-Richland Operations Office
DOT	U.S. Department of Transportation
DQA	data quality assessment
DQI	data quality indicator
DQO	data quality objective
DUP	field duplicate
DWS	drinking water standard
EAF	Experimental Animal Farm
EB	equipment blank
ECO	Environmental Compliance Officer
Ecology	Washington State Department of Ecology
EPA	U.S. Environmental Protection Agency
FEAD	Format for Electronic Analytical Data
FSO	Field Sampling Operations
FTB	full trip blank
FWS	Field Work Supervisor
FXR	field transfer blank
HASP	health and safety plan
HASQARD	*Hanford Analytical Services Quality Assurance Requirements Document* (DOE/RL-96-68)
HEIS	Hanford Environmental Information System

LCS	laboratory control sample
LRA	lead regulatory agency
MB	method blank
MNA	monitored natural attenuation
MS	matrix spike
MSA	Mission Support Alliance
MSD	matrix spike duplicate
NCO	nuclear chemical operator
OU	operable unit
PPE	personal protective equipment
PSQ	principal study question
QA	quality assurance
QAPjP	quality assurance project plan
QC	quality control
RAO	remedial action objective
RCT	Radiological Control Technician
RDR	request for data review
RDR/RAWP	remedial design report/remedial action work plan
RI/FS	remedial investigation/feasibility study
ROD	record of decision
RUM	Ringold Formation upper mud unit
SAF	sample authorization form
SAP	sampling and analysis plan
SMILE	*Sample Management Integrated Lifecycle Environment*
SMR	Sample Management and Reporting
SPLIT	field split sample
SUR	surrogate
TCE	trichloroethene
TPA	Tri-Party Agreement
Tri-Party Agreement	*Hanford Federal Facility Agreement and Consent Order*

VOC	volatile organic compound
WAC	*Washington Administrative Code*

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A1 Introduction

This sampling and analysis plan (SAP) presents the performance monitoring plan for the 100-FR-3 groundwater operable unit (OU). The 100-FR-3 OU comprises groundwater contaminated by releases from facilities and waste sites associated with past operation of the 100-F Reactor and biological experiments (Figure A-1). In September 2014, the 100-F/IU record of decision (ROD) (EPA and DOE, 2014, *Record of Decision Hanford 100 Area Superfund Site 100-FR-1, 100-FR-2, 100-FR-3, 100-IU-2, and 100-IU-6 Operable Units*) was issued for the 100-FR-3 Groundwater OU. The 100-F/IU ROD (EPA and DOE, 2014) selected monitored natural attenuation (MNA) of groundwater and institutional controls (ICs) to restrict groundwater use as the final remedial actions. MNA will be implemented for hexavalent chromium (Cr(VI)), nitrate, strontium-90, and trichloroethene (TCE) in the 100-FR-3 OU groundwater. Performance monitoring of these contaminants of concern (COCs) in the groundwater as a component of the MNA remedy will be performed until cleanup levels are met.

This SAP consists of five chapters. The remainder of this chapter addresses the project scope and objectives, background, data quality objectives (DQOs), groundwater contaminants, and project schedule; Chapter A2 presents the quality assurance project plan (QAPjP); and Chapter A3 provides the field sampling plan. Chapters A4 and A5 address waste management and health and safety requirements.

Upon approval of DOE/RL-2014-44, *Integrated Remedial Design Report/Remedial Action Work Plan for 100-F/IU* (Integrated Remedial Design Report/Remedial Action Work Plan [RDR/RAWP]) and Groundwater Addendum, to which this document is an appendix, this SAP will supersede DOE/RL-2003-49, *100-FR-3 Operable Unit Sampling and Analysis Plan*, and DOE/RL-2009-43, *Sampling and Analysis Plan for the 100-FR-1, 100-FR-2, 100-FR-3, 100-IU-2, and 100-IU-6 Operable Units Remedial Investigation/Feasibility Study*.

A1.1 Project Scope and Objectives

The scope of groundwater monitoring presented in this SAP satisfies the requirements for performance monitoring of the MNA remedy identified in the 100-F/IU ROD (EPA and DOE, 2014) and described in the *Remedial Design Report/Remedial Action Work Plan for 100-F/IU Groundwater* (hereinafter called the Groundwater Addendum), to which this document is an appendix. This includes identification of the groundwater monitoring network; installation of new monitoring wells; periodic sampling of new and existing wells, aquifer tubes, and a riverbank seep; laboratory analysis; and data evaluation.
The monitoring locations are designed to collect groundwater data sufficient to evaluate natural attenuation processes, rates of attenuation, and overall protectiveness with respect to the following 100-FR-3 remedial action objectives (RAOs) identified in the 100-F/IU ROD (EPA and DOE, 2014):

- **RAO 1:** Prevent unacceptable risk to human health from ingestion of and incidental exposure to groundwater containing contaminant concentrations above federal and state standards and risk-based thresholds.
- **RAO 2:** Prevent unacceptable risk to human health and ecological receptors from groundwater discharges to surface water containing contaminant concentrations above federal and state standards and risk-based thresholds.
- **RAO 7:** Restore groundwater impacted from 100-FR-1, 100-FR-2, 100-IU-2, and 100-IU-6 releases to proposed cleanup levels, which include drinking water standards (DWSs), within a time frame that is reasonable given the particular circumstances of the site.

Performance monitoring of natural attenuation for Cr(VI), strontium-90, nitrate, and TCE and the COCs identified in the 100-F/IU ROD (EPA and DOE, 2014) is included in this SAP. As discussed in the Groundwater Addendum (Section 3.1.1), performance monitoring consists of two phases: remediation

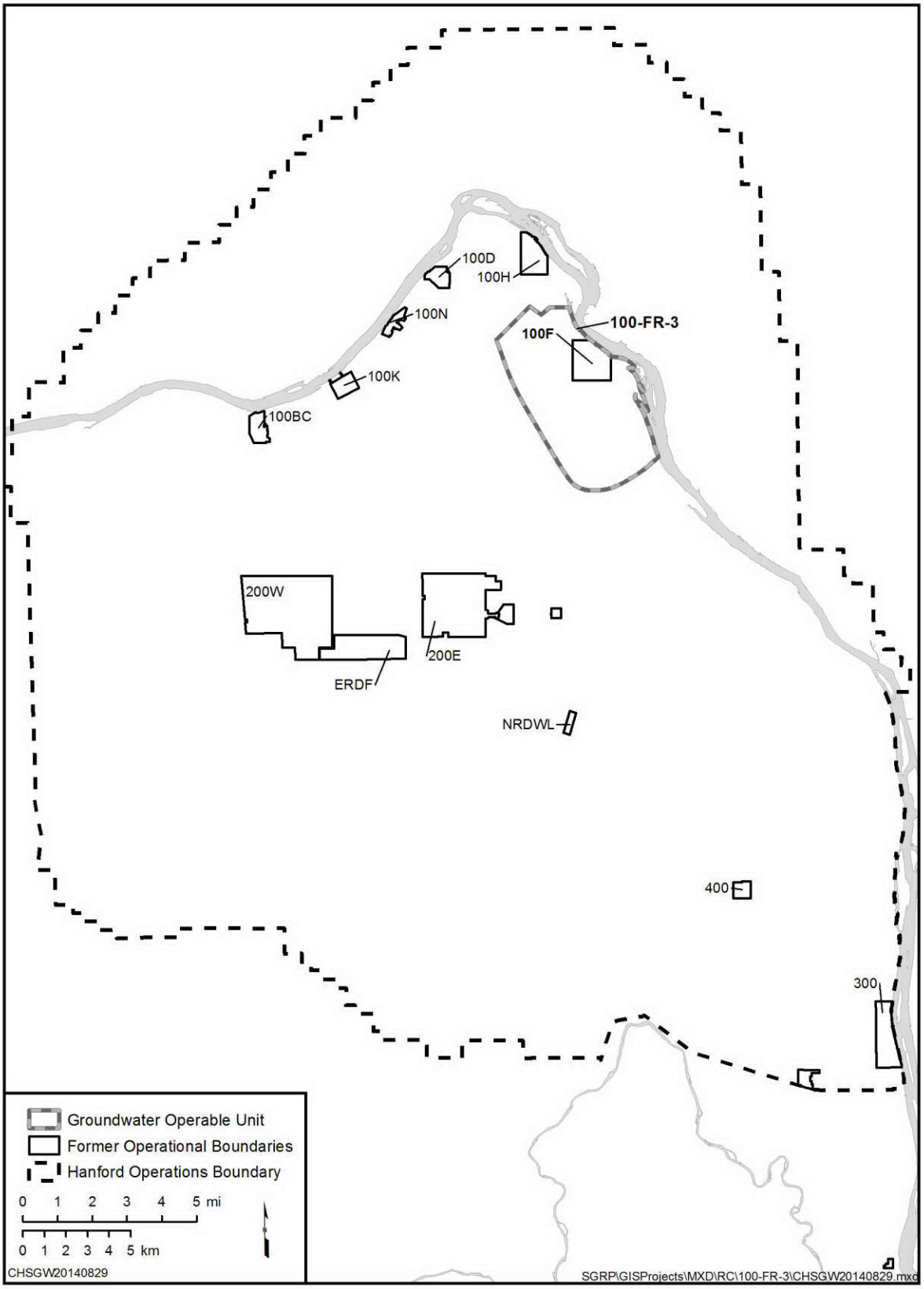


Figure A-1. Location of the 100-FR-3 Groundwater Operable Unit

monitoring and attainment monitoring. The first phase (remediation monitoring) refers to the phase of the remedy where remedial activities are being implemented to reach groundwater cleanup levels. During this phase, groundwater monitoring data are collected to evaluate contaminant migration and changes in COC concentrations over time.

A description of methods used to evaluate the progress of attenuation and determine cleanup level attainment is presented in Chapter 6 of the Groundwater Addendum.

The attainment monitoring phase occurs after the remediation monitoring phase is complete. Once the groundwater is observed to have reached steady-state conditions, data are collected and evaluated to confirm that the cleanup level has been attained.

Protection of Columbia River aquatic receptors is monitored using data collected to track COC plumes in the aquifer near the point of discharge. Protection of human health is accomplished by preventing exposure through implementing ICs to restrict groundwater use. The sample data collected will be used to monitor the progress of natural attenuation and determine when cleanup levels have been achieved.

Degradation products of TCE are also identified for sampling. These chemicals include *cis*-1,2-dichloroethene and vinyl chloride. Due to analytical uncertainties identified in the 100-F/IU remedial investigation/feasibility study (RI/FS) report (DOE/RL-2010-98, *Remedial Investigation/Feasibility Study for the 100-FR-1, 100-FR-2, 100-FR-3, 100-IU-2, and 100-IU-6 Operable Units*), sampling and analysis will also be conducted for antimony, cadmium, and cobalt.

The objectives of this SAP are as follows:

- MNA of identified COCs (Cr(VI), strontium-90, nitrate, and TCE) in meeting the RAOs identified in the 100-F/IU ROD (EPA and DOE, 2014).
- Determine if antimony, cadmium, and cobalt are present below action levels.
- Evaluate the influence of seasonal variation and geology and hydrogeology in the southern portion of the 100-FR-3 OU on hydraulic gradients.
- Determine if RAOs and cleanup levels have been achieved.

Implementation of this plan provides groundwater monitoring data that will be evaluated and reported as part of the Hanford Site annual groundwater report and in separate reports on a less frequent basis. The remediation monitoring phase for Cr(VI), strontium-90, nitrate, and TCE natural attenuation will continue until the progress evaluations demonstrate that cleanup levels have been attained, as described in the Groundwater Addendum. After the remediation monitoring evaluation at a given well demonstrates that cleanup levels have been attained, each COC will undergo an attainment monitoring phase at that well.

The DQO process supporting the performance monitoring design included an evaluation of existing monitoring wells, aquifer tubes, and riverbank seeps with respect to the 2013 Cr(VI), strontium-90, TCE, and nitrate plume configurations. Historical sampling locations and analytical results generated during groundwater monitoring in the 100-FR-3 OU through 2013 were reviewed. The objective of the evaluation was to select a representative monitoring network and identify sampling requirements to address the principal study questions (PSQs) and meet data needs. The evaluation defined locations needed for contaminant monitoring and determined an appropriate sampling frequency. The criteria applied to identify monitoring locations and select an appropriate sampling frequency are provided in a

DQO report (SGW-58291, *Data Quality Objectives for 100-FR-3 Monitored Natural Attenuation*). The report is included with this appendix for convenience.

Water levels will be measured manually at periods of low, high, and moderate river stage. A network of wells will be incorporated into an automated water level network (AWLN) for hourly measurements. Water level data will be used to improve interpretations and models of groundwater flow in the 100-FR-3 OU.

A1.2 Background

This section summarizes hydrogeology, groundwater flow, contaminant sources, and contaminant plumes of the 100-FR-3 OU.

A1.2.1 Site Hydrogeology

A detailed description of the 100-F/IU site history and hydrogeologic conditions is included in Sections 1.2 and 3.4 through 3.6 of the 100-F/IU RI/FS (DOE/RL-2010-98). The primary geologic units are the Hanford formation, the Ringold Formation upper mud unit (RUM), deeper units of the Ringold Formation, and Columbia River Basalt (Figure A-2). Chapter 3 of the 100-F/IU RI/FS (DOE/RL-2010-98) includes detailed information about site geology.

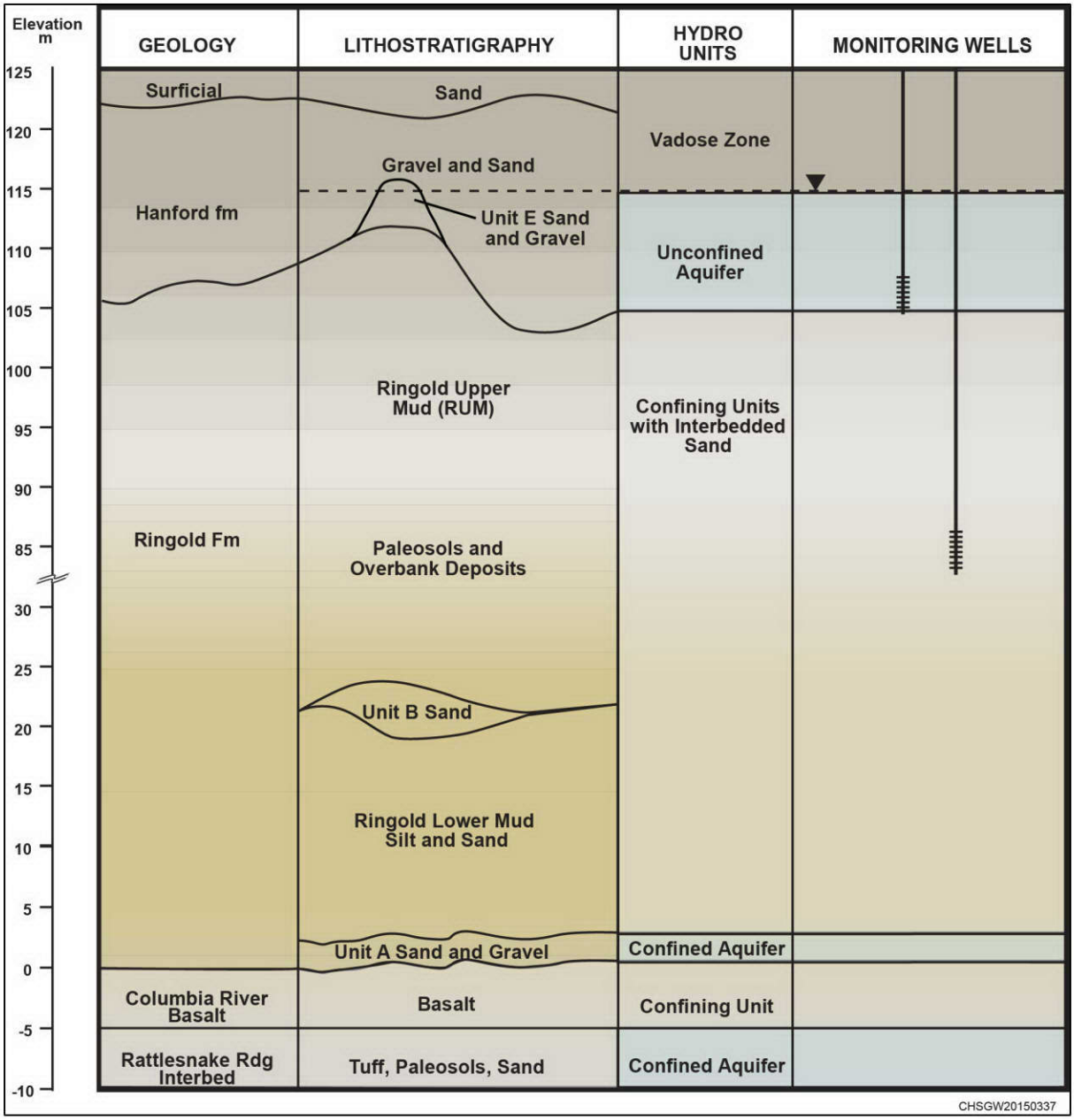
Figure A-3 is a geologic cross section through 100-F Area, trending southwest to northeast. A thick unit of Ringold Formation mud (silt) forms the base of the section. In some locations, remnants of Ringold unit E (silty gravelly sand) overlie the mud. The uppermost geologic unit (Hanford formation) varies in thickness from approximately 6 m (20 ft) in the southwest to approximately 21 m (69 ft) in the northeast. Gravel-rich strata appear to be most common. Sand-dominated intervals also are present but appear to be local in extent. Silt-dominated strata have not been identified at 100-F.

Figure A-4 is a geologic cross section through the eastern end of Gable Mountain to the Columbia River. The cross section parallels the northern section of the 100-FR-3 OU nitrate plume. Most of the well logs do not provide sufficient detail to distinguish between Hanford and Ringold E sediments, nor between RUM and other Ringold silt/clay units. The top of the RUM north of Gable Mountain is at approximately the same elevation as the Ringold lower mud south of the structure.

Ringold unit E is not present beneath much of the 100-FR-3 OU. However, recent interpretations of borehole logs from some wells suggest the presence of remnants of this unit. Figure A-5 illustrates the elevation extent of these remnants, with the largest one in southwestern 100-F Area and smaller remnants in central and eastern 100-F Area. Where unit E extends above the water table, it comprises the entire unconfined aquifer. Ringold unit E is less transmissive than the Hanford formation, which may contribute to the persistence of the TCE plume in groundwater (Figure A-5; Section A1.2.4).

The RUM underlies the Hanford formation (and Ringold unit E, where present) beneath the 100-F Area. Figure A-6 illustrates a recent interpretation of the RUM surface beneath 100-F Area. It slopes generally from southwest to northeast.

The unconfined aquifer beneath the 100-F Area comprises Hanford formation gravels or Ringold Formation silty sandy gravels (Figure A-2). The thickness of the uppermost aquifer in the 100-FR-3 OU ranges from less than 1 to 8 m (3 to 26 ft). The unconfined aquifer is absent in a region just north of Gable Mountain. Below the unconfined aquifer, the Ringold Formation consists of a series of aquitards and water bearing zones. The low-permeability RUM is the base of the unconfined aquifer.



Source: DOE/RL-2010-98, *Remedial Investigation/Feasibility Study for the 100-FR-1, 100-FR-2, 100-FR-3, 100-IU-2, and 100-IU-6 Operable Units*.

Figure A-2. Stratigraphy and Hydrogeologic Units of 100-F Area

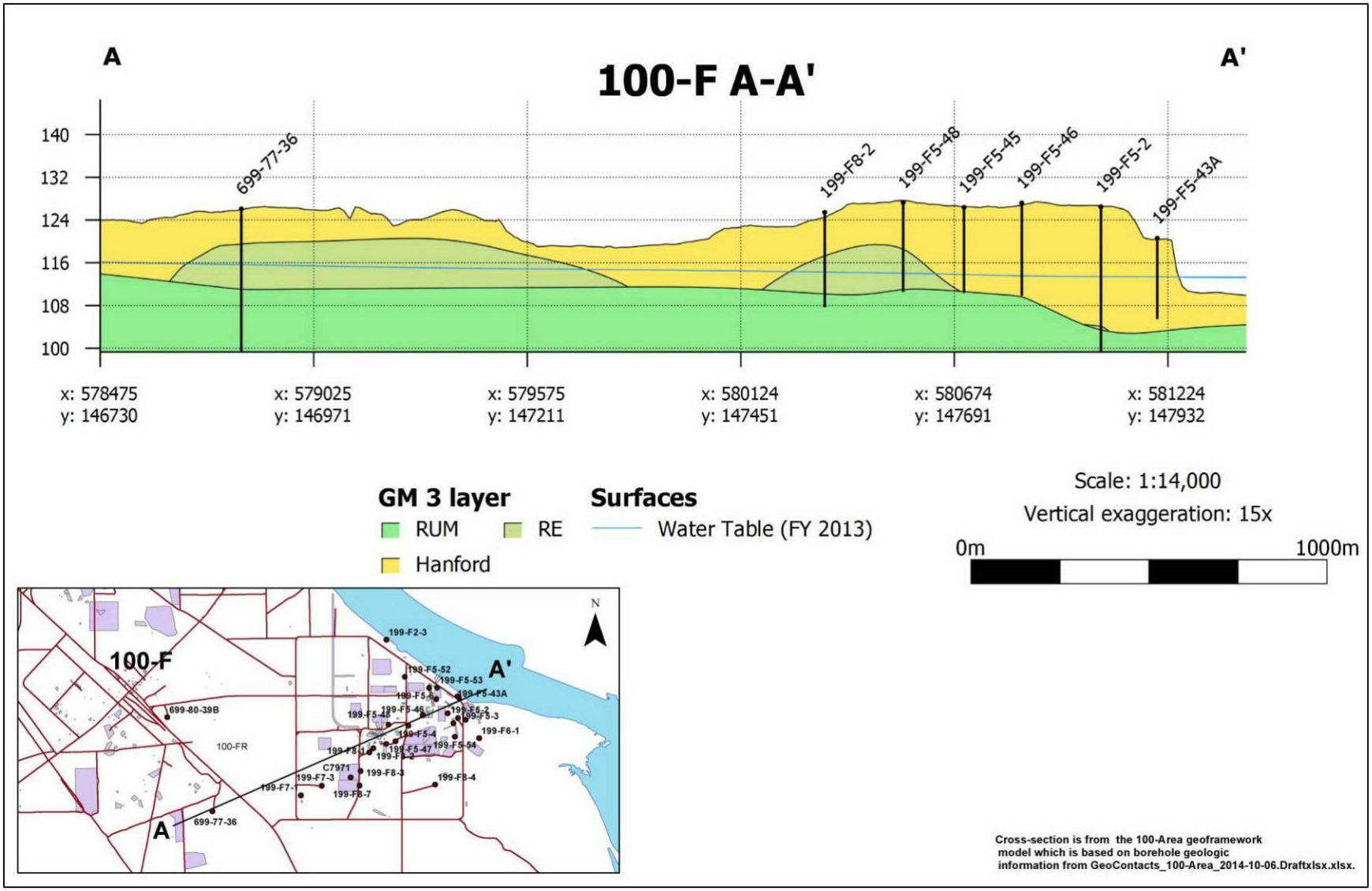
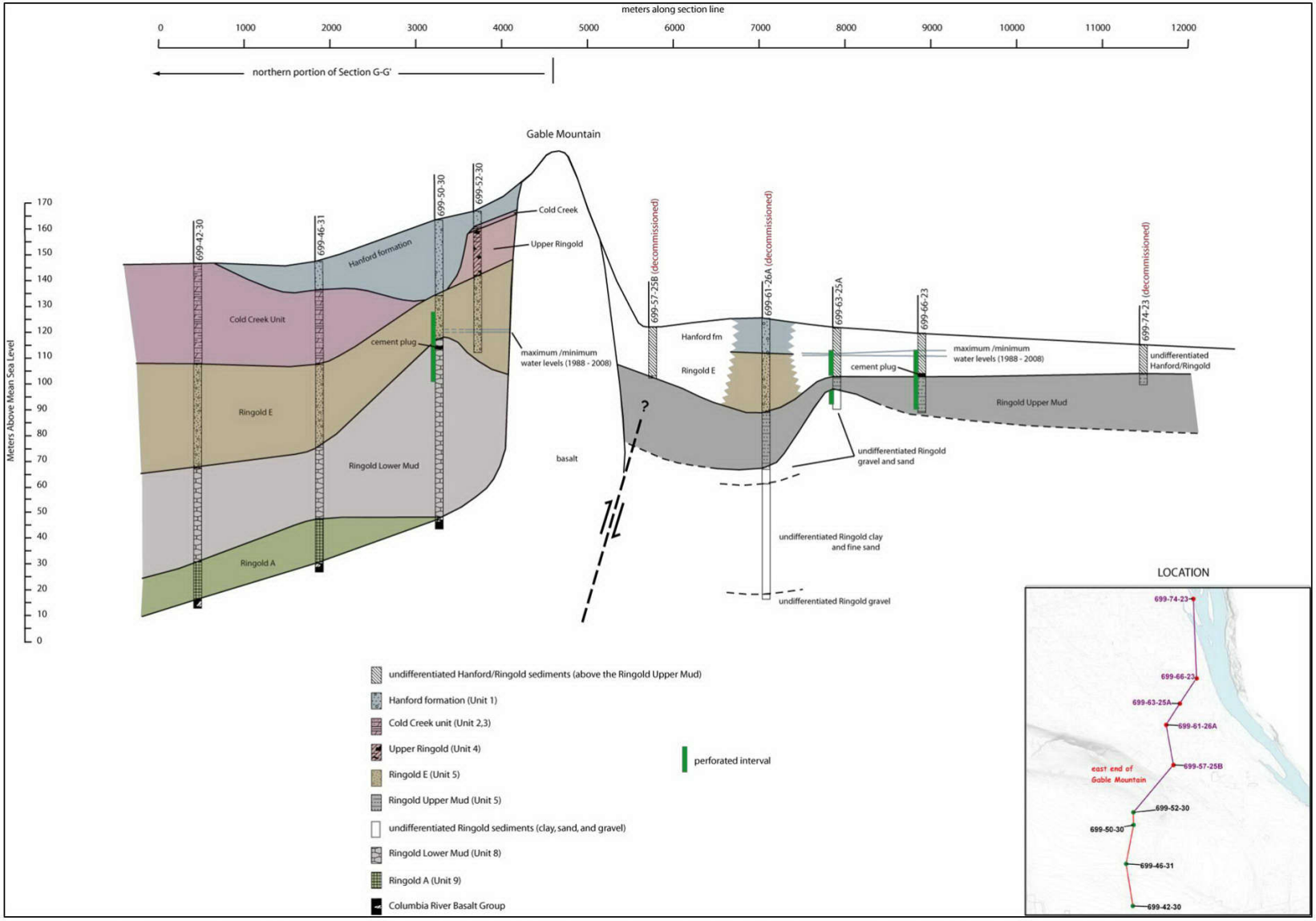


Figure A-3. Geologic Cross Section through 100-F Area



Source: DOE/RL-2010-98, *Remedial Investigation/Feasibility Study for the 100-FR-1, 100-FR-2, 100-FR-3, 100-IU-2, and 100-IU-6 Operable Units*.

Figure A-4. Geologic Cross Section South to North across Gable Mountain Paralleling 100-F Nitrate Plume in Northern Section

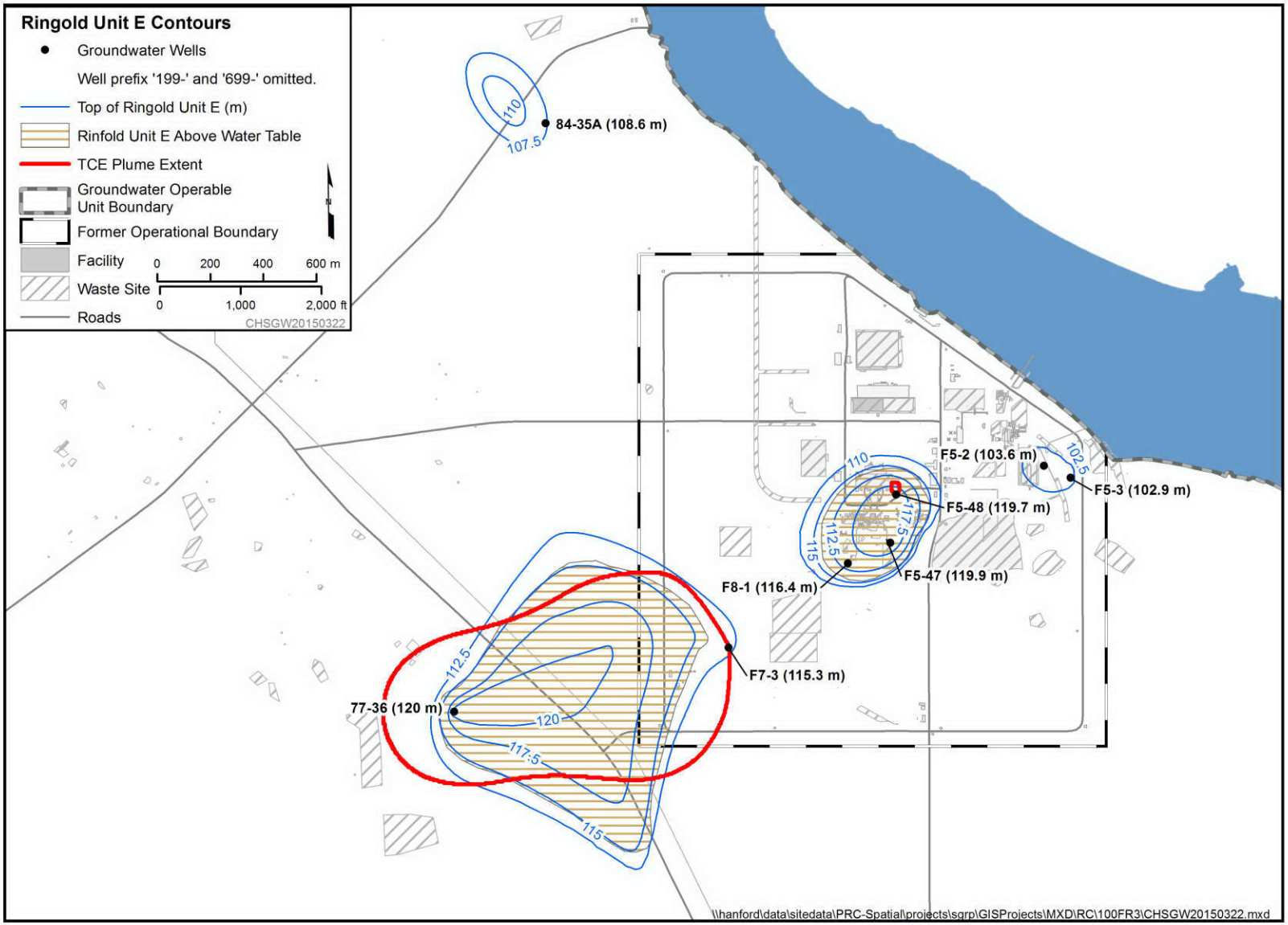


Figure A-5. Extent and Elevation of Top of Ringold Formation Unit E in 100-F Area

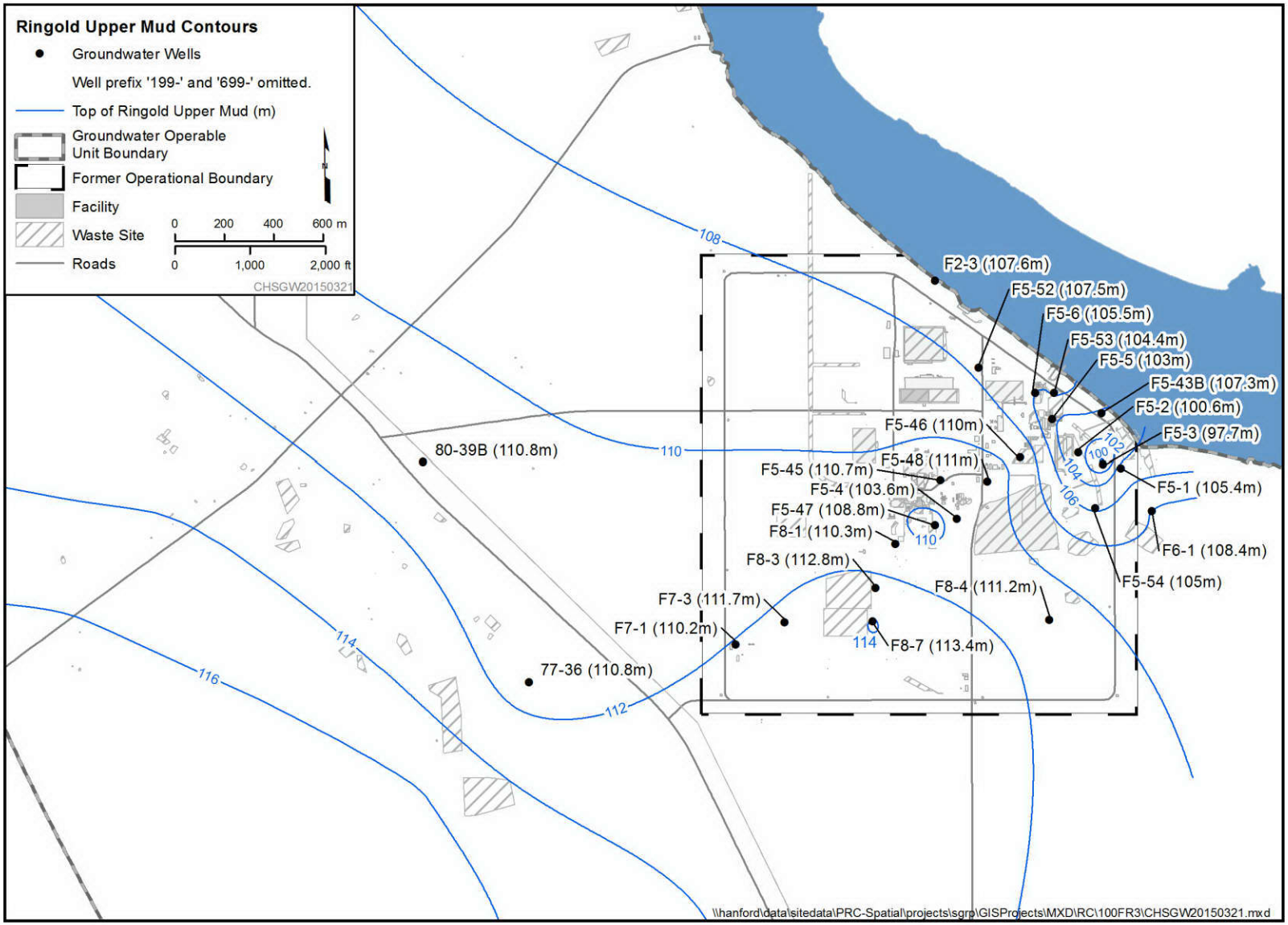


Figure A-6. Elevation of Top of Ringold Formation Upper Mud Unit in 100-F Area

Well 199-F5-43B is screened in a clayey silt or silty clay 39 m (129 ft) below the water table. Well 199-F5-53 is screened in silt 19 m (62 ft) below the water table. These sediments are considered part of the RUM or underlying, fine grained sediments but produce sufficient water for sampling.

No wells are screened below the RUM in the 100-F Area. A series of piezometers monitors deeper units in Well 699-84-35A, located northwest of 100-F Area. Documentation of the geology and well completion is limited, but the piezometers appear to monitor the Ringold units below the RUM, with the deepest piezometer monitoring the Ringold lower mud.

Hydraulic conductivity of the Hanford formation aquifer, based on slug tests, ranges from 14 to 48 m/d (46 to 157 ft/d). Slug tests in RUM wells 199-F5-43B and 199-F5-53 yielded hydraulic conductivity two orders of magnitude lower (0.8 and 0.2 m/d [3 and 1 ft/d]), respectively.

A1.2.2 Groundwater Flow

Figures A-7 and A-8 illustrate locations of monitoring wells and aquifer tubes and include water table contours based on data collected in March 2014. In the northern portion of 100-F Area, groundwater flow is to the northeast, discharging to the Columbia River. In the southern 100-F Area, groundwater flows primarily to the east and then curves to the southeast. Southeast of 100-F Area (Figure A-8), the water table slopes very gently at elevations ranging from 111 to 112 m (364 to 367 ft). This is approximately the same elevation as the Columbia River at this location. Consequently, the average direction of groundwater flow is approximately parallel to the river. Groundwater discharge is believed to occur ~2 to 3 km (1.2 to 1.9 mi) downstream of 100-F Area, where aquifer tubes such as 75-D exhibit higher specific conductance and detectable levels of groundwater contaminants. A recent study of groundwater upwelling (WCH-380, *Field Summary Report for Remedial Investigation of Hanford Site Releases to the Columbia River, Hanford Site, Washington*) supported the interpretation that little groundwater discharge occurs at 100-F Area.

Normal seasonal variability in the water table at 100-F Area is more than 3 m (10 ft) in wells near the river and decreases farther inland. When the river stage is high (e.g., June 2014; Figure A-9), groundwater flow near the river in northeastern 100-F Area reverses, and water flows from the river into the aquifer. Figure A-10 illustrates the magnitude and direction of the hydraulic gradient in three regions of 100-F over various time periods. In southwestern 100-F Area, direction of the gradient varies from northeast to southeast. The gradient south of 100-F Area slopes toward the south or southeast even in March and October when the river stage is low to moderate. The magnitude of the gradients range from 9×10^{-4} to 1×10^{-3} m/m (Figure A-10).

Vertical hydraulic gradients within the unconfined aquifer at 100-F Area (Hanford formation) have not been quantified. The aquifer is thin, and the vertical component of flow is probably minor.

The vertical gradient between the unconfined aquifer and the RUM is variable, based on data from pressure transducers in well pair 199-F5-43A and 199-F5-43B. During a period of low river stage, the overall difference in head between the two wells was negligible, indicating only a slight vertical gradient. During a period of high river stage, there was a consistently downward hydraulic gradient that averaged 2×10^{-3} m/m.

A1.2.3 Sources of Groundwater Contamination

The 100-F Reactor was supported by multiple facilities associated with services for water treatment, air filtration, nuclear fuel handling, effluent disposal, and laboratories, with various other administrative buildings. The 100-F Area also included the Experimental Animal Farm (EAF), where biological research studies were performed to examine the effects of radiation and radioactive contamination on plants, animals, and fish. All of the former waste sites in 100-F have been remediated or were determined not to

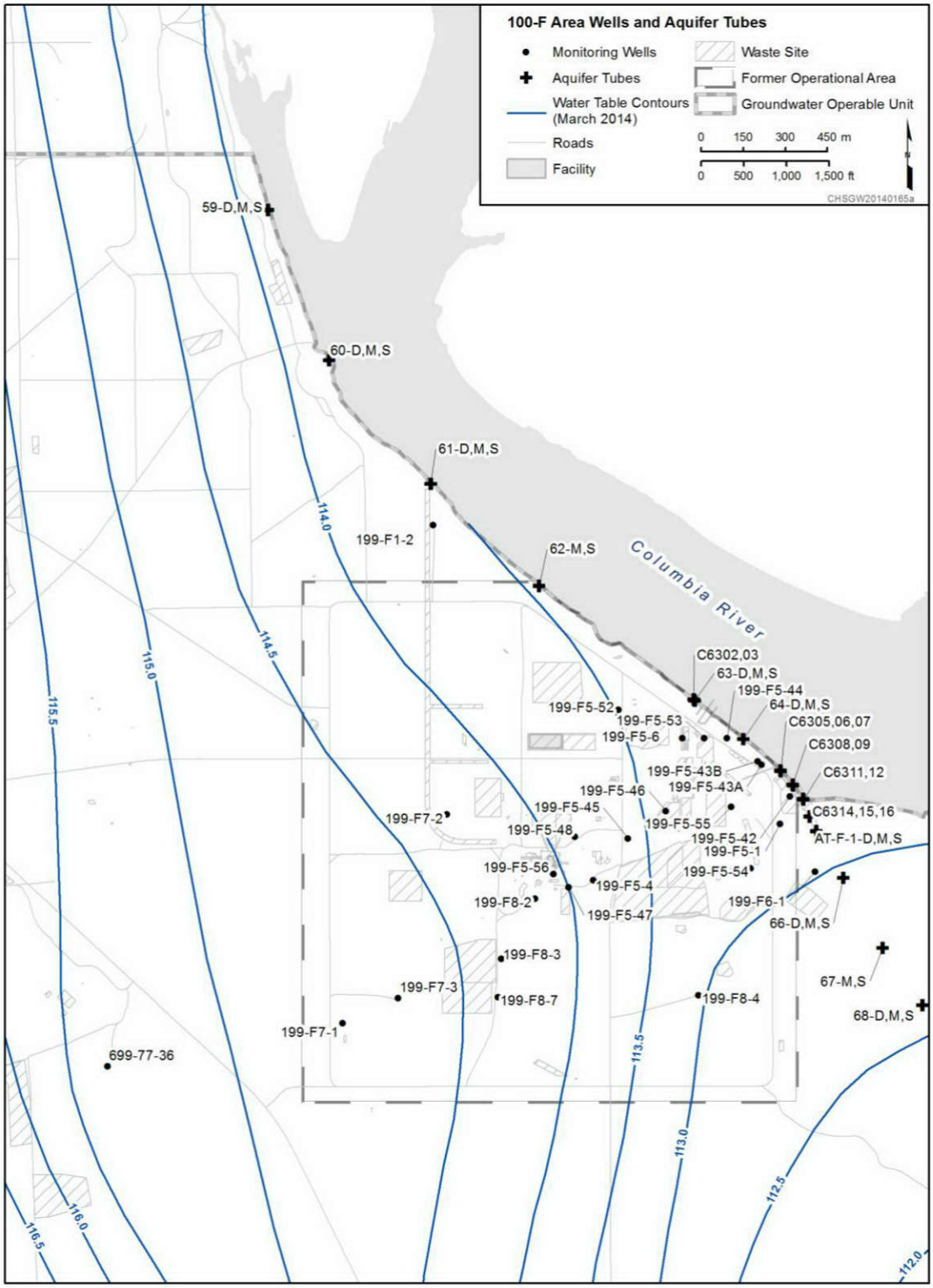


Figure A-7. Groundwater Monitoring Wells, Aquifer Tubes, and March 2014 Water Table in 100-F Area (Moderate River Stage)

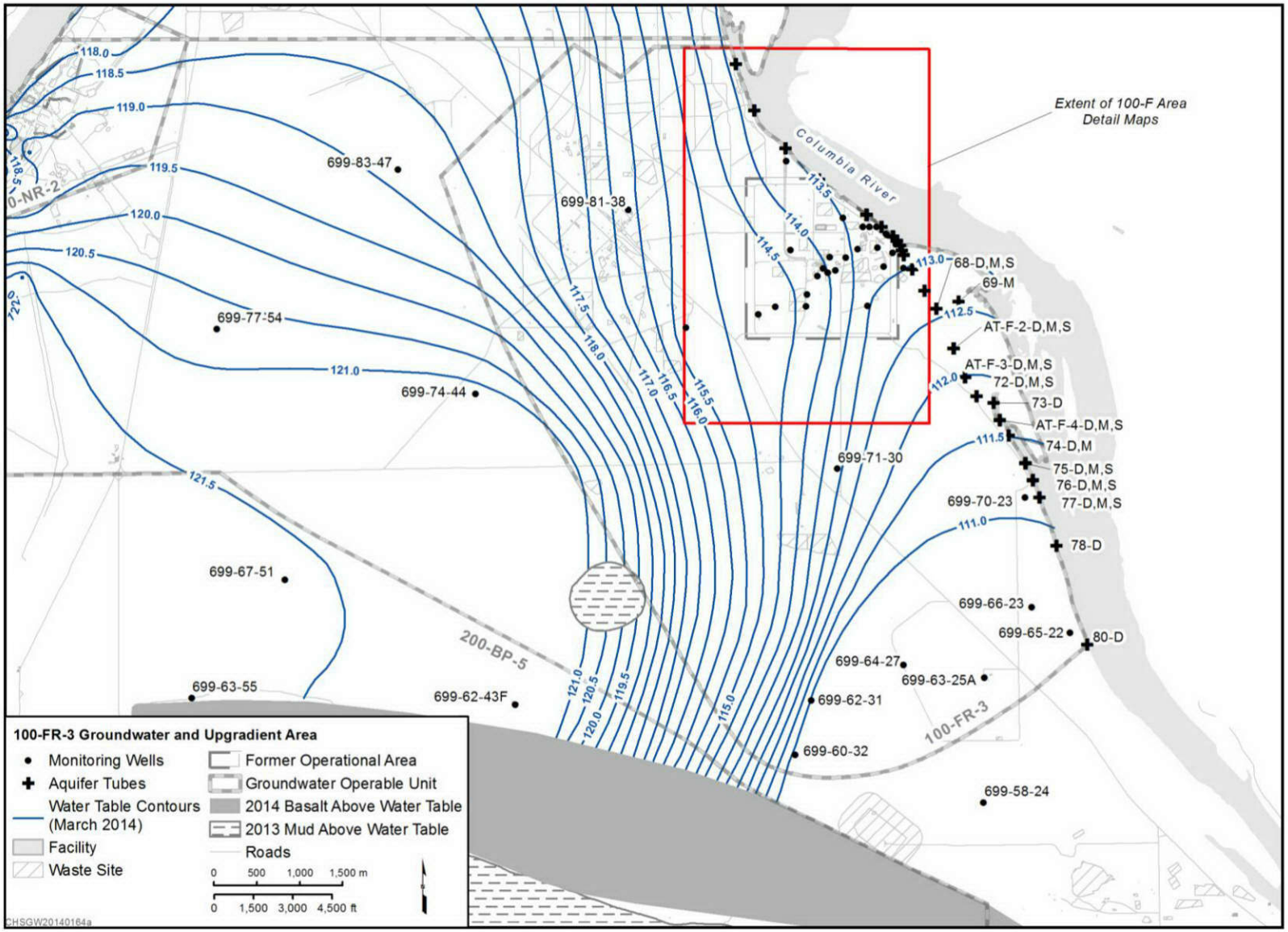
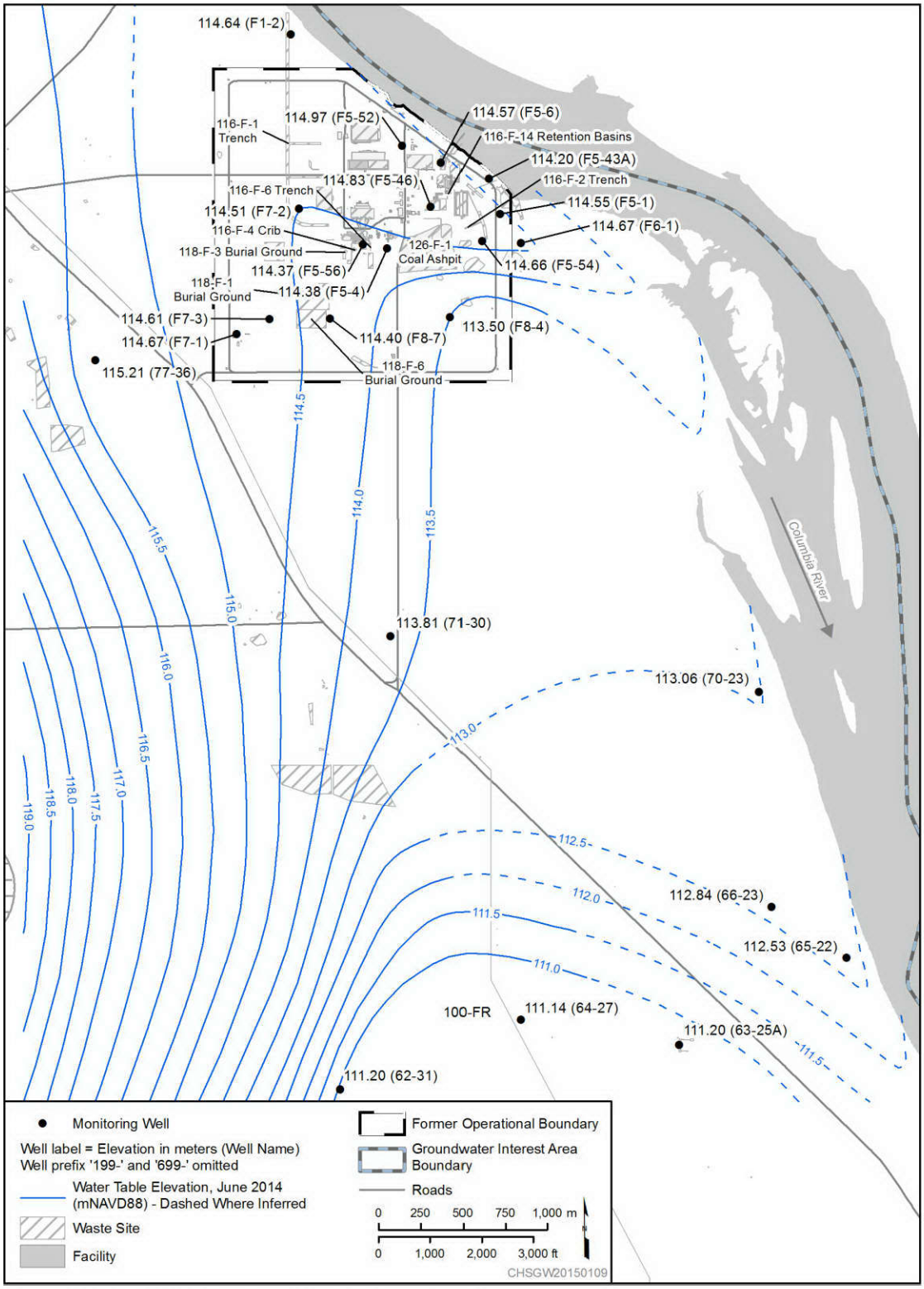
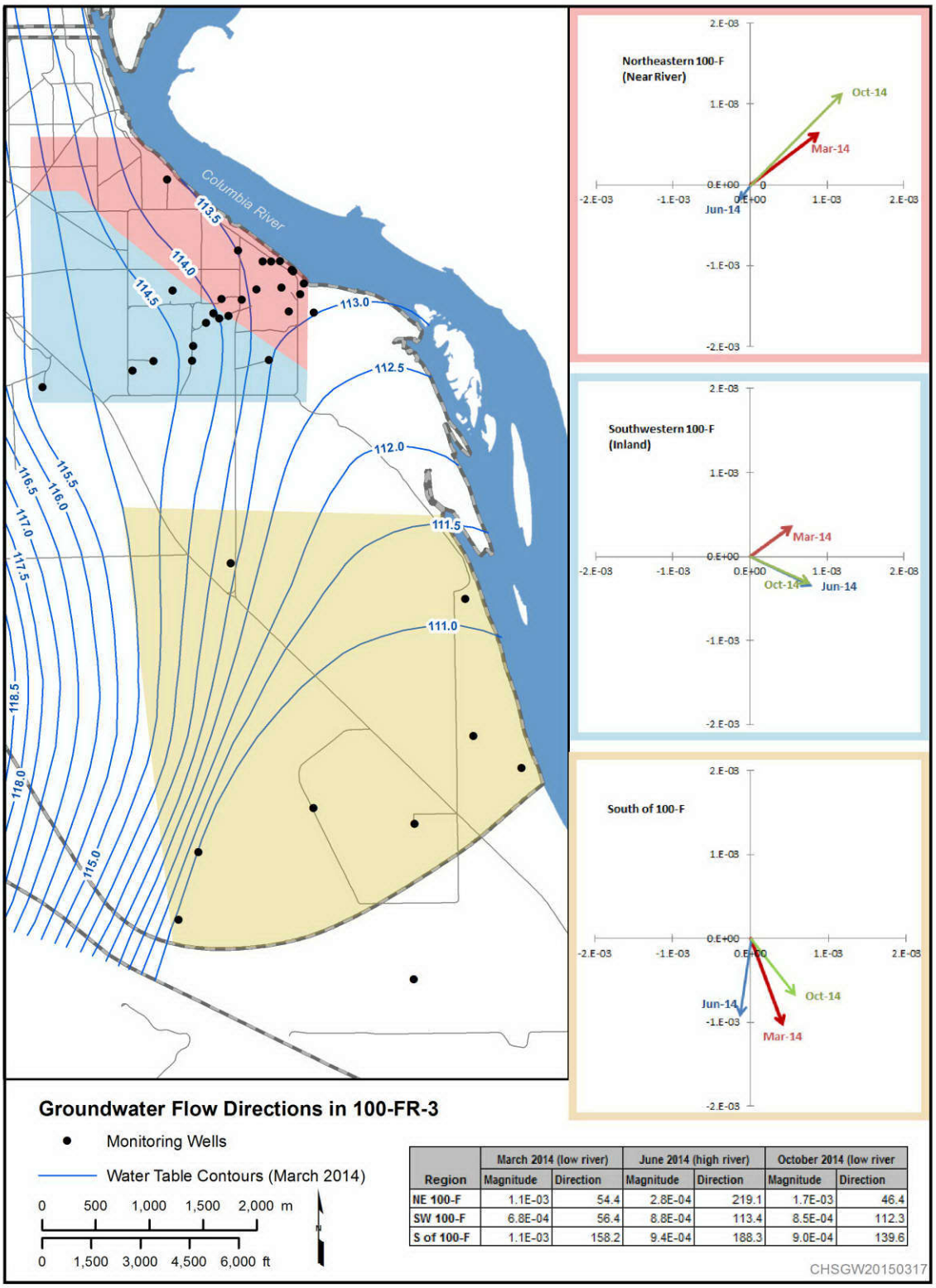


Figure A-8. Groundwater Monitoring Wells, Aquifer Tubes, and March 2014 Water Table at the 100-FR-3 Operable Unit



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

Figure A-9. June 2014 Water Table (High River Stage)



Region	March 2014 (low river)		June 2014 (high river)		October 2014 (low river	
	Magnitude	Direction	Magnitude	Direction	Magnitude	Direction
NE 100-F	1.1E-03	54.4	2.8E-04	219.1	1.7E-03	46.4
SW 100-F	6.8E-04	56.4	8.8E-04	113.4	8.5E-04	112.3
S of 100-F	1.1E-03	158.2	9.4E-04	188.3	9.0E-04	139.6

Figure A-10. Magnitude and Direction of Hydraulic Gradient in 100-F Area

require remediation. Operations within 100-IU-2 and 100-IU-6 were primarily related to other uses, such as historical agricultural uses and uses associated with human occupation.

Liquid wastes from reactor operations and associated facilities were released to the soil column and the Columbia River. Solid wastes were disposed in burial grounds associated with the facilities. Wastes released to or buried within the environment created secondary sources of contamination, such as liquid waste sites (ponds, trenches, cribs, and french drains), burial grounds, and numerous small miscellaneous waste sites scattered throughout the River Corridor.

Former sources of Cr(VI) in 100-F included facilities near the reactor building, trenches and retention basins near the Columbia River, and pipelines from the reactor building to these near-river facilities, primarily in northern and eastern 100-F. Past sources of nitrate contamination included EAF and various septic tanks and leach fields located throughout 100-F. Nitrate contamination was likely transported inland during operations when effluent discharge resulted in groundwater mounding and changes in hydraulic gradients.

Major sources of strontium-90 included the 116-F-14 Retention Basin and the 116-F-2 Trench, located in northeastern 100-F Area. The main groundwater plume is in eastern 100-F Area near these former sources. A smaller plume is present in the central 100-F Area.

The source of TCE contamination in the 100-FR-3 OU is believed to have been from a number of waste sites, including a group of waste sites west of the 100-F Area that have been remediated. TCE can be present as a gas in the vadose zone and as a dissolved species in soil moisture and groundwater.

A1.2.4 Contaminant Plumes

A large nitrate plume with concentrations above 45 mg/L extends from 100-F Area approximately 5 km (3.1 mi) to the south (Figure A-11). The highest concentrations (greater than 120 mg/L) are in central 100-F Area. Wells near the Columbia River have low nitrate concentrations. The water in these wells has low specific conductance (160 to 250 μS/cm), indicating the influence of inflowing river water even during periods of low river stage. Thus, the highest nitrate concentrations do not flow directly into the Columbia River adjacent to the 100-F Area.

The fact that the nitrate plume migrated southward is explained by the location of some of the nitrate sources in southern 100-F Area, where groundwater flow is toward the south and south-southeast. Because there are relatively few monitoring wells to define the western portion of the plume, the western extent of nitrate contamination above 45 mg/L is uncertain.

TCE concentrations exceed the 4 μg/L cleanup level in three wells in southwestern 100-F Area and sporadically in wells in central 100-F Area (Figure A-12). Process knowledge of the former 600-127 waste site, located just west of 100-F Area, suggests that it may have contributed to the TCE plume. This site was remediated in 2010. The lack of wells to the south creates uncertainty in the interpretation, and the plume may extend farther south than can be interpreted based on available data. Well 699-71-30, approximately 2 km (1.2 mi) to the south, had no detectable TCE in 2013 (<0.5 μg/L).

TCE concentrations have declined since 1992 in Wells 699-77-36 and 199-F7-1 in southwestern 100-F Area. The trend in 199-F7-3 shows the arrival of the plume in the late 1990s and stable or declining concentrations since 2002. The monitoring wells in this location are screened across the entire aquifer thickness, which is less than 3 m (10 ft).

Cr(VI) in the 100-FR-3 OU is present in a relatively small, low-concentration plume (Figure A-13). Historically, the highest concentrations were in Well 199-F5-46, where levels have declined from greater than 300 μg/L in the early 1990s to 26 μg/L in 2013. Concentrations in wells near the Columbia River are lower, and concentrations in aquifer tubes in 2013 continued to be below the 10 μg/L cleanup level.

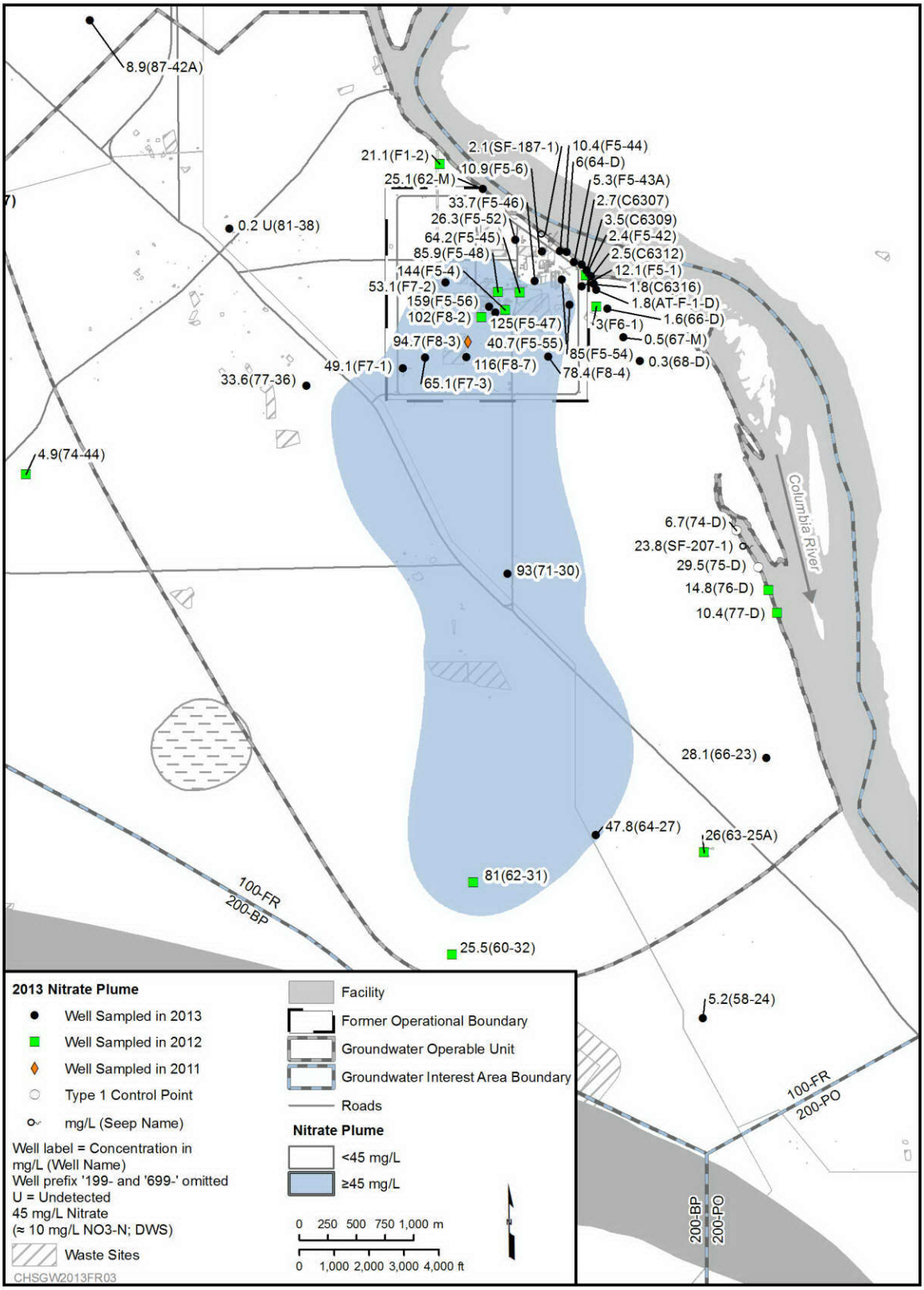


Figure A-11. Nitrate Plume in the 100-FR-3 Operable Unit

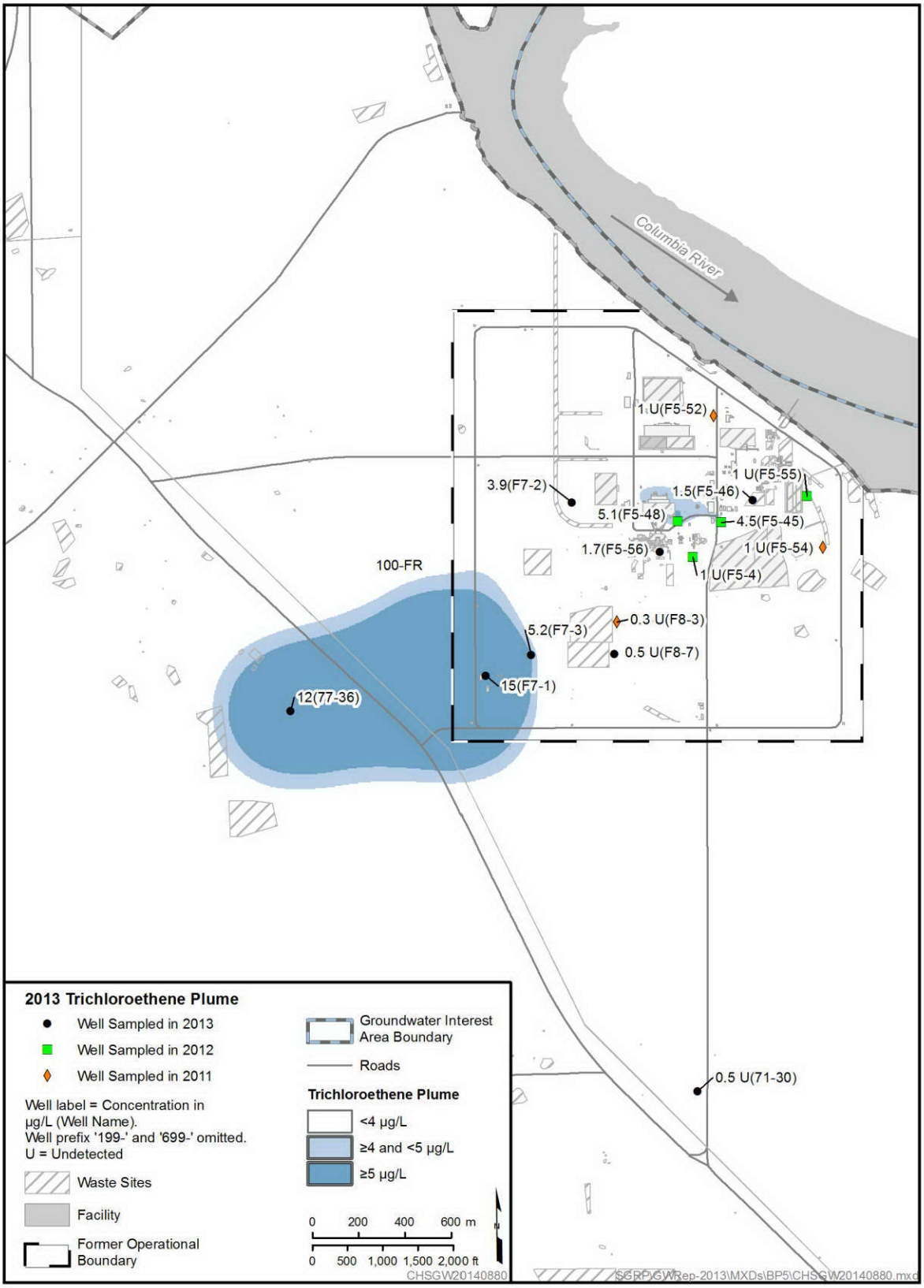


Figure A-12. Trichloroethene Plume in the 100-FR-3 Operable Unit

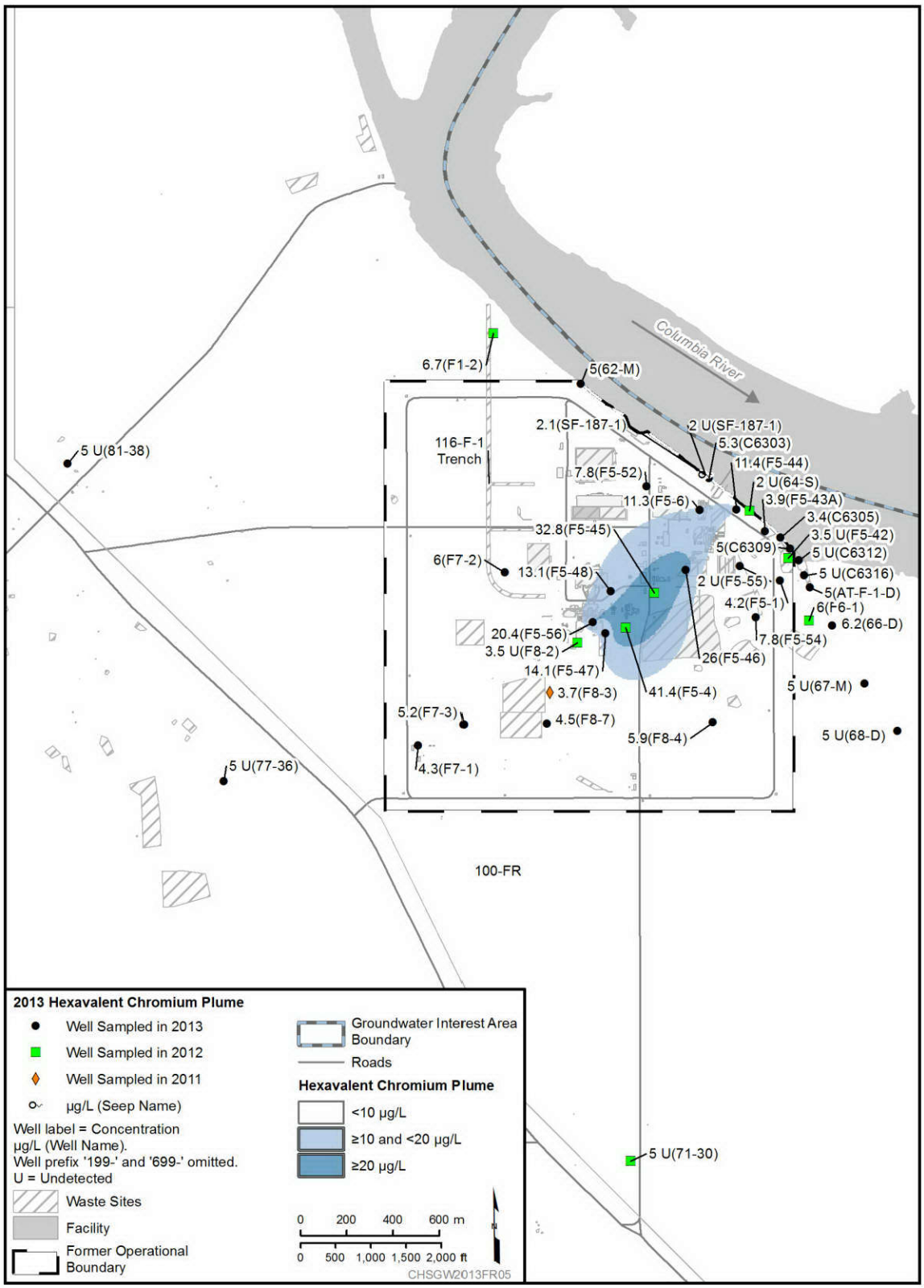


Figure A-13. Hexavalent Chromium Plume in the 100-FR-3 Operable Unit

Two aquifer tubes formerly had concentrations slightly above the cleanup level, but levels have declined. Previous data from pore water samples indicate that the plume does not reach the Columbia River at concentrations above the 10 µg/L cleanup level (DOE/RL-2010-98).

Primary sources of strontium-90 included the 116-F-14 Retention Basins and 116-F-2 Trench in eastern 100-F Area. Additional sources of strontium-90 were present near the reactor building and burial grounds. The main plume in groundwater is in eastern 100-F Area. A smaller plume is present in the central 100-F Area (Figure A-14).

In eastern 100-F Area, two wells (199-F5-55 and 199-F5-1) continued to have strontium-90 concentrations above the 8 pCi/L cleanup level in 2013 (Figure A-14). Concentrations in aquifer tubes have been below the standard, except in a single sample collected in 2012, at 9.6 pCi/L. The concentration declined to 2.7 pCi/L in that aquifer tube in 2013. Previous data from pore water samples indicate that the plume does not reach the Columbia River at concentrations above the 8 pCi/L cleanup level (DOE/RL-2010-98).

Well 199-F5-55 had the highest strontium-90 concentrations in 2013 (Figure A-14), with an annual average of 170 pCi/L. This borehole was installed in the former 116-F-14 Retention Basin to characterize the vadose zone and was completed as a monitoring well to obtain representative groundwater samples. The next nearest downgradient well (199-F5-1) has much lower concentrations.

Well 199-F5-56, near the 105-F Reactor building, had an annual average strontium-90 concentration of 44 pCi/L in 2013. This borehole was drilled to characterize a waste site and completed as a well to obtain representative groundwater samples. It was the only well in the central 100-F Area with detectable strontium-90.

Contaminants are not present beneath the unconfined aquifer. Wells screened in RUM water producing zones consistently have low or nondetectable levels of Cr(VI), strontium-90, TCE, and nitrate.

A1.3 Data Quality Objective Summary

A site-specific DQO process was performed to identify the data needs for the 100-FR-3 OU MNA remedy performance monitoring. The groundwater monitoring network for each COC was identified during the DQO process. Locations were identified to monitor COC concentrations, detect changes in plume area, and refine the understanding of local hydraulic gradients. The DQO report (SGW-58291) is included with this appendix for convenience.

A1.4 Contaminants

Table A-1 identifies the specific contaminants for MNA performance monitoring. The contaminants listed were identified in the 100-F/IU ROD (EPA and DOE, 2014) and RI/FS report (DOE/RL-2010-98).

A1.5 Project Schedule

This SAP will direct performance monitoring activities for the 100-FR-3 OU as described in the Groundwater Addendum. Implementation of 100-FR-3 OU performance monitoring will begin after approval of the Integrated RDR/RAWP (DOE/RL-2014-44). Installation of new monitoring wells is projected to be initiated immediately following RDR/RAWP approval and are anticipated to be completed 6 months after RDR/RAWP approval.

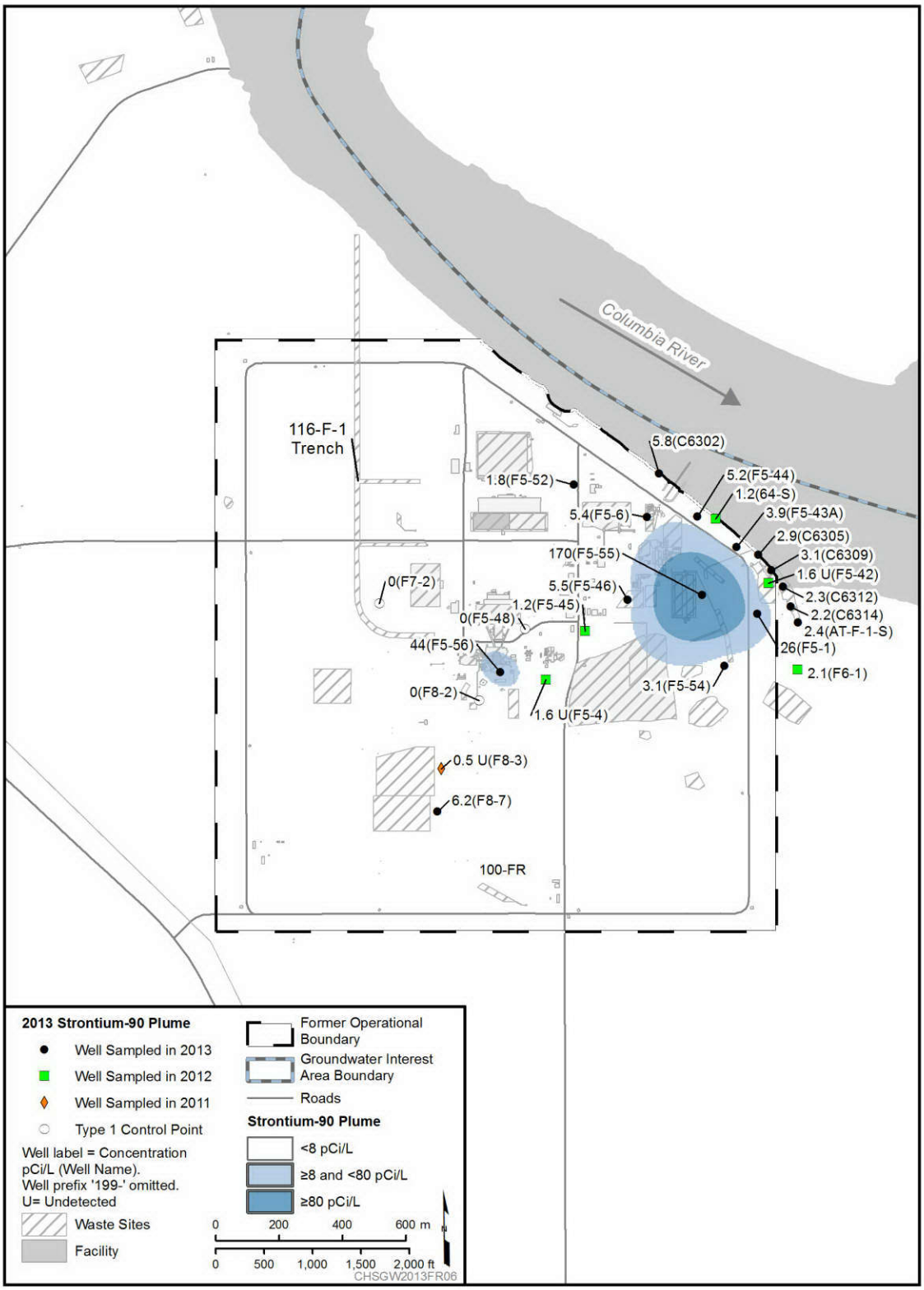


Figure A-14. Strontium-90 Plume in the 100-FR-3 Operable Unit

Table A-1. Analytes for 100-FR-3 Operable Unit Groundwater Monitoring

Contaminant	Chemical Abstracts Service Number
Inorganics – Metals	
Antimony	7440-36-0
Cadmium	7440-43-6
Chromium (Hexavalent)	18540-29-9
Cobalt	7440-48-4
Inorganics – Anions	
Nitrate	14797-55-8
Volatile Organics	
Trichloroethene	79-01-6
cis-1,2-Dichloroethene	156-59-2
Vinyl Chloride	75-01-4
Radionuclides	
Strontium-90	10098-97-2
Field Measurements	
Dissolved Oxygen	Not applicable
pH	Not applicable
Specific Conductance	Not applicable
Temperature	Not applicable
Turbidity	Not applicable
Depth to Groundwater	Not applicable

Data from the new and existing wells will be obtained in the first monitoring year; however, completion of quarterly sampling for all Phase 1 wells will extend into the second monitoring year. The first full year of monitoring at Phase 1 wells will be completed 1 year from the final Phase 1 well acceptance date. A report detailing Phase 1 well results and an initial evaluation of the monitoring program and recommendations of Phase 2 monitoring wells is projected to be completed 6 months after the first year of monitoring data is obtained for all Phase 1 wells. Additional Phase 2 monitoring wells, if required, will be completed within approximately 1 year after regulatory approval of the well recommendations. Approval of the cultural resource reviews may require up to 6 months. Results from the monitoring network will be evaluated for changes to the sampling plan, including additional wells or aquifer tubes, after the first 5 years of monitoring.

The duration of the performance monitoring sampling, analysis, and data evaluation period is based on the model estimated time frame for each COC to achieve its cleanup level as described in the 100-F/IU RI/FS (DOE/RL-2010-98). The estimated time frames are rounded up to account for model uncertainties. The following time frames are estimated for each COC:

- Cr(VI) = 35 years (based on 10 µg/L cleanup level)
- Strontium-90 = 150 years
- Trichloroethene = 50 years
- Nitrate = 80 years

Once cleanup levels for each COC are achieved, 5 years of attainment monitoring will be performed. The 5-year attainment monitoring period is not included in the time frame estimates.

The sampling schedule will be established through the *Sample Management Integrated Lifecycle Environment* (SMILE), or equivalent system, which optimizes the overall number of well trips and limits schedule redundancy. SMILE allows for the tracking of overlapping requirements, so single well trips can co-sample wells and optimize schedules.

A2 Quality Assurance Project Plan

A QAPjP establishes the quality requirements for environmental data collection. It includes planning, implementation, and assessment of sampling tasks, field measurements, and laboratory analysis and data review. This QAPjP complies with requirements from the following documents:

- EPA/240/B-01/003, *EPA Requirements for Quality Assurance Project Plans (EPA QA/R-5)*
- DOE/RL-96-68, *Hanford Analytical Services Quality Assurance Requirements Document (HASQARD)*

This chapter describes the applicable quality requirements and controls. Sections 6.5 and 7.8 of the *Hanford Federal Facility Agreement and Consent Orde*r [Tri-Party Agreement (TPA)] Action Plan (Ecology et al., 1989b) require quality assurance (QA)/quality control (QC) and sampling and analysis activities to specify the QA requirements for treatment, storage, and disposal units, as well as for past-practice processes. Therefore, this QAPjP follows the QA elements of EPA/240/B-01/003. This QAPjP also demonstrates conformance to Ecology Publication No. 04-03-030, *Guidelines for Preparing Quality Assurance Project Plans for Environmental Studies*, and EPA/240/R-02/009, *Guidance for Quality Assurance Project Plans (EPA QA/G-5)*. This QAPjP is intended to supplement the contractor's environmental QA program plan.

This QAPjP is divided into the following four sections, which describe the quality requirements and controls applicable to Hanford Site OU groundwater monitoring activities: Project Management, Data Generation and Acquisition, Assessment and Oversight, and Data Review and Usability.

A2.1 Project Management

This section addresses project goals, management approaches planned, and planned output documentation.

A2.1.1 Project/Task Organization

The contractor, or its approved subcontractor, is responsible for planning, coordinating, sampling, and shipping samples to the laboratory. The contractor is also responsible for preparing and maintaining configuration control of the SAP and assisting the U.S. Department of Energy (DOE)-Richland Operations Office (RL) Project Manager in obtaining approval of the SAP and future proposed revisions.

The project organization (regarding routine groundwater monitoring) is described in the following subsections and illustrated in Figure A-15.

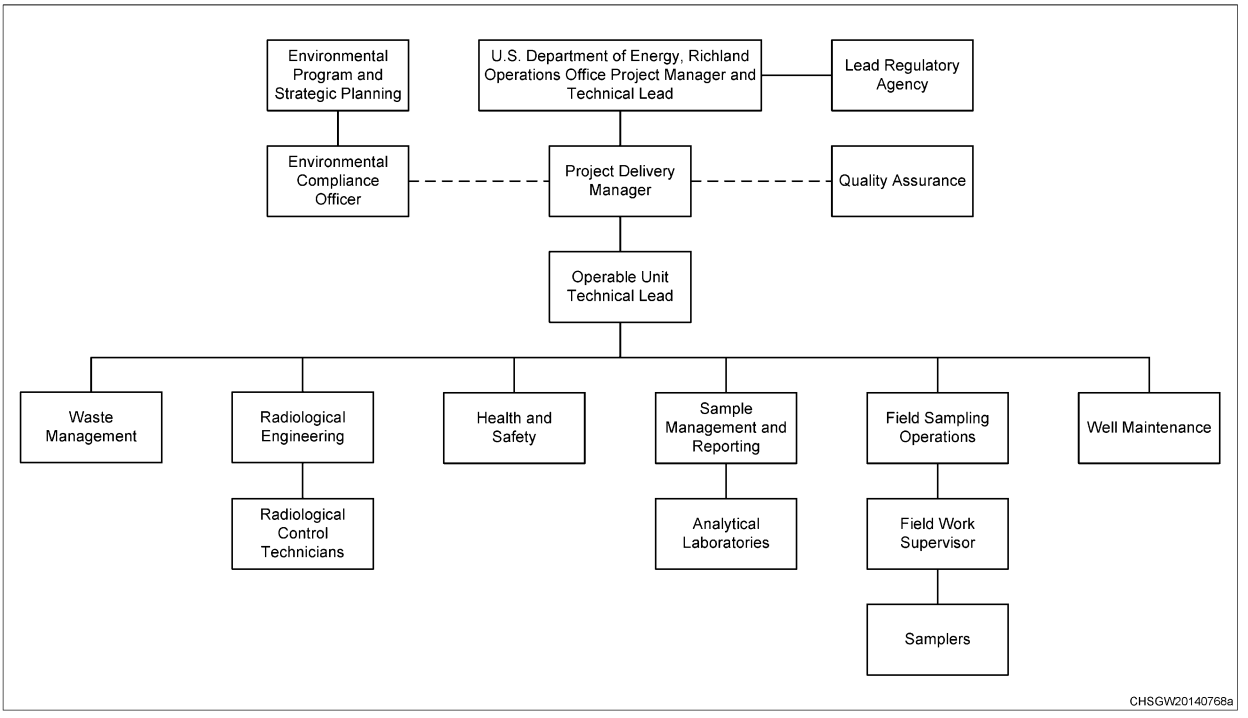


Figure A-15. Project Organization

A2.1.1.1 Regulatory Lead

The lead regulatory agency (LRA) is responsible for regulatory oversight of cleanup projects and activities. LRA has SAP approval authority for the OUs managed and works with DOE-RL to resolve concerns over the work described in this SAP in accordance with the TPA (Ecology et al., 1989a).

A2.1.1.2 DOE-RL Project Manager

The DOE-RL Project Manager is responsible for the following activities:

- Monitoring the contractor's performance of activities under the TPA (Ecology et al., 1989a), *Comprehensive Environmental Response, Compensation, and Liability Act of 1980*; *Resource Conservation and Recovery Act of 1976*; and *Atomic Energy Act of 1954* for the Hanford Site
- Obtaining LRA approval of the SAP
- Authorizing field sampling activities

A2.1.1.3 DOE-RL Technical Lead

The DOE-RL Technical Lead is responsible for the following activities:

- Providing day-to-day oversight of the contractor's work scope performance, for working with the contractor and the regulatory agencies to identify and resolve technical issues
- Providing technical input to the DOE-RL Project Manager

A2.1.1.4 Operable Unit Project Manager

The OU Project Manager (or designee) is responsible and accountable for the following activities:

- Project-related activities
- Coordinating with DOE-RL, regulators, and contactor management in support of sampling activities to ensure that work is performed safely and cost effectively
- Managing sampling documents and requirements, field activities, and subcontracted tasks and ensuring that the project file is properly maintained

A2.1.1.5 Operable Unit Technical Lead

The OU Technical Lead is responsible for the following activities:

- Developing specific sampling design, analytical requirements, and QC requirements either independently or as defined through a systematic planning process
- Ensuring that sampling and analysis activities, as delegated by the OU Project Manager, are carried out in accordance with the SAP
- Working closely with the Environmental Compliance Officer (ECO), QA, Health and Safety, Field Work Supervisor (FWS), and Sample Management and Reporting (SMR) organization to integrate these and other technical disciplines in planning and implementing the work scope

A2.1.1.6 Environmental Compliance Officer

The ECO is responsible for the following activities:

- Providing technical oversight, direction, and acceptance of project and subcontracted environmental work
- Developing appropriate mitigation measures to minimize adverse environmental impacts
- Overseeing project implementation for compliance with applicable internal and external environmental requirements

A2.1.1.7 Quality Assurance

The QA point-of-contact is responsible for the following activities:

- Addressing QA issues on the project
- Overseeing implementation of the project QA requirements
- Reviewing project documents (including DQO summary report, QAPjP, and SAP)
- Reviewing data validation reports from third-party data validation contractors, as appropriate
- Participating in QA assessments on sample collection and analysis activities, as appropriate

A2.1.1.8 Health and Safety

The Health and Safety organization is responsible for the following activities:

- Coordinating industrial safety and health support within the project, in accordance with the health and safety program, job hazard analyses, and other pertinent federal regulations
- Assisting project personnel in complying with the applicable health and safety program

- Coordinating with Radiological Engineering to determine personal protective equipment (PPE) requirements

A2.1.1.9 Radiological Engineering

Radiological Engineering is responsible for the following activities:

- Supporting radiological engineering and project health physics
- Conducting as low as reasonably achievable (ALARA) reviews, exposure and release modeling, and radiological controls optimization
- Identifying radiological hazards and ensuring that appropriate controls are implemented to maintain worker exposures to hazards at ALARA levels
- Interfacing with the project Health and Safety representative, and other appropriate personnel as needed, to plan and direct project Radiological Control Technician (RCT) support

A2.1.1.10 Sample Management and Reporting

The SMR organization is responsible for the following activities:

- Interfacing between the OU Technical Lead, Field Sampling Operations (FSO), Well Maintenance Organization, and analytical laboratories
- Generating field sampling documents, labels, and instructions for field sampling personnel
- Monitoring the entire sample and data process
- Coordinating laboratory analytical work, and ensuring that the laboratories conform to Hanford Site QA requirements (or their equivalent), as approved by DOE, the U.S. Environmental Protection Agency (EPA), and the Washington State Department of Ecology (Ecology)
- Resolving sample documentation deficiencies or issues associated with FSO, laboratories, or other entities to ensure that project needs are met
- Receiving analytical data from the laboratories
- Ensuring that data are uploaded into the Hanford Environmental Information System (HEIS)
- Arranging for and overseeing data validation, as requested
- Informing the OU Project Manager and/or OU Technical Lead of any issues reported by the analytical laboratory
- Developing the sample authorization form (SAF), which provides information and instruction to the analytical laboratories
- Providing instructions to FSO samplers on the collection of samples, as specified in a SAP

A2.1.1.11 Analytical Laboratories

Analytical laboratories are responsible for the following activities:

- Analyzing samples in accordance with established methods
- Providing data packages containing analytical and QC results

- Providing explanations in response to resolution of analytical issues
- Meeting HASQARD (DOE/RL-96-68) QA requirements
- Being on the Mission Support Alliance (MSA) Evaluated Suppliers List
- Being accredited by Ecology for the analyses performed for the Soil and Groundwater Remediation Project

A2.1.1.12Waste Management

Waste Management is responsible for the following activities:

- Communicating policies and protocols
- Ensuring compliance for waste storage, transportation, disposal, and tracking in a safe and cost effective manner
- Identifying waste management sampling/characterization requirements to ensure regulatory compliance
- Interpreting data to determine waste designations and profiles
- Preparing and maintaining other documents confirming compliance with waste acceptance criteria

A2.1.1.13Field Sampling Organization

FSO is responsible for the following activities:

- Planning, coordinating, and conducting field sampling activities
- Ensuring that samplers are appropriately trained and available
- Ensuring that the sampling design is understood and can be performed, as specified by the nuclear chemical operators (NCOs), which is achieved by directing NCO training, performing mock-ups, and holding practice sessions with field personnel
- Directing NCOs
- Ensuring that NCOs collect all salient samples, in accordance with sampling documentation
- Completing field logbook entries and chain-of-custody forms and shipping paperwork and ensuring delivery of samples to the analytical laboratory
- Acting as a technical interface between the OU Project Manager and the field crew supervisors (such as the Drilling Buyer's Technical Representative [BTR], and Geologist-BTR) and ensuring that technical aspects of the field work are met
- Reviewing the SAP for field sample collection concerns, analytical requirements, and special sampling requirements
- Resolving issues regarding implementing technical requirements to field operations and coordinating resolution of sampling issues through consultation with the OU Project Manager and SMR

A2.1.1.14Well Maintenance

The Well Maintenance Manager is responsible for the following activities:

- Completing well maintenance activities

- Coordinating with the OU Technical Lead to identify field constraints that could affect groundwater sampling

A2.1.2 Quality Objectives and Criteria

The QA objective of this plan is to ensure that generation of analytical data of known and appropriate quality are acceptable and useful for decision making. In support of this objective, statistics and data descriptors, known as data quality indicators (DQIs), help determine the acceptability and utility of data to the user. Principal DQIs are precision, accuracy, representativeness, comparability, completeness, bias, and sensitivity. Analytical methods, detection limits, and precision and accuracy requirements for each analysis to be performed are summarized in Table A-2.

Table A-2. Data Quality Indicators

DQI	Definition	Determination Methodologies	Corrective Actions
Precision	Precision measures the agreement among a set of replicate measurements. Field precision is assessed through the collection and analysis of field duplicates. Analytical precision is estimated by duplicate/replicate analyses, usually on laboratory control samples, spiked samples, and/or field samples. The most commonly used estimates of precision are the relative standard deviation and, when only two samples are available, the relative percent difference.	Use the same analytical instrument to make repeated analyses on the same sample. Use the same method to make repeated measurements of the same sample within a single laboratory. Acquire replicate field samples for information on sample acquisition, handling, shipping, storage, preparation, and analytical processes and measurements.	If duplicate data do not meet objective: • Evaluate apparent cause (e.g., sample heterogeneity) • Request reanalysis or re-measurement • Qualify the data before use
Accuracy	Accuracy is the closeness of a measured result to an accepted reference value. Accuracy is usually measured as a percent recovery. Quality control analyses used to measure accuracy include standard recoveries, laboratory control samples, spiked samples, and surrogates.	Analyze a reference material or reanalyze a sample to which a material of known concentration or amount of pollutant has been added (a spiked sample).	If recovery does not meet objective: • Qualify the data before use • Request reanalysis or re-measurement
Representativeness	Sample representativeness expresses the degree to which data accurately and precisely represent a characteristic of a population, parameter variations at a sampling point, a process condition, or an environmental condition. It is dependent on the proper design of the sampling program and will be satisfied by ensuring the approved plans were followed during sampling and analysis.	Evaluate whether measurements are made and physical samples collected in such a manner that the resulting data appropriately reflect the environment or condition being measured or studied.	If results are not representative of the system sampled: • Identify the reason for them not being representative • Flag for further review • Review data for usability • If data are usable, qualify the data for limited use and define the portion of the system that the data represent • If data are not usable, flag as appropriate

Table A-2. Data Quality Indicators

DQI	Definition	Determination Methodologies	Corrective Actions
			• Redefine sampling and measurement requirements and protocols • Resample and reanalyze, as appropriate
Comparability	Comparability expresses the degree of confidence with which one data set can be compared to another. It is dependent upon the proper design of the sampling program and will be satisfied by ensuring that the approved plans are followed and that proper sampling and analysis techniques are applied.	Use identical or similar sample collection and handling methods, sample preparation and analytical methods, holding times, and quality assurance protocols.	If data are not comparable to other data sets: • Identify appropriate changes to data collection and/or analysis methods • Identify quantifiable bias, if applicable • Qualify the data as appropriate • Resample and/or reanalyze if needed • Revise sampling/analysis protocols to ensure future comparability
Completeness	Completeness is a measure of the amount of valid data collected compared to the amount planned. Measurements are considered valid if they are unqualified or qualified as estimated data during validation. Field completeness is a measure of the number of samples collected versus the number of samples planned. Laboratory completeness is a measure of the number of valid measurements compared to the total number of measurements planned.	Compare the number of valid measurements completed (samples collected or samples analyzed) with those established by the project's quality criteria (data quality objectives or performance/ acceptance criteria).	If data set does not meet completeness objective: • Identify appropriate changes to data collection and/or analysis methods • Identify quantifiable bias, if applicable • Resample and/or reanalyze if needed • Revise sampling/analysis protocols to ensure future completeness.
Bias	Bias is the systematic or persistent distortion of a measurement process that causes error in one direction (e.g., the sample measurement is consistently lower than the sample's true value). Bias can be introduced during sampling, analysis, and data evaluation. Analytical bias refers to deviation in one direction (i.e., high, low, or unknown) of the measured value from a known spiked amount.	Sampling bias may be revealed by analysis of replicate samples. Analytical bias may be assessed by comparing a measured value in a sample of known concentration to an accepted reference value or by determining the recovery of a known amount of contaminant spiked into a sample (matrix spike).	For sampling bias: • Properly select and use sampling tools • Institute correct sampling and subsampling procedures to limit preferential selection or loss of sample media • Use sample handling procedures, including proper sample preservation, that limit the loss or gain of constituents to the sample media Analytical data that are known to be affected by either sampling or analytical bias are

Table A-2. Data Quality Indicators

DQI	Definition	Determination Methodologies	Corrective Actions
			flagged to indicate possible bias. Laboratories that are known to generate biased data for a specific analyte are asked to correct their methods to remove the bias as best as practicable. Otherwise, samples are sent to other laboratories for analysis.
Sensitivity	Sensitivity is an instrument's or method's minimum concentration that can be reliably measured (i.e., instrument detection limit or limit of quantitation).	Determine the minimum concentration or attribute to be measured by an instrument (instrument detection limit) or by a laboratory (limit of quantitation). The lower limit of quantitation is the lowest level that can be routinely quantified and reported by a laboratory.	If detection limits do not meet objective: • Request reanalysis or re-measurement using methods or analytical conditions that will meet required detection or limit of quantitation • Qualify/reject the data before use

Source: SW-846, Pending, *Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, Third Edition; Final Update V*, as amended.

Data quality is defined by the degree of rigor in the acceptance criteria assigned to the DQIs. Typically, acceptance criteria are set by the analytical method itself; however, project-specific requirements, as indicated by DQOs, may result in more stringent acceptance criteria. The applicable QC guidelines, DQI acceptance criteria, and levels of effort for assessing data quality are dictated by the intended use of the data and the requirements of the analytical method. DQIs are evaluated during the data quality assessment (DQA) process (Section A2.4).

A2.1.3 Special Training/Certification

A graded approach is used to ensure that workers receive a level of training commensurate with their responsibilities and compliant with applicable DOE orders and government regulations. The FWS, in coordination with line management, will ensure that special training requirements for field personnel are met.

Typical training requirements or qualifications have been instituted by the contractor management team to meet training and qualification programs to satisfy multiple training drivers imposed by the applicable *Code of Federal Regulations* (CFR) and *Washington Administrative Code* (WAC) requirements. For example, the environmental, safety, and health training program provides workers with the knowledge and skills necessary to execute assigned duties safely. Field personnel typically complete the following training before starting work:

- Occupational Safety and Health Administration 40-Hour Hazardous Waste Worker Training and supervised 24-hour hazardous waste site experience
- 8-Hour Hazardous Waste Worker Refresher Training (as required)
- Hanford General Employee Training (including Hanford General Employee Radiation Training)

- Radiological Worker Training

Project-specific safety training, focused specifically to project activities, is provided in OU-specific addenda. Project-specific training may include the following:

- Training qualifications needed to comply with QA requirements
- Requirement that samplers have training and certifications for the type of sampling being performed
- RCT qualifications established by the Radiation Protection Program (RCTs assigned to projects will be qualified through the prescribed training program and will undergo ongoing training and qualification activities)

In addition, pre-job briefings, in accordance with work management and work release document evaluation activities and associated hazards, include the following:

- Objective of the activities
- Individual tasks to be performed
- Hazards associated with the planned tasks
- Controls applied to mitigate the hazards
- Environment in which the job will be performed
- Facility where the job will be performed
- Equipment and material required
- Safety protocols applicable to the job
- Training requirements for individuals assigned to perform the work
- Level of management control
- Proximity of emergency contacts

Training records are maintained for each employee in an electronic training record database. The contractor's training organization maintains the training records system. Line management confirms that an employee's training is appropriate and up-to-date prior to performing any field work.

A2.1.4 Documents and Records

The OU Project Manager (or delegate) is responsible for ensuring that the current version of the SAP is being used and providing updates to field personnel. Version control is maintained by the administrative document control process. Changes to the sampling document are handled consistent with HASQARD (DOE/RL-96-68) and the TPA Action Plan (Ecology et al., 1989b). The OU Project Manager is responsible for tracking all SAP changes, obtaining appropriate review, and alerting DOE-RL of these changes. Appropriate documentation will follow, in accordance with the requirements for the type of change. Table A-3 summarizes the changes that may be made and their documentation requirements.

Table A-3. Change Control for Sampling Projects

Type of Change[a]	Type of Change (TPA Action Plan[b])	Action	Documentation
Minor Change. Change has no impact on the sample or field analytical result, and little or no impact on performance or cost. Further, the change does not affect the DQOs specified in the SAP.	**Minor Field Change.** Changes that have no adverse effect on the technical adequacy of the job or the work schedule.	The field personnel recognizing the need for a field change will consult with the OU Project Manager or designee prior to implementing the field change.	Minor field changes will be documented in the field logbook. The logbook entry will include the field change, the reason for the field change, and the names and titles of those approving the field change.
Significant Change. Change has a considerable effect on performance or cost but still allows for meeting the DQOs specified in the SAP.	**Minor Change.** Changes to approved plans that do not affect the overall intent of the plan or schedule.	The OU Project Manager will inform the DOE-RL Project Manager and the Regulatory Lead of the change and seek concurrence at a Unit Manager's Meeting or comparable forum. LRA determines there is no need to revise the document.	Documentation of this change approval would be in the Unit Manager's Meeting minutes or comparable record such as a change notice[c].
Fundamental Change. Change has significant effect on the sample or the field analytical result, performance, or cost, and the change does not meet the requirements specified in the DQOs in the sampling document.	**Revision Necessary.** LRA determines changes to approved plans require revision to document.	If it is anticipated that a fundamental change will require the approval of the Regulatory Lead, the applicable DOE-RL Project Manager will be notified by the OU Project Manager and will be involved in the decision prior to implementation of a fundamental change. The LRA determines the change requires a revision to the document.	Formal revision of the sampling document.

a. Consistent with DOE/RL-96-68, *Hanford Analytical Services Quality Assurance Requirements Document* (HASQARD).

b. Consistent with Sections 9.3 and 12.4 of the TPA Action Plan (Ecology et al., 1989b, *Hanford Federal Facility Agreement and Consent Order Action Plan*).

c. The TPA Action Plan, Section 9.3, defines the minimum elements of a change notice.

DOE-RL = U.S. Department of Energy-Richland Operations Office

DQO = data quality objective

LRA = lead regulatory agency

OU = operable unit

SAP = sampling and analysis plan

TPA = Tri-Party Agreement

The FWS, SMR, and appropriate BTR are responsible for ensuring that field instructions are maintained and aligned with any revisions or approved changes to the SAP. SMR will ensure that any deviations from the SAP are reflected in revised paperwork for the samplers and analytical laboratory. The FWS or appropriate BTR will ensure that deviations from the SAP or problems encountered in the field are documented appropriately (e.g., in the field logbook or on nonconformance report forms) in accordance with corrective action protocols.

The OU Project Manager, FWS, or designee is responsible for communicating field corrective action requirements and ensuring that immediate corrective actions are applied to field activities.
The OU Project Manager is also responsible for ensuring that project files are maintained. The project files will contain project records or references to their storage locations. Project files may include, as appropriate, the following information:

- Operational records and logbooks
- Data forms
- Global positioning system data (a copy will be provided to SMR)
- Inspection or assessment reports and corrective action reports
- Field summary reports
- Interim progress reports
- Final reports
- Forms required by WAC 173-160, "Minimum Standards for Construction and Maintenance of Wells," and the master drilling contract

The following records are managed and maintained by SMR personnel:

- Field sampling logbooks
- Groundwater sample reports and field sample reports
- Chain-of-custody forms
- Sample receipt records
- Laboratory data packages
- Analytical data verification and validation reports
- Analytical data "case file purges" (i.e., raw data purged from laboratory files) provided by offsite analytical laboratories

The laboratory is responsible for maintaining, and having available upon request, the following items:

- Analytical logbooks
- Raw data and QC sample records
- Standard reference material and/or proficiency test sample data
- Instrument calibration information

Records may be stored in either electronic or hard copy format. Documentation and records, regardless of medium or format, are controlled in accordance with work requirements and processes to ensure that stored records are accurate and can be retrieved. Records required by the TPA (Ecology et al., 1989a) will be managed in accordance with the requirements therein.

A2.2 Data Generation and Acquisition

The following sections present the requirements for analytical methods, measurement and analysis, data collection or generation, data handling, and field and laboratory QC. Requirements for instrument calibration and maintenance, supply inspections, and data management also are addressed.

A2.2.1 Analytical Methods Requirements

Analytical method performance requirements for samples collected are presented in Table A-4. Laboratory operations and analytical services must comply with HASQARD (DOE/RL-96-68).

In consultation with the laboratory and OU Project Manager, SMR can approve changes to analytical methods as long as the new method is based upon a nationally recognized standard method (e.g., EPA and ASTM International, formerly the American Society for Testing and Materials [ASTM]), and the new method delivers analytical data that are comparable to those provided by the old method. The new method must achieve project DQOs, as well as or better than the replaced method, and is required due to the nature of the sample (e.g., high radioactivity). The laboratory using the new method must be accredited by Ecology to perform that method. Issues that may affect analytical results are resolved by SMR in coordination with the OU Project Manager.

Table A-4. Performance Requirements for Groundwater Analysis

Constituent	CAS Number	Action Level[a]	Analytical Method[b]	Highest Allowable PQL[c]	Accuracy (Percent)	Precision (Percent)
Inorganics – Metals (µg/L)						
Antimony	7440-36-0	6.0	EPA 200.8 – ICP/MS	5	80 to 120[d]	≤20[d]
Cadmium	7440-43-6	5/0.25[e]	EPA 200.8 – ICP/MS	2	80 to 120[d]	≤20[d]
Chromium (Hexavalent)	18540-29-9	10	EPA 7196	10[f]	80 to 120[d]	≤20[d]
Cobalt	7440-48-4	4.8	EPA 200.8 – ICP/MS	2.6	80 to 120[d]	≤20[d]
Inorganics – Anions (µg/L)						
Nitrate	14797-55-8	45,000	EPA 300.0	250	80 to 120[d]	≤20[d]
Organics – Volatile Organics (µg/L)						
Trichloroethene	79-01-6	4.0	EPA 8260	1	80 to 120[d]	≤20[d]
cis-1,2-dichloroethene	156-59-2	16	EPA 8260	5	80 to 120[d]	≤20[d]
Vinyl Chloride	75-01-4	0.061	EPA 8260	10[g]	80 to 120[d]	≤20[d]

Table A-4. Performance Requirements for Groundwater Analysis

Constituent	CAS Number	Action Level[a]	Analytical Method[b]	Highest Allowable PQL[c]	Accuracy (Percent)	Precision (Percent)
Radionuclides (pCi/L)						
Strontium-90	10098-97-2	8	Strontium-90 CS/GPC Laboratory Specific	2.0	80 to 120[h]	≤20[h]
Field Measurements[i]						
Dissolved Oxygen	N/A	N/A	Probe	N/A	N/A	N/A
Oxidation Reduction Potential	N/A	N/A	Probe	N/A	N/A	N/A
pH	N/A	N/A	EPA 150.1 Probe	0.1 pH unit	N/A	N/A
Specific Conductance	N/A	N/A	Probe	1 µS/cm	N/A	N/A
Temperature	N/A	N/A	Probe	N/A	N/A	N/A
Turbidity	N/A	N/A	Probe	N/A	N/A	N/A
Depth to Groundwater	N/A	N/A	Probe	N/A	N/A	N/A

a. Action level as presented in DOE/RL-2010-98, *Remedial Investigation/Feasibility Study for the 100-FR-1, 100-FR-2, 100-FR-3, 100-IU-2, and 100-IU-6 Operable Units*. Sources include the following:

40 CFR 131, "Water Quality Standards.

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

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

WAC 173-340-720(4)(b)(ii)(A) and (B), "Groundwater Cleanup Standards," "Noncarcinogens and Carcinogens."

b. Equivalent methods may be substituted. For EPA Method 200.8, see EPA-600/R-94/111, *Methods for the Determination of Metals in Environmental Samples, Supplement 1*. For EPA Methods 150.1 and 300.0, see EPA-600/4-79-020, *Methods for Chemical Analysis of Water and Wastes*. For four-digit EPA methods, see SW-846, *Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, Third Edition; Final Update IV-B*. Field measurements are carried out using various probes in accordance with manufacturer specifications and standard methods.

c. Highest allowable practical quantitation limits are specified in contracts with analytical laboratories. Actual quantitation limits vary by laboratory and may be lower. Method detection limits are three to five times lower than quantitation limits. For radionuclides, values in this column are the highest allowable minimum detectable concentrations. For a given constituent of concern nearing the end of remediation monitoring phase at a specific well, the quantitation limit may be reviewed to determine if advanced analytical capabilities are available and should be utilized to assist in confirmation of cleanup level attainment at that well.

d. The accuracy criterion shown is the minimum for associated batch laboratory control sample percent recoveries. Laboratories must meet statistically based control, if more stringent. Additional accuracy criteria include analyte-specific evaluations performed for matrix spike, and surrogate recoveries as appropriate to the method. The precision criterion shown is for batch laboratory replicate matrix spike analysis RPDs.

e. The action level for inland wells should meet the cleanup level of 5 µg/L. Wells that will be used to determine if state and federal surface water quality standards are attained should meet the ambient water quality criteria of 0.25 µg/L. The best available quantitation limit is higher than the lower action level.

Table A-4. Performance Requirements for Groundwater Analysis

Constituent	CAS Number	Action Level[a]	Analytical Method[b]	Highest Allowable PQL[c]	Accuracy (Percent)	Precision (Percent)

f. The practical quantitation limit and method detection limit for hexavalent chromium are currently 5 and 1.8 µg/L, respectively, at the primary analytical laboratory that will be used for this analysis for this sampling and analysis plan.

g. The practical quantitation limit and method detection limit for vinyl chloride are currently 2 µg/L and 0.3 µg/L, respectively, at the primary analytical laboratory that will be used for this analysis for this sampling and analysis plan.

h. For radionuclides, the accuracy criterion shown is for associated batch laboratory control sample percent recoveries. Additional accuracy criteria include analysis-specific evaluations performed for matrix spike, tracer, and/or carrier recoveries as appropriate to the method. The precision criterion shown is for batch laboratory replicate sample RPDs.

i. Field measurements have no specific quality control except to perform the manufacturer's required performance checks.

CAS = Chemical Abstracts Service

CS = chemical separation

EPA = U.S. Environmental Protection Agency

GPC = gas proportional counting

MS = mass spectrometry

N/A = not applicable

ICP = inductively coupled plasma

PQL = practical quantitation limit

RPD = relative percent difference

A2.2.2 Field Analytical Methods

Chemical field screening and radiological field survey data used for site characteristics will be measured in accordance with HASQARD (DOE/RL-96-68) approved methodology (as applicable). Field analytical methods are also carried out in accordance with manufacturer specifications and standard methods. Chapter A3 provides the parameters identified for field survey analyses.

A2.2.3 Quality Control

QC requirements specified in the SAP must be followed in the field and analytical laboratory to ensure that reliable data are obtained. Field QC samples will be collected to evaluate the potential for cross-contamination and provide information pertinent to sampling variability. Laboratory QC samples estimate the precision, bias, and matrix effects of the analytical data. Field and laboratory QC sample requirements are summarized in Table A-5. Acceptance criteria for field QC are shown in Table A-6.

Data will be qualified, and a data qualifier will be assigned in HEIS, as appropriate. Data qualifier descriptions are provided in CP-15383, *Common Requirements of the Format for Electronic Analytical Data (FEAD)*.

Table A-5. Project Quality Control Requirements

Sample Type	Frequency	Characteristics Evaluated
Field Quality Control		
Field Duplicates	1 in 20 well trips	Precision, including sampling and analytical variability
Field Splits	As needed. When needed, the minimum is one for every analytical method, for analyses performed where detection limit and precision and accuracy criteria have been defined in the Analytical Performance Requirements table (Table A-4).	Precision, including sampling, analytical, and interlaboratory
Full Trip Blanks	1 per 20 well trips	Cross-contamination from containers or transportation
Field Transfer Blanks	1 per 20 well trips when VOCs are sampled	VOC contamination from sampling site
Equipment Blanks	As needed. If only disposable equipment is used or equipment is dedicated to a particular well, then an equipment blank is not required. Otherwise, one for every 20 samples for each media.[a,b]	Adequacy of sampling equipment decontamination and contamination from nondedicated equipment
Analytical Quality Control[c]		
Laboratory Duplicates	1 per analytical batch[d]	Laboratory Reproducibility and Precision
Matrix Spikes	1 per analytical batch[d]	Matrix Effect/Laboratory Accuracy
Post-Preparation Spike	1 per analytical batch[d]	Matrix Effect/Laboratory Accuracy
Matrix Spike Duplicates	1 per analytical batch[d]	Laboratory Reproducibility and Precision
Laboratory Control Samples	1 per analytical batch[d]	Evaluate Laboratory Accuracy
Method Blanks	1 per analytical batch[d]	Laboratory Contamination
Surrogates	1 per analytical batch[d]	Recovery/Yield
Tracers	1 per analytical batch[d]	Recovery/Yield

a. For portable pumps, an equipment blank is collected for every 10 well trips. Whenever a new type of nondedicated equipment is used, an equipment blank will be collected every time sampling occurs until it can be shown that less frequent collection of equipment blanks is adequate to monitor the decontamination methods for nondedicated equipment.

b. Vendor provided borehole equipment is considered dedicated equipment, and equipment blanks are not typically performed.

c. Batching across projects is allowed for similar matrices (e.g., all Hanford groundwater).

d. Unless not required by, or different frequency is called out in, laboratory analysis methods.

VOC = volatile organic compound

Table A-6. Field and Laboratory Quality Control Elements and Acceptance Criteria

Analysis	Quality Control Element	Acceptance Criteria	Corrective Action
General Chemical Parameters			
Hexavalent Chromium	MB	< MDL < 5% Sample Concentration	Flagged with "C"
	LCS	80 to 120% Recovery[a]	Data Reviewed[b]
	Laboratory Matrix Duplicate or MS/MSD	≤ 20% RPD	Data Reviewed[b]
	MS[b]	75 to 125% Recovery[a]	Flagged with "N"
	EB	< 2 Times MDL	Flagged with "Q"
	DUP	≤ 20% RPD[c]	Flagged with "Q"
Anions			
Anions by IC	MB	< MDL < 5% Sample Concentration	Flagged with "C"
	LCS	80 to 120% Recovery[a]	Data Reviewed[b]
	Laboratory Matrix Duplicate or MS/MSD	≤ 20% RPD	Data Reviewed[b]
	MS	75 to 125% Recovery[a]	Flagged with "N"
	EB, FTB	< 2 Times MDL	Flagged with "Q"
	DUP	≤ 20% RPD[c]	Flagged with "Q"
Metals			
Metals by ICP or ICP/MS	MB	< Required Detection Limit < 5% Sample Concentration	Flagged with "C"
	LCS	80 to 120% Recovery[a]	Data reviewed [b]
	MS	75 to 125% Recovery[a]	Flagged with "N"
	MSD	75 to 125% Recovery[a]	Flagged with "N"
	MS/MSD	≤ 20% RPD	Data Reviewed[b]
	EB, FTB	< 2 Times MDL	Flagged with "Q"
	DUP	≤ 20% RPD[c]	Flagged with "Q"
Volatile Organic Compounds			
Volatiles by GC/MS	MB	< MDL[d] < 5% Sample Concentration	Flagged with "B"
	LCS	Statistically Derived[c]	Data Reviewed[b]
	MS	% Recovery Statistically Derived[c]	Flagged with "T" if analyzed by GC/MS, otherwise "N" based on FEAD

Table A-6. Field and Laboratory Quality Control Elements and Acceptance Criteria

Analysis	Quality Control Element	Acceptance Criteria	Corrective Action
	MSD	% Recovery Statistically Derived[c]	Flagged with "T" if analyzed by GC/MS, otherwise "N" based on FEAD
	MS/MSD	%RPD Statistically Derived[c]	Data reviewed[b]
	SUR	Statistically Derived[c]	Data reviewed[b]
	EB, FTB, FXR	<2 Times MDL[d]	Flagged with "Q"
	DUP	≤20% RPD[c]	Flagged with "Q"
Radiochemical Analyses			
Strontium-90	MB	<MDA <5% Sample Concentration	Flagged with "B"
	LCS	70 to 130% Recovery	Data Reviewed[b]
	MS	60 to 140% Recovery	Flagged with "N"
	Tracer (Where Applicable)	20 to 105% Recovery	Data Reviewed[b]
	Carrier (Where Applicable)	30 to 105% Recovery	Data Reviewed[b]
	EB, FTB	<2 Times MDA	Flagged with "Q"
	DUP	≤20% RPD[c]	Flagged with "Q"

a. Determined by the laboratory based on historical data or statistically-derived control limits. Limits are reported with the data. Where specific acceptance criteria are listed, those acceptance criteria may be used in place of statistically derived acceptance criteria.

b. After review, corrective actions are determined on a case-by-case basis.

c. Applies only in cases where both results are greater than 5 times the minimum detectable concentration.

d. For common laboratory contaminants, such as acetone, methylene chloride, 2-butanone, toluene, and phthalate esters, the acceptance criteria is <5 times the MDL.

DUP = field duplicate
EB = equipment blank
FEAD = Format for Electronic Analytical Data
FTB = full trip blank
FXR = field transfer blank
GC/MS = gas chromatography/mass spectrometry
IC = ion chromatography
ICP = inductively coupled plasma
ICP/MS = inductively coupled plasma/mass spectrometry
LCS = laboratory control sample
MB = method blank
MDA = minimum detectable activity
MDL = method detection limit
MS = matrix spike
MSD = matrix spike duplicate
RPD = relative percent difference
SUR = surrogate

Data Flags:

B (organics)/C (inorganics/wetchem) = Analyte was detected in both the associated quality control blank and the sample
N = All except GC/MS – matrix spike outlier
Q = Associated quality control sample is out of limits
T = Volatile organic analyte and semivolatile organic analyte GC/MS – matrix spike outlier

A2.2.3.1 Field Quality Control Samples

Field QC samples are collected to evaluate the potential for cross-contamination and provide information pertinent to field sampling variability and laboratory performance to help ensure reliable data are obtained. Field QC samples include field duplicates (DUPs), split samples, and three types of field blanks (full trip blanks [FTBs], field transfer blanks [FXRs], and equipment blanks [EBs]). Field blanks are typically prepared using high-purity reagent water. QC sample definitions and their required frequency for collection are described in this section.

Field Duplicates (DUPs): independent samples collected as close as possible to the same time and same location as the schedule sample, and are intended to be identical. DUPs are placed in separate sample containers and analyzed independently. DUPs are used to determine precision for both sampling and laboratory measurements.

Field Splits (SPLITs): two samples collected as close as possible to the same time and same location that are intended to be identical. SPLITs will be stored in separate containers and analyzed by different laboratories for the same analytes. SPLITs are inter-laboratory comparison samples used to evaluate comparability between laboratories.

Full Trip Blanks (FTBs): bottles prepared by the sampling team prior to traveling to the sampling site. The preserved bottle set is either for volatile organic analysis only or identical to the set that will be collected in the field. It is filled with high-purity reagent water (or dead water from Well 699-S11-E12AP for low-level tritium FTBs[1]), and the bottles are sealed and transported, unopened, to the field in the same storage containers used for samples collected that day. Collected FTBs are typically analyzed for the same constituents as the samples from the associated sampling event. FTBs are used to evaluate potential contamination of the samples attributable to the sample bottles, preservative, handling, storage, and transportation.

Field Transfer Blanks (FXR): filled at the sampling site by pouring reagent water from a cleaned glass container into volatile organic compound (VOC) sample vials pre-loaded with any required preservative. After collection, the FXR is treated in the same manner as the other samples collected during the sampling event. One FXR is collected each day groundwater samples are collected for VOCs. If the VOC samples collected on a given day will be shipped to multiple laboratories, then an FXR is collected for each laboratory for that day. FXRs are used to check for VOC contamination associated with sampling activities.

Equipment Blanks (EBs): reagent water passed through or poured over the decontaminated sampling equipment identical to the sample set collected and placed in sample containers, as identified on the SAF. EB sample bottles are placed in the same storage containers with the samples from the associated sampling event. EB samples will be analyzed for the same constituents as the samples from the associated sampling event. EBs are used to evaluate the effectiveness of the decontamination process. EBs are not required for disposable sampling equipment.

A2.2.3.2 Laboratory Quality Control Samples

Internal QA/QC programs are maintained by the laboratories used by the project. Laboratory QA includes a comprehensive QC program that includes the use of matrix spikes (MSs), matrix duplicates, matrix spike duplicates (MSDs), laboratory control samples (LCSs), surrogates (SURs), tracers, and method blanks (MBs). These samples are recommended in the guidance documents and are required by

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[1] Because of the low detection levels achieved in the low-level tritium analysis, special low-level tritium water must be used. This low-level tritium water, known as "dead water," is collected yearly, or as needed, from Well 699-S11-E12AP or other approved source.

EP-600/4-79-20, *Methods for Chemical Analysis of Water and Wastes*. QC checks outside of control limits are documented in analytical laboratory reports during DQAs. Laboratory QC and their typical frequencies are listed in Table A-5. Acceptance criteria are shown in Table A-6. The following text describes the various laboratory QC samples.

Sample Duplicate: an intralaboratory replicate sample that is used to evaluate the precision of a method in a given sample matrix.

Matrix Spike: an aliquot of a sample spiked with a known concentration of target analyte(s). MS is used to assess the bias of a method in a given sample matrix. Spiking occurs prior to sample preparation and analysis.

Post-preparation Spike: the same as an MS; however, the spiking occurs after sample preparation.

Matrix Spike Duplicate: a replicate spiked aliquot of a sample that is subjected to the entire sample preparation and analytical process. MSD results are used to determine the bias and precision of a method in a given sample matrix.

Laboratory Control Sample: a control matrix (e.g., reagent water) spiked with analytes representative of the target analytes or a certified reference material that is used to evaluate laboratory accuracy.

Method Blank: an analyte-free matrix to which all reagents are added in the same volumes or proportions as used in the sample processing. The MB is carried through the complete sample preparations and analytical procedure and is used to quantify contamination resulting from the analytical process.

Surrogate: a compound added to all samples in the analysis batch (field samples and QC samples) prior to preparation. SURs are typically similar in chemical composition to the analyte being determined, yet is not normally encountered. SURs are expected to respond to the preparation and measurement systems in a manner similar to the analytes of interest. Because SURs are added to all standards, samples, and QC samples, they are used to evaluate overall method performance in a given matrix. SURs are used only in organic analyses.

Tracer: a known quantity of radioactive isotope that is different from that of the isotope of interest but is expected to behave similarly and is added to an aliquot of sample. Sample results are generally corrected based on tracer recovery.

Sample Storage Blanks: will be used as appropriate. Storage blanks are used to monitor potential cross-contamination of samples due to improper storage conditions. This type of monitoring should be described in laboratory-specific standard operating procedures.

The laboratories are required to analyze samples within the holding time specified in Table A-7. In some instances, constituents in the samples not analyzed within the holding times may be compromised by volatilizing, decomposing, or other chemical changes. Data from samples analyzed outside the holding times are flagged in the HEIS database with an "H."

Table A-7. Sample Container, Preservation, and Holding Time Guidelines for Groundwater Samples by Analytical Method

Method Name	Number of Bottles	Bottle Type	Volume (mL)	Preservation Requirement	Holding Time
Metals by EPA 200.8 – ICP/MS	1	G/P	500	Nitric Acid to pH <2	6 Months (Mercury – 28 Days)
Anions by EPA 300.0	1	G/P	500	Cool ≤6°C	28 Days/ 48 Hours
Hexavalent Chromium by EPA 7196	1	aG	500	Cool ≤6°C	24 Hours
VOCs by EPA 8260	4	aG Volatile Organic Analysis Vial with Teflon® Lined Septum	40	Cool ≤6°C, Hydrochloric Acid to pH <2	14 Days
Strontium-90 CS/GPC	1	G/P	1,000	Nitric Acid to pH <2	6 Months

Sources: For EPA Method 200.8, see EPA-600/R-94/111, *Methods for the Determination of Metals in Environmental Samples, Supplement 1*.

For EPA Method 300.0, see EPA-600/4-79-020, *Methods for Chemical Analysis of Water and Wastes*.

For four-digit EPA methods, see SW-846, *Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, 3rd Edition; Final Update IV-B*.

Note: Teflon is a registered trademark of E.I. du Pont de Nemours and Company, Wilmington, Delaware.

aG = amber glass
CS = chemical separation
EPA = U.S. Environmental Protection Agency
G = glass
GPC = gas proportional counting
ICP/MS = inductively coupled plasma/mass spectrometry
P = plastic

A2.2.4 Measurement Equipment

Each user of the measuring equipment is responsible to ensure that equipment is functioning as expected, properly handled, and properly calibrated at required frequencies in accordance with methods governing control of the measuring equipment. Onsite environmental instrument testing, inspection, calibration, and maintenance will be recorded in accordance with approved methods. Field screening instruments will be used, maintained, and calibrated in accordance with manufacturer specifications and other approved methods.

A2.2.5 Instrument and Equipment Testing, Inspection, and Maintenance

Collection, measurement, and testing equipment should meet applicable standards (e.g., ASTM) or have been evaluated as acceptable and valid in accordance with instrument-specific methods, requirements, and specifications. Software applications will be acceptance tested prior to use in the field.

Measurement and testing equipment used in the field or in the laboratory will be subject to preventive maintenance measures to ensure minimization of downtime. Laboratories must maintain and calibrate their equipment. Maintenance requirements (e.g., documentation of routine maintenance) will be included

in the individual laboratory and onsite organization's QA plan or operating protocols, as appropriate. Maintenance of laboratory instruments will be performed in a manner consistent with maintenance requirements specified in HASQARD (DOE/RL-96-68) and applicable Hanford Site requirements.

A2.2.6 Instrument/Equipment Calibration and Frequency

Specific field equipment calibration information is provided in Section A3.5. Analytical laboratory instruments are calibrated in accordance with the laboratory's QA plan and HASQARD (DOE/RL-96-68).

A2.2.7 Inspection/Acceptance of Supplies and Consumables

Consumables, supplies, and reagents will be reviewed in accordance with SW-846, *Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, Third Edition; Final Update IV-B*, requirements and will be appropriate for their use. Supplies and consumables used in support of sampling and analysis activities are procured in accordance with internal work requirements and processes. Responsibilities and interfaces necessary to ensure that items procured/acquired for the contractor meet the specific technical and quality requirements must be in place. The procurement system ensures that purchased items comply with applicable procurement specifications. Supplies and consumables are checked and accepted by users prior to use.

A2.2.8 Nondirect Measurements

Data obtained from sources such as computer databases, programs, literature files, and historical databases will be technically reviewed to the same extent as the data generated as part of any sampling and analysis QA/QC effort. All data used in evaluations will be identified by source.

A2.2.9 Data Management

The SMR organization, in coordination with the OU Project Manager, is responsible for ensuring that analytical data are appropriately reviewed, managed, and stored in accordance with the applicable programmatic requirements governing data management methods.

Electronic data access, when appropriate, will be through a Hanford Site database (e.g., HEIS) or a project-specific database, whichever is applicable for the data being stored. Where electronic data are not available, hard copies will be provided in accordance with Section 9.6 of the TPA Action Plan (Ecology et al., 1989b).

Laboratory errors are reported to the SMR organization on a routine basis. For reported laboratory errors, a sample issue resolution form will be initiated in accordance with applicable methods. This process is used to document analytical errors and establish their resolution with the OU Project Manager. The sample issue resolution forms become a permanent part of the analytical data package for records and future reference.

A2.3 Assessment and Oversight

Assessment and oversight activities address the effectiveness of project implementation and associated QA/QC activities. The purpose of assessment is to ensure that the QAPjP is implemented as prescribed.

A2.3.1 Assessments and Response Actions

Random surveillances and assessments verify compliance with the requirements outlined in this SAP, OU-specific addenda, project field instructions, the project quality management plan, methods, and regulatory requirements. Deficiencies identified by these assessments will be reported in accordance with existing programmatic requirements. The project's line management chain coordinates the corrective actions/deficiencies resolutions in accordance with the QA program, corrective action management

program, and associated methods implementing these programs. When appropriate, corrective actions will be taken by the OU Project Manager (or designee).

Oversight activities in the analytical laboratories, including corrective action management, are conducted in accordance with the laboratories' QA plans. The contractor oversees offsite analytical laboratories and verifies that laboratories are qualified to perform Hanford Site analytical work.

A2.3.2 Reports to Management

Management will be made aware of deficiencies identified by self-assessments, corrective actions from ECOs, and findings from QA assessments and surveillances. Issues reported by laboratories are communicated to the SMR organization, which then initiates a sample issue resolution form. This process is used to document analytical or sample issues and establish resolution with the OU Project Manager.

A2.4 Data Review and Usability

This section addresses the QA activities that occur after data collection. Implementation of these activities determines whether the data conform to the specified criteria, thus satisfying the project objectives.

A2.4.1 Data Review and Verification

Data review and verification are performed to confirm that sampling and chain-of-custody documentation are complete. This review includes linking sample numbers to specific sampling locations, reviewing sample collection dates and sample preparation and analysis dates to assess whether holding times have been met, and reviewing QC data to determine whether analyses have met the data quality requirements specified in this SAP.

The criteria for verification include, but are not limited to, review for contractual compliance (samples were analyzed as requested), use of the correct analytical method, transcription errors, correct application of dilution factors, appropriate reporting of dry weight versus wet weight, and correct application of conversion factors.

Errors identified by the laboratories are reported to the SMR organization's project coordinator, who initiates a sample issue resolution form. This process is used to document analytical errors and establish resolution with the OU Technical Lead.

Relative to analytical data in sample media, field screening results are of lesser importance in making inferences regarding risk. Field QA/QC results will be reviewed to ensure that they are usable.

The OU Technical Lead data review will help determine if observed changes reflect improved/degraded groundwater quality or potential data errors and may submit a request for data review (RDR) on questionable data. The laboratory may be asked to check calculations, re-analyze the sample, or resample the well. Results of the RDR process are used to flag the data appropriately in the HEIS database and/or to add comments.

A2.4.2 Data Validation

Data validation activities will be performed at the discretion of the OU Project Manager and under the direction of SMR.

A2.4.3 Reconciliation with User Requirements

The DQA process compares completed field sampling activities to those proposed in corresponding sampling documents and provides an evaluation of the resulting data. The purpose of the DQA is to determine whether quantitative data are of the correct type and are of adequate quality and quantity to

meet the project DQOs. For routine groundwater monitoring undertaken through this SAP, the DQA is captured in QC associated with the annual groundwater report (e.g., DOE/RL-2014-32, *Hanford Site Groundwater Monitoring Report for 2013*), evaluating field and lab QC, and usability of data. Further DQAs will be performed at the discretion of the OU Project Manager and documented in a report overseen by SMR.

A3 Field Sampling Plan

This chapter lists the groundwater wells and aquifer tubes to be monitored, sampling frequency, and constituents to be analyzed.

The data will be evaluated as described in Chapter 6 of the Groundwater Addendum.

A3.1 Sampling Objectives

The primary objective of groundwater sampling in the 100-FR-3 OU is to monitor the natural attenuation of groundwater COCs in accordance with the data requirements identified in the DQO report (SGW-58291). Monitoring results will be used to assess the effectiveness of natural attenuation in meeting cleanup levels. Contaminants in groundwater in 100-FR-3 OU that will be managed through MNA are nitrate, Cr(VI), TCE, and strontium-90. Monitoring for TCE degradation products (*cis*-1,2-dichloroethene and vinyl chloride) will also be performed.

Due to analytical uncertainties identified in the 100-F/IU RI/FS (DOE/RL-2010-98), an investigation of antimony, cadmium, and cobalt was identified in the DQO report (SGW-58291) to determine if these analytes are present below the action level. Sampling for these metals will be performed using an analytical method with a sufficiently low detection limit.

These objectives are accomplished in the field by sampling groundwater at designated wells, aquifer tubes, and a riverbank seep and analyzing the samples for the COCs and other identified analytes.

A3.2 Sample Location, Frequency, and Constituents to be Monitored

The DQO process was used to identify sample locations, frequencies for collection, and constituents for monitoring. Problem statements were used to identify PSQs that can be answered using data inputs to satisfy specific data needs. PSQs are discussed in Section A3.2.1 and in the DQO report. (SGW-58291). The locations of the 100-FR-3 OU monitoring network, including wells, aquifer tubes, and a seep, are presented in Figures A-16 and A-17.

Based on the DQO (SGW-58291), eight locations were identified for installation of new Phase 1 monitoring wells. Details on the installation of the wells are presented in Section A3.2.2. The sample locations, frequency, and constituents to be monitored are identified in Table A-8. Additional samples may be collected on an as needed basis.

A3.2.1 Principal Study Questions

The following subsections present a brief summary of the criteria that were used in the DQO process for each PSQ, with the results of the DQO selection process identified in Table A-8. Groundwater data will be used to evaluate the PSQs, as described in Chapter 6 of the Groundwater Addendum.

A3.2.1.1 PSQ 1: Is natural attenuation of Cr(VI), nitrate, TCE, and strontium-90 in groundwater occurring as expected?

PSQ 1a: Are contaminant concentrations and plume area/mass decreasing?

PSQ 1b: Are rates of decline consistent with expectations?

PSQ 1c: Are there changes in environmental conditions that may reduce the efficacy of natural attenuation?

PSQ 1d: Are there unacceptable impacts to the Columbia River?

and

PSQ 1e: Is there evidence of new or continuing releases of contaminants to the environment that could impact the effectiveness of the natural attenuation remedy?

To address PSQ 1a and 1b, monitoring wells (as well as aquifer tubes and the seep) were selected based on locations relative to the contaminant plumes, proximity to the Columbia River, distance between wells, and review of historical and recent sampling results. New wells are in locations that will refine interpretations of contaminant distribution, thereby improving estimates of plume size and shrinkage.

Environmental conditions that might affect the efficacy of MNA (PSQ 1c) include groundwater flow direction and rate and general chemistry of groundwater. To address PSQ 1c, water levels will be measured in a robust network of wells; pH and dissolved oxygen will be monitored.

Sampling of aquifer tubes and the seep primarily addresses PSQ 1d. Aquifer tubes identified for sampling were selected based on location relative to the contaminant plumes and a review of historical and recent sampling results. Aquifer tubes are screened 5.2 to 8.8 m (17 to 29 ft) below ground surface and do not represent discharge to the river. However, along with near-river monitoring wells, they provide data on contaminant concentrations closest to the river. Seeps are natural features that represent discharge to the river.

Contaminant sources were removed during previous remedial action. Monitoring wells in the 100-F Area would detect any unanticipated releases from remaining sources (PSQ 1e).

Sampling will be scheduled with consideration for high and low river stages, which affect water table elevation and hydraulic gradients. Annual and biennial sampling will be scheduled for September through November (low river stage). Wells scheduled semiannually will have an additional sample collected in May through early July (high river stage). Quarterly wells will have two additional sample events scheduled between high and low stage periods. Sampling events will be scheduled to collect at all the sample locations within a relatively short time period so a representative point in time is collected for the entire area. Sampling will be scheduled for the same time each year to attempt to enhance year-to-year comparability of results.

The analytical methods meet desired cleanup levels for the four COCs (Table A-4). Cr(VI) samples will be filtered to eliminate interference in the analysis.

A3.2.1.2 PSQ 2: Are concentrations of antimony, cadmium, and cobalt below action levels?

Monitoring locations for sampling analytes identified for further quantitation were identified based on previous detections and spatial distribution of wells. These constituents will be analyzed using methods with detection limits below action levels, where available (Table A-4). Samples will be collected during the first 10 years of performance monitoring until sufficient data are obtained for evaluation (8 samples). The results will be used to determine if a risk assessment should be performed for these analytes.

Section 7.1.12 of the DQO report (SGW-58291) explains the rationale for selection of wells for trace metals analyses.

A3.2.1.3 PSQ 3: Do new geologic and hydrogeologic data confirm the conceptual site model?

Geologic interpretation of the region south of 100-F Area will be refined, based on geophysical logging of existing wells and geologic and geophysical logging of new wells. Installation of the new wells will provide data on the elevation of geologic contacts (between Hanford and Ringold E, where present, and top of RUM) from the borehole geologic log and from borehole geophysical logging, where performed. Slug tests and/or single-well pumping tests will provide data on the transmissivity of the unconfined aquifer. Water level measurements will provide data on the water table elevation.

Table A-8. 100-FR-3 Operable Unit Summary of Monitoring Locations, Frequencies, and Constituents

Monitoring Location	Analytes					Water Level[a]		Data Need							Sample Frequency		
	Cr(VI) (Filtered)	TCE and Degradation Products	Nitrate	Strontium-90	Trace Metals[b]	AWLN	Manual	PSQ 1a, 1b: Contamination Decreasing as expected?	PSQ 1c: Changes in environmental conditions that reduce effectiveness?	PSQ 1d: Unacceptable impacts to river?	PSQ 1e: Evidence of new contaminant releases?	PSQ 2: Trace metals below action levels?	PSQ 3: Geologic and hydrologic data confirm Conceptual Site Model?	PSQ 4a, 4b: Remediation objectives achieved?	Year 1	Year 2 to Year 5	Year 6 and Onward
Existing Monitoring Wells																	
199-F5-1			X	X			X	X	X		X			X	A, S[c]	A, S[c]	B
199-F5-4	X	X	X		X		X	X	X		X	X		X	A, S[d]	A, S[d]	B[e]
199-F5-42	X		X	X			X	X	X	X				X	A	A	B
199-F5-43A	X		X	X	X		X	X	X	X		X	X	X	A	A	B[e]
199-F5-44	X		X	X			X	X	X	X				X	A	A	B
199-F5-45	X	X	X				X	X	X		X		X	X	A	A	B
199-F5-46	X	X	X	X			X	X	X		X			X	S	S	B
199-F5-47	X		X	X			X	X	X		X			X	A	A	B
199-F5-48	X	X	X		X		X	X	X		X	X		X	A	A	B[e]
199-F5-52	X		X			X	X	X	X	X	X		X	X	A	A	B
199-F5-54	X		X	X			X	X	X		X			X	A	A	B
199-F5-55	X		X	X			X	X	X		X			X	A, S[c]	A, S[c]	B
199-F5-56	X	X	X	X			X	X	X		X			X	A	A	B
199-F5-6	X		X	X			X	X	X	X	X			X	A, S[f]	A, S[f]	B
199-F6-1	X		X	X		X	X	X	X	X	X		X	X	A	A	B
199-F7-1		X	X			X	X	X	X		X		X	X	A	A	B
199-F7-2		X	X			X	X	X	X		X		X	X	A	A	B
199-F7-3		X	X				X	X	X		X			X	A	A	B
199-F8-2	X			X			X	X	X		X			X	A	A	B
199-F8-4			X			X	X	X	X				X	X	A	A	B
199-F8-7		X	X	X	X		X	X	X		X	X		X	A	A	B[e]
699-58-24							X		X						A[g]	A[g]	B[g]
699-59-32[h]			X			X	X	X	X				X	X	A	A	B

Table A-8. 100-FR-3 Operable Unit Summary of Monitoring Locations, Frequencies, and Constituents

Monitoring Location	Analytes					Water Level[a]		Data Need							Sample Frequency		
	Cr(VI) (Filtered)	TCE and Degradation Products	Nitrate	Strontium-90	Trace Metals[b]	AWLN	Manual	PSQ 1a, 1b: Contamination Decreasing as expected?	PSQ 1c: Changes in environmental conditions that reduce effectiveness?	PSQ 1d: Unacceptable impacts to river?	PSQ 1e: Evidence of new contaminant releases?	PSQ 2: Trace metals below action levels?	PSQ 3: Geologic and hydrologic data confirm Conceptual Site Model?	PSQ 4a, 4b: Remediation objectives achieved?	Year 1	Year 2 to Year 5	Year 6 and Onward
699-60-32[h]			X			X	X	X	X				X	X	A	A	B
699-61-37						X	X						X		A[g]	A[g]	B[g]
699-62-31			X				X	X	X				X	X	A	A	B
699-63-25A			X				X	X	X				X	X	A	A	B
699-64-27			X			X	X	X	X				X	X	A	A	B
699-66-23			X			X	X	X	X	X			X	X	A	A	B
699-70-23						X	X		X				X		A[g]	A[g]	B[g]
699-71-30		X	X			X	X	X	X				X	X	A	A	B
699-74-44							X		X				X		A[g]	A[g]	B[g]
699-77-36		X	X			X	X	X	X				X	X	A	A	B
New Monitoring Wells (Phase 1)																	
C9472		X	X				X	X	X				X	X	Q	A	B
C9474			X			X	X	X	X	X			X	X	Q	A	B
C9475		X	X			X	X	X	X				X	X	Q	A	B
C9476		X	X			X	X	X	X				X	X	Q	A	B
C9477			X			X	X	X	X	X			X	X	Q	A	B
C9478			X			X	X	X	X				X	X	Q	A	B
C9479			X			X	X	X	X				X	X	Q	A	B
C9480			X			X	X	X	X	X			X	X	Q	A	B

Table A-8. 100-FR-3 Operable Unit Summary of Monitoring Locations, Frequencies, and Constituents

Monitoring Location	Analytes					Water Level[a]		Data Need							Sample Frequency		
	Cr(VI) (Filtered)	TCE and Degradation Products	Nitrate	Strontium-90	Trace Metals[b]	AWLN	Manual	PSQ 1a, 1b: Contamination Decreasing as expected?	PSQ 1c: Changes in environmental conditions that reduce effectiveness?	PSQ 1d: Unacceptable impacts to river?	PSQ 1e: Evidence of new contaminant releases?	PSQ 2: Trace metals below action levels?	PSQ 3: Geologic and hydrologic data confirm Conceptual Site Model?	PSQ 4a, 4b: Remediation objectives achieved?	Year 1	Year 2 to Year 5	Year 6 and Onward
Aquifer Tubes																	
64-M	X		X	X				X		X					A	A	B
C6302	X		X	X				X		X					A	A	B
C6303	X		X					X		X					A	A	B
C6306	X		X	X				X		X					A	A	B
C6309	X		X	X				X		X					A	A	B
C6315	X		X	X				X		X					A	A	B
Riverbank Seep																	
Seep 187-1	X		X					X		X					A	A	B
River Gauge																	
100-F River Gauge						X			X	X			X				

a. Manual water level measurements will be obtained at low, high, and moderate river stage during sample years for the first 10 years of performance monitoring. For wells identified for only manual water level measurements, measurements will be taken each year for the first 5 years, and biennially thereafter. Manual water level measurements will not be obtained from wells within the AWLN during the operational period.

b. Trace metals include antimony, cadmium, and cobalt. These analytes are included for samples collected only during the first 10 years of monitoring until sufficient data are obtained for evaluation (eight samples).

c. Semiannual sample frequency will be performed for strontium-90. Other analytes are sampled at an annual frequency.

d. Semiannual sample frequency will be performed for Cr(VI), TCE, and nitrate. Trace metals sampled at an annual frequency.

e. Antimony, cadmium, and cobalt are not included for analysis after year 10.

f. Semiannual sample frequency will be performed for Cr(VI). Other analytes sampled at an annual frequency.

g. Water level measurements only.

h. Only one of Wells 699-59-32 and 699-60-32 will be included in the monitoring network. The decision of which well to be included will be based on well investigation results.

A = annual
B = biennial
AWLN = automated water level network
Cr(VI) = hexavalent chromium
PSQ = principal study question
S = semiannual
TCE = trichloroethene

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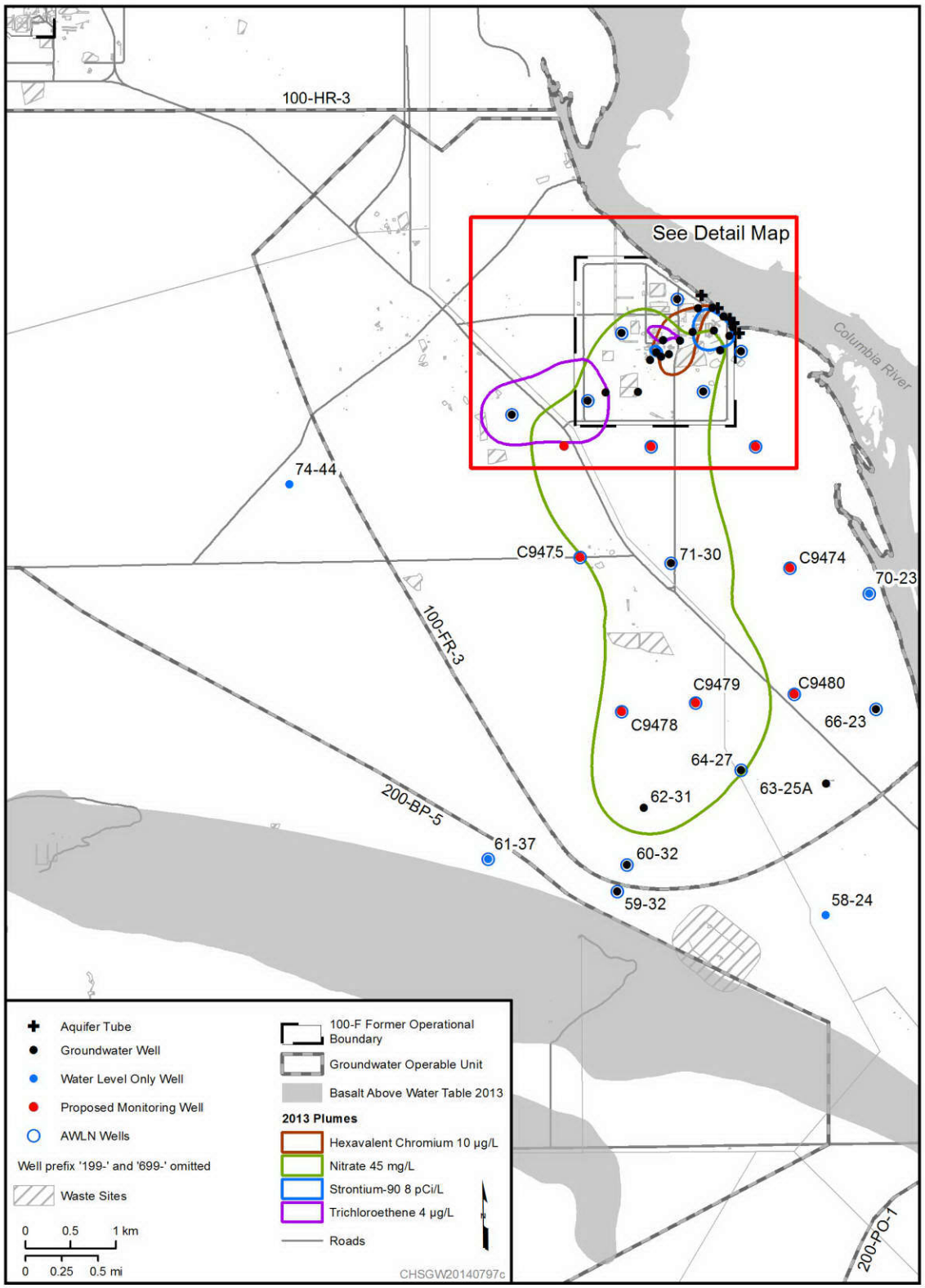

Note: Either Well 59-32 or 60-32 will be included in the network depending on field investigation results.

Figure A-16. 100-FR-3 Operable Unit Performance Monitoring Network

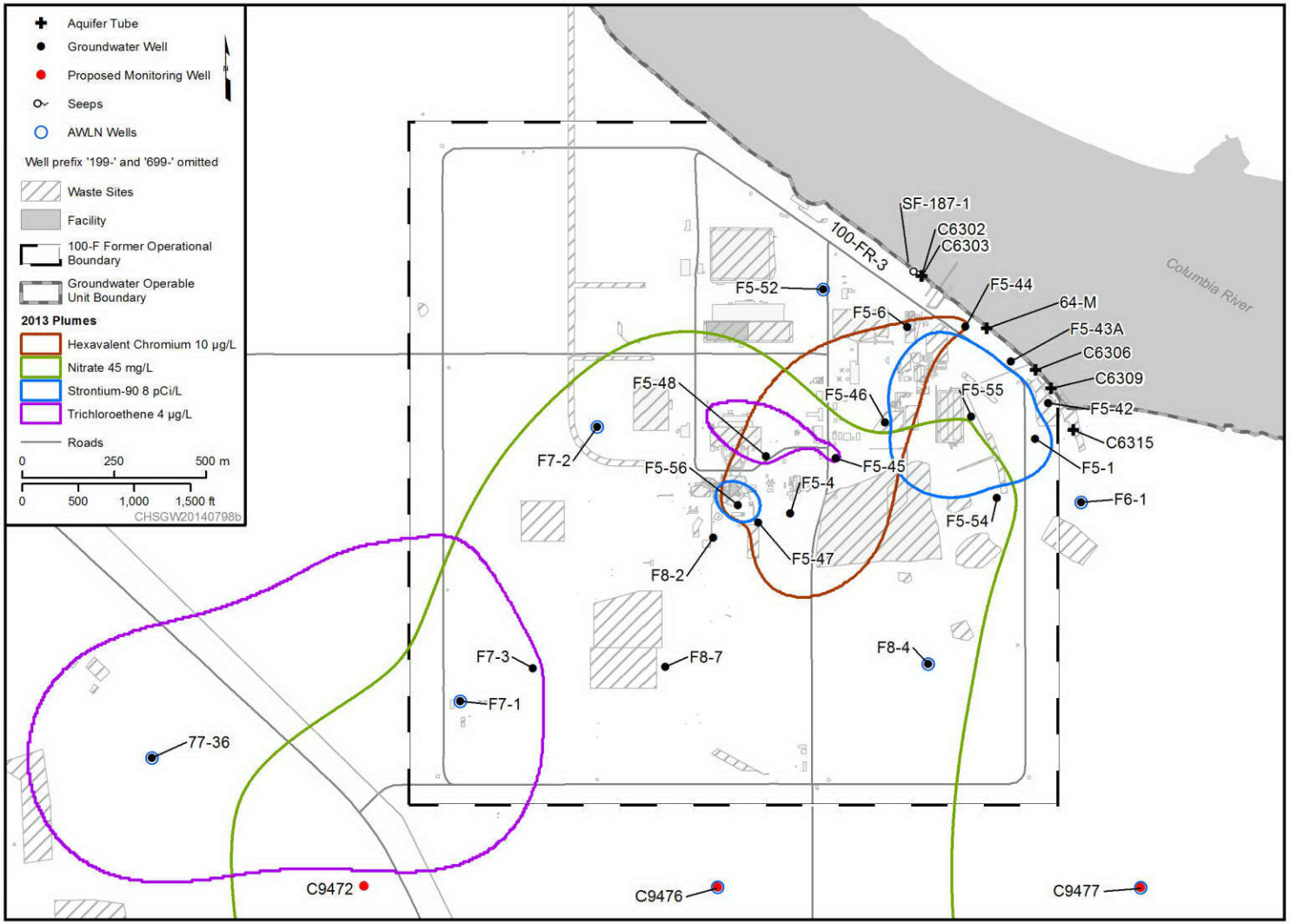

Figure A-17. Detail Map of 100-FR-3 Operable Unit Performance Monitoring Network near 100-F Area

The 100-F river gauge station and 19 monitoring wells were identified for creating the AWLN for the first 5 years of monitoring. AWLN measurements will be recorded hourly. The need for continuation of the AWLN will be evaluated as part of the 5-year performance reports.

Groundwater levels are measured annually in March across the Hanford Site to construct water table maps that are used to determine the direction and rate of groundwater flow in the unconfined aquifer (SGW-38815, *Water-Level Monitoring Plan for the Hanford Site Soil and Groundwater Remediation Project*). In addition to the March water table map, at a minimum, the high and low river stage maps will be provided in the Phase 1 well report and the comprehensive 5-year performance monitoring reports for as long as the AWLN remains active.

Groundwater measurements also will be recorded at monitoring locations concurrent with collection of groundwater samples.

A3.2.1.4 PSQ 4: Have RAOs been achieved?

PSQ 4a: Are concentrations of COCs below cleanup levels?

PSQ 4b. Will groundwater continue to meet the cleanup levels in the future?

Performance monitoring of the 100-FR-3 OU will produce data usable for determining if groundwater RAOs have been achieved. The following groundwater specific RAOs are identified in the 100-F/IU ROD (EPA and DOE, 2014):

RAO 1: Prevent unacceptable risk to human health from ingestion of and incidental exposure to groundwater containing contaminant concentrations above federal and state standards and risk-based thresholds.

RAO 2: Prevent unacceptable risk to human health and ecological receptors from groundwater discharges to surface water containing contaminant concentrations above federal and state standards and risk-based thresholds.

RAO 7: Restore groundwater impacted from 100-FR-1, 100-FR-2, 100-IU-2, and 100-IU-6 releases to proposed cleanup levels, which include DWSs, within a time frame that is reasonable given the particular circumstances of the site.

Only data from monitoring wells will be used in calculations and evaluation of compliance with cleanup levels. Results from aquifer tubes and the seep will be used to determine changes in plume size and, in the case of aquifer tubes, assess COC concentrations nearest the surface water.

A3.2.2 New Groundwater Monitoring Well Installation

The first phase of new wells to support performance monitoring includes eight locations. Approximate coordinates for the new well locations are presented in Table A-9. Field walk downs of the identified locations will be performed prior to drilling. These locations may require adjustment based on accessibility or results of ecological/cultural reviews. Well locations may also require change if the aquifer is not present at the drilling location. If the new location is more than 100 m (330 ft) from the original location, EPA and DOE will be consulted for concurrence prior to drilling.

During drilling, a well site geologist will collect drill cutting samples for archive approximately every 1.5 m (5 ft) and complete geologic logs according to project procedures. Samples from the desired screen depth will be collected for sieve analyses. No other soil or water samples are required during drilling. When the boreholes reach total depth, project staff will determine whether borehole geophysical logging is needed.

After wells are completed and developed, project staff will determine whether slug tests and/or single-well pumping tests will be performed to characterize hydraulic conductivity.

Additional Phase 2 monitoring wells may be identified based on evaluation of results from the Phase 1 well samples. Phase 2 wells will be constructed using the same instruction as the Phase 1 wells.

A3.2.2.1 Well Depth and Screen Placement

Each new well will be drilled approximately 3 m (10 ft) into the RUM unit to facilitate geologic and geophysical interpretations. Estimated depths of each well are presented in Table A-9. A 6.1 m (20 ft) screen will be installed at the top of the unconfined aquifer, with approximately 1 to 1.5 m (3 to 5 ft) of screen above the water table.

A3.2.2.2 Well Drilling, Completion, and Development

Well drilling and completion will be performed in accordance with WAC 173-160. The wells will be drilled using 20 cm (8 in.) diameter (or larger) temporary casing. Each well will be constructed with 10 cm (4 in.) diameter stainless steel casing and a 6.1 m (20 ft) long, continuous wire-wrap stainless steel screen, atop a 1.0 to 1.5 m (3 to 5 ft) long stainless steel sump with end cap.

Table A-9. 100-FR-3 Operable Unit Phase 1 Monitoring Well Locations

Well Identification	Northing (m)	Easting (m)	Estimated Drill Depth (ft)*
C9472	146518.7	579424.8	46
C9474	145173.9	581917.5	49
C9475	145292.3	579601.4	23
C9476	146516.3	580385.7	33
C9477	146514.8	581538.1	43
C9478	143589.5	580059.3	76
C9479	143688.6	580874.3	43
C9480	143783.7	581960.7	62

* Estimated depth is to top of Ringold Formation upper mud unit plus 3 m (10 ft).

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, and Portland cement will be used for cement grout.

Wells will be properly developed to restore natural hydraulic properties and chemistry that may be altered by the drilling process. Development requirements will be specified in drilling contract documents.

Surface construction consisting of protective casing, protective guard posts, and cement pad must be in place before job completion.

Final well design, including screen placement and length, will be determined by concurrence of the field geologist, drilling lead, and OU lead based upon field conditions.

Following completion, well locations and elevations will be surveyed, and dedicated sampling pumps will be installed in each well.

A3.2.3 Automated Water Level Network

AWLN is the combination of equipment, hardware, and software for the measurement, collection, transmittal, storage, and management of water level data in the aquifer. Water-level data are measured by submersible pressure transducers installed in a network of monitoring locations. The data are then directly transmitted to a base station via telemetry or can be manually downloaded to portable computers.

The 100-F automated river gauge and 19 monitoring wells will comprise the AWLN for the 100-FR-3 OU (Table A-8). Twelve existing wells and seven new wells will be incorporated into the AWLN and equipped as required for the automated measurements. Two of the existing wells (699-61-37 and 699-70-23) are included in the network for the purpose of the AWLN only. For new wells, equipment necessary for automated measurements will be installed when the wells are completed. The 100-F river gauge station will also be re-established to allow safe access to the location. The AWLN may be modified based on field conditions and data needs.

The AWLN will be operated for the first 5 years of the performance monitoring period. At the end of the fifth year, the continuing need for AWLN will be evaluated. When AWLN is no longer needed, the associated equipment will be removed from the wells.

A3.2.4 Rehabilitation of Old Wells

Several existing wells that were installed prior to 1987 were identified for the monitoring network (Table A-10). Some of these wells require investigation and/or rehabilitation prior to use. Investigation of the wells will be performed with a downhole camera survey. Geophysical logging will be performed on selected wells to determine the depth of geologic contacts.

Several pre-1987 wells that extend into the RUM will require rehabilitation to isolate the unconfined aquifer. Grout will be added to the base of these wells to fill the portion of the well in the RUM. Information from the geophysical investigation will be used to determine the depth of grout needed to ensure sampling of the unconfined aquifer.

A3.3 Sampling Methods

Sampling may include, but not be limited to, the following methods:

- Field screening measurements
- Radiological screening
- Groundwater sampling
- Aquifer tube sampling
- Riverbank seep sampling
- Water level measurements

Table A-10. Pre-1987 Monitoring Wells Requiring Investigation and/or Rehabilitation

Well	Construction Year	Depth to Bottom (ft Below Top of Casing)	Camera Survey?	Geophysical Logging?	Rehabilitation?	Comment
199-F7-1	1956	60.7	Yes	No	Yes	Grout to approximately 10 m (33 ft) below ground surface to isolate unconfined aquifer
699-59-32	1971	74.8	Yes	No	No	Either 699-59-32 or 699-60-32 to be within monitoring network depending on investigation results
699-60-32	1971	83.1	Yes	Yes	No	
699-63-25A	1949	102.4	Yes	Yes	Yes	Grout to top of the RUM
699-66-23	1961	74.1	Yes	Yes	Yes	Grout to top of the RUM
699-71-30	1957	79.5	Yes	Yes	Yes	Grout to top of the RUM
699-77-36	1957	78.4	Yes	Yes	Yes	Grout to top of the RUM

RUM = Ringold Formation upper mud unit

Water samples will be collected according to the current revision of applicable operating methods. Water samples are collected after field measurements of purged groundwater have stabilized:

- pH – two consecutive measurements agree within 0.2 pH units
- Temperature – two consecutive measurements agree within 0.2ºC
- Conductivity – two consecutive measurements agree within 10 percent of each other
- Turbidity – less than 5 nephelometric turbidity units prior to sampling (or project scientist's recommendation)

For certain types of samples, preservatives are required. While the preservative may be added to collection bottles before their use in the field, it is allowable to add the preservative at the sampling vehicle immediately after collection. Samples may require filtering in the field, as noted on the chain-of-custody forms. All Cr(VI) samples will be filtered.

To ensure sample and data usability, sampling associated with this SAP will be performed according to HASQARD (DOE/RL-96-68) pertaining to sample collection, collection equipment, and sample handling.

Suggested sample container, preservation, and holding time requirements are specified in Table A-7 for groundwater samples. These requirements are in accordance with the analytical method specified. The final container type and volumes will be identified on the SAF and chain-of-custody form. This SAP defines a sample as a filled sample bottle for starting the clock for holding time restrictions.

Holding time is the elapsed period between sample collection and analysis. Exceeding required holding times could result in changes in constituent concentrations due to volatilization, decomposition, or other chemical alterations. Required holding times depend on the analytical method, as specified for appropriate EPA methods (EPA-600/4-79-020 and SW-846, *Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, Third Edition; Final Update IV-B*).

A3.3.1 Decontamination of Sampling Equipment

To prevent potential contamination of the samples, care should be taken to use decontaminated equipment for each sampling activity. Wells will be equipped with dedicated sampling pumps, and aquifer tubes are sampled with a peristaltic pump that does not contact sample water. If a nondedicated sampling pump needs to be used, it will be decontaminated in accordance with the sampling equipment decontamination methods.

Special care should be taken to avoid the following common ways in which cross-contamination or background contamination may compromise the samples:

- Improperly storing or transporting sampling equipment and sample containers
- Contaminating the equipment or sample bottles by setting the equipment/sample bottle on or near potential contamination sources (e.g., uncovered ground)
- Handling bottles or equipment with dirty hands or gloves
- Improperly decontaminating equipment before sampling or between sampling events

A3.3.2 Field Screening

Appropriate radiological and volatile organic field screening will be performed by the RCT or other qualified personnel to support drilling efforts. The RCT will record field measurements, noting the depth of the sample and the instrument reading. Measurements will be relayed to the field geologist (for boreholes and wells) for daily inclusion in the field logbook or operational records, as applicable.

The following information will be distributed to personnel performing work in support of this SAP:

- Instructions to RCTs on the methods required to measure sample activity and media for gamma, alpha, and/or beta emissions, and VOCs, as appropriate.
- Information regarding the portable radiological field instrumentation, including a physical description of the instruments, radiation and energy response characteristics, calibration/maintenance and performance testing descriptions, and the application/operation of the instrument (these instruments are commonly used on the Hanford Site to obtain measurements of removable surface contamination measurements and direct measurements of the total surface contamination)
- Instructions regarding the minimum requirements for documenting radiological controls information in accordance with 10 CFR 835, "Occupational Radiation Protection"
- Instructions for managing the identification, creation, review, approval, storage, transfer, and retrieval of radiological information
- Minimum standards and practices necessary for preparing, performing, and retaining radiological related information
- Requirements associated with preparing and transporting regulated material

- Daily reports of radiological surveys and measurements collected during conduct of field investigation activities (data will be cross-referenced between laboratory analytical data and radiation measurements to facilitate interpreting the investigation results)

A3.3.3 Water Levels (Manual)

Manual water level measurements will be obtained at periods of low, high, and moderate river stage for the first 10 years of the monitoring period at the wells identified in Table A-8. The monitoring years during which manual measurements are obtained correspond to the years in which analytical samples are obtained (three times each year for years 1 through 5 and three times every other year thereafter). Two wells (699-58-24 and 699-74-44) are identified for only manual water level measurement with no analytical sampling (Table A-8). Wells 699-61-37 and 699-70-23 are included in the AWLN and will have manual water level measures performed three times every other year at the conclusion of the AWLN period.

Groundwater levels are measured annually across the Hanford Site to construct water table maps that are used to determine the direction and rate of groundwater flow in the unconfined aquifer (SGW-38815). These measures may be used in conjunction with the water level measures prescribed by this SAP.

A measurement of depth to water also is recorded in each well prior to sampling, using calibrated depth measurement tapes. Two consecutive measurements are taken that agree within 6 mm (0.02 ft). These are recorded along with the date, time, measuring tape number, and so forth. The depth to groundwater is subtracted from the elevation of a reference point (usually the top of casing) to obtain the water level elevation. Tops of casings are known elevation reference points because they have been surveyed to local reference data.

A3.4 Documentation of Field Activities

Logbooks or data forms are required for field activities. A logbook must be identified with a unique project name and number. The individual(s) responsible for logbooks will be identified in the front of the logbook, and only authorized persons may make entries in logbooks. Logbook entries will be reviewed by the FWS, cognizant scientist/engineer, or other responsible manager; the review will be documented with a signature and date. Logbooks will be permanently bound, waterproof, and ruled with sequentially numbered pages. Pages will not be removed from logbooks for any reason. Entries will be made in indelible ink. Corrections will be made by marking through the erroneous data with a single line, entering the correct data, and initialing and dating the changes.

Data forms may be used to collect field information; however, the information recorded on data forms must follow the same requirements as those for logbooks. The data forms must be referenced in the logbooks.

A summary of information to be recorded in logbooks is as follows:

- Purpose of activity
- Day, date, time, and weather conditions
- Names, titles, and organizations of personnel present
- Deviations from the QAPjP
- All site activities, including field tests
- Materials quality documentation (e.g., certifications)

- Details of samples collected (e.g., preparation, splits, DUPs, MS, and EBs)
- Location and types of samples
- Chain-of-custody details and variances relating to chain-of-custody
- Field measurements
- Field calibrations testing, inspections, maintenance and surveys, and equipment identification numbers, as applicable
- Equipment decontaminated, number of decontaminations, and variations to decontamination methods
- Equipment failures or breakdowns and descriptions of any corrective actions
- Telephone calls relating to field activities

A3.4.1 Corrective Actions and Deviations for Sampling Activities

The OU Project Manager, FWS, appropriate BTR (or designee), and SMR personnel must document deviations from protocols, problems pertaining to sample collection, chain-of-custody forms, target analytes, contaminants, sample transport, or noncompliant monitoring. Examples of deviations include samples not collected because of field conditions, changes in sample locations because of physical obstructions, or additions of sample depth(s).

As appropriate, such deviations or problems will be documented in the field logbook or on nonconformance report forms in accordance with internal corrective action methods. The OU Project Manager, FWS, appropriate BTR (or designee), or SMR personnel will be responsible for communicating field corrective action requirements and for ensuring immediate corrective actions are applied to field activities.

Changes in sample activities that require notification, approval, and documentation will be performed as specified in Table A-3.

A3.5 Calibration of Field Equipment

Construction management, the appropriate BTR, or the FWS is responsible for ensuring that field equipment is calibrated appropriately. Onsite environmental instruments are calibrated in accordance with the manufacturer's operating instructions, internal work requirements and processes, and/or field instructions that provide direction for equipment calibration or verification of accuracy by analytical methods. The results from all instrument calibration activities are recorded according to HASQARD (DOE/RL-96-68).

Field instrumentation, calibration, and QA checks will be performed as follows:

- Prior to initial use of a field analytical measurement system
- At the frequency recommended by the manufacturer or methods, or as required by regulations
- Upon failure to meet specified QC criteria
- Calibration of radiological field instruments on the Hanford Site is performed by the MSA prime contractor, as specified by their calibration program
- Daily calibration checks that will be performed and documented for each instrument used to characterize areas under investigation (these checks will be made on standard materials sufficiently

like the matrix under consideration for direct comparison of data; analysis times will be sufficient to establish detection efficiency and resolution)

- Standards used for calibration that are traceable to nationally or internationally recognized standard agency source or measurement system, if available

A3.6 Sample Handling

Sample handling and transfer will be in accordance with established methods to preclude loss of identity, damage, deterioration, and loss of sample. Custody seals or custody tape will be used to verify that sample integrity has been maintained during sample transport. The custody seal will be inscribed with the sampler's initials and date.

A sampling and tracking database is used to track the samples from the point of collection through the laboratory analysis process.

A3.6.1 Containers

Pre-cleaned sample containers with certificates of analysis denoting compliance with EPA specifications (EPA 540/R-93/051, *Specifications and Guidance for Contaminant-Free Sample Containers*) for the intended analyses will be used for samples collected for chemical analysis. Container sizes may vary depending on laboratory-specific volumes/requirements for meeting analytical detection limits.
The Radiological Engineering organization will measure both the contamination levels and dose rates associated with the filled sample containers. This information, along with other data, will be used to select proper packaging, marking, labeling, and shipping paperwork and to verify that the sample can be received by the analytical laboratory in accordance with the laboratory's radioactivity acceptance criteria. If the dose rate on the outside of a sample container or the curie content exceeds levels acceptable by an offsite laboratory, the FWS (in consultation with the SMR organization), can send smaller volumes to the laboratory. Container types and sample amounts/volumes are identified in Table A-7.

A3.6.2 Container Labeling

Each sample container will be labeled with the following information on firmly affixed, water-resistant labels:

- SAF
- HEIS number
- Sample collection date and time
- Analysis required
- Preservation method (if applicable)
- Chain-of-custody number
- Bottle type and size
- Laboratory performing the analyses
- Sampler's name
- Sample location

In addition, sample records must include the following information:

- Analysis required
- Source of sample
- Matrix (water)

- Field data (pH, temperature, turbidity, and conductivity)
- Radiological readings

The following information may be specified by the project:

- Dissolved oxygen
- Redox potential

A3.6.3 Sample Custody

Sample custody will be maintained in accordance with existing protocols to ensure the maintenance of sample integrity throughout the analytical process. Chain-of-custody protocols will be followed throughout sample collection, transfer, analysis, and disposal to ensure sample integrity is maintained. A chain-of-custody record will be initiated in the field at the time of sampling and will accompany each set of samples shipped to any laboratory.

Shipping requirements will determine how sample shipping containers are prepared for shipment. The analyses requested for each sample will be indicated on the accompanying chain-of-custody form. Each time the responsibility for the custody of the sample changes, the new and previous custodians will sign the record and note the date and time. The sampler will make a copy of the signed record before sample shipment and will transmit the copy to the SMR organization within 48 hours of shipping.

The following information is required on a completed chain-of-custody form:

- Project name
- Signature of sampler
- Unique sample number
- Date and time of collection
- Matrix
- Preservatives
- Signatures of individual involved in sample transfer
- Requested analyses (or reference thereto)

Samplers should note any anomalies with the samples that would prevent batching. If anomalies are found, the samplers should inform SMR before adding any information regarding batching on the chain-of-custody form.

A3.6.4 Sample Transportation

All packaging and transportation instructions will comply with applicable transportation regulations and DOE requirements. Regulations for classifying, describing, packaging, marking, labeling, and transporting hazardous materials, hazardous substances, and hazardous wastes are enforced by the U.S. Department of Transportation (DOT) as described in 49 CFR 171, "Transportation," "General Information, Regulations, and Definitions," through 177, "Carriage by Public Highway." Sample shipments conveyed by air freight providers shall also comply with carrier-specific requirements defined in the International Air Transportation Association Dangerous Goods Regulations.

Samples containing hazardous constituents will be considered hazardous material in transportation and transported according to DOT 49 CFR and International Air Transportation Association requirements. If the sample material is known or can be identified, then it will be classified, described, packaged, marked, labeled, and transported according to the specific instructions for that material.

Materials are classified by DOT as radioactive when the isotope-specific activity concentration and the exempt consignment limits described in 49 CFR 173, "Shippers—General Requirements for Shipments and Packagings," are both exceeded. Samples will be screened, or relevant historical data will be used, to determine whether these values are exceeded. When screening or historical data indicate samples are radioactive, they will be properly classified, described, packaged, marked, labeled, and transported according to DOT requirements.

A4 Management of Waste

Appendix C of the Groundwater Addendum, "Waste Management Plan for the 100-FR-3 Operable Unit," provides details on the specific requirements for waste identification, characterization, segregation, packaging, labeling, storage, and inspection for waste generation activities associated with the 100-FR-3 OU performance monitoring activities.

Offsite analytical laboratories are responsible for disposal of unused sample quantities. Pursuant to 40 CFR 300.440, "National Oil and Hazardous Substances Pollution Contingency Plan," "Procedures for Planning and Implementing Off Site Response Actions," approval from the DOE Remedial Project Manager is required before returning unused samples or waste from offsite laboratories.

A5 Health and Safety

The remediation contractor's hazardous waste operations safety and health program was developed for employees involved in hazardous waste site activities. The program was developed to comply with the requirements of 29 CFR 1910.120, "Occupational Safety and Health Standards," "Hazardous Waste Operations and Emergency Response," and 10 CFR 835, to ensure the safety and health of workers during hazardous waste operations.

The health and safety program was developed in accordance with the overall remediation contractor's health and safety program to define the chemical, radiological, and physical hazards and to specify the controls and requirements for day-to-day work activities on the overall Hanford Site. It also incorporates applicable core functions and guiding principles, outlined in the Integrated Safety Management System, and governs minimal personal training, control of industrial safety and radiological hazards, PPE, site control, and general emergency response to spills, fire, accidents, injury, and incident reporting.

Access and work activities will be controlled in accordance with approved work packages, as required by established internal work requirements and processes. The health and safety plan (HASP), which addresses the health and safety hazards of each phase of site operation, includes the requirements for hazardous waste operations and/or construction activities, as specified in 29 CFR 1910.120.

Project field staff will be required to comply with the HASP at all times. Unescorted site visitors are required to read and sign the HASP before entering the construction area and must have completed the required training outlined in the HASP. Escorted visitors are briefed on health and safety concerns and must be escorted by the site superintendent (or designee) at all times when they are in the construction area.

During operations, emergency response for the 100-FR-3 OU remedial activities will be covered by the HASP. The HASP specifies primary emergency response actions for site personnel, area alarms, implementation of the emergency action plan and emergency equipment at the task site, emergency coordinators, emergency response procedures, and spill containment procedures.

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Data Quality Assessment for Appendix A

Reprint of SGW-58291, Data Quality Objectives for 100-FR-3 Monitored Natural Attenuation, Revision 0, published June 2015

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SGW-58291
Revision 0

Data Quality Objectives for 100-FR-3 Monitored Natural Attenuation

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

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

P.O. Box 1600
Richland, Washington 99352

Approved for Public Release;
Further Dissemination Unlimited

SGW-58291
Revision 0

Data Quality Objectives for 100-FR-3 Monitored Natural Attenuation

Date Published
June 2015

Prepared for the U.S. Department of Energy
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P.O. Box 1600
Richland, Washington 99352

APPROVED
By Julia Raymer at 9:38 am, Jun 15, 2015

Release Approval | Date

Approved for Public Release;
Further Dissemination Unlimited

SGW-58291
Revision 0

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Terms

COC	contaminant of concern
Cr(VI)	hexavalent chromium
CSM	conceptual site model
DOE	U.S. Department of Energy
DQO	data quality objective
EPA	U.S. Environmental Protection Agency
FS	feasibility study
HEIS	Hanford Environmental Information System
MNA	monitored natural attenuation
OU	operable unit
PSQ	principal study question
QA	quality assurance
QC	quality control
RAO	remedial action objective
RDR/RAWP	remedial design report/remedial action work plan
RI	remedial investigation
ROD	record of decision
RUM	Ringold Formation upper mud
SAP	sampling and analysis plan
TCE	trichloroethene

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Data Quality Objectives for 100-FR-3 Monitored Natural Attenuation

The 100-FR-3 Groundwater Operable Unit (OU) comprises groundwater contaminated by releases from facilities and waste sites associated with past operation of the 100-F Reactor and biological experiments. The U.S. Environmental Protection Agency (EPA) issued the 100-F/IU record of decision (ROD) for 100-FR-1, 100-FR-2, 100-FR-3, 100-IU-2, and 100-IU-6 in September 2014 (EPA and DOE, 2014, *Record of Decision Hanford 100 Area Superfund Site 100-FR-1, 100-FR-2, 100-FR-3, 100-IU-2, and 100-IU-6 Operable Units*). The ROD (EPA and DOE, 2014) specifies monitored natural attenuation (MNA) of groundwater and institutional controls to restrict groundwater use as the final remedial actions. MNA will be implemented for hexavalent chromium (Cr(VI)), nitrate, strontium-90, and trichloroethene (TCE) in 100-FR-3 groundwater. Performance monitoring of these contaminants of concern (COCs) in the groundwater is a component of the MNA remedy. Performance monitoring includes two phases:

1. The remediation monitoring phase occurs while remedial activities (in this case, natural attenuation processes) are being implemented to reach groundwater cleanup levels.
2. The attainment monitoring phase occurs after the remediation phase is complete. Data are collected and evaluated to confirm that the cleanup level for each COC has been met and that groundwater will continue to meet cleanup levels in the future.

A data quality objectives (DQOs) workshop was conducted August 6 and 7, 2014 (when the ROD [EPA and DOE, 2014] was still in draft form), to support design of a groundwater sampling and analysis plan (SAP). Additional work was performed after the workshop, including review and contribution from the U.S. Department of Energy (DOE) SAP panel. This report summarizes the output of the DQO process.

Several EPA documents provide criteria and guidance for MNA. Section 3.1.2 of DOE/RL-2014-44-ADD2, *Remedial Design Report/Remedial Action Work Plan Addendum for 100-F/IU Groundwater* (Groundwater Addendum), and DOE/RL-2014-44, *Integrated Remedial Design Report/Remedial Action Work Plan for 100-F/IU* (Integrated RDR/RAWP), lists applicable documents that were considered in DQO planning. Table 1 cross-references EPA criteria with the principal study questions (PSQs) presented in this DQO document.

1 Step 1: State the Problem

Summary: *The problem statement is created to clearly define the issue that requires new environmental data so that the focus of the study will be clear and unambiguous. Pertinent information from similar studies and assumptions should be organized, reviewed, identified, evaluated, and documented.*

- Give a concise description of the problem.
- Identify planning team.
- Develop conceptual site model (CSM).
- Determine resources.

Output of Step 1: Document the four elements listed in this step.

1.1 100-FR-3 Problem Statements

- There is a need to monitor the performance of the natural attenuation remedy.
- There is a need to demonstrate at the end of the remedial action period that cleanup levels for groundwater have been attained.
- There is a need to confirm that concentrations of antimony, cadmium, and cobalt are below action levels.

Table 1. 100-FR-3 Principal Study Questions as Related to EPA Guidance on Monitored Natural Attenuation

Principal Study Question	EPA Guidance*
PSQ 1a. Are contaminant concentrations and plume area/mass decreasing?	**Step 1:** Demonstrate that natural attenuation is occurring according to expectations **Step 3:** Identify any potentially toxic and/or mobile transformation products **Step 4:** Verify the plume is not expanding downgradient, laterally or vertically
PSQ 1b. Are rates of decline consistent with expectations?	**Step 1:** Demonstrate that natural attenuation is occurring according to expectations **Step 3:** Identify any potentially toxic and/or mobile transformation products
PSQ 1c. Are there changes in environmental conditions that may reduce the efficacy of natural attenuation?	**Step 2:** Detect changes in environmental conditions that may reduce the efficacy of any of the natural attenuation processes
PSQ 1d. Are there unacceptable impacts to the Columbia River?	**Step 5:** Verify no unacceptable impact to down-gradient receptors
PSQ 1e. Is there evidence of new or continuing releases of contaminants to the environment that could impact the effectiveness of the natural attenuation remedy?	**Step 6:** Detect new releases of contaminants to the environment that could impact effectiveness
PSQ 2. Are concentrations of antimony, cadmium, and cobalt below action levels?	Not in EPA guidance; required to resolve previous analytical uncertainty
PSQ 3. Do new geologic and hydrogeologic data confirm the conceptual site model?	**Step 1:** Demonstrate that natural attenuation is occurring according to expectations **Step 2:** Detect changes in environmental conditions that may reduce the efficacy of any of the natural attenuation processes **Step 4:** Verify the plume is not expanding downgradient, laterally or vertically
PSQ 4a. Are concentrations of COCs below cleanup levels?	**Step 8:** Verify attainment of the remediation objectives
PSQ 4b. Will groundwater continue to meet the cleanup level in the future?	
Not an identified PSQ; evaluated within EPA performance monitoring guidance	**Step 7:** Demonstrate the efficacy of institutional controls that were put in place to protect potential receptors

* Source: EPA 600/R-11/204, *An Approach for Evaluating the Progress of Natural Attenuation in Groundwater*.

COC = contaminant of concern

EPA = U.S. Environmental Protection Agency

PSQ = principal study question

1.2 Planning Team

Table 2 lists planning team members and roles.

Table 2. 100-F/IU Planning Team

Name	Organization	Role
Brad Bessinger*	SSPA	MNA and performance monitoring
Phil Burke*	CHPRC	OU Lead
Chris Guzzetti	EPA	EPA Project Manager
Mary Hartman*	CHPRC	OU Project Scientist; DQO Facilitator
Scott McKinley	CH2M HILL	Senior Review
Leland Scantlebury*	CHPRC Intern	Support
Greg Sinton*	DOE/RL	DOE Project Manager
Alex Spiliotopoulos*	SSPA	Groundwater Modeling Support
Heather Sulloway*	CH2M HILL	Performance Monitoring Plan lead
Matt Tonkin*	SSPA	Groundwater Modeling Support
DOE SAP Panel	DOE and others	Review DQO output; later review SAP

* Workshop participant

CHPRC = CH2M HILL Plateau Remediation Company
DOE = U.S. Department of Energy
DOE/RL = DOE Richland Operations Office
DQO = data quality objective
EPA = U.S. Environmental Protection Agency
MNA = monitored natural attenuation
OU = operable unit
SAP = sampling and analysis plan
SSPA = S.S. Papadopulos and Associates, Inc.

1.3 Conceptual Site Model

The CSM is described in the remedial investigation (RI)/feasibility study (FS) (DOE/RL-2010-98, *Remedial Investigation/Feasibility Study for the 100-FR-1, 100-FR-2, 100-FR-3, 100-IU-2 and 100-IU-6 Operable Units*), and supplemented by data in the Hanford Environmental Information System (HEIS). The CSM will be refined with collection of additional data and an updated computer model. Figure 1 illustrates a water table map for the region. Figures 2 through 6 show contaminant plumes.

1.4 Resources

Resources are to be planned outside of the workshop.

2 Step 2: Identify the Goals of the Study

***Summary**: Identify the question(s) that the study will address and alternative actions or outcomes that may result based on the results. Define the decision that will be resolved using the data collected to address the problem.*

- Identify PSQs.
- Consider alternative outcomes.
- For decision problems, develop decision statements. For estimation problems, state what needs to be estimated and key assumptions.

Outputs of Step 2:

- Well-defined PSQs
- A listing of alternative outcomes or actions as a result of addressing PSQs
- For decision problems, a list of decision statements that address the study question
- For estimation problems, a list of estimation statements that address the study question

2.1 100-F/IU Principal Study Questions

1. Is natural attenuation of Cr(VI), nitrate, TCE, and strontium-90 in groundwater occurring as expected?
   a. Are contaminant concentrations and plume area/mass decreasing?
   b. Are rates of decline consistent with expectations?
   c. Are there changes in environmental conditions that may reduce the efficacy of NA?
   d. Are there unacceptable impacts to the Columbia River?
   e. Is there evidence of new or continuing releases of contaminants to the environment that could impact the effectiveness of the MNA remedy?
2. Are concentrations of antimony, cadmium, and cobalt below action levels?
3. Do new geologic and hydrogeologic data confirm the conceptual site model?
4. Have remedial action objective (RAOs) been achieved?
   a. Are concentrations of COCs below cleanup levels?
   b. Will groundwater continue to meet cleanup levels in the future?

2.2 Alternative Outcomes

- Continue monitoring program with no change.
- Modify monitoring program.
- Reconsider another alternative for remediation.

2.3 Decision Statements

1. Determine whether natural attenuation of Cr(VI), nitrate, TCE, and strontium-90 in groundwater is occurring as expected so that natural attenuation may continue, or if other options should be evaluated.
2. Determine whether antimony, cadmium, and cobalt concentrations are below action levels so that monitoring for these metals may cease, or if risks need to be assessed.
3. Determine whether new geologic and hydrogeologic data confirm the conceptual site model, or if the model needs updating.
4. Determine whether COC concentrations are below cleanup levels and attainment monitoring may proceed, or if MNA should continue.

3 Step 3: Identify Information Inputs

Summary: *The third step of the DQO process is to identify information inputs needed to support the decision statements and to specify which inputs will require environmental measurements.*

- Identify types and sources of information needed to produce estimates or resolve decisions.
- Identify the basis of information that will guide or support choices to be made in later steps of the DQO process.
- Select appropriate sampling and analysis methods for generating the information.

Outputs of Step 3:

- Lists of environmental characteristics that will resolve the decision or estimate and potential sources for the desired information inputs
- Information on the number of variables that will need to be collected
- Type of information needed to meet performance or acceptance criteria
- Information on the performance of appropriate sampling and analysis methods

3.1 Action Levels

Table 3 lists action levels for COCs, trace metals, and degradation products of TCE.

Table 3. 100-FR-3 Action Levels

Contaminant	Category	Cleanup or Action Level	Type
Hexavalent Chromium	COC	10 µg/L at Columbia River	Cleanup level
Trichloroethene	COC	4 µg/L	Cleanup level
Nitrate	COC	45 mg/L as NO_3^-*	Cleanup level
Stronium-90	COC	8 pCi/L	Cleanup level
Antimony	Trace metal	6 µg/L	Action level in RI
Cadmium	Trace metal	0.25 µg/L surface water; 5 µg/L DWS	Action level in RI

Table 3. 100-FR-3 Action Levels

Contaminant	Category	Cleanup or Action Level	Type
Cobalt	Trace metal	4.8 µg/L	Action level in RI
cis-1,2-dichloroethene	Degradation product	16 µg/L	Action level in RI
Vinyl Chloride	Degradation product	0.061 µg/L	Action level in RI

* Nitrate may be expressed as nitrate nitrogen (NO_3-N) or as nitrate (NO_3^-). The cleanup level of 45 mg/L as NO_3^- is derived from the DWS of 10 mg/L as NO_3-N.

COC = contaminant of concern

DWS = drinking water standard

RI = remedial investigation

3.1.1 Other Input

- Groundwater sample data from new and existing wells and aquifer tubes (COCs and supporting parameters)
- Historical chemistry and water level data
- Sample data from riverbank seeps
- Groundwater levels
- River stage
- Geologic information
- Updated geologic interpretations from existing wells

3.2 Sampling and Analysis Methods

- Continue current methods of sampling monitoring wells, aquifer tubes, and seeps (per project procedures).
- Analytical methods will be selected to meet required action levels.

4 Step 4: Define the Boundaries of the Study

Summary: *Define the specific spatial and temporal boundaries that are included in the decision.*

- Define the target population of interest and its relevant spatial boundaries.
- Define what constitutes a sampling unit.
- Specify temporal boundaries and other practical constraints associated with data collection.
- Specify the smallest unit on which decisions or estimates will be made.

Outputs of Step 4:

- Definition of the target population with detailed descriptions of geographic limits (spatial boundaries)
- Detailed descriptions of what constitutes a sampling unit

- Time frame appropriate for collecting data and making the decision or estimate, together with those practical constraints that may interfere with data collection
- Appropriate scale for decision making or estimation

4.1 Target Population and Spatial Boundaries

Unconfined groundwater in the 100-FR-3 OU includes 100-F, region south, and region west (upgradient).

4.2 Temporal Boundaries

- Predicted time to cleanup based on the maximum concentrations calculated by the RI model:
  - Cr(VI) at 10 µg/L cleanup level (state surface water quality standard) – 35 years
  - Cr(VI) at 48 µg/L WAC 173-340, "Model Toxics Control Act—Cleanup," groundwater cleanup level – 20 years
  - Nitrate at 45 mg/L cleanup level – 80 years
  - Strontium-90 at 8 pCi/L cleanup level – 150 years
  - TCE at 4 µg/L cleanup level – 50 years
- Trace metals – Time necessary to collect at least 8 independent samples
- As specified in the RI/FS (DOE/RL-2010-98), monitoring will be performed for an additional 5 years after cleanup level for each COC is initially achieved to confirm remediation goals (see Section 7.1.13)
- Automated water level measurements – operate robust network for at least 5 years, then re-evaluate

4.3 Decision Units

- Spatial:
  - Nitrate plume boundaries at >45 mg/L
  - Nitrate plume high-concentration core at >90 mg/L
  - Cr(VI) plume boundaries at >10 µg/L
  - TCE plume boundaries at >4 µg/L
  - Strontium-90 plume boundaries at >8 pCi/L
  - Selected wells for trace metals (see rationale in Step 7)
- Time: 5-year periods (to facilitate 5-year reviews)

4.4 Practical Constraints

- Resource availability for well installation, sample collection, and laboratory analysis (funding)
- Analytical detection limits
- Cultural and ecological constraints on new well locations
- Seasonal variability of river stage and water table

5 Step 5: Develop the Analytic Approach

Summary: *Integrate the outputs from the previous steps into a statement(s) that describes the logical basis to select amongst the alternative actions. This includes specifying the population parameter (e.g., mean, percentile), determining the action level, and constructing the decision rule. A decision rule is determined for each PSQ. At this point, it is assumed that perfect information is available for decision making.*

- Specify appropriate population parameters for making decisions or estimates.
- For decision problems, choose a workable action level and generate and "If… then… else" decision rule.
- For estimation problems, specify the estimator and estimation procedure.

Outputs of Step 5:

- Identification of the population parameters most relevant for making inferences and conclusions on the target population.
- For decision problems, the "if..., then...else..." theoretical decision rule based upon a chosen action level.
- For estimation problems, the specification of the estimator to be used.

5.1 100-FR-3 Parameters of Interest

- Concentrations/trends for each COC and trace metal (as expressed by statistical parameters)
- Plume area or mass for each COC (changes with time)
- Comparison of observations to modeled conditions

5.2 Decision Rules (If/Then)

Table 4 lists decision rules associated with each PSQ.

Table 4. 100-FR-3 Principal Study Questions and Decision Rules

	Principal Study Question	Decision Rule
1	Is natural attenuation of Cr(VI), nitrate, TCE, and strontium-90 in groundwater occurring as expected?	If the weight of evidence indicates that natural attenuation is occurring as expected, then continue MNA; otherwise evaluate other options.
2	Are concentrations of antimony, cadmium, and cobalt below action levels?	If monitoring indicates that concentrations are not greater than the action level or practical quantitation limit, then discontinue monitoring; otherwise perform risk assessment.
3	Do new geologic and hydrogeologic data confirm the CSM?	If new geologic and hydrogeologic data confirm the CSM, then retain the model; otherwise update it.
4	Have RAOs been achieved? Are concentrations of COCs below cleanup levels? Will groundwater continue to meet cleanup levels in the future?	If RAO has been achieved for an individual COC, then proceed to attainment monitoring for that COC; otherwise continue MNA.

COC = contaminant of concern
CSM = conceptual site model
MNA = monitored natural attenuation
NA = natural attenuation
OU = operable unit
RAO = remedial action objective

6 Step 6: Specify Performance or Acceptance Criteria

Summary: *Define how much uncertainty can be tolerated when making the decision of interest, and establish appropriate performance goals for limiting uncertainty in the data. The guidance document says this is where you "face the reality that you will not have perfect information from which to formulate your conclusions." Discuss severity of consequences of making wrong decisions.*

- For decision problems, specify the decision rule as a statistical hypothesis test, examine consequences of making incorrect decisions from the test, and place acceptable limits on the likelihood of making decision errors.
- For estimation problems, specify acceptable limits on estimation uncertainty.

Output of Step 6:

- A set of performance or acceptance criteria (i.e., DQOs) that data should achieve in order to minimize the possibility of either making a decision error or failing to keep uncertainty in estimates to within acceptable levels

6.1 100-FR-3 Criteria

Traditional statistical sample designs are not typically identified for groundwater investigations. Sampling design will be judgmental.

Criteria for evaluating the data with respect to the PSQs will employ both statistical and nonstatistical methods. Methods of evaluation will be derived from sources such as OSWER 9283.1-44, *Recommended Approach for Evaluating Completion of Groundwater Restoration Remedial Actions at a Groundwater Monitoring Well*. Details are included in Chapter 6 of the Groundwater Addendum (DOE/RL-2014-44-ADD2). Table 1 relates 100-FR-3 PSQs to EPA's criteria for evaluating MNA.

1. Is natural attenuation of Cr(VI), nitrate, TCE, and strontium-90 in groundwater occurring as expected?
    a. Are contaminant concentrations and plume area/mass decreasing? *Statistical evaluation.*
    b. Are rates of decline consistent with expectations? *Statistical evaluation.*
    c. Are there changes in environmental conditions that may reduce the efficacy of NA? *Nonstatistical evaluation*
    d. Are there unacceptable impacts to the Columbia River? *Statistical and nonstatistical evaluation.*
    e. Is there evidence of new or continuing releases of contaminants to the environment that could impact the effectiveness of the MNA remedy? *Nonstatistical evaluation.*
2. Are concentrations of antimony, cadmium, and cobalt below action levels? *Statistical evaluation.*
3. Do new geologic and hydrogeologic data confirm the conceptual site model? *Nonstatistical evaluation.*
4. Have RAOs been achieved?
    a. Are concentrations of COCs below cleanup levels? *Statistical evaluation.*
    b. Will groundwater continue to meet cleanup levels in the future? *Statistical evaluation.*

6.2 Decision Errors and Mitigating Measures

This section describes possible errors for each of the major decision rules. The sources of errors that lead to those decision errors, and factors to mitigate them, are listed in Table 5.

Decision Rule 1: If the weight of evidence indicates that natural attenuation is occurring as expected, then continue MNA; otherwise evaluate other options.

- Decision Error 1a: MNA is deemed ineffective, and a more aggressive form of remediation is implemented unnecessarily. Consequence: Funding could be diverted from higher-priority projects. Severity: Low to moderate.
- Decision Error 1b: MNA is deemed effective and, in fact, it is not. Consequences: Remediation timeline is longer than predicted. Severity: Low.

Decision Rule 2: If monitoring indicates that concentrations of antimony, cadmium, and cobalt are not above action levels or quantitation limits, then discontinue monitoring; otherwise perform risk assessment.

- Decision Error 2a: Monitoring for metals continues even though they are not above action levels. Consequence: Funding could be diverted from higher-priority projects. Severity: Low to moderate.
- Decision Error 2b: Monitoring for metals is discontinued, but they are in fact above action levels. Consequence: Contamination remains in the aquifer or migrates to receptors. Severity: Low to moderate.

Decision Rule 3: If new geologic and hydrologic data confirm the conceptual site model, then retain the model; otherwise update it.

- Decision Error 3a: Conceptual site model is updated unnecessarily. Consequence: Minor outlay of resources. Severity: Low.
- Decision Error 3b: Conceptual site model is not updated, and results do not reflect the natural system accurately. Severity: Low to moderate.

Decision Rule 4: If RAO has been achieved for an individual COC, then proceed to attainment monitoring for that COC; otherwise continue MNA.

- Decision Error 4a: MNA continues longer than needed. Consequences: Continued monitoring would reveal that goals have been achieved. Severity: Low.
- Decision Error 4b: Attainment monitoring begins prematurely. Consequence: Attainment monitoring would reveal the error, and MNA would continue. Severity: Low.

Table 5. Sources of Error and Mitigating Measures

Source of Error	Mitigating Measures
Variability in concentrations causing inaccurate estimates of attenuation rates (e.g., variability due to seasonal or longer-term changes in water table; plume migration)	Consistent schedule for sampling to increase comparability; more frequent monitoring in wells with variable concentrations
Uncertainty in estimates of plume size (interpolation, extrapolation)	Robust monitoring network, including new monitoring wells to reduce uncertainty in plume interpretations; geostatistical methods to evaluate plume size

Table 5. Sources of Error and Mitigating Measures

Source of Error	Mitigating Measures
Uncertainties in model predictions (limitations of model input)	Improvements to model based on new geologic information and expanded automated water level network
New or unknown sources of contamination	Monitor near former source areas with greater density of wells and higher sampling frequency
Analytical error	Robust quality assurance/quality control program to minimize analytical uncertainties

7 Step 7: Develop the Plan for Obtaining Data

***Summary**: Using results from the previous steps, identify the most resource-effective sampling and analysis design for generating data that are expected to satisfy the DQOs.*

1. Compile all information and outputs generated in Steps 1 through 6.
2. Use this information to identify alternative sampling and analysis designs that are appropriate for your intended use.
3. Select and document a design that will yield data for best achievement of performance or acceptance criteria.

Outputs of Step 7:

- Full documentation of the final sampling and analysis design, along with a discussion of the key assumptions underlying this design
- Details on how the design should be implemented together with contingency plans for unexpected events
- Quality assurance (QA) and quality control (QC) procedures that would be performed to detect and correct problems and so ensure defensible results
- Documentation of these items in a SAP

7.1 100-FR-3 Sampling and Analysis Plan

The team designed a monitoring network, analyte list, and sampling frequencies, summarized in the following subsections. Table 6 lists all of the wells and aquifer tubes considered for sampling, and which (if any) PSQs they address. Plume maps with available well locations are attached as Figures 2 through 6. Figures 7 and 8 show locations of the proposed monitoring networks, including new wells.

7.1.1 Monitoring Network for Water Samples (Table 6)

Monitoring wells were selected within and downgradient of contaminant plumes to monitor attenuation and possible migration (PSQs 1a and 1b). Near-river wells, aquifer tubes, or seeps were selected to monitor potential impacts to the Columbia River (PSQ 1d). Wells were preferred over aquifer tubes or seeps. Aquifer tubes or seeps were only selected where there are no wells between the shoreline and the plume boundary.

Wells within the former operational area were selected to monitor for new releases (PSQ 1e). Section 7.1.2 describes the rationale for selection of wells for trace metals (PSQ 2).

The monitoring network comprises the following:

- 28 existing wells, 8 new wells (phase 1), and up to 6 possible additional wells based on results of phase 1
- 6 existing aquifer tubes
- 1 riverbank seep
- Monitoring networks for the attainment phase (PSQ 4) will be determined closer to the end of remediation monitoring phase for each COC.

7.1.2 Rationale for New Well Locations (Phase 1; Figures 7 and 8)

- C9472: South of TCE – monitor plume shrinkage and migration
- C9474: East of 699-71-30 – sentinel well for nitrate
- C9475: West of 699-71-30 – monitor nitrate plume shrinkage
- C9476: Nitrate near south (in plume) – monitor shrinkage of >90 mg/L contour
- C9477: Nitrate near south (east of plume) – monitor plume shrinkage and sentinel well
- C9478: Nitrate far south (upgradient) – monitor nitrate plume shrinkage
- C9479: Nitrate far south (in plume) – monitor plume shrinkage
- C9480: Nitrate far south (east of plume) – monitor plume shrinkage and sentinel well

Proposed locations may need to be moved based on accessibility or results of ecological/cultural reviews. If a location is moved more than ~100 m (330 ft), DOE and EPA will be consulted for concurrence.

Several other locations were considered for new wells during the DQO workshop. After subsequent reviews by the DOE Panel, the team concluded that the following wells were not needed for decision making and were, therefore, eliminated:

- Southeast of Cr(VI) plume and south of strontium-90 plume to delimit plumes and monitor shrinkage (C9469): Plumes are sufficiently delineated by existing wells.
- Northwest edge of Cr(VI) plume to refine plume interpretation and monitor plume shrinkage (C9470): Plume is sufficiently delineated by existing wells.
- North of TCE in area of 1995 study to refine interpretation and monitor plume shrinkage (C9471): This location is within an area where TCE was elevated in groundwater in 1995. However, groundwater flow to the east and south would have decreased concentrations in this region since then, and continued declines can be assumed.
- West of TCE and nitrate to monitor upgradient conditions and refine interpretation of TCE plume (C9473): This location was outside the boundary of the TCE plume in 1995. Because groundwater flow is to the east and south, it is reasonable to assume that the upgradient area remains clean.
- Southeast of nitrate plume to monitor plume shrinkage and possible migration (C9481): Concentrations in wells within the 45 mg/L contour at the south end of the plume are declining or stable. The plume can be monitored adequately with existing wells.

7.1.3 Rationale for Phase 2 Wells

Locations of additional wells will be determined based on evaluation of monitoring data approximately 2 years after the final phase 1 well installation.

7.1.4 Additional Data from New Wells

- Geologic samples
- Aquifer properties

7.1.5 Use of Old Wells

- Evaluate pre-WAC 173-160, "Minimum Standards for Construction and Maintenance of Wells," wells for suitability (e.g., review documentation where available and perform camera surveys, borehole geophysics, and field inspections).
- Rehabilitate wells as appropriate (e.g., grout in lower portions of wells with long perforated intervals that span unconfined and part of the Ringold Formation upper mud [RUM]).
- It is unclear if Well 699-60-32 monitors the unconfined aquifer or the RUM. It will be evaluated and, if it monitors the RUM, nearby Well 699-59-32 may be substituted into the monitoring network.

7.1.6 Water Level Monitoring

- Supports PSQs 1c and 4 (Table 6)
- Automated water level stations in 19 wells
- Automated river gauge
- Manual measurements in 41 wells

7.1.7 Analytes

- COCs specific to each location (Table 6)
- TCE degradation products (vinyl chloride and *cis*-1,2-dichloroethene)
- Trace metals in selected wells (Table 6)
- Field parameters (specific conductance, pH, dissolved oxygen, turbidity, and temperature)

7.1.8 Sampling Frequency

- Frequency intervals listed in Table 6
- Minimum of annual sampling for first 5 years to establish new baseline that (a) reflects conditions after completion of source remediation, (b) determines conditions based on consistent set of wells, and (c) provides more data for input to regression calculations
- New wells quarterly for 1 year to establish baseline and seasonal variability
- Selected wells semiannually (high and low river stage) where changes in water table are likely to affect concentrations
- Frequency reduced after 5 years unless data indicate a need for more frequent monitoring
- Attainment monitoring frequency (see Section 7.1.13)
- Major sampling campaigns scheduled for fall when river stage is low (September or October). Semiannual wells (twice per year) also to be sampled at high river stage (mid-May through mid-July)

7.1.9 Quality Assurance and Quality Control Program

QA/QC will be integrated with the entire Soil and Groundwater Remediation Project.

7.1.10 Rationale for Automated Water Level Network

Obtain a good distribution of wells to create triangles for calculating hydraulic gradients. Assume these stations need to be maintained for first 5 years of monitoring, then re-evaluate.

7.1.11 Rationale for Manual Water Levels

Obtain comprehensive set of water level measurements during low river stage (October, concurrent with sampling), high river stage (June), and moderate stage (March, in conjunction with sitewide measurements).

7.1.12 Rationale for Trace Metal Wells

Select a subset of wells to evaluate antimony, cadmium, and cobalt, based on previous exceedances of action levels (Table 7). These wells will go into the SAP for trace metals analysis, and Decision Rule 2 will apply. The process included the following steps:

1. The process began with well lists from the 100-F spatial/temporal network of the RI/FS (DOE/RL-2010-98). Section 4.3.1.2 of the RI/FS (DOE/RL-2010-98) states that no further groundwater monitoring is required for 100-IU-2 and 100-IU-6.
2. The HEIS database was queried for antimony, cadmium, and cobalt data from January 1, 2007 through August 1, 2014.
3. The data were filtered for values above action levels and not flagged U.
4. Four wells with exceedances (~20 percent of available wells in 100-F Area) were selected for further analysis of trace metals.
5. No wells exceeded more than one analyte, and none had a high frequency of exceedance. Concentrations did not vary greatly. Therefore, wells were selected based on spatial spread.

7.1.13 Attainment Monitoring

After a cleanup level is achieved for a COC, a subset of monitoring wells will be sampled for 5 years to verify that cleanup is complete. The well network will be selected based on the location of contamination at the time. Sampling frequency may be quarterly for two years to detect seasonal variability and may be reduced to annually for the next 3 years. Actual number of wells is not known; assumptions for cost estimation are given in Table 8.

7.1.14 Rationale for Wells and Aquifer Tubes Not Sampled

Additional existing wells and aquifer tubes were considered and excluded from the monitoring network. Table 6 lists rationale for not sampling.

Table 6. Monitoring Wells, Aquifer Sampling Tubes, and Seeps Considered for 100-FR-3 Monitoring Network

Well Name	Screened Unit	Year Installed	Casing and Screen Type	Elevation Top Screen or Perf (m)	Elevation Bottom Screen or Perf (m)	Rationale								Wtr Lvl		Yr 1 Frequency					Yr 2 to 5 Frequency					Yr 6+ Frequency[b]				Rationale for Not Monitoring, or Other Comment
						PSQ 1a, 1b	PSQ 1c	PSQ 1d	PSQ 1e	PSQ 2	PSQ 3	PSQ 4	Sample	Automated	Manual[a]	Cr(VI)	TCE & Deg. Prod.	Nitrate	Sr-90	Trace Metals	Cr(VI)	TCE & Deg. Prod.	Nitrate	Sr-90	Trace Metals[c]	Cr(VI)	TCE & Deg. Prod.	Nitrate	Sr-90	
EXISTING WELLS																														
199-F1-2	Unconfined	1992	SS, Screen	115.5	110.9								N																	Not in or downgradient of any plume
199-F5-1	Unconfined	1948	CS, Perf	113.9	105.4	X	X		X			X	Y		X			A	S				A	S				B	B	Possible seasonal variation
199-F5-4	Unconfined[d]	1953	CS, Perf	116.0	94.6	X	X		X	X		X	Y		X	S	S	S		A	S	S	S		A	B	B	B		Possible seasonal variation
199-F5-42	Unconfined	1992	SS, Screen	114.7	108.6	X	X	X				X	Y		X	A		A	A		A		A	A		B		B	B	
199-F5-43A	Unconfined	1992	SS, Screen	114.7	108.6	X	X	X		X	X	X	Y		X	A		A	A	A	A		A	A	A	B		B	B	
199-F5-43B	RUM	1992	SS, Screen	76.3	73.3								N																	Monitors RUM; not in scope
199-F5-44	Unconfined	1992	SS, Screen	114.4	108.3	X	X	X				X	Y		X	A		A	A		A		A	A		B		B	B	
199-F5-45	Unconfined	1992	SS, Screen	115.3	110.6	X	X		X		X	X	Y		X	A	A	A			A	A	A			B	B	B		
199-F5-46	Unconfined	1992	SS, Screen	114.8	110.2	X	X		X			X	Y		X	S	S	S	S		S	S	S	S		B	B	B	B	Possible seasonal variation
199-F5-47	Unconfined	1992	SS, Screen	115.8	109.7	X	X		X			X	Y		X	A		A	A		A		A	A		B		B	B	
199-F5-48	Unconfined	1992	SS, Screen	115.7	111.1	X	X		X	X		X	Y		X	A	A	A		A	A	A	A		A	B	B	B		
199-F5-52	Unconfined	2010	SS, Screen	115.5	109.4	X	X	X	X		X	X	Y	X	X	A		A			A		A			B		B		
199-F5-53	RUM	2010	SS, Screen	96.1	93.1								N																	Monitors RUM; not in scope
199-F5-54	Unconfined	2010	SS, Screen	115.0	108.9	X	X		X			X	Y		X	A		A	A		A		A	A		B		B	B	
199-F5-55	Unconfined	2011	PVC, Screen	114.7	111.7	X	X		X			X	Y		X	A		A	S		A		A	S		B		B	B	Possible seasonal variation
199-F5-56	Unconfined	2011	PVC, Screen	115.3	112.2	X	X		X			X	Y		X	A	A	A	A		A	A	A	A		B	B	B	B	
199-F5-6	Unconfined[d]	1956	CS, Perf	116.4	104.5	X	X	X	X			X	Y		X	S		A	A		S		A	A		B		B	B	Possible seasonal variation
199-F6-1	Unconfined	1992	SS, Screen	114.5	108.6	X	X	X	X		X	X	Y	X	X	A		A	A		A		A	A		B		B	B	
199-F7-1	Unconfined	1956	CS, Perf	117.0	112.4	X	X		X		X	X	Y	X	X		A	A				A	A				B	B		Blank casing below perf'd interval; rehab
199-F7-2	Unconfined	1988	SS, Screen	116.1	111.3	X	X		X		X	X	Y	X	X		A	A				A	A				B	B		
199-F7-3	Unconfined	1992	SS, Screen	115.3	110.7	X	X		X			X	Y		X		A	A				A	A				B	B		
199-F8-2	Unconfined	1960	CS, Perf	123.2	110.1	X	X		X			X	Y		X	A			A		A			A		B			B	
199-F8-3	Unconfined	1992	SS, Screen	115.6	112.5								N																	Redundant with nearby wells
199-F8-4	Unconfined	1992	SS, Screen	114.4	111.3	X	X				X	X	Y	X	X			A					A					B		
199-F8-7	Unconfined	2008	SS, Screen	116.5	113.4	X	X		X	X		X	Y		X		A	A	A	A		A	A	A	A		B	B	B	

Table 6. Monitoring Wells, Aquifer Sampling Tubes, and Seeps Considered for 100-FR-3 Monitoring Network

Well Name	Screened Unit	Year Installed	Casing and Screen Type	Elevation Top Screen or Perf (m)	Elevation Bottom Screen or Perf (m)	Rationale								Wtr Lvl		Yr 1 Frequency					Yr 2 to 5 Frequency					Yr 6+ Frequency[b]				Rationale for Not Monitoring, or Other Comment
						PSQ 1a, 1b	PSQ 1c	PSQ 1d	PSQ 1e	PSQ 2	PSQ 3	PSQ 4	Sample	Automated	Manual[a]	Cr(VI)	TCE & Deg. Prod.	Nitrate	Sr-90	Trace Metals	Cr(VI)	TCE & Deg. Prod.	Nitrate	Sr-90	Trace Metals[c]	Cr(VI)	TCE & Deg. Prod.	Nitrate	Sr-90	
699-58-24	Unconfined	1971	CS, Perf	113.7	110.7		X				X		N		X															Far downgradient of nitrate plume; water levels only
699-59-32	Unconfined	1971	CS, Screen	110.5	107.5	X?	X?						?	X?	X?															Redundant with nearby well
699-60-32	RUM?	1971	CS, Screen	107.8	104.7	X	X				X	X	Y	X	X			A					A					B		Evaluate; 59-32 instead?
699-61-37	Unconfined	1971	CS, Screen	114.9	111.9						X		N	X	X															No monitoring objective; water levels only
699-62-31	Unconfined	1972	CS, Screen	109.9	106.9	X	X				X	X	Y		X			A					A					B		In south part nitrate plume
699-62-43F	Unconfined	1959	CS, Perf	125.2	110.6								N																	No monitoring objective
699-63-25A	Unconfined[d]	1949	CS, Perf	112.7	92.0	X	X				X	X	Y		X			A					A					B		Long perf interval; may need rehab
699-64-27	Unconfined	1974	CS, Perf	112.0	104.7	X	X				X	X	Y	X	X			A					A					B		
699-65-22	Unknown	Unknown	Galv, unkn										N																	Redundant with nearby well
699-66-23	Unconfined[d]	1961	CS, Perf	113.5	95.2	X	X	X			X	X	Y	X	X			A					A					B		Long perf interval; may need rehab
699-66-38	Unconfined[d]	1962	CS, Perf	125.1	111.1								N																	Monitors mud; not in scope
699-66-39	Unconfined[d]	1971	CS, Perf	126.7	118.5								N																	Monitors mud; not in scope
699-67-51	Unconfined[d]	1962	CS, Perf	130.4	84.7								N																	No monitoring objective; Host well with piezometers
699-69-38	Unknown	Unknown	ABS, unkn										N																	ABS casing in cement well; no monitoring objective
699-69-45	Unconfined[d]	1961	CS, Perf	125.0	58.0								N																	No monitoring objective; host well with piezometers
699-70-23	Unknown	Unknown	CS, unkn								X		N	X	X															Redundant with nearby well for sampling; water levels only
699-71-30	Unconfined[d]	1957	CS, Perf	115.1	96.5	X	X				X	X	Y	X	X		A	A				A	A				B	B		Long perf interval; may need rehab
699-71-52	Unconfined	1954	CS, Perf	123.9	111.7								N																	No monitoring objective
699-74-44	Unconfined	1957	CS, Perf	131.1	115.9		X				X		N		X															No monitoring objective; water levels only
699-77-36	Unconfined[d]	1957	CS, Perf	116.4	101.2	X	X				X	X	Y	X	X		A	A				A	A				B	B		Long perf interval; may need rehab
699-77-54	Unconfined	1957	CS, Perf	125.8	111.5								N																	No monitoring objective
699-80-43P	Lower Mud/ Basalt Top	1965	CS, Screen	-5.5	-8.5								N																	Monitors mud; not in scope

Table 6. Monitoring Wells, Aquifer Sampling Tubes, and Seeps Considered for 100-FR-3 Monitoring Network

Well Name	Screened Unit	Year Installed	Casing and Screen Type	Elevation Top Screen or Perf (m)	Elevation Bottom Screen or Perf (m)	Rationale								Wtr Lvl		Yr 1 Frequency					Yr 2 to 5 Frequency					Yr 6+ Frequency[b]				Rationale for Not Monitoring, or Other Comment
						PSQ 1a, 1b	PSQ 1c	PSQ 1d	PSQ 1e	PSQ 2	PSQ 3	PSQ 4	Sample	Automated	Manual[a]	Cr(VI)	TCE & Deg. Prod.	Nitrate	Sr-90	Trace Metals	Cr(VI)	TCE & Deg. Prod.	Nitrate	Sr-90	Trace Metals[c]	Cr(VI)	TCE & Deg. Prod.	Nitrate	Sr-90	
699-80-43S	Unknown	1965	CS, Screen	117.7	111.6								N																	No monitoring objective; piezometer; uncertain completion
699-81-38	Unconfined	Unknown	Galv, unkn										N																	No monitoring objective; strange and uncertain construction
699-83-47	Unconfined	1957	CS, Perf	122.5	107.3								N																	No monitoring objective
699-84-34B	Basalt	1981	Unknown										N																	Artesian well (basalt); not in scope
699-86-42	Unconfined	Unknown	Galv, unkn	125.9	117.9								N																	No monitoring objective
699-87-42A	Unconfined	Unknown	Galv, unkn	128.0	117.7								N																	No monitoring objective
PHASE 1 NEW WELLS																														
C9472	Unconfined	FY16	SS, Screen			X	X				X	X	Y		X		Q	Q				A	A				B	B		
C9474	Unconfined	FY16	SS, Screen			X	X	X			X	X	Y	X	X			Q					A					B		
C9475	Unconfined	FY16	SS, Screen			X	X				X	X	Y	X	X		Q	Q				A	A				B	B		
C9476	Unconfined	FY16	SS, Screen			X	X				X	X	Y	X	X		Q	Q				A	A				B	B		
C9477	Unconfined	FY16	SS, Screen			X	X	X			X	X	Y	X	X			Q					A					B		
C9478	Unconfined	FY16	SS, Screen			X	X				X	X	Y	X	X			Q					A					B		
C9479	Unconfined	FY16	SS, Screen			X	X				X	X	Y	X	X			Q					A					B		
C9480	Unconfined	FY16	SS, Screen			X	X	X			X	X	Y	X	X			Q					A					B		
PHASE 2 NEW WELLS (temporary well names)																														
FIU-A	Unconfined	TBD	SS, Screen										Y																	
FIU-B	Unconfined	TBD	SS, Screen										Y																	
FIU-C	Unconfined	TBD	SS, Screen										Y																	
FIU-D	Unconfined	TBD	SS, Screen										Y																	
FIU-E	Unconfined	TBD	SS, Screen										Y																	
FIU-F	Unconfined	TBD	SS, Screen										Y																	
AQUIFER SAMPLING TUBES																														
59-D	Unconfined	1997	Poly, mesh	108.0	107.8								N																	No monitoring objective
59-M	Unconfined	1997	Poly, mesh	109.8	109.7								N																	No monitoring objective

Table 6. Monitoring Wells, Aquifer Sampling Tubes, and Seeps Considered for 100-FR-3 Monitoring Network

Well Name	Screened Unit	Year Installed	Casing and Screen Type	Elevation Top Screen or Perf (m)	Elevation Bottom Screen or Perf (m)	Rationale								Wtr Lvl		Yr 1 Frequency					Yr 2 to 5 Frequency					Yr 6+ Frequency[b]				Rationale for Not Monitoring, or Other Comment
						PSQ 1a, 1b	PSQ 1c	PSQ 1d	PSQ 1e	PSQ 2	PSQ 3	PSQ 4	Sample	Automated	Manual[a]	Cr(VI)	TCE & Deg. Prod.	Nitrate	Sr-90	Trace Metals	Cr(VI)	TCE & Deg. Prod.	Nitrate	Sr-90	Trace Metals[c]	Cr(VI)	TCE & Deg. Prod.	Nitrate	Sr-90	
59-S	Unconfined	1997	Poly, mesh	111.5	111.4								N																	No monitoring objective
60-D	Unconfined	1997	Poly, mesh	106.9	106.8								N																	No monitoring objective
60-M	Unconfined	1997	Poly, mesh	109.7	109.5								N																	No monitoring objective
60-S	Unconfined	1997	Poly, mesh	112.4	112.3								N																	No monitoring objective
61-D	Unconfined	1997	Poly, mesh	106.9	106.8								N																	No monitoring objective
61-M	Unconfined	1997	Poly, mesh	109.7	109.5								N																	No monitoring objective
61-S	Unconfined	1997	Poly, mesh	112.5	112.3								N																	No monitoring objective
62-M	Unconfined	1997	Poly, mesh	109.8	109.6								N																	No monitoring objective
62-S	Unconfined	1997	Poly, mesh	112.7	112.6								N																	Single depth sufficient
63-D	Unconfined	1997	Poly, mesh	108.1	107.9								N																	Redundant with nearby tubes
63-M	Unconfined	1997	Poly, mesh	110.2	110.1								N																	Redundant with nearby tubes
63-S	Unconfined	1997	Poly, mesh	112.0	111.9								N																	Redundant with nearby tubes
64-D	Unconfined	1997	Poly, mesh	106.8	106.7								N																	Single depth sufficient
64-M	Unconfined	1997	Poly, mesh	109.9	109.7	X		X					Y			A		A	A		A		A	A		B		B	B	
64-S	Unconfined	1997	Poly, mesh	113.1	112.9								N																	Single depth sufficient
66-D	Unconfined	1997	Poly, mesh	105.9	105.7								N																	No monitoring objective
66-M	Unconfined	1997	Poly, mesh	108.6	108.4								N																	No monitoring objective
66-S	Unconfined	1997	Poly, mesh	111.4	111.2								N																	No monitoring objective
67-M	Unconfined	1997	Poly, mesh	108.8	108.7								N																	No monitoring objective
67-S	Unconfined	1997	Poly, mesh	111.9	111.7								N																	No monitoring objective
68-D	Unconfined	1997	Poly, mesh	107.8	107.7								N																	No monitoring objective
68-M	Unconfined	1997	Poly, mesh	109.9	109.7								N																	No monitoring objective
68-S	Unconfined	1997	Poly, mesh	112.3	112.1								N																	No monitoring objective
69-D	Unconfined	1997	Poly, mesh	110.4	110.3								N																	No monitoring objective
72-D	Unconfined	1997	Poly, mesh	103.6	103.5								N																	No monitoring objective
72-M	Unconfined	1997	Poly, mesh	106.7	106.5								N																	No monitoring objective

Table 6. Monitoring Wells, Aquifer Sampling Tubes, and Seeps Considered for 100-FR-3 Monitoring Network

Well Name	Screened Unit	Year Installed	Casing and Screen Type	Elevation Top Screen or Perf (m)	Elevation Bottom Screen or Perf (m)	Rationale								Wtr Lvl		Yr 1 Frequency					Yr 2 to 5 Frequency					Yr 6+ Frequency[b]				Rationale for Not Monitoring, or Other Comment
						PSQ 1a, 1b	PSQ 1c	PSQ 1d	PSQ 1e	PSQ 2	PSQ 3	PSQ 4	Sample	Automated	Manual[a]	Cr(VI)	TCE & Deg. Prod.	Nitrate	Sr-90	Trace Metals	Cr(VI)	TCE & Deg. Prod.	Nitrate	Sr-90	Trace Metals[c]	Cr(VI)	TCE & Deg. Prod.	Nitrate	Sr-90	
72-S	Unconfined	1997	Poly, mesh	109.3	109.1								N																	No monitoring objective
74-D	Unconfined	1997	Poly, mesh	103.3	103.1								N																	No monitoring objective
74-M	Unconfined	1997	Poly, mesh	106.9	106.8								N																	No monitoring objective
75-D	Unconfined	1997	Poly, mesh	103.9	103.7								N																	No monitoring objective
75-M	Unconfined	1997	Poly, mesh	106.3	106.2								N																	No monitoring objective
75-S	Unconfined	1997	Poly, mesh	108.8	108.6								N																	No monitoring objective
76-D	Unconfined	1997	Poly, mesh	104.5	104.3								N																	No monitoring objective
76-M	Unconfined	1997	Poly, mesh	106.3	106.2								N																	No monitoring objective
76-S	Unconfined	1997	Poly, mesh	108.8	108.6								N																	No monitoring objective
77-D	Unconfined	1997	Poly, mesh	104.1	103.9								N																	No monitoring objective
77-M	Unconfined	1997	Poly, mesh	106.5	106.4								N																	No monitoring objective
77-S	Unconfined	1997	Poly, mesh	108.9	108.8								N																	No monitoring objective
80-D	Unconfined	1997	Poly, mesh	104.2	104.0								N																	No monitoring objective
AT-F-1-D	Unconfined	2004	Poly, mesh	106.8	106.6								N																	Redundant with nearby tubes
AT-F-1-M	Unconfined	2004	Poly, mesh	109.2	109.1								N																	Redundant with nearby tubes
AT-F-1-S	Unconfined	2004	Poly, mesh	111.6	111.5								N																	Redundant with nearby tubes
AT-F-3-D	Unconfined	2004	Poly, mesh	108.4	108.2								N																	Redundant with nearby tubes
AT-F-3-M	Unconfined	2004	Poly, mesh	109.4	109.2								N																	Redundant with nearby tubes
AT-F-3-S	Unconfined	2004	Poly, mesh	110.8	110.6								N																	Redundant with nearby tubes
AT-F-4-D	Unconfined	2004	Poly, mesh	102.3	102.1								N																	Redundant with nearby tubes
AT-F-4-M	Unconfined	2004	Poly, mesh	106.6	106.5								N																	Redundant with nearby tubes
AT-F-4-S	Unconfined	2004	Poly, mesh	109.9	109.8								N																	Redundant with nearby tubes
C6302	Unconfined	2008	Poly, mesh	111.3	111.1	X		X					Y			A		A	A		A		A	A		B		B	B	
C6303	Unconfined	2008	Poly, mesh	109.4	109.3	X		X					Y			A		A			A		A			B		B		
C6305	Unconfined	2008	Poly, mesh	111.1	111.0								N																	Single depth sufficient
C6306	Unconfined	2008	Poly, mesh	109.4	109.2	X		X					Y			A		A	A		A		A	A		B		B	B	

Table 6. Monitoring Wells, Aquifer Sampling Tubes, and Seeps Considered for 100-FR-3 Monitoring Network

Well Name	Screened Unit	Year Installed	Casing and Screen Type	Elevation Top Screen or Perf (m)	Elevation Bottom Screen or Perf (m)	Rationale								Wtr Lvl		Yr 1 Frequency					Yr 2 to 5 Frequency					Yr 6+ Frequency[b]				Rationale for Not Monitoring, or Other Comment
						PSQ 1a, 1b	PSQ 1c	PSQ 1d	PSQ 1e	PSQ 2	PSQ 3	PSQ 4	Sample	Automated	Manual[a]	Cr(VI)	TCE & Deg. Prod.	Nitrate	Sr-90	Trace Metals	Cr(VI)	TCE & Deg. Prod.	Nitrate	Sr-90	Trace Metals[c]	Cr(VI)	TCE & Deg. Prod.	Nitrate	Sr-90	
C6307	Unconfined	2008	Poly, mesh	108.6	108.4								N																	Single depth sufficient
C6308	Unconfined	2008	Poly, mesh	111.0	110.8								N																	Single depth sufficient
C6309	Unconfined	2008	Poly, mesh	108.9	108.7	X		X					Y			A		A	A		A		A	A		B		B	B	
C6311	Unconfined	2008	Poly, mesh	110.8	110.7								N																	Redundant with nearby tubes
C6312	Unconfined	2008	Poly, mesh	108.9	108.7								N																	Redundant with nearby tubes
C6314	Unconfined	2008	Poly, mesh	111.1	110.9								N																	Single depth sufficient
C6315	Unconfined	2008	Poly, mesh	109.0	108.9	X		X					Y			A		A	A		A		A	A		B		B	B	
C6316	Unconfined	2008	Poly, mesh	106.3	106.2								N																	Single depth sufficient
SEEPS																														
Seep 207-1	Shoreline	N/A	N/A	N/A	N/A								N																	No monitoring objective
Seep 187-1	Shoreline	N/A	N/A	N/A	N/A	X		X					Y			A		A			A		A			B		B		
RIVER STAGE																														
100-F gauge	River Stage						X	X			X			X																

Note: "X?" and "N?" indicate contingency wells. If evaluation indicates that 699-60-32 does not monitor the unconfined aquifer, 699-59-32 will be sampled instead. If 699-60-32 monitors the unconfined aquifer, then 699-59-32 will be used for water levels only.

a. Manual measurements three times per year at low, moderate, and high river stages.

b. Frequency will be evaluated during year 5; assume biennial for planning purposes.

c. Monitoring for trace metals will cease after eight independent samples have concentrations below action levels or practical quantitation limits.

d. Monitors unconfined aquifer and >1 m of the RUM.

A = to be sampled annually
B = to be sampled biennially (every other year)
Cr(VI) = hexavalent chromium
CS, Perf = carbon steel casing, perforated casing
FY = fiscal year
Galv, unkn = galvanized metal casing; unknown material screen
N or Y in sample column = no (not sampled) or yes (sampled)
N/A = not applicable
Poly, mesh = flexible polyethylene tubing with stainless steel mesh screen
PSQ = principal study question
PVC = polyvinyl chloride casing and screen
Q = to be sampled quarterly
RUM = Ringold upper mud unit
S = to be sampled semiannually (twice per year)
Sr-90 = strontium-90
Wtr Lvl = water level
Yr = year
SS, Screen = stainless steel casing and screen
TBD = to be determined
TCE & Deg Prod = trichloroethene and degradation products
Trace Metals = antimony, cadmium, and cobalt

Table 7. 100-F Wells with Action Level Exceedances for Trace Metals

Antimony (5.6 µg/L)		Cadmium (0.25 µg/L[a,b])		Cobalt (4.8 µg/L)	
Well	**Result, Method**	**Well**	**Result, Method**	**Well**	**Result, Method**
199-F5-4	51.7, 6010	None	None	199-F5-43A	13.1 C, 6010
199-F5-4	43.6 C Y, 6010			199-F5-43A	11.6 C, 6010
199-F8-7	34.8 B, 6010			199-F5-44	12.1 C, 6010
				199-F5-44	12.7 C, 6010
				199-F5-48	9 B, 6010

Note: Highlighted wells selected for further analysis of antimony, cadmium, and cobalt.

a. Applies to river.

b. Only 114 of 370 results had detection limits below the 0.25 µg/L action level. Thus, cadmium is included despite no exceedances.

B = below required detection limit and above method detection limit

C = blank contamination

Y = suspected error

Table 8. Assumed Number of Wells for Attainment Monitoring

COC	Number of Wells[a]	Number Samples[b]	Total Samples
Hexavalent Chromium	10	11	110
Nitrate	20	11	220
Strontium-90	7	11	77
Trichloroethene	10	11	110

a. Assumed to be approximately half the number of wells sampled for the COC before cleanup levels achieved. Excludes aquifer tubes and seeps.

b. Assume quarterly sampling for 2 years and annual sampling for 3 years.

COC = contaminant of concern

8 References

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EPA and DOE, 2014, *Record of Decision Hanford 100 Area Superfund Site 100-FR-1, 100-FR-2, 100-FR-3, 100-IU-2, and 100-IU-6 Operable Units*, U.S. Environmental Protection Agency and U.S. Department of Energy, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0083577.

OSWER 9283.1-44, 2014, *Recommended Approach for Evaluating Completion of Groundwater Restoration Remedial Actions at a Groundwater Monitoring Well*, Office of Solid Waste and Emergency Response, U.S. Environmental Protection Agency, Washington, D.C. Available at: http://www.epa.gov/superfund/health/conmedia/gwdocs/pdfs/GWcompletion-recommendedapproach-final-8.4.2014.pdf.

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

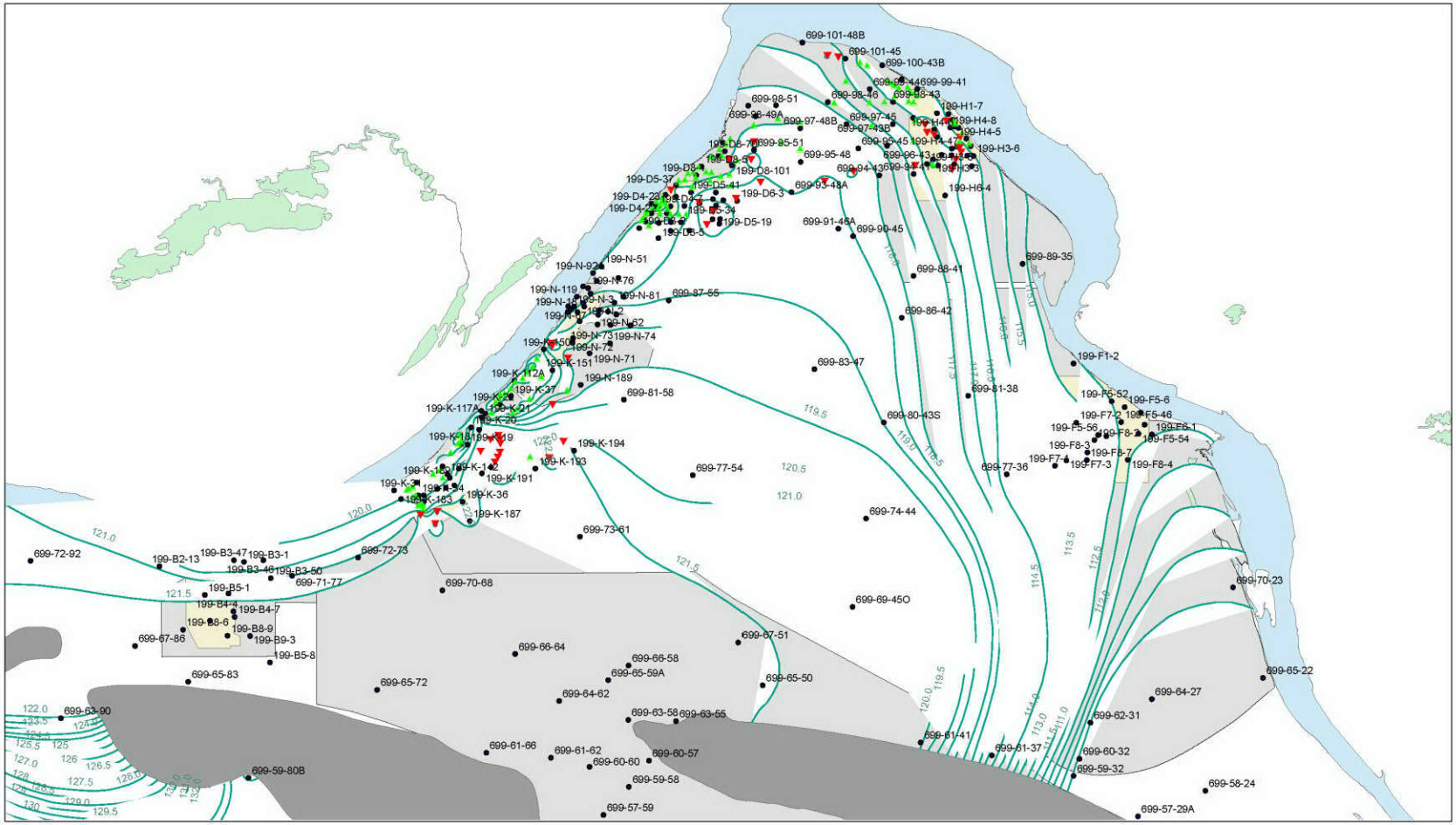

Figure 1. March 2014 Water Table in the Northern Portion of the Hanford Site (Showing Wells Used to Interpret Water Table)

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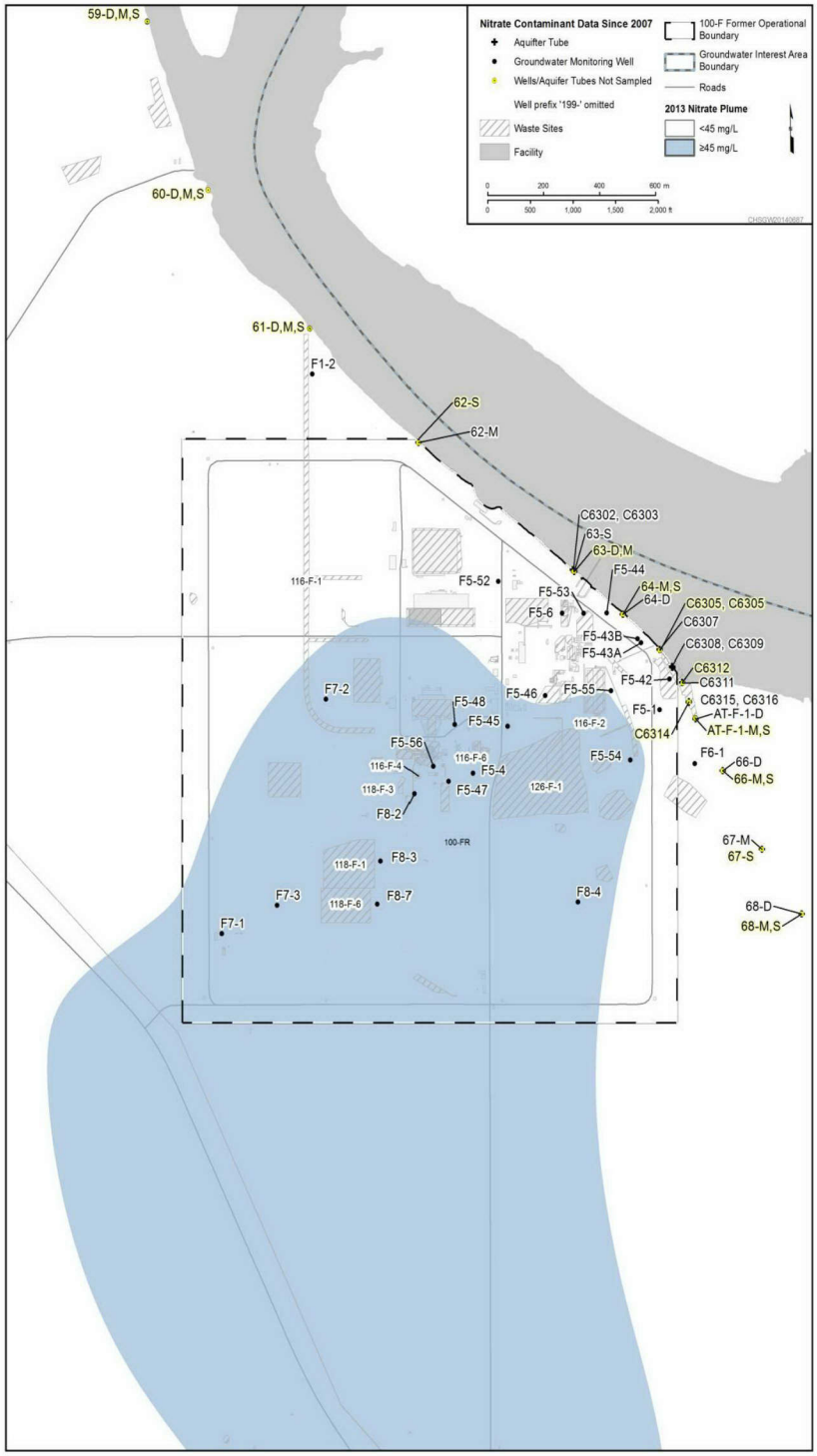

Figure 2. 2013 Nitrate Plume (with Wells Sampled for Nitrate since 2007)

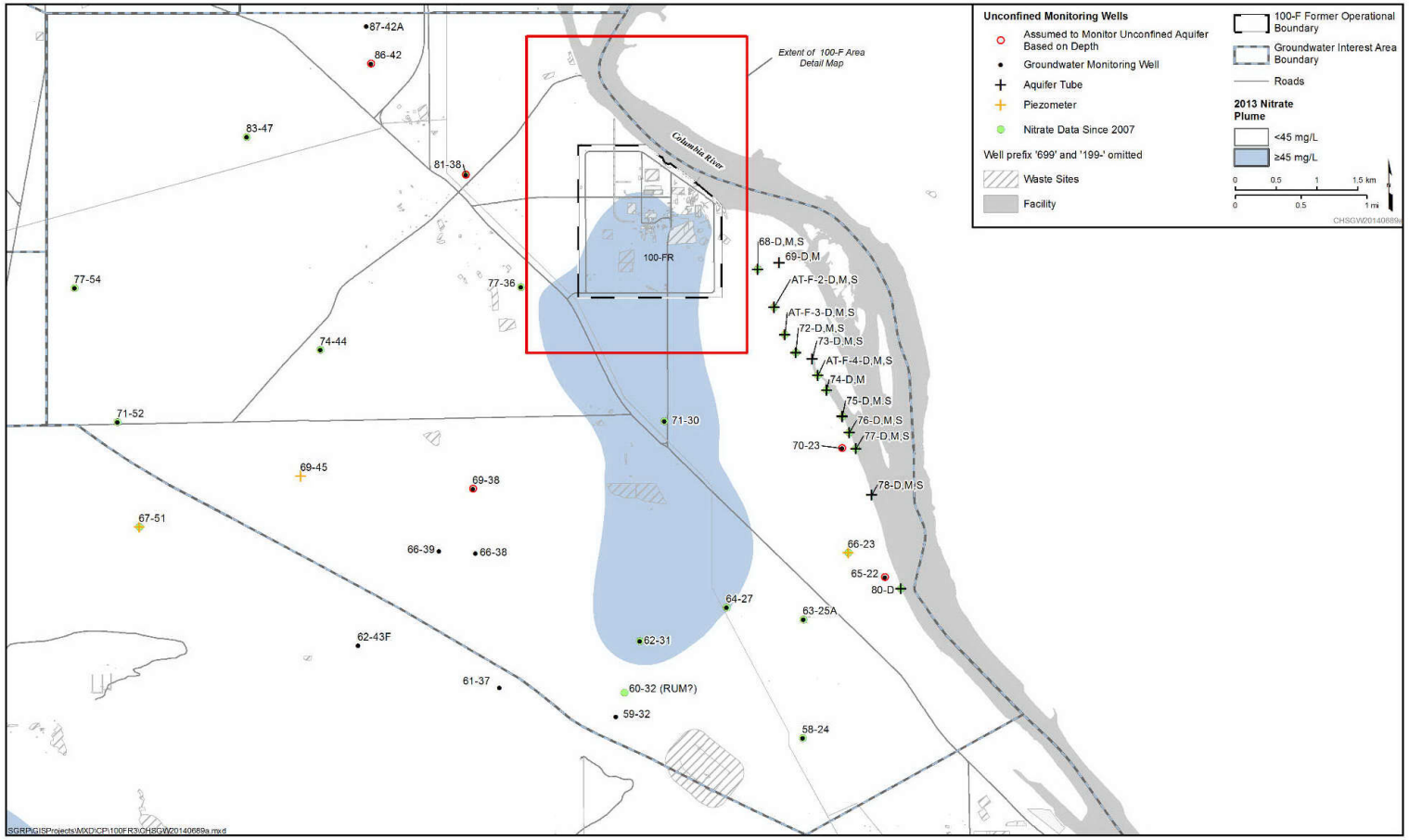

Figure 3. Available Unconfined Aquifer Monitoring Wells in the 600 Area Near 100-F (with 2013 Nitrate Plume)

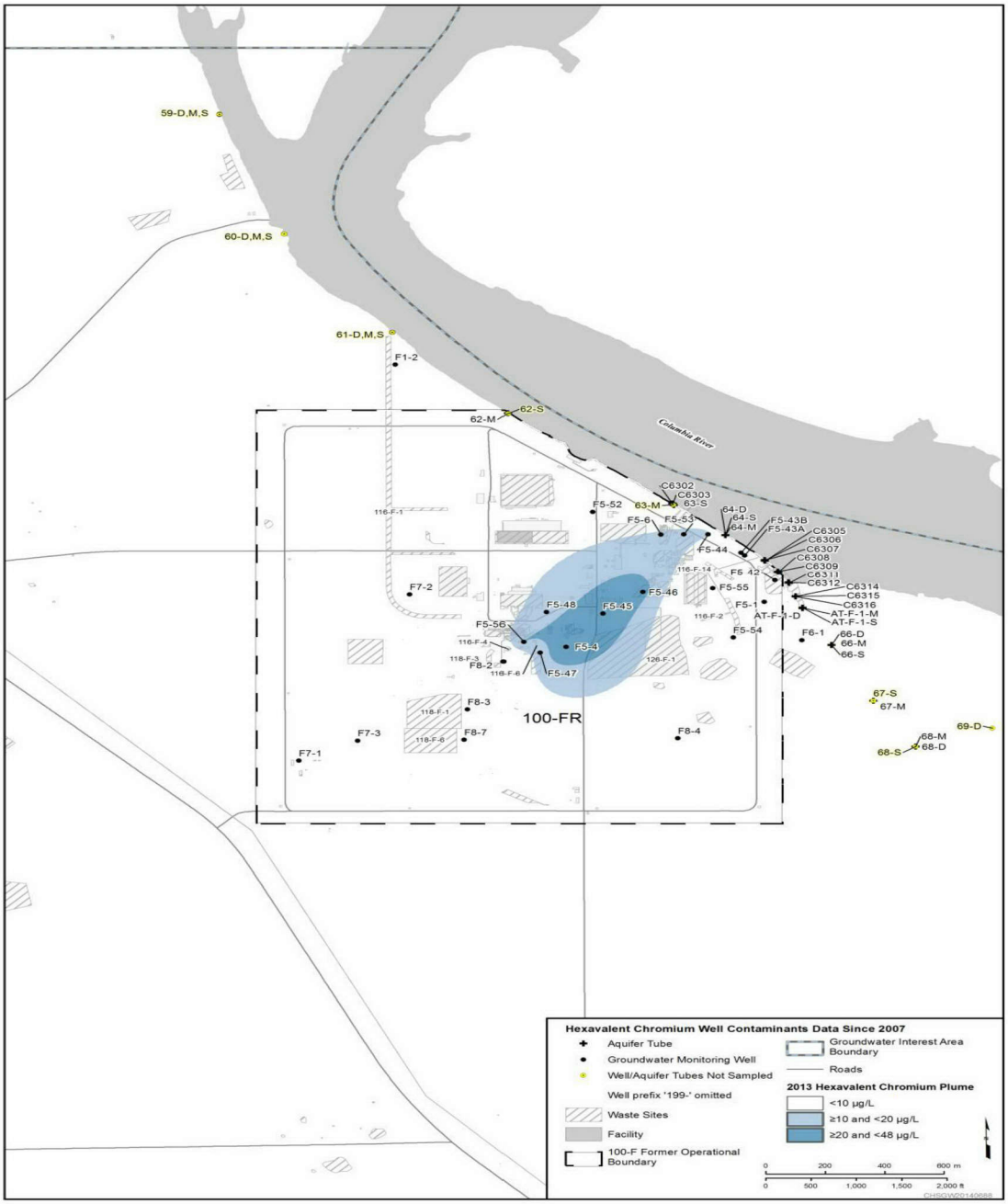

Figure 4. 2013 Chromium Plume (with Wells Sampled for Chromium since 2007)

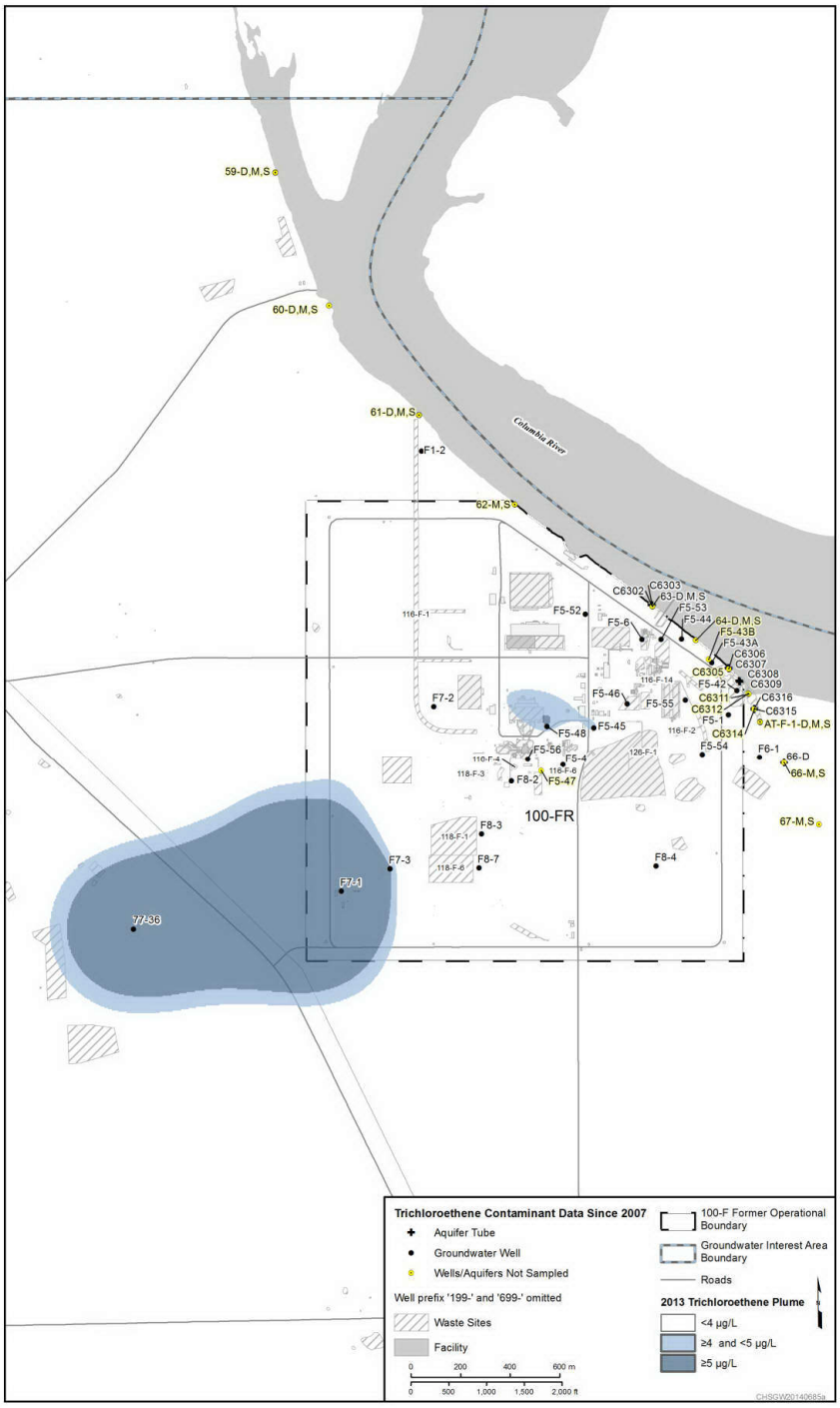

Figure 5. 2013 Trichloroethene Plume (with Wells Sampled for TCE since 2007)

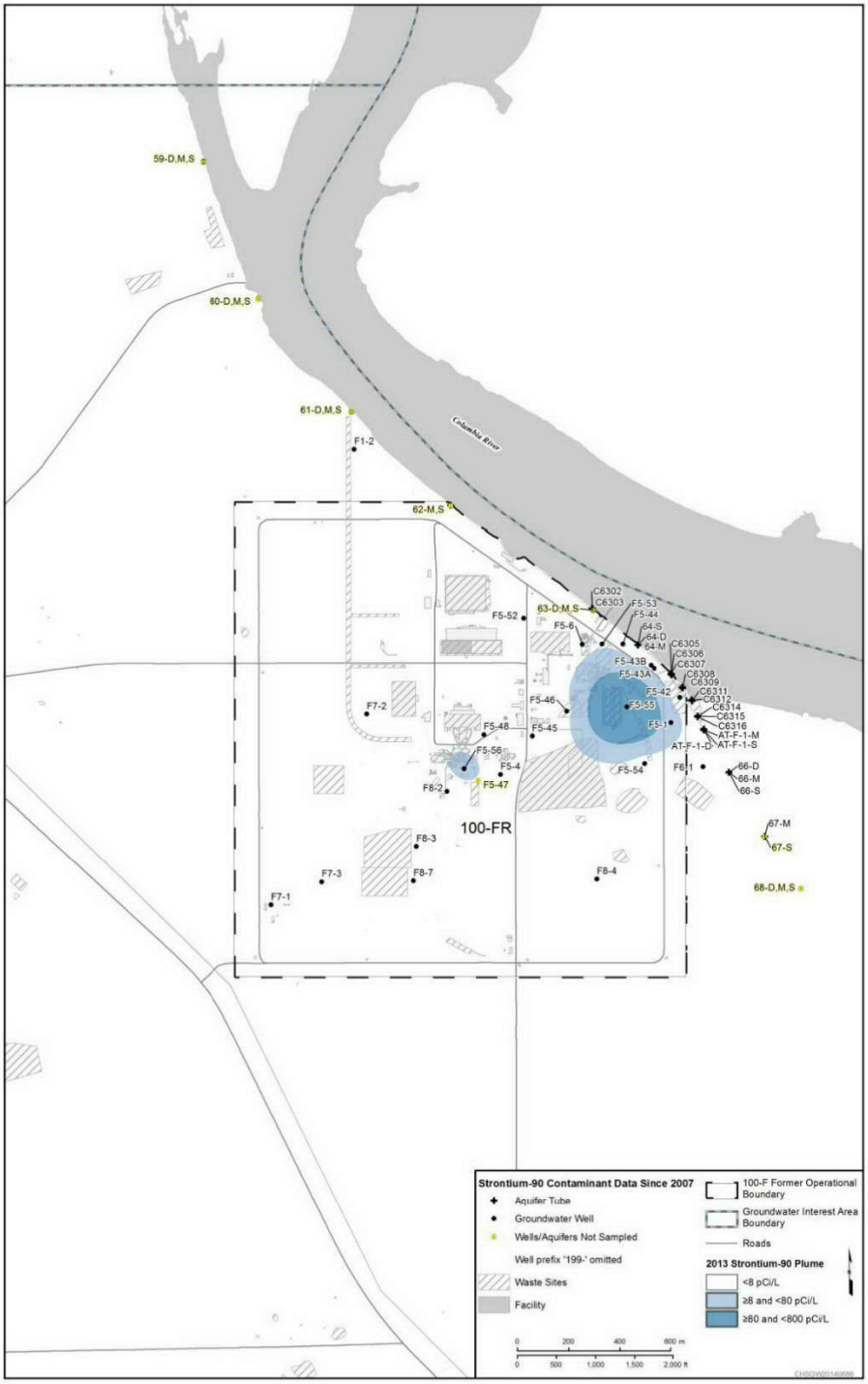

Figure 6. 2013 Stronium-90 Plume (with Wells Sampled for Strontium-90 since 2007)

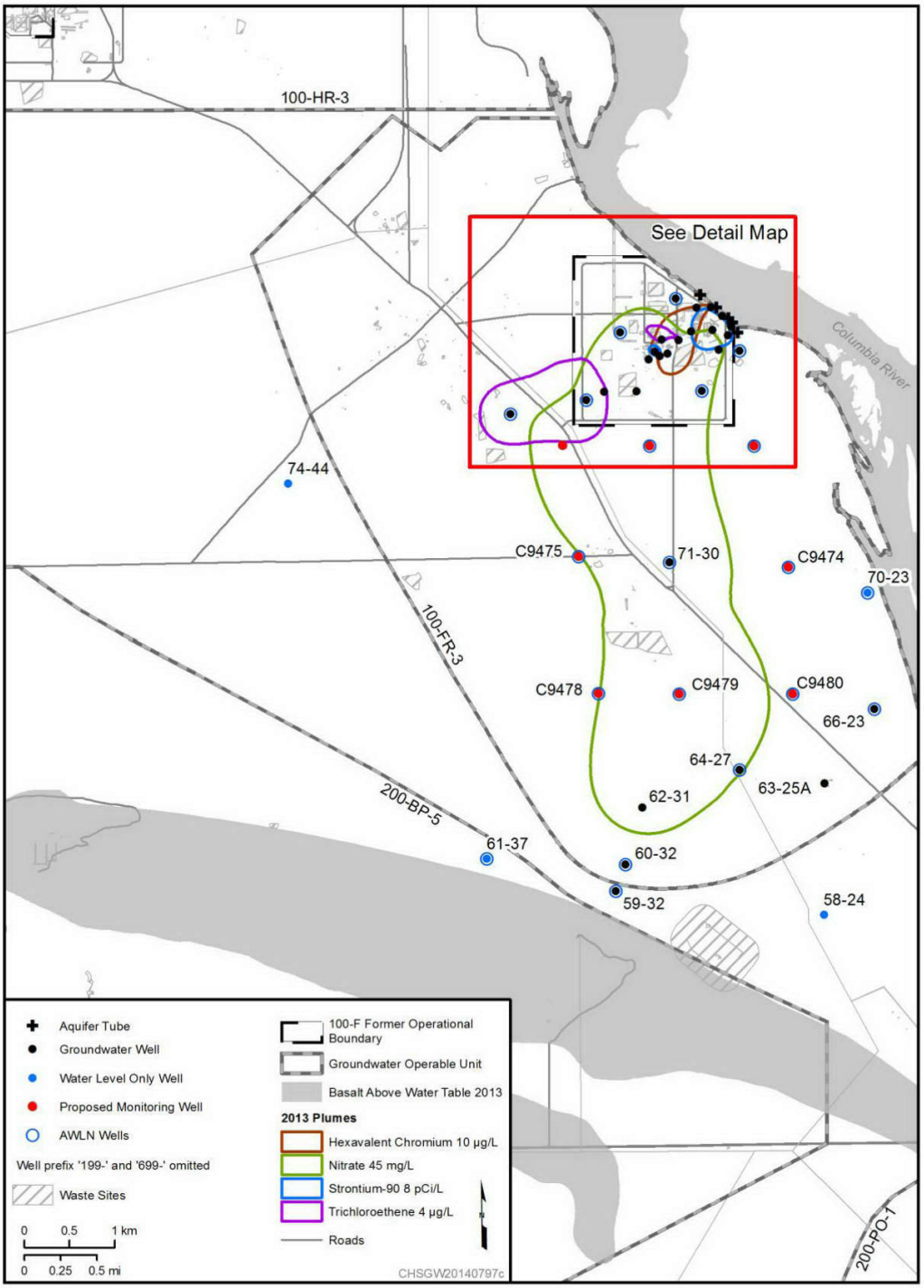

Figure 7. Proposed Monitoring Network, Including New Well Locations (Phase 1)

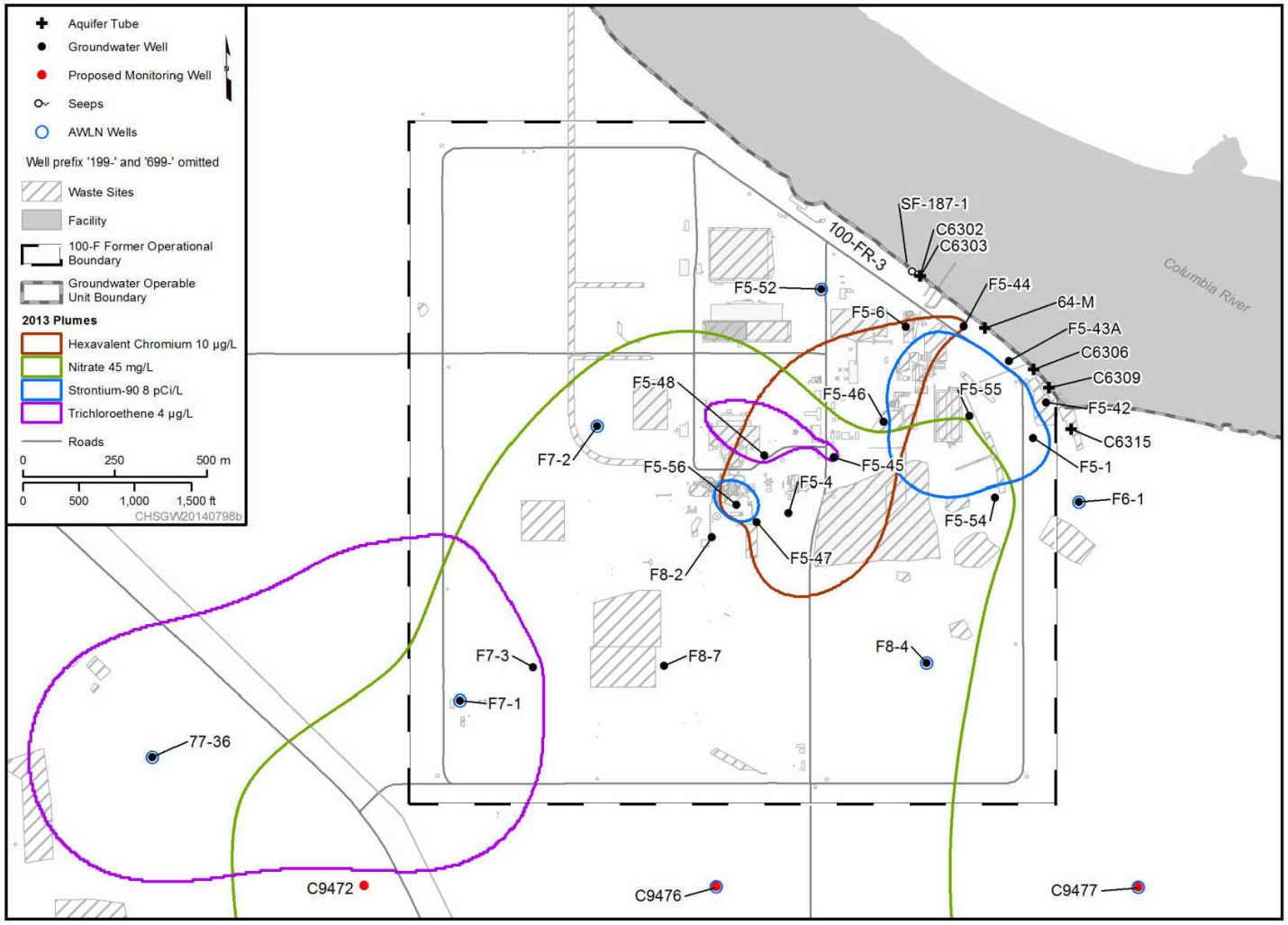

Figure 8. Proposed Monitoring Network (100-F Area Detail)

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Appendix B

100-FR-3 Monitoring Network Operations and Maintenance Plan

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Terms

AWLN	automated water level network
COC	contaminant of concern
DOE	U.S. Department of Energy
EPA	U.S. Environmental Protection Agency
MNA	monitored natural attenuation
O&M	operations and maintenance
OU	operable unit
ROD	record of decision
SAP	sampling and analysis plan

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B1 Introduction

This operations and maintenance (O&M) plan outlines the activities necessary to operate and maintain the network identified for groundwater monitoring of the 100-FR-3 Groundwater Operable Unit (OU) (Figures B-1 and B-2). In September 2014, the U.S. Environmental Protection Agency (EPA) and U.S. Department of Energy (DOE) issued *Record of Decision Hanford 100 Area Superfund Site 100-FR-1, 100-FR-2, 100-FR-3, 100-IU-2, and 100-IU-6 Operable Units*, hereinafter called the 100-F/IU Record of Decision (ROD), for the 100-FR-3 Groundwater OU. The 100-F/IU ROD (EPA and DOE, 2014) selected monitored natural attenuation (MNA) of groundwater and institutional controls to restrict groundwater use as the final remedial actions. MNA will be implemented for hexavalent chromium, nitrate, strontium-90, and trichloroethene in groundwater. Performance monitoring of these contaminants in the groundwater as a component of the MNA remedy will be performed until cleanup levels are met.

The remedial design report/remedial action work plan (DOE/RL-2014-44, *Integrated Remedial Design Report/Remedial Action Work Plan for 100-F/IU*) addresses the soil and groundwater OUs and is accompanied by two addenda. The two addenda correspond to the two distinct media (soil and groundwater). The groundwater monitoring network components identified for MNA performance monitoring, including wells, aquifer tubes, a riverbank seep, and the 100-F river gauge station, are presented in a groundwater sampling and analysis plan (SAP) in Appendix A of *Remedial Design Report/ Remedial Action Work Plan for 100-F/IU Groundwater* (hereinafter called the Groundwater Addendum). Selected monitoring wells and the 100-F river gauge station will be included in an automated water level network (AWLN). This O&M plan is also an appendix to the Groundwater Addendum.

B1.1 Purpose

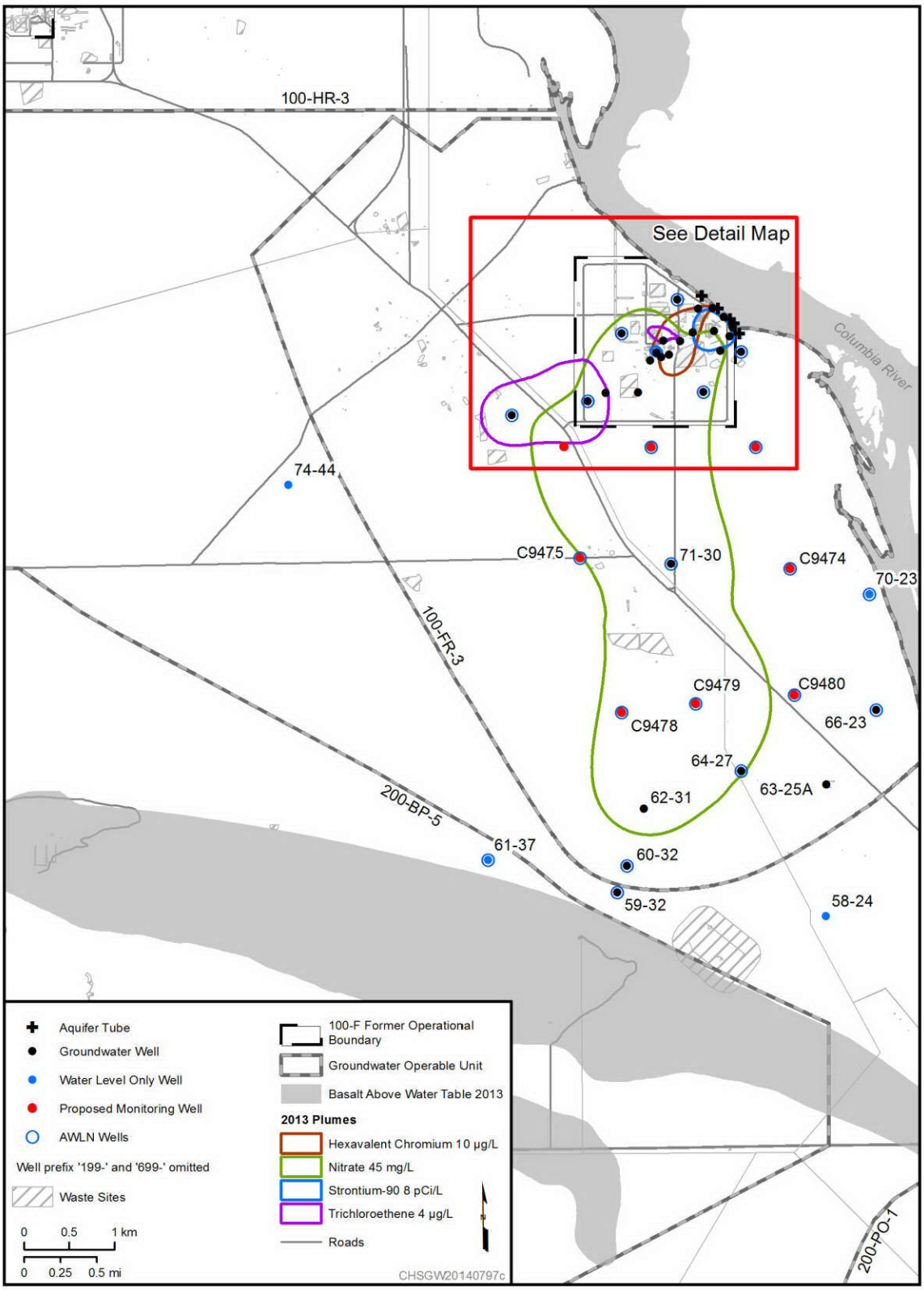
An O&M plan is needed to operate and maintain the performance monitoring network as a necessary component of the MNA remedy.

B1.2 Scope

This O&M plan scope encompasses monitoring wells and aquifer tubes within the performance monitoring network for the 100-FR-3 OU. This O&M plan also includes the 100-F river gauge station.

B1.3 Objectives

The objective of this O&M plan is to maintain the monitoring network needed for performance monitoring of the MNA remedy at the 100-FR-3 OU. The time frame for groundwater monitoring for individual plumes varies depending on the contaminant of concern (COC). The strontium-90 plume, estimated to require 150 years to achieve the cleanup level, has the longest monitoring period.



Note: Either Well 59-32 or 60-32 will be included in the network, depending on field investigation results.

Figure B-1. 100-FR-3 Operable Unit Monitoring Network

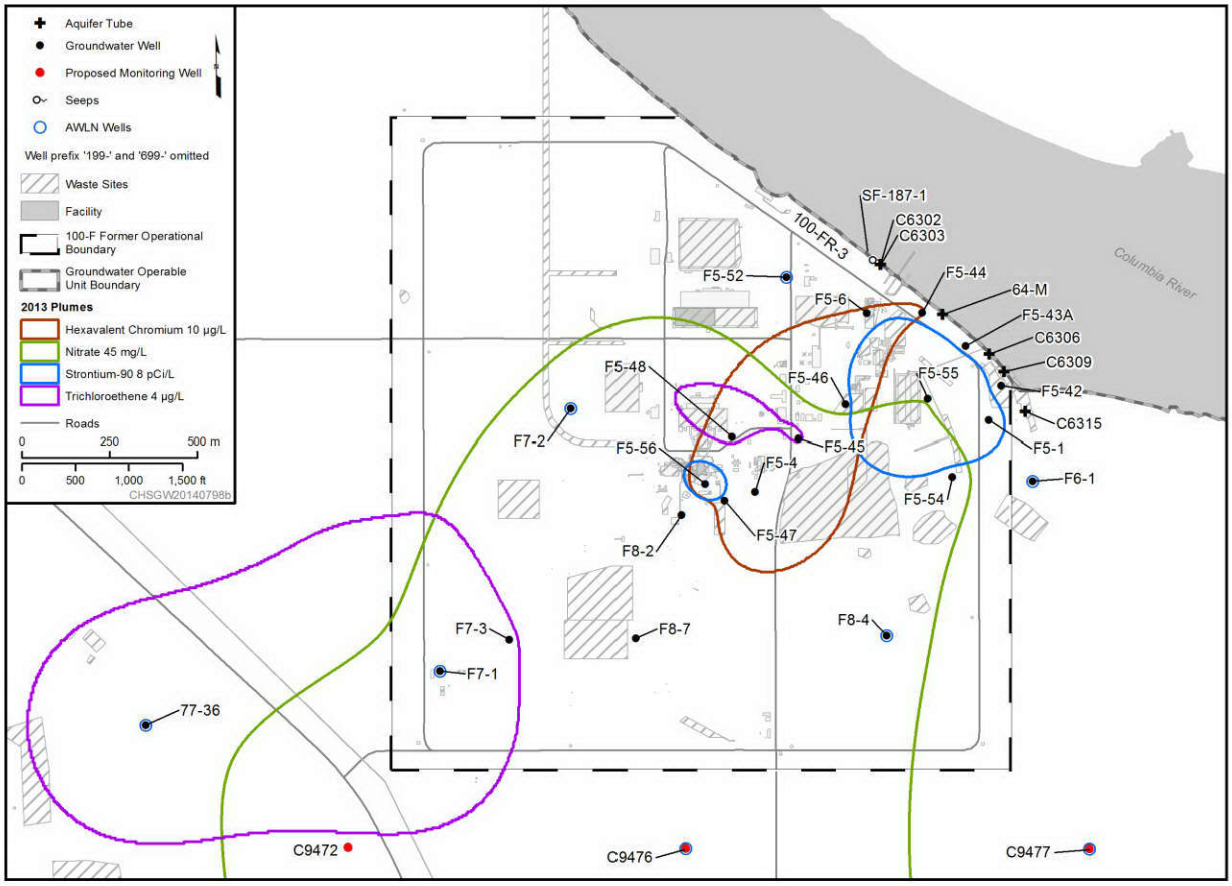


Figure B-2. Detail Map of 100-FR-3 Operable Unit Monitoring Network near 100-F Area

B2 Operations

The operational goal is to sample at designated monitoring wells, aquifer tubes, and the river gauge station during the natural attenuation performance monitoring period. An AWLN will be operated continuously through at least the initial 5 years of monitoring. As the concentrations of COCs are reduced and the plume sizes reduce, the monitoring network will be adjusted. Wells and aquifer tubes will not be arbitrarily removed from service unless they are determined to be no longer needed in the groundwater monitoring network due to decreasing COC plume size. Wells taken out of service due to shrinking of the COC plumes will be scheduled for future decommissioning if it is determined that they are not potentially needed for future monitoring.

B3 Monitoring Network Maintenance

B3.1 Well Maintenance

Well maintenance will be necessary for some wells during the time frame of the MNA remedy. Maintenance includes repair or replacement of pumps and wellhead inspection and maintenance.

Well maintenance will be performed on an as-needed basis. During scheduled sample collection events, sampling crews will inspect the wells. If problems with the wellhead or pump are observed, or if there is a problem obtaining samples (e.g., excessive drawdown or high turbidity), well maintenance will be performed. Well maintenance may also be performed based on unusual sampling results.

The following activities may be initiated if a well is determined to require maintenance:

- Removal and inspection of all downhole well components (e.g., pump and riser pipe, level transducer, and wiring)
- Downhole camera inspection (includes recording the inspection)
- Swabbing the well to loosen any accumulated solids from the well casing and screen
- Surging (with a dual-plate surge block) and pumping to redevelop the well screen and filter pack and remove accumulated solids from the well (continue surging the well until no more than 30 cm [0.1 ft] infill during 15 minutes surge is achieved)
- Final camera survey (includes recording the inspection)

During the performance monitoring period, which extends up to 150 years for strontium-90, it is highly likely that some wells will require replacement. In the event that the condition of a well has deteriorated and is not repairable, the DOE-Richland Operations Office and lead regulatory agency will determine if the well should be replaced.

B3.2 AWLN Maintenance

An AWLN will be installed and operated for a 5-year period at selected monitoring locations identified in the Groundwater Addendum SAP (Appendix A). After 5 years, the project will evaluate the need for continued AWLN operation.

AWLN data will be checked against manual water level measurements at least once per year, and instruments will be recalibrated when necessary. Stations within the AWLN will undergo installation, maintenance, upgrades, removal, and replacement in accordance with specific maintenance procedures. Maintenance may include troubleshooting, component change-outs, and upgrades to station telemetry equipment in support of the AWLN.

At the end of the AWLN monitoring period, system components will be removed from the monitoring wells.

B3.3 Aquifer Tube Maintenance

During scheduled sample collection events, sampling crews will inspect the aquifer tubes. Repairs to the aquifer tubes will be performed, as needed.

B4 Waste Management

Appendix C of the Groundwater Addendum, "Waste Management Plan for the 100-FR-3 Operable Unit," establishes the requirements for management and disposal of waste generated from the installation, monitoring, sampling, maintenance, and decommissioning activities associated with the performance monitoring network at the 100-FR-3 OU. Waste is managed in accordance with Appendix C.

B5 Monitoring Network Maintenance Reporting

Any well maintenance activities that affect sample quality will be summarized in the Hanford Site annual groundwater report (e.g., DOE/RL-2014-32, *Hanford Site Groundwater Monitoring Report for 2013*). The performance monitoring results will be included as part of the annual groundwater report following each sample collection year.

B6 References

DOE/RL-2014-32, 2014, *Hanford Site Groundwater Monitoring Report for 2013*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0084842.

DOE/RL-2014-44, 2015, *Integrated Remedial Design Report/Remedial Action Work Plan for 100-F/IU*, Draft A, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

EPA and DOE, 2014, *Record of Decision Hanford 100 Area Superfund Site 100-FR-1, 100-FR-2, 100-FR-3, 100-IU-2, and 100-IU-6 Operable Units*, U.S. Environmental Protection Agency and U.S. Department of Energy, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0083577.

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Appendix C

Waste Management Plan for the 100-FR-3 Operable Unit

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Terms

COC	contaminant of concern
DOE	U.S. Department of Energy
EPA	U.S. Environmental Protection Agency
ERDF	Environmental Restoration Disposal Facility
MNA	monitored natural attenuation
OU	operable unit
RDR/RAWP	remedial design report/remedial action work plan
ROD	record of decision
SAP	sampling and analysis plan
TBD	to be determined

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C1 Introduction

This waste management plan establishes the requirements for management and disposal of waste associated with the groundwater remedial action identified in 2014 by the U.S. Environmental Protection Agency (EPA) and U.S. Department of Energy (DOE) in *Record of Decision Hanford 100 Area Superfund Site 100-FR-1, 100-FR-2, 100-FR-3, 100-IU-2, and 100-IU-6 Operable Units* (100-F/IU record of decision [ROD]). The 100-F/IU ROD (EPA and DOE, 2014) encompasses the 100-FR-3 Groundwater Operable Unit (OU) (Figure C-1), which comprises groundwater contaminated by releases from facilities and waste sites associated with past operation of the 100-F Reactor and the Experimental Animal Farm. The 100-F/IU ROD (EPA and DOE, 2014) selected monitored natural attenuation (MNA) of groundwater and institutional controls to restrict groundwater use as the final remedial actions. MNA will be implemented for the 100-FR-3 OU contaminants of concern (COCs): hexavalent chromium, nitrate, strontium-90, and trichloroethene.

Performance monitoring of the 100-FR-3 OU COCs as a component of the MNA remedy is identified in the 100-F/IU ROD (EPA and DOE, 2014) and described in DOE/RL-2014-44, *Integrated Remedial Design Report/Remedial Action Work Plan for 100-F/IU* (Integrated RDR/RAWP), and *Remedial Design Report/Remedial Action Work Plan for 100-F/IU Groundwater* (Groundwater Addendum), to which this document is an appendix. Performance monitoring includes identification of the groundwater monitoring network, installation of new monitoring wells, and periodic sampling of the monitoring network. Monitoring will be performed until cleanup levels are achieved.

This document includes the requirements for management and disposal of waste generated from the installation of new monitoring wells and monitoring activities at monitoring wells, aquifer tubes, riverbank seeps, and the 100-F Area automated river gauge station. The components of the performance monitoring network are presented in a Groundwater Sampling and Analysis Plan (SAP) (Appendix A of the Groundwater Addendum). Complete lists of wells and aquifer tubes associated with the 100-FR-3 OU that are under the purview of this plan are presented in Tables C-1 and C-2, respectively. The tables will be updated as wells or aquifer tubes are added, decommissioned, or removed from service.

The following activities will likely generate waste:

- Groundwater well installation
- Groundwater well or aquifer tube development, sampling, maintenance, and decommissioning
- Water level and other in situ groundwater measurements
- Seep sampling
- River gauge sampling
- Screening and analysis of samples
- Decontamination of equipment and material

Upon approval of the Integrated RDR/RAWP (DOE/RL-2014-44) and the Groundwater Addendum, to which this document is an appendix, this waste management plan will supersede DOE/RL-2004-31, *Waste Control Plan for the 100-FR-3 Operable Unit.*

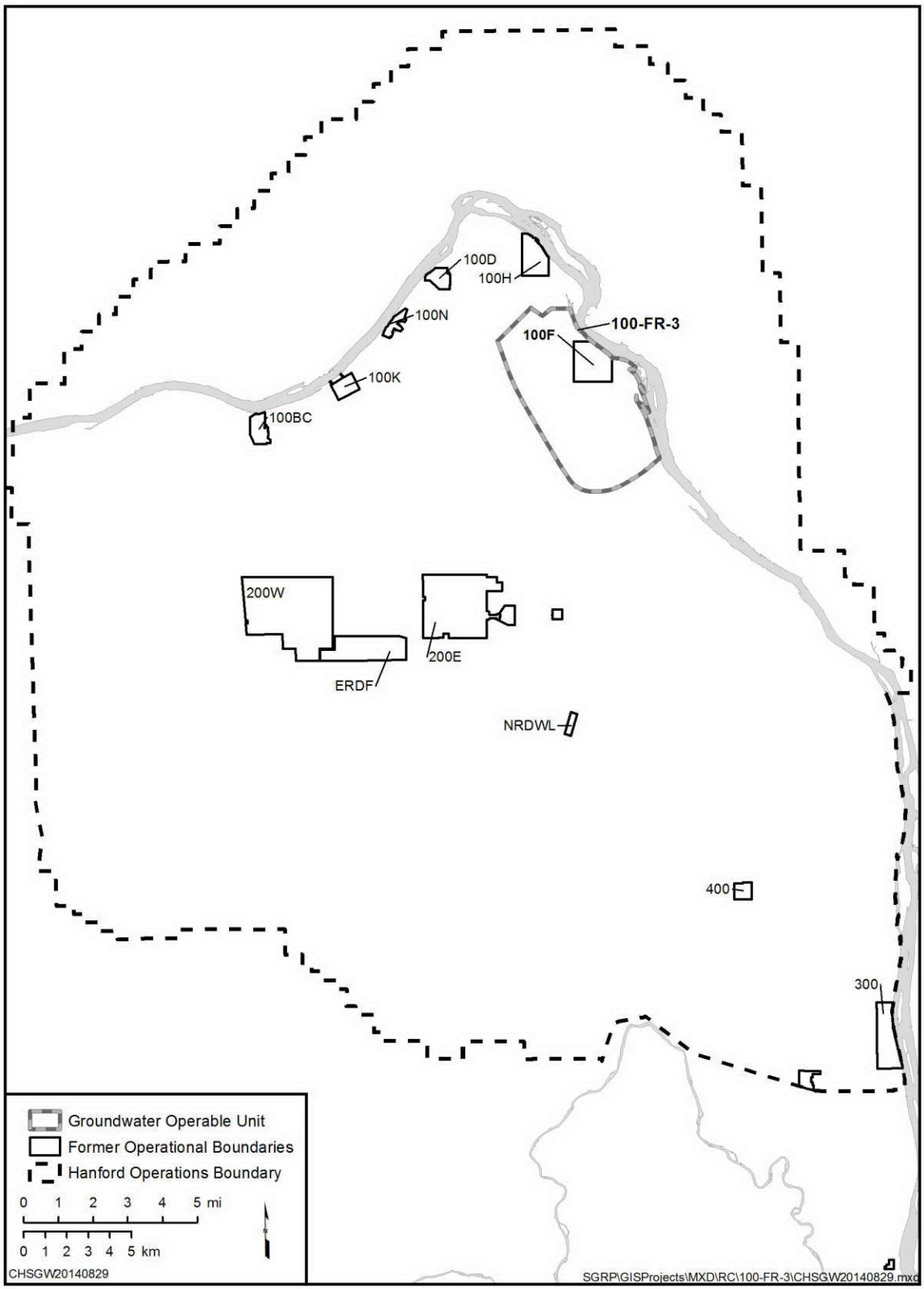

Figure C-1. Location of the 100-FR-3 Groundwater Operable Unit

Table C-1. Wells Associated with the 100-FR-3 Operable Unit

Well Name	Well Identification	Well Name	Well Identification	Well Name	Well Identification
199-F1-2	A4586	199-F8-2	A4607	699-69-45R	A9761
199-F5-1	A4587	199-F8-3	A4608	699-70-23	A5318
199-F5-4	A4590	199-F8-4	A4609	699-71-30	A5320
199-F5-42	A4591	199-F8-7	C6834	699-71-52	A5321
199-F5-43A	A4592	699-57-29A	A5267	699-74-44	A5328
199-F5-43B	A4593	699-57-29B	A5268	699-77-36	A5330
199-F5-44	A4594	699-58-24	A5275	699-77-54	A5331
199-F5-45	A4595	699-59-32	A5276	699-80-43P	A8993
199-F5-46	A4596	699-60-32	A5279	699-80-43S	A5336
199-F5-47	A4597	699-62-31	A5287	699-81-38	A5337
199-F5-48	A4598	699-63-25A	A5289	699-83-47	A5341
199-F5-52	C7790	699-64-27	A5295	699-84-34B	A9021
199-F5-53	C7791	699-65-22	A5297	699-84-35A	A5342
199-F5-54	C7792	699-66-23	A5306	699-84-35AO	A9769
199-F5-55	C7970	699-66-38	A5307	699-84-35AP	A9770
199-F5-56	C7972	699-66-39	A5308	699-84-35AQ	A9771
199-F5-6	A4600	699-69-38	A5316	699-84-35AR	A9772
199-F6-1	A4602	699-69-45	A8967	699-84-35AS	A9773
199-F7-1	A4603	699-69-45O	A5317	699-86-42	A5344
199-F7-2	A4604	699-69-45P	A9759	699-87-42A	A5345
199-F7-3	A4605	699-69-45Q	A9760		
Phase 1 Wells To Be Installed					
TBD	C9472	TBD	C9476	TBD	C9479
TBD	C9474	TBD	C9477	TBD	C9480
TBD	C9475	TBD	C9478		

Note: Wells identified in Table C-1 are associated with the 100-FR-3 groundwater interest area as of January 2015.

TBD = to be determined

Table C-2. Aquifer Tubes Associated with the 100-FR-3 Operable Unit

Well Name	Well Identification	Well Name	Well Identification	Well Name	Well Identification
59-D	B8325	68-D	B8352	AT-F-2-D	C4392
59-M	B8326	68-M	B8353	AT-F-2-M	C4393
59-S	B8327	68-S	B8354	AT-F-2-S	C4394
60-D	B8328	69-D	B8355	AT-F-3-D	C4383
60-M	B8329	72-D	B8364	AT-F-3-M	C4384
60-S	B8330	72-M	B8365	AT-F-3-S	C4385
61-D	B8331	72-S	B8366	AT-F-4-D	C4386
61-M	B8332	74-D	B8370	AT-F-4-M	C4387
61-S	B8333	74-M	B8371	AT-F-4-S	C4388
62-M	B8335	75-D	B8373	C6302	C6302
62-S	B8336	75-M	B8374	C6303	C6303
63-D	B8337	75-S	B8375	C6305	C6305
63-M	B8338	76-D	B8376	C6306	C6306
63-S	B8339	76-M	B8377	C6307	C6307
64-D	B8340	76-S	B8378	C6308	C6308
64-M	B8341	77-D	B8379	C6309	C6309
64-S	B8342	77-M	B8380	C6311	C6311
66-D	B8346	77-S	B8381	C6312	C6312
66-M	B8347	80-D	B8388	C6314	C6314
66-S	B8348	AT-F-1-D	C4389	C6315	C6315
67-M	B8350	AT-F-1-M	C4390	C6316	C6316
67-S	B8351	AT-F-1-S	C4391		

Note: Aquifer tubes identified in Table C-2 are associated with the 100-FR-3 groundwater interest area as of January 2015.

C2 Projected Waste Streams

Similar types of waste specific to the 100-FR-3 OU will be managed uniformly. Projected waste streams may include the following:

- Miscellaneous solid waste, such as filters, wipes, gloves, and other personal protective equipment, cloth, sampling and measuring equipment, pumps, pipe, wire, plastic sheeting, tools, bentonite, sand, paper, wood, construction debris, metal, and glass

- Drill cuttings and associated waste
- Purgewater generated during groundwater well or aquifer sampling tube installation, development, testing, monitoring, maintenance, and decommissioning
- Purgewater generated during decanting of soils and slurries
- Decontamination fluids
- Liquids generated during screening analysis
- Materials generated from cleanup of unplanned releases
- Equipment and construction material (e.g., well casings, drill string, drive barrel, construction equipment and materials, decommissioning materials, and wooden pallets)

C3 Waste Designation and Disposal

Waste will be designated in accordance with WAC 173-303, "Dangerous Waste Regulations," using process knowledge, historical analytical data, or analyses of samples identified in the referenced documents or Groundwater SAP (Groundwater Addendum, Appendix A), as appropriate.
The 100-FR-3 OU has an extensive groundwater well and aquifer tube sampling network. Many years of historical analytical data are available to be used as the basis of waste designation. New waste streams are not anticipated but would be characterized as necessary for designation purposes.

Miscellaneous solid waste and decommissioning debris that have contacted potentially contaminated materials may be segregated from other materials and will be disposed of based on the waste designation. Contaminated materials or materials that have contacted contaminated media may be disposed of to the Environmental Restoration Disposal Facility (ERDF) if the acceptance criteria can be met or, if the criteria cannot be met, to another facility that is approved by the lead regulatory agency (EPA).

Contact solid waste that is nonhazardous and radiologically released, or waste that has not contacted potentially contaminated materials, may be disposed offsite to a Subtitle D solid waste landfill or recycled, as appropriate.

Purgewater that is generated will be managed as specified in Section C4.2.

C4 Waste Stream-Specific Management

This chapter describes the management of waste streams produced from well installation, sample collection, maintenance activities, decommissioning, and miscellaneous solid waste.

C4.1 Drill Cuttings

Drill cuttings (soils and slurries) from outside an area of known or suspected contamination will be collected in stockpiles near the point of generation. Soils and slurries from known or suspect contaminated areas will be placed on a tarp or in containers. Contained soil slurries will be decanted, and free liquids remaining in the container will be eliminated by evaporation and/or the addition of absorbent material prior to disposal, as necessary. Decanted water will be managed as purgewater. Soils and slurries may be placed on the ground, near the point of generation, if they meet the following criteria:

- Soil cleanup criteria in the 100-F/IU ROD (EPA and DOE, 2014)
- Not designated as a dangerous waste

- Below WAC 173-340-740 "Model Toxics Control Act—Cleanup," "Unrestricted Land Use Soil Cleanup Standards"
- Radiologically released

Decanting slurries and eliminating free liquids are authorized without prior approval. Decanted slurries may be disposed as purgewater.

C4.2 Purgewater

Purgewater is generated during well or aquifer tube installation, development, testing, monitoring, sampling, maintenance, and decanting of saturated soils during drilling activities. Purgewater will be dispositioned in accordance with this section.

C4.2.1 Purgewater Discharge

All extracted groundwater, including purgewater and free liquids separated from sediments and/or other materials generated during well drilling, well construction, and well development, will be discharged to the ground surface in accordance with the following subsections, collected for management at the modular storage unit(s), or transported to another appropriate unit (e.g., 200 Area Effluent Treatment Facility or pump-andtreat facilities). Transportation of the groundwater by truck, storage of nonempty trucks during off-hours, and collection of groundwater at the modular storage unit is governed by DOE/RL-2009-39 (as amended), *Investigation Derived Waste Purgewater Management Action Memorandum*, and DOE/RL-2009-80 (as amended), *Investigation Derived Waste Purgewater Management Work Plan*.

For returning groundwater to the environment, DOE can discharge according to guidelines found in the Purgewater Management Work Plan (DOE/RL-2009-80, as amended). When a discharge request is required, DOE can propose a discharge to EPA for a well or group of wells through Tri-Party Agreement (TPA) (Ecology et al., 1989, *Hanford Federal Facility Agreement and Consent Order*) project manager meetings. EPA will evaluate the discharge request and, when approved, the discharge request will be recorded in TPA (Ecology et al., 1989) Project Manager Meeting minutes.

C4.2.2 Groundwater Discharge Guidelines

The following guidelines may be used to evaluate and discharge purgewater. DOE can discharge without a discharge request for purgewater meeting the following criteria:

Purgewater may be discharged to the ground surface in accordance with Section C4.2.2.2 under the following criteria:

- Water from wells where groundwater is below cleanup levels, when purgewater is generated in support of monitoring (e.g., aquifer testing), or
- Low-purge and low-flow sampling methods for groundwater sample collection resulting in purgewater volumes of 19 L (5 gal) or less, or
- Purgewater from aquifer tube samples

For purgewater not meeting these criteria, DOE will prepare a discharge request. Discharge requests will be prepared with the information required by Sections C4.2.2.1 through C4.2.2.3. Before EPA will grant a new discharge request allowing groundwater to be discharged to the environment, the EPA will evaluate the potential impact of the proposed action based on the criteria in Sections C4.2.2.1 through C4.2.2.3. If EPA does not approve the discharge request within 30 days, the request will be considered denied.

If the request is denied, purgewater will be collected and transported to the modular storage unit(s) or other appropriate Hanford location.

Some aquifer tubes are located within the seasonal high-water mark of the Columbia River. When these tubes are sampled during high-water periods, these very low-volume discharges to the Columbia River are allowed.

C4.2.2.1 Chemistry

DOE will evaluate radiological groundwater data to meet the requirements of DOE Order 5400.5, *Radiation Protection of the Public and the Environment*, or subsequent replacement. DOE will submit discharge requests relating to nonradiological parameters for purgewater to EPA. Decisions will be based on existing data and will consider the following:

- Applicable regulatory requirements
- Approved, applicable TPA (Ecology et al., 1989) decision documents
- Previously approved contained-in determinations

The discharge request will contain applicable analytical data and associated quality assurance/quality control data to demonstrate that the discharge decision is appropriate.

C4.2.2.2 Location

Discharge to the ground is not allowed where it may remobilize potential existing contamination and may not occur within or on the following areas:

- 100-F/IU waste site boundary
- No irrigation institutional control waste site
- Burial grounds
- Effluent disposal sites (ponds, cribs, ditches, or trenches)
- Surface or subsurface soil contamination areas

Discharges will be 6.1 m (20 ft) or greater from the well head to prevent channeling of water along the annulus of the well. DOE shall not propose to establish new waste sites by the approval of discharge requests.

C4.2.2.3 Volume

DOE will evaluate purgewater volume along with chemistry and location considerations. Purgewater discharges to the ground are exempt from WAC 173-216, "State Waste Discharge Permit Program," permitting based on condition G.12.A of Ecology, 2005, *State Waste Discharge Permit Number ST 4511*.

C4.3 Decontamination Fluids

Decontamination fluids (water and/or nonhazardous cleaning solutions), generated from cleaning equipment and tools in the OU, will be managed as purgewater.

Small volumes of decontamination fluids may be stabilized to eliminate free liquids and then disposed to ERDF, provided the waste acceptance criteria can be met (WCH-191, *Environmental Restoration Disposal Facility Waste Acceptance Criteria*).

Following removal of visible residue, decontamination of sample equipment may be conducted at the centralized sample equipment cleaning facility located in Building 6269 in the 600 Area.

C4.4 Analysis Screening Fluids

Unaltered liquid waste generated during screening analysis may be managed as purgewater, as previously described. Altered sample wastes will be disposed to the Effluent Treatment Facility, ERDF, modular storage units, or another appropriate facility, as authorized by the regulatory agency, depending on the waste designation. Some liquids may be neutralized and/or stabilized to meet disposal facility waste acceptance criteria.

C4.5 Miscellaneous Solid Wastes

Solid wastes are generated during groundwater well, aquifer tube, and seep sampling; aquifer testing; groundwater well or aquifer tube installation and development; well maintenance; decommissioning and alteration; water level measurements (both manual and transducer); screening of analysis liquids; and equipment decontamination. Miscellaneous solid waste that has contacted potentially contaminated materials will be segregated from other materials and placed in containers that are appropriate for the material and disposal facility. Miscellaneous solid waste that has contacted contaminated media may be disposed of at ERDF if the waste acceptance criteria can be met (WCH-191). If the ERDF waste acceptance criteria (WCH-191) cannot be met, the waste will be shipped to an offsite facility, as appropriate, and authorized by the lead regulatory agency (EPA), depending on the waste designation.

Miscellaneous solid waste that has not contacted contaminated media, has contacted miscellaneous solid waste that is nondangerous, and has been released for radionuclides may be disposed of at an offsite solid waste landfill.

C4.6 Decommissioning Debris

Decommissioning debris, such as concrete, wood, rebar, metal/plastic pipe and screens, wire, liners, bentonite/sand/gravel, equipment, and pumps, is generated during well decommissioning. Debris that has contacted contaminated media may be disposed of at ERDF if the ERDF waste acceptance criteria can be met, or at an approved offsite facility if the ERDF waste acceptance criteria cannot be met (WCH-191). Contact debris that is nondangerous and radiologically released, or materials that have not contacted potentially contaminated materials, may be disposed of offsite at a solid waste landfill or a Subtitle D solid waste landfill or recycled, as appropriate.

C4.7 Well Decommissioning

Wells that are identified for decommissioning will be removed from the wells listed in Table C-1. Aquifer tubes that are no longer in service will be removed from Table C-2.

C5 Packaging and Labeling

Materials requiring collection will generally be placed in drums or other suitable containers. However, packaging for large or irregular-shaped waste (e.g., well casing) may include containment other than drums. The packaging will provide insurance against migration of contaminants and protection from environmental degradation. The packaging may include, but is not limited to, plastic wrap.

Low-volume miscellaneous materials associated with activities such as groundwater well sampling, water level measurements, and groundwater well maintenance may be temporarily stored near the wellhead in an appropriate container (e.g., 208 L [55 gal] drum) or may be bagged, taped, and labeled with the well

number at the well head. The bagged material will be transported in a protective manner (i.e., containment of the material is maintained) with the workers while proceeding from well to well in the OU. Upon arrival at the storage location, materials will be placed in an accumulation container and managed as waste. The material may also be taken directly to ERDF for disposal, if appropriate, without storage.

State regulatory requirements for management of containers are established in WAC 173-303-630, "Use and Management of Containers," and WAC 173-303-160, "Containers." All containers of waste will be managed in accordance with the applicable substantive federal and/or state requirements, including labels which define the known major risk(s), dangerous waste codes, and if awaiting analysis, wording which states "waste pending analysis" with the date of initial sampling.

C6 Storage and Transportation

This chapter describes the storage and transportation of waste produced from well installation, sample collection, maintenance activities, decommissioning, and miscellaneous solid waste.

C6.1 Storage Location

Much of the waste is generated in small quantities on an ongoing basis. Waste will be stored at the centralized location identified in Figure C-2 until analytical data are evaluated for proper waste designation. Some waste (e.g., field decontamination fluids) may be temporarily (generally less than 2 weeks after generation) accumulated near the point of generation in the 100-FR-3 OU, then staged at the centralized storage location identified in Figure C-2. Because of the low volumes of waste generated, EPA has agreed that waste associated with the 100-FR-3 OU may be stored for up to 12 months, measured from the time waste is first placed in the container.

While in storage, waste will be managed in accordance with this plan. Most contaminated waste will be disposed at ERDF if it meets the waste acceptance criteria (WCH-191). However, based upon field screening instrumentation and/or analytical data, it may be determined that it is appropriate to manage certain types of waste at another approved facility, rather than at the ERDF. Waste that cannot be treated to meet the waste acceptance criteria for the approved disposal facility will remain on the waste site or in the centralized storage location pending disposal at an appropriate facility.

C6.2 Substantive Container Management Requirements

Federal and state regulatory requirements for management of containers are established in WAC 173-303-630 and WAC 173-303-160. All containers of waste will be managed in accordance with the applicable substantive state requirements including labels which define the known major risk(s), dangerous waste codes, and if awaiting analysis, wording which states "waste pending analysis" with the date of initial sampling.

C6.3 Release Reporting

Reporting of any release of waste shall be done in accordance with applicable provisions of WAC 173-303-145, "Spills and Discharges into the Environment," and 40 CFR 302, "Designation, Reportable Quantities, and Notification."

C6.4 Transportation

Waste will be transported in accordance with WAC 173-303 and U.S. Department of Transportation requirements (49 CFR, "Transportation"), as appropriate.

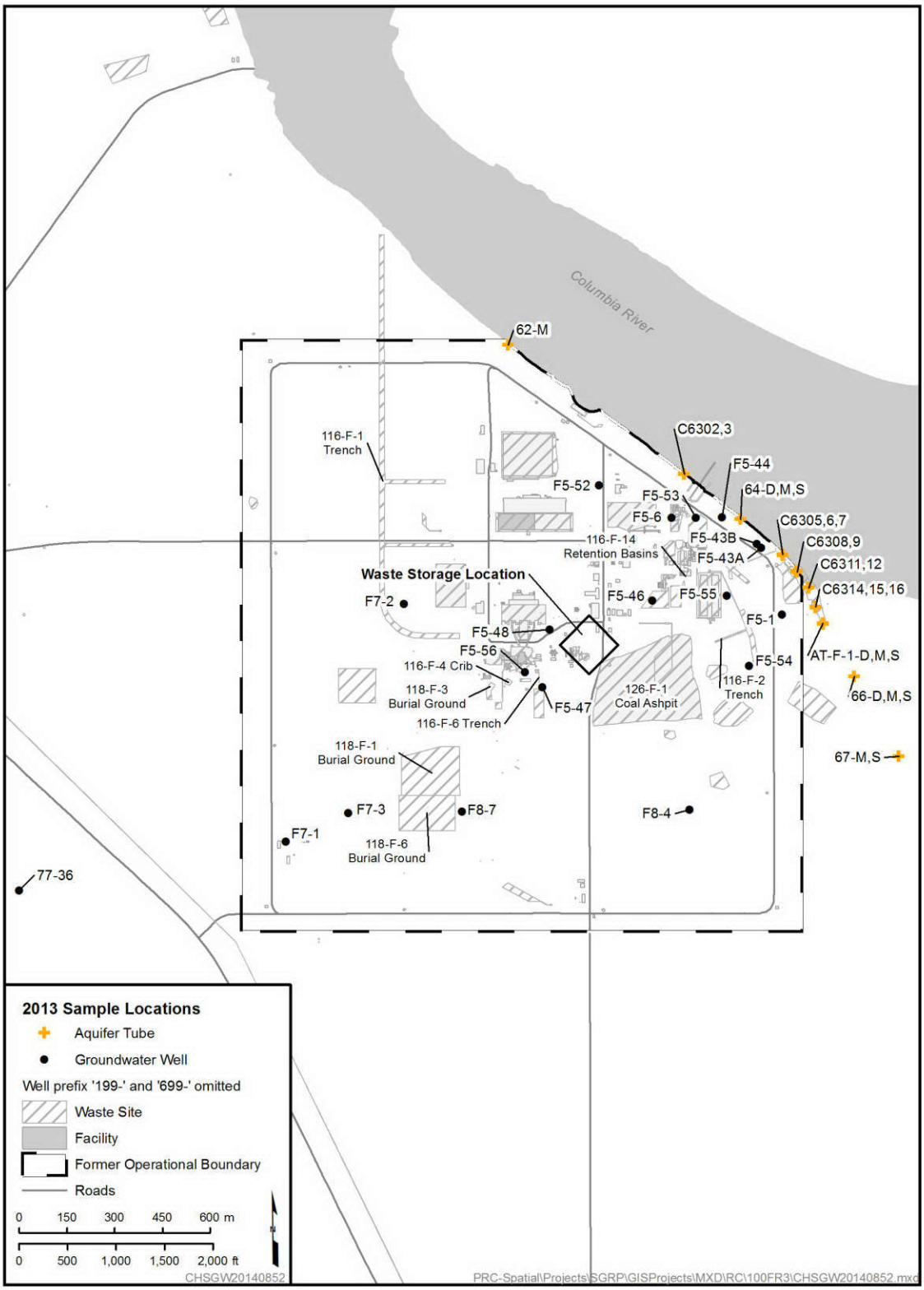

Figure C-2. 100-FR-3 Operable Unit Centralized Storage Location

C7 References

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