

Groundwater Quality Assessment Plan for the Single-Shell Tank Waste Management Area B-BX-BY

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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Executive Summary

Waste Management Area (WMA) B-BX-BY is regulated under interim status requirements of the *Resource Conservation and Recovery Act of 1976* (RCRA),¹ including the requirements of WAC 173-303-400² and 40 CFR 265, Subpart F.³ Groundwater is monitored under a groundwater quality assessment program.

WMA B-BX-BY is also subject to the *Hanford Federal Facility Agreement and Consent Order*,⁴ with Ecology identified as the lead regulatory agency for all single-shell tank farms.

This plan supersedes PNNL-13022, Rev. 1⁵ and updates the groundwater monitoring project management organization. This plan has identified the presence of cyanide at well 299-E33-47 as a “dangerous waste or dangerous waste constituent” under 40 CFR 265, Subpart F, as well as dangerous constituent as defined in WAC 173-303-645[4]⁶ associated with the B Tank Farm. This plan also redefines the monitoring network as a result of changing flow conditions. Because the site had not been assessed for dangerous constituents listed in Ecology Publication 97-407⁷ (which reproduces a previous version of 40 CFR 264, Appendix IX⁸), the sampling criteria were expanded. However, limits were associated with expansion based on major

¹ *Resource Conservation and Recovery Act of 1976*, 42 USC 6901, et seq.

² WAC 173-303-400, “Dangerous Waste Regulations,” “Interim Status Facility Standards,” *Washington Administrative Code*, Olympia, Washington.

³ 40 CFR 265, “Interim Status Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities,” Subpart F, “Ground-Water Monitoring,” *Code of Federal Regulations*.

⁴ Ecology, EPA, and DOE, 1989, *Hanford Federal Facility Agreement and Consent Order*, 2 vols., as amended, Washington State Department of Ecology, U.S. Environmental Protection Agency, and U.S. Department of Energy, Olympia, Washington.

⁵ PNNL-13022, 2006, *RCRA Assessment Plan for Single-Shell Tank Waste Management Area B-BX-BY at the Hanford Site*, Rev. 1, Pacific Northwest National Laboratory, Richland, Washington.

⁶ WAC 173-303-645, “Dangerous Waste Regulations,” “Releases from Regulated Units,” *Washington Administrative Code*, Olympia, Washington.

⁷ Ecology Publication 97-407, 2009, *Chemical Testing Methods for Designating Dangerous Waste: WAC 173-303-090 & -100*, Appendix 5, “Appendix IX of 40 CFR 264,” Washington State Department of Ecology, Olympia, Washington.

⁸ 40 CFR 264, “Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities,” Appendix IX, “Ground-Water Monitoring List,” *Code of Federal Regulations*.

constituent categories associated with specific single-shell tank constituents to address risk assessment and performance criteria (RPP-23403⁹).

This plan describes the facility, its operating history, waste characteristics, hydrogeology, previous monitoring at the WMA, groundwater and vadose zone contamination associated with the WMA, and the conceptual model. It also addresses (1) the adequacy of the wells monitoring groundwater for WMA B-BX-BY; (2) sampling requirements and schedule; (3) constituents, groundwater parameters, and analytical methods; (4) procedures for evaluating groundwater quality data; and (5) reporting requirements.

This groundwater monitoring plan is the principal controlling document for conducting RCRA groundwater monitoring at WMA B-BX-BY.

⁹ RPP-23403, 2006, *Single-Shell Tank Component Closure Data Quality Objectives*, Rev. 3, CH2M HILL Hanford Group, Inc., Richland, Washington.

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Terms

AEA	<i>Atomic Energy Act of 1954</i>
bgs	below ground surface
CCU	Cold Creek unit
CERCLA	<i>Comprehensive Environmental Response, Compensation, and Liability Act of 1980</i>
DOE	U.S. Department of Energy
DQO	data quality objective
Ecology	Washington State Department of Ecology
EPA	U.S. Environmental Protection Agency
HEIS	Hanford Environmental Information System
ITS	in-tank solidification
IX	ion exchange
OU	operable unit
PUREX	Plutonium-Uranium Extraction (Plant)
QAPjP	quality assurance project plan
RCRA	<i>Resource Conservation and Recovery Act of 1976</i>
REDOX	Reduction-Oxidation (Plant)
SST	single-shell tank
TEDF	Treated Effluent Disposal Facility
TOC	total organic carbon
Tri-Party Agreement	<i>Hanford Federal Facility Agreement and Consent Order</i>
UPR	unplanned release
WIDS	Waste Information Data System
WMA	waste management area

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1 Introduction

This document provides the *Resource Conservation and Recovery Act (RCRA)* groundwater assessment plan for Waste Management Area (WMA) B-BX-BY. The WMA contains the B, BX, and BY Tank Farms and is located in the northwest portion of the Hanford Site's 200 East Area (Figure 1-1). These tank farms provided interim storage of radioactive mixed waste for the bismuth phosphate process at B Plant, the tributyl phosphate process at U Plant, the fractionation process at B Plant, the Plutonium-Uranium Extraction (PUREX) Plant organic wash waste and neutralized acid waste, and Reduction-Oxidation (REDOX) Plant waste. The WMA is regulated under WAC 173-303 ("Dangerous Waste Regulations") and the *Hanford Federal Facility Agreement and Consent Order (Tri-Party Agreement)* (Ecology et al., 1989). The revised monitoring network is shown in Figure 1-2.

Groundwater monitoring objectives for RCRA; the *Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA)*; and the *Atomic Energy Act of 1954 (AEA)* often differ slightly, and the contaminants monitored are not always the same. For RCRA-regulated units, monitoring focuses on nonradioactive constituents. Radionuclides (source, special nuclear, and byproduct materials) may be discussed to support objectives under AEA and/or CERCLA.

This document supersedes the previous groundwater monitoring plan (PNNL-13022, Rev. 1, *RCRA Assessment Plan for Single-Shell Tank Waste Management Area B-BX-BY at the Hanford Site*) to respond to changes that have occurred in groundwater at the WMA and in project management for groundwater monitoring. This plan implements the requirements of WAC 173-303-400(3) ("Interim Status Facility Standards"), incorporating by reference 40 CFR 265.92(d) ("Interim Status Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities," "Sampling and Analysis"), and documents the assessment-level groundwater program for WMA B-BX-BY. Previous assessment monitoring had not determined that any dangerous waste constituents had affected groundwater, but the presence of non-RCRA contaminants was affecting groundwater quality. More recently, significant metal increases have led to assessment of well casing corrosion. Continued assessment through revision of this document (including historical process chemistry research, leak assessments, and past and current groundwater constituent distribution) led to the determination that cyanide has impacted the groundwater beneath the B Tank Farm at well 299-E33-47. Cyanide is a "dangerous waste or dangerous waste constituent" under 40 CFR 265, Subpart F ("Ground-Water Monitoring"), as well as a "dangerous constituent" as defined in WAC 173-303-645(4) ("Releases from Regulated Units"). Therefore, it is anticipated that a final status plan will be written to supersede this plan in the future. In addition, it was observed that total organic carbon (TOC) may help in determining if organic complexing agents associated with the B Tank Farm and/or BX Tank Farm are associated with elevated metal results at wells 299-E33-337 and 299-E33-339 on the south side of the tank farms. In addition, this plan implements a new site monitoring design in response to the recent groundwater flow direction change.

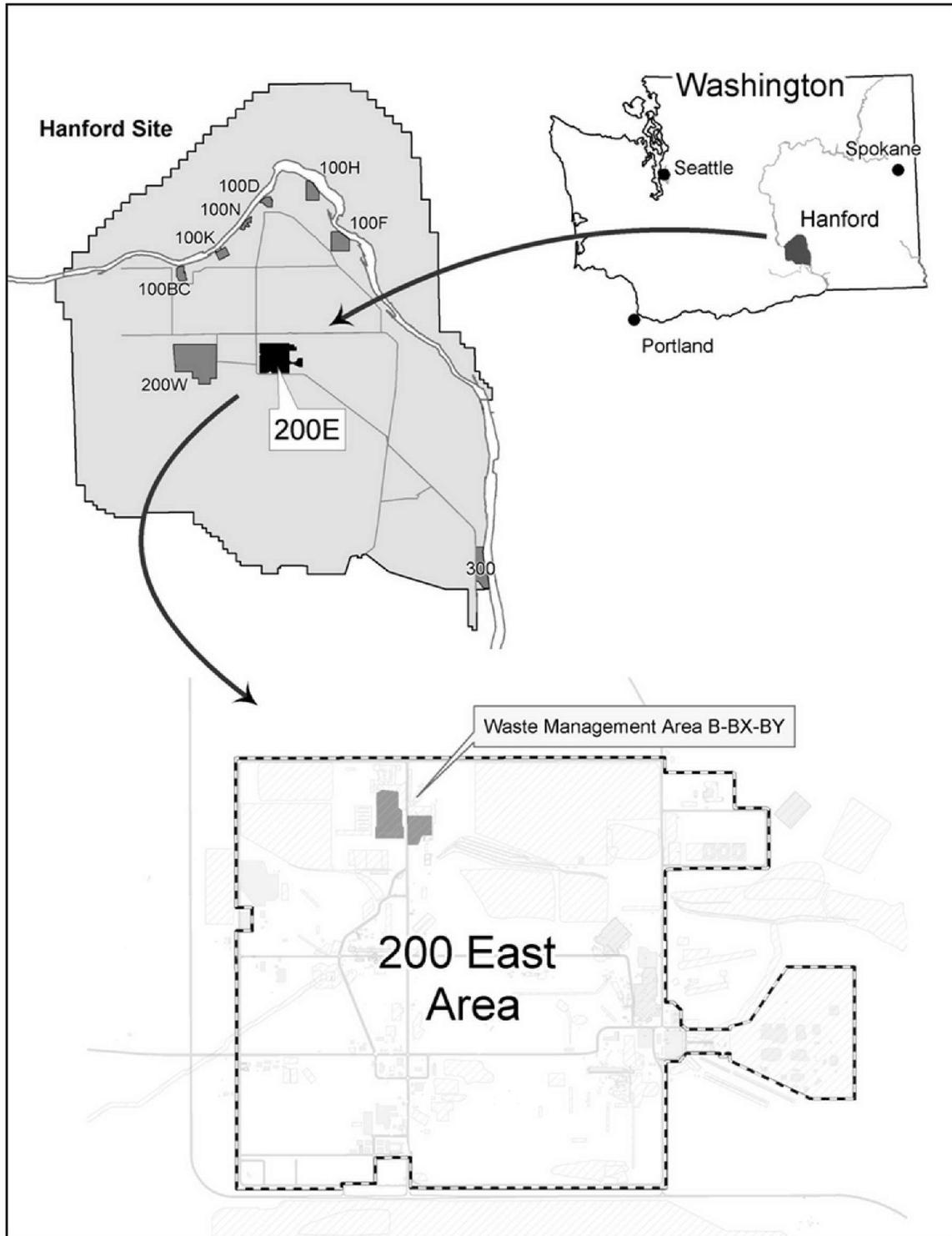


Figure 1-1. Location of WMA B-BX-BY on the Hanford Site

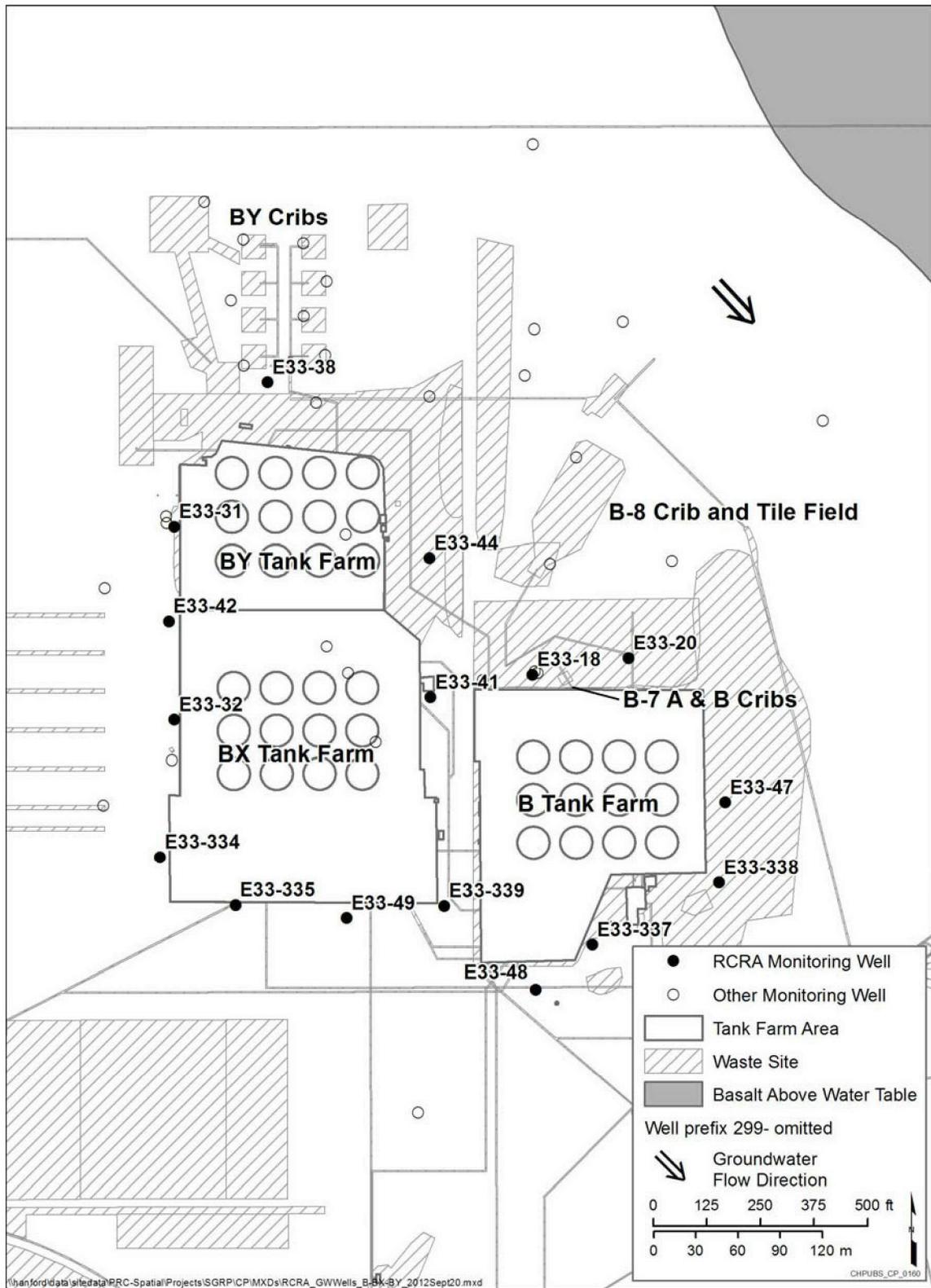


Figure 1-2. WMA B-BX-BY Monitoring Network

The remainder of this assessment plan addresses the following:

- **Chapter 2:** Describes WMA B-BX-BY and the nature of the waste, summarizes geology and hydrogeology, summarizes previous RCRA groundwater monitoring results, and presents a conceptual model. The information is then evaluated relative to the regulatory requirements to provide site-specific decision statements.
- **Chapter 3:** Presents the revised groundwater assessment monitoring program. Lists of wells, constituents, and sampling frequency are provided.
- **Chapter 4:** Describes methods of evaluating the groundwater monitoring data for WMA B-BX-BY. This chapter also presents reporting requirements and describes the process for corrective action and change control.
- **Chapter 5:** Provides a list of the references cited in this document.
- **Appendix A:** Provides the quality assurance project plan (QAPjP).

2 Background

This chapter provides an overview of WMA B-BX-BY and a general description of the tank wastes. The geology and hydrogeology of the region are described, previous vadose zone investigations are listed, and previous RCRA groundwater monitoring results are summarized. This chapter also presents a conceptual model of waste migration.

As mentioned in Chapter 1, the following information is provided to assist in the assessment of potential vadose zone contaminant transport pathways toward two WMA B-BX-BY groundwater monitoring wells, 299-E33-47 and 299-E33-337. The wells are located adjacent to the east and south side of the B Tank Farm. Elevated constituents in groundwater have been identified in these wells during the previous 2 years, as discussed in annual reports (DOE/RL-2010-11, *Hanford Site Groundwater Monitoring and Performance Report for 2009*; DOE/RL-2011-118, *Hanford Site Groundwater Monitoring for 2011*). A common elevated constituent, chromium, is found in both wells 299-E33-337 and 299-E33-47. This constituent has been attributed with well degradation in the past. Another potential dangerous waste/dangerous waste constituent in well 299-E33-337 is nickel, which has also been attributed to well degradation in the past. The maximum unfiltered nickel concentration in this well has been as high as 3,640 µg/L compared with a maximum of 49 µg/L for chromium. According to the standard composition of stainless steel for groundwater wells, chromium is generally a minimum of 18 percent and nickel is a minimum of 8 percent. The concentration difference in well 299-E33-337 suggests that either nickel is preferentially degraded over chromium, or some other mechanism is responsible for the elevated nickel in this well. Likewise, cyanide has recently been observed at well 299-E33-47. The August 2012 cyanide concentrations are one to two orders of magnitude higher at well 299-E33-47 (729 µg/L) than the upgradient wells 299-E33-18 (7.56 µg/L) and 299-E33-20 (43.5 µg/L). This significant spatial difference in concentration suggests a possible release from B Tank Farm. Other water quality parameters are also elevated in these wells.

It should be noted that the setting for following discussion, within the northwest portion of the 200 East Area, has also been referred to as the “B Complex” region. This region encompasses WMA B-BX-BY, the BY Cribs, the 216-B-7-A and 7-B Cribs, and the 216-B-8 Crib.

2.1 Facility Description and Operational History

The following subsections discuss the general tank design and the history of the waste types stored in all of the tanks. Part of this discussion focuses on tank release information for the B and BX Tank Farms. Hypotheses are formed for assessing if potential contaminant transport to the above-mentioned wells is plausible. The plausibility of these releases reaching groundwater was based on the volume of the release (if given), the assumption of a dense alkaline release, and the presence of possible dangerous waste/dangerous waste contaminants in the groundwater. Because some possible groundwater dangerous waste/dangerous waste constituents could be confused with similar contaminants from nearby waste sites (i.e., 216-B-7A&B Cribs, 216-B-8 Crib, 216-B-11A&B french drains, and/or BY Cribs), the volume and history of waste types released is provided for these waste sites. During this informational discussion, certain groundwater monitoring parameters are recommended to differentiate the relationship between the tank releases and waste site releases for the groundwater. These recommended parameters were added to the constituent monitoring list in Chapter 3.

2.1.1 Facility Description

The Hanford Site generated dangerous waste associated with plutonium production for national defense activities. Mixed waste remaining from the processing of irradiated fuel rods was stored in 149 underground single-shell tanks (SSTs). The WMA B-BX-BY consists of three separate tank farms:

B Tank Farm, BX Tank Farm, and BY Tank Farm (Figure 1-2). Two tank farms contain 12 SSTs with 2 million L (530,000 gal) capacity, while the BY Tank Farm consists of 12 tanks with 2.9 million L (758,000 gal) capacity. In addition, the B Tank Farm has four smaller SSTs along the northern farm boundary, each with a capacity of 208,000 L (55,000 gal). Also included are ancillary equipment consisting of seven diversion boxes, associated piping, sluice and valve pits, pump pits, and the 244-BXR waste transfer vault.

The large-capacity tanks are constructed of reinforced concrete with a single, inner carbon-steel liner (RPP-10435). The concrete reinforcement consists of steel rebar located in the base slab, footings, sidewalls, and tank dome. Between the outer concrete shell and the inner steel liner is a three-ply, asphaltic, waterproof membrane. Between the membrane and the steel liner is an additional 5.1 cm (2 in.) thick protective grout with reinforced wire mesh for protection against the carbon-steel liner. The concrete shell consists of a 15.2 cm (6 in.) thick base and 61 cm (2 ft) thick walls.

The inner carbon-steel liner varies by tank farm, with a 6.35 mm (0.25 in.) base plate at the B Tank Farm, while the BX/BY Tank Farms have 9.5 mm (0.375 in.) base plates. The carbon-steel plate thickens to 7.9 mm (0.3125 in.) at the bottom corner of tanks at the B and BX Tank Farms and tapers back to 6.35 mm (0.25 in.) thick sidewalls. The tank at the BY Tank Farm consists of a 9.5 mm (0.374 in.) thick carbon-steel liner at the tank corners and also tapers back to 6.35 mm (0.25 in.) thick sidewalls. The steel plate sidewalls of tanks at the B/BX Tank Farms extend 5.79 m (19 ft) above bottom, which is 61 cm (2 ft) above the liquid design capacity of the tank. The steel liner walls of the BY Tank Farm tanks extended 7.6 m (25 ft) above the tank bottom, which is 40.6 cm (16 in.) above the liquid design capacity of the tank. Lead flashing was installed continuously around the top of the carbon-steel liner to protect the outside of the liner from vapor reflux condensate running down the inside face of the concrete dome.

2.1.2 Tank Waste History

The tanks at the B/BX/BY Tank Farms have stored waste from every separation process completed at the Hanford Site (WHC-MR-0132, *A History of the 200 Area Tank Farms*). Initially, fission product waste streams were low enough in concentration that self-boiling was not a concern. By design, none of the self-boiling wastes from the PUREX or REDOX Plants were sent to the B/BX/BY Tank Farms prior to removal of high-heat-generating fission products. Over the years, wastes sent to these tanks contained both inorganic and organic wastes. The following discussion presents a general description of some of the separation processes and waste components that were received and temporarily stored at the B/BX/BY Tank Farms underground storage tanks. It should be noted that the descriptions of the various waste processes are not all-inclusive. Through the years, separation of various products was refined and numerous fission products were included. These changes become a laborious task to detail and are not necessary for the scope of this assessment plan. However, a general understanding is needed to determine key indicator parameters for differentiating past-practice CERCLA waste from state-regulated RCRA waste. In addition, it is not the scope of this plan to resolve discrepancies between different reports.

The bismuth phosphate process wastes included metal waste, first- and second-cycle decontamination waste, aluminum jacket waste (i.e., coating waste), and 224 Building waste. A description of the chemicals used that created the different types of waste is provided in Appendix A of *Data Quality Objective Summary Report in Support of the 200-BP-5 Groundwater Operable Unit Remedial Investigation/Feasibility Study Process* (WMP-28945). Because the 216-B-8 Crib received over 35 million L (9.25 million gal) of first-cycle decontamination waste, it is difficult to distinguish whether elevated chromium in the groundwater at well 299-E33-47 is associated with the B Tank Farm or the 216-B-8 Crib. In addition, information in the Waste Information Data System (WIDS) database for the 216-B-11A&B Cribs indicates that 216-B-8 Crib waste was re-routed to the 216-B-11A&B french drains, located north of the 241-B fence line and 241-B-103 and 241-B-106 tanks, in 1954. The location of the

french drains is adjacent to well 299-E33-20 (Figure 1-2). According to *Hanford Soil Inventory Model, Rev. 1* (RPP-26744), the 216-B-11A&B french drains inventory of chromium was inconsequential compared to the volume of liquid received. However, when comparing the RPP-26744 chromium inventory between 1953 and 1954, there does not appear to be an increase in chromium inventory to account for first-cycle decontamination waste. Another source of chromium in this area, located approximately 46 m (151 ft) west of the 216-B-11 french drains, is the 216-B-7A&B Cribs. These cribs received early waste streams from the 224 Building. Although the waste streams contained chromium, vadose zone investigation results indicate that chromium was not in a mobile valence state. Thus, the 216-B-8 and 216-B-11A&B waste sites, which have definitely impacted groundwater, make it impossible to determinations if chromium at well 299-E33-47 is also associated with a B Tank Farm source.

In the 1951, high-level waste storage space was limited, so actions were taken to reduce the liquid portion of the waste through evaporation. The 242-B evaporator used a two-pass process to reduce the liquid volume by approximately 80 percent. The evaporator bottom slurries were returned to the tanks for cooling and settling. The resulting solids were sludge-like, with interstitial liquids (RPP-10435, *Single-Shell Tank System Integrity Assessment Report*). The process did not change the chemistry of the waste but instead concentrated the waste. The condensate from the evaporation process was routed to the 216-B-11A&B french drains. Because the condensate contained only volatile constituents, RPP-26744 calculated very low inventories for contaminants of concern. Based on the volume of water, none of the constituents amount to concentrations that would be detectable in the groundwater. For example, nitrate concentrations, which present the highest inventory, calculate to 10 mg/L. However, because of dilution with the aquifer thickness, when this reaches the groundwater it would barely be detectable.

In the mid-1950s, the bismuth phosphate metal waste was transferred to U Plant where a tributyl phosphate process was used to recover uranium. The resulting waste was sent to the B/BX/BY Tank Farms for storage. Appendix A of WMP-28945 provides a description of the chemicals used that generated the waste.

Coincident with the uranium recovery process, ferrocyanide was used to precipitate cesium so liquid waste could be discharged to the soil column. A description of the chemicals used to generate the waste is provided in Appendices A and B of WMP-28945. The seven BY Cribs, located north of the BY Tank Farm, received between 2 million and 7 million L (528,344 and 1.8 million gal) of this ferrocyanide scavenged waste. Because the groundwater flow direction changed in 2011 to the southeast, differentiating cyanide sources from the BY Cribs and possible BY Tank Farm sources were deemed impossible under these conditions and, therefore, are not included in this assessment. However, as of August 2012, the leading edge of the highly contaminated BY Cribs cyanide plume (greater than the drinking water standard) was north of the B and BX Tank Farms; thus, differentiating elevated cyanide concentrations in the groundwater beneath these tank farms from the BY Cribs does not present a problem.

In the late 1950s to early 1960s, some of the tanks in the B/BX/BY Tank Farms received coating and organic wash waste from the PUREX process. The coating waste was similar to the aluminum jacket waste for the bismuth phosphate process. The organic wash waste included tributyl phosphate and kerosene-range hydrocarbons in the neighborhood of undecane (HW-31000, *PUREX Technical Manual*). After initial extraction and separation of uranium and plutonium products, the organic solution was chemically washed in a warm solution of sodium carbonate and centrifuged to remove small quantities of impurities. Potassium permanganate was later added for recycling the organic solution (HW-56933, *Process Specifications for Operational Control: PUREX Plant*).

Concern over the integrity of the SSTs in the late 1950s led to a plan to remove the SST waste (SD-WM-TI-302, *Hanford Waste Tank Sluicing History*). The first part of the plan, which began in 1961, was associated with fission product recovery from stored waste. The project targeted removing long-lived, heat-emitting fission products from current and stored PUREX high-level wastes (ISO-986, *B-Plant Phase III Flowsheets*). The waste was initially sent to the Strontium Semiworks Facility, but by 1967, the process was completed at B Plant. According to WHC-MR-0132, cesium- and strontium-depleted aqueous waste (designated as fission product waste and B Plant low-level waste after concentrating in cell 23) was sent to several tanks in the B/BX Tank Farms.

The fission recovery process at B Plant treated both supernate and slurried sludge tank waste. The cesium recovery process fed neutralized PUREX acid waste supernate and supernate derived from PUREX acid sludge to an ion-exchange (IX) column. The composition of these waste streams is provided in ISO-986. The IX process removed about 99 percent of the cesium, as well as adding water, ammonium hydroxide, and ammonium carbonate.

The strontium recovery process used a solvent extraction process and was expected to recover 98 percent of the strontium. Although slight modifications were made to the strontium recovery process for various waste streams, the following describes the most prominent method used.

Prior to tank sludge transport and arrival at B Plant, the waste was treated with a sulfate strike-carbonate metathesis process to reduce iron and aluminum (ISO-986). Lead nitrate was added to precipitated strontium. The strontium cake was later dissolved with nitric acid and transferred to feed storage for solvent extraction within B Plant. The solvent extraction was initially designed to use trisodiumnitrioltriacetate to form complexes; however, hydroxyethyl ethylenediamine triacetic acid and ethylene diamine tetraacetic acid were added to the process (ARH-CD-691, *Strontium Recovery from PUREX Acidified Sludge*). Hydroxyacetic acid was also added as a buffering agent. Tartaric acid was added to increase extraction kinetics. The feed solution was adjusted to the desired pH with sodium hydroxide and then transferred to the solvent extraction tank. As the feed solution came in contact with the organic solution (tributylphosphate and di-2-ethylhexylphosphoric acid in normal paraffin hydrocarbon), the di-2-ethylhexylphosphoric acid extracted the metallic ions. The metallic ions extracted from the feed solution included strontium, rare earths, uranium, yttrium, calcium, neptunium, and trace quantities of other cations. The waste solution was neutralized to a pH greater than 8 and sent to the various tank farms, including the B/BX Tank Farms (the waste solution contained the organics listed above). The organic solution with the metallic ions was then contacted with an aqueous solution containing hydroxyacetic acid, sodium hydroxide, and a small complexant concentration (citrate and diethylene triamine pentaacetic acid). The complexant was mainly used to scrub sodium from the organic solution. Next, the strontium and a significant amount of calcium were stripped from the organic solution with dilute nitric acid, and trace amounts of other cations were also stripped. The rare earths, the majority of the calcium, and trace amounts of other metallic fission products were then stripped by concentrated nitric acid. After this process, the organic was contacted with sodium hydroxide and sodium tartrate to remove the bulk impurities, which also removed mono-2-ethylhexylphosphoric acid (a degradation product of di-2-ethylhexylphosphoric acid). The solvent was then butted with nitric acid for recycling.

Several of the associated waste streams were routed back to underground storage tanks between 1969 and 1975 (WHC-MR-0132). ISO-986 provides tables listing the composition breakdown through the various separation steps, depending on the origin of the waste.

In addition to the fission recovery process, an in-tank solidification (ITS) process was used to reduce the resulting liquid waste volume. The initial ITS unit evaporator was installed in tank 241-BY-101 in 1965. The unit compressed air and heated it to 649°C (1,200°F). The heated air was contained in a pipe-in-pipe

arrangement that extended into the tank. A radial pipe distribution at an elevation of 5.3 m (17.5 ft) from the bottom of the tank (1.9 m [74 in.] below the maximum liquid level) was used to sparge the heated air. The hot air rose through the supernate and induced localized evaporation. The offgas stream went through a demister, filter bed, and condenser tower before it was discharged to the atmosphere. The condensate was sent to the 216-B-50 and 216-B-57 Cribs. The ITS unit was later transferred to tank 241-BY-102, where it became a receiver tank for diluted waste from other tank farms. The waste was concentrated until the material in the bottom of the tank was approximately 10 percent solids. The batch was transferred to other tanks where the waste was allowed to crystallize. Another ITS unit was also added to tank 241-BY-112.

In 1977, the 242-A evaporator started up to further reduce the liquid volume of interstitial liquids. The evaporator induced the concentrated waste slurry to crystallize. Non-complexed and complexed waste from this process was sent to several tanks in the B/BX/BY Tank Farms between 1978 and 1980.

In November 1980, the SSTs were removed from active service and were replaced by double-shell tanks. Efforts are still ongoing to transfer all the SST waste to the double-shell tanks.

2.1.3 Facility Conditions Potentially Impacting Groundwater

Various types of waste have been received at WMA B-BX-BY, as discussed in Section 2.1.2. Unplanned releases (UPRs) of these wastes have been investigated through multiple gamma-ray monitoring events, high-resolution resistivity surveys, and soil sample analysis. Currently, only one UPR (241-BX-102) has been determined to impact the groundwater associated with WMA B-BX-BY (PNNL-19277, *Conceptual Models for Migration of Key Groundwater Contaminants Through the Vadose Zone and Into the Upper Unconfined Aquifer Below the B-Complex*). Although the inventory for this release initially did not seem sufficient to have a significant impact on groundwater, later conceptual transport models included contributions from leaking water lines as a transport driver (RPP-10098, *Field Investigation Report for Waste Management Area B-BX-BY*). Based on the comparison between release concentrations from RPP-26744 and the porewater uranium concentrations derived from samples collected in the silt-dominated Cold Creek unit (CCU), an estimated 3.785 million L (1 million gal) or more of leaked water is estimated to have assisted in migration of the uranium through the vadose zone. This estimate is also consistent with calculations of the perched water horizons liquid volume. Currently, only the mobile constituents (nitrate, sulfate, and various radionuclides) associated with the metal waste release have impacted groundwater. The primary reason that dangerous waste constituents have not impacted groundwater is because the associated waste was a metal waste in which the waste components have elevated distribution coefficients and readily sorb to the vadose zone sediments. However, recent metal increases in groundwater near wells 299-E33-47, 299-E33-337, and 299-E33-339 have led to further assessment of other releases in the B/BX Tank Farms. As part of this assessment, it was recognized that some releases were associated with complexing agents, which have not been investigated at WMA B-BX-BY. Thus, a literature review was completed to determine the appropriate dangerous waste constituents to analyze and to identify plausible releases that could be associated with elevated metals at wells 299-E33-47, 299-E33-337, and 299-E33-339. The primary release information was obtained from *Hanford B-Farm Leak Inventory Assessments Report* (RPP-RPT-49089) and *Hanford BX-Farm Leak Assessments Report* (RPP-RPT-47562). Prior to discussing the literature findings, a brief discussion is provided below regarding the rationale for initially determining that the elevated metals were associated with well degradation (DOE/RL-2011-118).

Previous RCRA assessment determinations have been based primarily on groundwater results. Levels of some possible dangerous waste constituents (chromium and nickel) have recently been found to be elevated within groundwater at WMA B-BX-BY. It was determined that these constituents were associated with well degradation after reviewing television surveys in wells 299-E33-337 and

299-E33-339. The surveys showed amorphous encrustation along the well screen. The encrustation was primarily orange in color; however, some brown to black spots were also visible. Other site studies with similar elevated constituents found that goethite and magnetite or maghemite were present in the orange and brown encrustation material (*Geochemistry and Microbiology of Iron-Related Well-Screen Encrustation and Aquifer Biofouling in Suffolk County, Long Island, New York* [USGS, 1997]). In these studies, the orange and brown encrusting material was primarily amorphous ferric hydroxide, with lesser amounts of crystalline iron oxyhydroxide mineral phases, quartz, and trace elements. The black material was composed mostly of amorphous or weakly crystalline iron-sulfide mineral phase, with lesser amounts of quartz. Because the dissolved oxygen levels and reduction-oxidation potential in the groundwater were elevated at this site, localized iron and manganese reduction was attributed to the following: iron-rich clay materials as a reducing agent, bacteria, and well casing material.

Previous studies have determined that sediments at the Hanford Site contain iron-rich clay material. Well logs in the area of WMA B-BX-BY have discussed the presence of clay associated with reworked Ringold sediments. According to *Geochemical Processes Data Package for the Vadose Zone in the Single-Shell Tank Waste Management Areas at the Hanford Site* (PNNL-16663), the iron-rich mineral fraction (likely less than 2 percent mass) contains magnetite, ilmenite, iron(II)/iron(III) phyllosilicates, iron(III) oxides (ferrihydrite), and goethite. The same report indicated that the iron-bearing mineral fraction is expected to show considerable variation in various formations. The clay-size fractions (less than 2 μm) of the sediment samples analyzed for mineralogy at the Hanford Site are dominated by four clay minerals: smectite, chlorite, kaolinite, and illite, with minor amounts of quartz, feldspar, and amphibole. Transmission electron microscopy/energy-dispersive X-ray spectroscopy analyses of the clay fractions of sediment samples from WMA S-SX indicate that the compositions of chlorites typically ranged from that of iron-rich clinocllore to magnesium-rich chamosite. These findings compare to the USGS (1997) study in which iron containing sediments can act as a catalyst creating localized reducing conditions. As a result, the elevated chromium and nickel in these wells was previously determined the result of well degradation.

As elevated levels of chromium and nickel at wells 299-E33-337 and 299-E33-339 have continued, questions arose as to why such elevated levels at only these wells. In addition, questions arose as to why cyanide would be present at such elevated levels at well 299-E33-47, when the leading edge of the BY Crib cyanide plume was considered further north and cyanide was not present in wells between these occurrences. Therefore, a review of wastes types and associated UPRs were completed for the B/BX Tank Farms. The release information was obtained mainly from reassessment of the past B/BX Tank Farm release inventories (RPP-RPT-49089 and RPP-RPT-47562, respectively); however, neither of these reports represents a formal tank leak integrity assessment.

2.1.3.1 B Tank Farm Leak Assessment Results

The details of 11 UPRs are presented in this subsection. Based on the available data, two sites (241-B-105 and 241-B-110) were considered plausible sites for groundwater contamination under worst-case release scenarios. The worst-case hypothetical conceptual model transport conditions assumed narrow radial migration pathways and dense alkaline complexant waste forms. Because limited deep vadose zone data are available to support the worst-case hypothetical conceptual models, additional evaluations are presented in Section 2.5 to assess the conceptual models presented in Section 2.6.

241-B-101 Tank. This tank was classified as having “questionable integrity” based on the 1974 gamma-ray activity in drywell 20-01-01. The drywell is located northeast of tank 241-B-101. Cesium-137 was reported at 12.8 m (42 ft) below ground surface (bgs) near the tank base (RPP-RPT-49089). Coincident with the release, the tank contained fractionation waste and evaporator bottoms. In April 1975, the activity level increased from the 1974 readings. The cesium inventory was estimated to be 450 Ci

(RPP-RPT-49089), which was based on a 1975 cesium-137 analytical result of 0.25 Ci/gal from a low-level evaporator bottom sample. The concentration led to estimating the release volume at approximately 7,570 L (2,000 gal) (RPP-RPT-49089). In addition, a metal waste UPR (UPR-200-E-108) occurred at the 102-B heel pit and contaminated the surrounding ground area in April 1953 (PNL-6456, *Hazard Ranking System Evaluation of CERCLA Inactive Waste Sites at Hanford*). However, based on the movement of contamination between 1974 and 1975, the release calculations above appear to be associated with the more recently received waste, as described below (e.g., cesium recovery waste from PUREX neutralized tank supernate).

RPP-RPT-49089 implies that the release resulted from the piping entering the tank. Spectral gamma-ray logging near these pipelines found elevated cesium-137 and cobalt-60 at between 11.6 and 17.7 m (38 and 58 ft) bgs (GJO-99-113-TAR, *Vadose Zone Characterization Project at the Hanford Tank Farms: B Tank Farm Report*). One of the drywells, 20-01-05 (299-E33-262, located 4.1 m [13.5 ft] from the tank), was a key part of the release volume calculation.

The waste storage history for this tank was obtained from WHC-MR-0132. The tank contained metal waste from 1945 through 1953, evaporator bottoms from 1953 through 1974, and fractionation waste from 1969 through 1974. Note that the fractionation waste was likely from cell 23 because the waste reported in WHC-MR-0132 was designated as B Plant low-level waste. According to ISO-986, the cell 23 waste was routed to the ITS unit before storage in the tank farms and consisted of the following:

- Head-end treatment waste streams of sulfate strike supernate and washes
- Metathesis supernates and washes
- 1A column wastes
- 1C column rare earth stream
- Organic wash waste
- IX column wash wastes and sodium scrub stream
- Overheads from the cell 5 concentrator

Because there were no gamma-ray findings suggesting strontium-90, it appears that there was no significant component of the 1C column rare earth stream. If it were IX column waste (as implied by RPP-RPT-49089), then elevated chloride would be a good indicator (ISO-986).

Based on the mean effective porosities provided in PNNL-19277 for a narrow radial contaminant plume of 4.1 m (13.5 ft), defined by the cesium-137 and the distance to the adjacent drywells, only 10.48 percent of the available effective pore space is filled to a depth of 17.7 m (58 ft). The vertical distance is defined by the vertical distance of the cesium. Based on the field capacity of 0.0842 cm³/cm³ (PNNL-19277), this release does not appear to be a plausible source for contact with the groundwater, particularly when the calculation does not account for possible dead space pores or the larger effective porosity for fine-grained material that may exist within these sediments. Also, according to *Vadose Zone Transport Field Study: Status Report* (PNNL-13679), although the natural moisture content is about 6 percent at the Hanford Site, the vadose zone can retain an extra 4 percent without migration. Thus, unless an extra driver were present (e.g., a nearby water leak), this release does not appear to be a plausible source for contact with the groundwater.

241-B-103 Tank. This tank was classified as “questionable integrity” based on 1978 gamma-ray activity in drywells 20-03-03 and 20-03-06 (RPP-RPT-49089), located to the east and south of the tank, respectively. According to GJO-99-113-TAR, cesium-137 and cobalt-60 were reported at depths shallower than for tank 241-B-101. Therefore, this release does not appear to be a plausible source for contact with the groundwater.

According to WHC-MR-0132, this tank contained metal waste from 1945 through 1953, evaporator bottoms from 1954 through 1969, coating waste and organic wash waste in 1969, and fractionation waste from 1970 through 1975.

241-B-105 Tank. This tank was classified as “questionable integrity” based on 1978 gamma-ray activity in drywells 20-06-06 and 20-05-06 (RPP-RPT-49089), which are located north and south of the tank, respectively. This same document recalled various releases associated with tanks 241-B-105 and 241-B-106. One event in 1953 was associated with the release of first-cycle decontamination waste. The line leading from tank 241-B-104 to 241-B-106 developed an underground process leak near the 241-B-106 tank, and liquid contamination rose to grade level over a 7 m² (75 ft²) area (RPP-RPT-49089). Another event at this location was documented when seals failed from a deep-well pump, causing contamination to spread (concentrated tributyl phosphate waste) at tanks 241-B-105 and 241-B-106. RPP-RPT-49089 estimated the release volumes at 140,045 L (37,000 gal) based on the assumption that cesium-137 activity at the drywells represented the edge of contamination. An equal release volume was calculated for the inlet to tank 241-B-105. The total loss based on this estimate is 280,090 L (74,000 gal).

The waste storage history for this tank was obtained from WHC-MR-0132. The tank contained second-cycle decontamination waste from 1947 through 1950, first-cycle decontamination waste from 1950 through 1952, and evaporator bottoms from 1952 through 1980. The evaporator bottoms came from tanks 241-B-101, 241-B-103, 241-B-110, and 241-B-111 during 1953 and 1954. Thus, the evaporator bottoms were associated with metal waste, first- and second-cycle decontamination, and 5-6 tank waste. It is notable that tank 241-B-106 received tributyl phosphate waste from tank 241-C-112, which is a ferrocyanide watch list tank, with transfers completed during 1957 and 1968. This is significant because this is the only tank in the B Tank Farm to receive this type of waste (WHC-MR-0132). Also, this type of waste is consistent with the constituents seen in well 299-E33-47.

Based on the mean effective porosities provided in PNNL-19277 for a narrow, radial contaminant plume of 4.6 m (15 ft), defined by the cesium-137 and the distance to the adjacent drywells, approximately 16 percent of the available effective pore space is filled throughout the vadose zone. Theoretically, since this value is larger than the field capacity, a dense saline solution (e.g., ferrocyanide) could reach the groundwater. According to PNNL-13679, a contaminant plume of this type would have less lateral spreading compared to water and may have a propensity to finger by displacing less dense fluids. Note that an east-west 10.2 cm (4 in.) raw water line was present just north of tank 241-B-106. Past experience indicates that these water lines are prone to leaks. Also, a significant perching horizon is present within the silt-dominated CCU north of this location. Thus, it may be possible that the elevated chromium and cyanide at well 299-E33-47 may be associated with releases near tanks 241-B-105 and 241-B-106; however, there was also a release of scavenged tributyl phosphate that covered an area of 46.5 m² (500 ft²) north of the B Tank Farm. Based on other dense aqueous releases that have occurred, the magnitude this release may have only been 190 to 380 L (50 to 100 gal). Thus, chromium and cyanide appear to make excellent indicator parameters for the first-cycle decontamination and tributyl phosphate waste, respectively, and will be added to sampling requirements for this assessment.

241-B-107 Tank. This tank was classified as “questionable integrity” based on a 7.6 cm (3 in.) liquid-level decrease between May 1968 and August 1969 (RPP-RPT-49089). The tank was pumped to a minimal level in August 1969 and removed from service. GJO-99-113-TAR reported cesium-137 and cobalt-60 at depths of 10.7 to 18.3 m (35 to 60 ft) bgs, similar to tank 241-B-101. RPP-RPT-49089 indicates that the release consisted of 14,000 gal of PUREX coating waste. No raw or potable water lines are located in this area. Because this release is similar to that of tank 241-B-101, it does not appear to be a plausible source for contact with the groundwater.

According to WHC-MR-0132, the tank contained first-cycle decontamination waste from 1945 through 1951, evaporator bottoms from 1952 through 1963, coating waste from 1963 to 1969, and first-cycle decontamination and evaporator bottoms from 1965 to 1969.

241-B-110 Tank. This tank was classified as “questionable integrity” based on a 7.6 cm (3 in.) liquid-level decrease in 1970 (RPP-RPT-49089). The tank was re-categorized as a “confirmed leaker” in June 1981. GJO-99-113-TAR reported very high cesium-137 results at drywell 20-10-12 from a depth of 7 to 32.6 m (23 to 107 ft) bgs. The well extends to a depth of 36.6 m (120 ft). GJO-99-113-TAR also indicated that other gamma-emitting radionuclides (e.g., cobalt-60 and europium-152) may be present, but their signatures would be overridden by the high cesium-137 results. GJO-99-113-TAR also reported indications of strontium-90 in this area, including four other nearby drywells. Because the cesium-137 results were not extensive (as reported in RPP-RPT-49089), the estimated release was determined at 49,200 L (13,000 gal). The waste appears to be fractionated PUREX sludge waste.

According to WHC-MR-0132, the tank contained second-cycle decontamination waste from 1945 to 1956, 5-6 tank waste from 1952 into 1963, first-cycle decontamination waste from 1952 through 1963, evaporator bottom in 1954, fractionation waste from 1963 to 1972, and evaporator bottoms from 1968 to 1969. It should be noted that a detailed report of this tank (RPP-16015, *Origin of Wastes in Single-Shell Tanks 241-B-110 and 241-B-111*) found some discrepancies between WHC-MR-0132 and the process records.

The strontium-90 fractionation waste contained complexants (hydroxyethyl ethylenediamine triacetic acid, trisodiumnitrilotriacetate, and di-2-ethylhexylphosphoric acid) according to ISO-986. These complexants form strong complexes with metallic ions. ISO-986 also reported that an extra 10 to 20 percent of these organics were added to the separation process at B Plant to ensure an adequate complex. The report also provided the waste composition from B Plant’s high-level, solidifiable waste compositions and generation rates for cell 23 as follows: less than 0.07 Ci/gal cesium-137, 1.46 Ci/gal strontium-90, significant metal inventories, and large organic inventories for di-2-ethylhexylphosphoric acid, ethylene diamine tetraacetic acid, hydroxyethyl ethylenediamine triacetic acid, trisodiumnitrilotriacetate, and tartrate. Four key metal indicator (chromium, nickel, manganese, and lead) concentrations were derived from molarities provided from Table 28 of ISO-986: 0.187, 0.434, 0.2967, and 4.558 g/L. However, only chromium compared well to the soil inventory model (RPP-26744). When groundwater ratios of nickel and manganese from wells 299-E33-337 and 299-E33-339 are compared, they agree with the soil inventory model (RPP-26744) ratio. However, chromium (which had a much larger inventory) is not found significantly elevated like the filtered nickel and manganese in these wells.

The specific gravity of the strontium recovery fractionation waste ranged between 1.25 and 1.3 (ISO-986). Thus, the release at tank 241-B-110 appears to be a dense saline solution that could preferentially migrate down through the vadose zone soil column with little lateral spreading. *Effect of Organic Complexants on the Mobility of Nickel and Cobalt in Soils: Status Report* (PNL-4389) showed that nickel has no discernible retardation factor and stays in solution when complexed with ethylene diamine tetraacetic acid in Hanford Site soils. *Hanford Waste-Form Release and Sediment Interaction: A Status Report with Rationale and Recommendations for Additional Studies* (PNL-7297) also showed that cesium can have a retardation factor of less than one when exposed to di-2-ethylhexylphosphoric acid or when competing with elevated concentrations of sodium, potassium, calcium, and ammonium. According to ISO-986, both sodium and ammonium were concentrated in cell 23 waste. Likewise, strontium is complexed by organic solutions such as di-2-ethylhexylphosphoric acid, ethylene diamine tetraacetic acid, and diethylene triamine pentaacetic acid. Thus, TOC and metals appear to make excellent indicator parameters for organic complexed waste and will be added to sampling requirements for this assessment. It should also be determined why chromium levels in the groundwater are not more elevated

(based on the inventory in RPP-26744) than the levels observed in wells 299-E33-337 and 299-E33-339 if TOC levels indicate a complexed waste associated with tank 241-B-110.

241-B-111 Tank. This tank was classified as “questionable integrity” based on gross-gamma results in drywell 20-11-09 when first drilled in 1973 (RPP-RPT-49089). According to GJO-99-113-TAR, the gamma results appear to be associated with tank 241-B-110. RPP-RPT-49089 implies that the questionable integrity classification may be rethought in the future. Therefore, this release does not appear to be a plausible source for contact with the groundwater.

241-B-112 Tank. This tank was classified as “questionable integrity” based on gross-gamma results in drywell 20-12-03 and 20-12-06 in 1978 (RPP-RPT-49089). According to GJO-99-113-TAR, the gamma results are either near the surface and indicate minor pipeline leaks, or are deep and appear to be associated with other releases. Therefore, this release does not appear to be a plausible source for contact with the groundwater.

241-B-201 Tank. This tank was classified as “assumed leaker” based on liquid-level changes, although the liquid-level measurements for these tanks were considered unreliable (RPP-RPT-49089). The leak volume estimate for this well was 4,540 L (1,200 gal). Because this release was much smaller than the tank 241-B-101 release, it is not considered to be a plausible source for contact with the groundwater.

According to WHC-MR-0132, the tank contained 224 Building waste from 1952 to 1974 and metal waste from 1952 to 1953.

241-B-203 and 241-B-204 Tanks. These tanks were classified as “assumed leakers” based on liquid-level changes, although the liquid-level measurements for these tanks were considered unreliable (RPP-RPT-49089). The leak volume estimate for these tanks was 4,540 L (1,200 gal). Because this release was much smaller than the tank 241-B-101 release, it is not considered to be a plausible source for contact with the groundwater.

According to WHC-MR-0132, the tank contained 224 Building waste from 1952 to 1976 and metal waste from 1952 to 1953.

241-B-151 Diversion Box. In August 1968, a soil cave-in at the southeast corner of this diversion box was observed. The cave-in was associated with a line leak to the 152-B diversion box, and the leak caused the ground to be undermined. The WIDS database indicated that the release was estimated at 19,700 L (5,200 gal). The leak volume estimate was much smaller than the tank 241-B-101 release; thus, the release is not considered to be a plausible source for contact with the groundwater.

The waste type from this release was not identified in RPP-RPT-49089; however, based on WHC-MR-0132, there were transfers of first-cycle decontamination evaporator bottoms, coating waste evaporator bottoms, and fission product waste evaporator bottoms. Note that the fission product waste was not designated, so it is not possible to determine if it was associated with cesium or strontium fractionation waste, or both.

A previous UPR (UPR-200-E-73) occurred at this site as well. Although the waste type is not provided, it was noted in the report that most of the contamination was removed (PNL-6456).

241-B-153 Diversion Box. In January 1968, a leak in the transfer line near the 241-B-153 diversion box occurred during a 20,441 L (5,400 gal) waste transfer from the 9-2 B Plant tank to tank 241-B-110 (UPR-200-E-76). The waste was documented as containing cerium-144 (4,780 Ci), ruthenium-106 (340 Ci), and zirconium-95Nb (850 Ci) (PNL-6456). It appears that this release is also related to UPR-200-E-38 based on the date. Based on comparisons of cerium-144 with the various ISO-986 waste

streams, this waste may have been associated with the PUREX acid waste extraction waste, and the waste contained some citrate. However, other notable comparisons are associated with the 1BP, precipitator slurry, and ICF waste streams of the PUREX acid sludge waste streams. Some of these contained organics such as hydroxyethyl ethylenediamine triacetic acid.

This site was also associated with a release between 1954 and 1955 (UPR-200-E-75). Although the released waste type is not specified, the release occurred when the various bismuth phosphate wastes were undergoing reduction via the 242-B evaporator. Therefore, the waste type could be associated with metal waste, first- or second-cycle decontamination waste, 5-6 waste, or some other combination.

According to *Completion Report for 241-B Tank Farm Hydraulic Rotary Hammer Direct Push Drilling, Probe Installation, and Sampling* (RPP-36315), cesium-137 was detected by spectral gamma logging to approximately 19.8 m (65 ft) bgs. The logging was completed within probe hole C5163, which was pushed to approximately 20.1 m (66 ft) bgs. The probe hole was located approximately 3 m (9.8 ft) south of the 241-B-153 diversion box. Other nearby probe holes, located approximately 13 m (42.7 ft) to the east, only showed elevated cesium at approximately 6.1 m (20 ft) bgs. This depth was coincident with high moisture readings in probe hole C5136, indicating a low-permeability zone of possibly sandy silt to silt. The findings appear to correlate with preferential vertical migration for dense saline solutions; however, it does not appear this release presents a plausible source for contact with the groundwater, particularly because there was no discussion of strontium-90 from the gamma results, indicating no significant complexing agents.

Other Release Sites at the B Tank Farm. Other release sites identified in RPP-RPT-49089 or the WIDS database are low in volume and are not considered to be a plausible source of contact with groundwater, therefore they are not mentioned.

2.1.3.2 BX Tank Farm

The details of six UPRs are presented in this subsection. Based on the available data, one site (241-BX-102) has impacted groundwater; however, based on the type of waste stream, vadose zone investigation findings, perched water results, and groundwater results, it does not appear that this site is associated with RCRA dangerous wastes or dangerous waste constituents in the groundwater. Two other sites (241-BX-110 and 241-BX-11) appear to be plausible sites for groundwater contamination under worst-case release scenarios; however, based on data reviewed during this assessment, it does not appear that these sites would be associated with the nickel and manganese reported in wells 299-E33-337 and 299-E33-339. It may be possible that complexing agents were associated with some of the evaporator bottoms received by these tanks; however, insufficient data was available through this review to confirm this hypothesis. Although TOC and other metals will be analyzed at wells 299-E33-337 and 299-E33-339 to determine if RCRA dangerous waste or dangerous waste constituents are present in the groundwater, determining the source will likely require additional information.

241-BX-101 Tank. This tank was classified as “questionable integrity” based on 1972 gamma-ray activity in drywell 21-01-01 (RPP-RPT-47562), located to the northeast of the tank. The leak was assumed to be associated with the riser in the sluicing pit, and the volume was estimated at less than 3,400 L (900 gal), assuming that the waste leaked was B Plant cesium IX supernate waste. Based on comparison with the tank 241-B-101 release, this release does not appear to be a plausible source for contact with the groundwater.

According to WHC-MR-0132, the tank contained metal waste from 1948 through 1953, tributyl phosphate waste from 1956 through 1968, coating waste from 1962 through 1968, low-level fractionation

waste (including both REDOX- and PUREX-derived resin waste) from 1968 through 1976, and PUREX organic wash waste and coating waste from 1970 through 1971.

241-BX-102 Tank. This tank was classified as “questionable integrity” based on a 1971 assessment and a 1972 gamma-ray activity in drywell 21-02-04 (RPP-RPT-47562). The assessment estimated a leak of 346,700 L (91,600 gal) from a plugged cascade line and associated overflow of the 241-BX-102 spare inlet. The 1971 assessment included the installation of several drywells to arrive at the estimated release volume. Some contamination is believed to have migrated both to the north and northeast, causing elevated gamma readings in drywells in these areas, including drywells 21-03-03 and 21-03-05 beneath tank 241-BX-103. Although this release volume could reach groundwater, comparison between uranium release derived concentration based on the mean volume and inventory from RPP-26744 and the porewater uranium concentrations derived from the silt-dominated CCU samples indicates that additional water was added. The additional water may have been associated with quick snowmelt or underground waterline leaks, or both. The dilution between the porewater results and the soil inventory model results (RPP-26744) indicates that 3.785 million L (1 million gal) or more of water assisted migration to the perched water horizon, or possibly even more if a 1962 to 1970 release occurred at this tank (as discussed in the next paragraph). The addition of another liquid source is consistent with the RPP-10098 conceptual model. Analytical results provided in PNNL-19277 indicate that chromium did not migrate with the mobile metal waste through the vadose zone soils. This is consistent with the fact that chromium was not part of the metal waste separation process (WMP-28945), but was instead present due to deterioration of B Plant stainless-steel tanks and lines from concentrated nitric acid. Note that nickel, although not provided in the results in PNNL-19277, had results similar to chromium.

RPP-RPT-47562 identifies another release that occurred between 1962 and 1970. The report attributes most of the cesium-137 to the later release and an additional 10,000 kg of uranium to the later release. The release volume was calculated at 18,900 L to less than 189,000 L (5,000 gal to less than 50,000 gal). Based on WHC-MR-0132, records during this time span indicate that the release would have been generated from one of the following waste streams: tributyl phosphate waste, coating waste, low-level fractionation waste, or PUREX organic wash waste. However, based on the uranium inventory provided in RPP-26744 for tributyl phosphate waste for the BY Cribs, this waste stream seems unlikely. Likewise, process flow charts for PUREX organic wash waste would not appear to provide this inventory of uranium. However, cesium recovery PUREX neutralized acid waste (associated with fractionation waste for head-end PUREX acid waste, including coating waste) could have generated this type of inventory. This would suggest a 1968 to 1970 release. Based on the process chemistry for this waste stream, chromium, nickel, and manganese would not be considered mobile contaminants within the vadose zone. Thus, neither of these wastes appears plausible source for the elevated chromium, nickel, and manganese levels at wells 299-E33-337 or 299-E33-339.

According to WHC-MR-0132, the tank contained metal waste from 1948 through 1954, tributyl phosphate waste from 1956 through 1963, coating waste from 1962 through 1970, low-level fractionation waste from 1968 to 1970, and PUREX organic wash waste in 1970.

241-BX-108 Tank. This tank was declared as “suspect leaker” in 1973 and “confirmed leaker” in 1974 based on gamma-ray activity in drywell 21-08-06 and declining liquid levels in the tank (RPP-RPT-47562). The drywell is located south of the tank. Later assessments found it difficult to distinguish the leak from this tank and other releases. Thus, it was decided that the leak from this tank was small compared to the transfer line leak between tanks 241-BX-107 and 241-B-110 to the southwest and/or other operation leaks. The volume was estimated at 9,450 L (2,500 gal). Based on comparison with the tank 241-B-101 release, this release does not appear to be a plausible source for contact with the groundwater.

According to WHC-MR-0132, the tank contained first-cycle decontamination waste from 1949 through 1952, tributyl phosphate waste from 1953 through 1964, coating waste from 1963 through 1968, and cesium recovery IX fractionation waste from 1969 through 1976.

241-BX-110 Tank. This tank was classified as “questionable integrity” in 1976 based on gamma-ray activity in drywells 21-10-03 and 21-10-05 (RPP-RPT-47562), located to the east and southeast of the tank. The assessment for RPP-RPT-47562 found that the tank liquid levels were higher than the port levels at different periods, and drywells near the spare inlet outlets showed increased activity.

The *Hanford Tank Farms Vadose Zone: Addendum to the BX Tank Farm Report* (GJO-98-40-TARA) indicated elevated cesium-137 and cobalt-60 in the drywell 21-10-03. The source of the cesium-137 was thought to be associated with a pipe leak at 2.4 m (8 ft) bgs. The report states that the cesium-137 detector was saturated over a 10.7 m (35 ft) interval in this drywell, which included the highest reading at 2.4 m (7.9 ft) bgs. RPP-RPT-47562 shows the spectral gamma logging results for all of the wells surrounding tank 241-BX-110. The saturated spectral gamma cesium-137 reading in drywell 21-10-03 extends from approximately 2.1 to 12.5 m (7 to 41 ft) bgs. Saturated spectral gamma cesium-137 readings were also noted in drywell 21-10-05 from 11 to 14.6 m (36 to 48 ft) bgs. Based on the spectral gamma logging results in both of these wells, cesium-137 continued downward to approximately 26.8 and 19.2 m (88 and 63 ft) bgs in drywells 21-10-03 and 21-10-05, respectively.

RPP-RPT-47562 identified a 1974 letter report indicating that the contaminants in drywell 21-10-05 were released prior to 1964 due to the absence of cesium-134. Based on WHC-MR-0132, the release would either be first-cycle decontamination waste or evaporator bottoms. The evaporator bottoms waste types are not specified in WHC-MR-0132. If the release time frame is as suggested in the letter report, then chromium would be a good indicator parameter; however, nickel and manganese would not be mobile constituents.

Unfortunately, RPP-26744 does not provide release volume or nature of contaminants for this release. Thus, uncertainty exists regarding what type of waste stream and release volume are associated with this release. Note that nearby water lines are not located in this area, and strontium-90 is not present, which is an indication of complexing agents. Therefore, either the release was significant or information is missing for cesium-137 to extend to the depth reported by spectral gamma logging in RPP-RPT-47562.

According to WHC-MR-0132, the tank contained first-cycle decontamination waste from 1949 through 1954 and 1963 to 1964, evaporator bottoms from 1954 to 1976, coating waste from 1965 through 1968, and cesium recovery IX fractionation waste from 1969 to 1970.

Based on available data, it is plausible that contaminants associated with this source could impact groundwater; however, the data do not seem consistent for the elevated nickel and manganese at wells 299-E33-337 and 299-E33-339. It may be possible that complexing agents were associated with some of the evaporator bottoms, which could explain the deep migration of cesium-137; however, there are insufficient data to confirm this hypothesis. Although TOC and metals will be analyzed to determine if RCRA dangerous waste or dangerous waste constituents are present in the groundwater, determining the source will likely require additional information.

241-BX-111 Tank. This tank was classified as “questionable integrity” in 1976 based on a liquid-level decrease in 1974 and gamma-ray activity in drywells 21-11-03, 21-11-04, 21-11-05, and 21-11-07 (RPP-RPT-47562). The drywells are located to the east to southwest of the tank.

The assessment for RPP-RPT-47562 found that the tank liquid levels were higher than the port levels at different periods, and drywells near the spare inlet outlets showed increased activity. Other than several

possible line transfer leaks between tanks 241-BX-110 and 241-BX-111, or tanks 241-BX-107 and 241-BX-108, RPP-RPT-47562 indicates a potential tank leak at tank 241-BX-111.

GJO-98-40-TARA reported high spectral gamma cesium-137 results at the base of the tank in drywells 21-11-03, 21-11-04, and 21-11-05. The report also states that the highest concentrations were in drywell 21-11-03. RPP-RPT-47562 provides evidence of the contamination moving through the vadose zone between 12.2 and 13.7 m (40 and 45 ft) and 19.8 and 21.3 m (65 to 70 ft) bgs in the 1980s.

RPP-RPT-47562 recommended further assessment of this tank. Note that nearby water lines are not located in this area, and strontium-90 is not present, which is an indication of complexing agents. Therefore, either the release was significant or information is missing regarding why cesium-137 has been reported to such a deep depth by spectral gamma logging in RPP-RPT-47562.

According to WHC-MR-0132, the tank contained first-cycle decontamination waste from 1950 through 1957 and again in 1963 to 1964, evaporator bottoms waste from 1954 through 1963, coating waste from 1964 through 1971, cesium recovery IX fractionation waste from 1969 to 1970, and evaporator bottoms waste from 1971 to 1977.

Based on available data, it is plausible contaminants associated with this source could impact groundwater; however, the data do not seem consistent for the elevated nickel and manganese at wells 299-E33-337 and 299-E33-339. It may be possible that complexing agents were associated with some of the evaporator bottoms, which could explain the deep migration of cesium-137; however, insufficient data are available to confirm this hypothesis. Although TOC and metals will be analyzed to determine if RCRA dangerous waste or dangerous waste constituents are present in the groundwater, determining the source will likely require additional information.

241-BX-153 Diversion Box. In July 1972, a release event (discussed in RPP-RPT-47562) associated with the V-342 line (which connects with tank 241-BX-110) was determined. The release area is not provided; however, the release was estimated to contain 30 Ci of cesium-denude waste from the 18-1 tank in B Plant. According to ISO-986, this waste was generated from the IX column. The cesium-137 concentration from the IX waste was less than 0.065 Ci/gal; thus, the release would have been at least 1,703 L (450 gal). No organics were associated with this waste. Based on comparison with the tank 241-B-101 release, this release does not appear to be a plausible source for contact with the groundwater.

Other Release Sites at the BX Tank Farm. Other release sites identified in RPP-RPT-47562 or the WIDS database are low in volume or are not considered a plausible source of contact with groundwater and, therefore, are not mentioned.

2.2 Regulatory Basis

In May 1989, the U.S. Department of Energy (DOE), the U.S. Environmental Protection Agency (EPA), and the Washington State Department of Ecology (Ecology) signed the Tri-Party Agreement (Ecology et al., 1989). This agreement established the roles and responsibilities of the agencies involved in regulating and controlling remedial restoration of the Hanford Site, which includes the SST WMAs. As part of the WAC 173-303 regulatory process implementing RCRA, an interim status Dangerous Waste Permit Application Part A (WA7890008967) and the SST closure work plan (DOE/RL-89-16) were submitted to Ecology for the SSTs. In 1996, the Washington State Attorney General determined that the effective date of mixed waste in Washington State was August 19, 1987.

Groundwater monitoring is conducted at WMA B-BX-BY in accordance with WAC 173-303-400(3) and, by reference, 40 CFR 265, Subpart F (“Ground-Water Monitoring”), which requires monitoring to

determine whether dangerous waste or dangerous waste constituents from the waste site have entered the groundwater. The WMA was placed in assessment monitoring (40 CFR 265.93[d][4], “Preparation, Evaluation, and Response”) after elevated specific conductance in downgradient monitoring well 299-E33-32 was observed and confirmed (WHC-SD-ENV-AP-002, *Assessment Groundwater Monitoring Plan for Single Shell Tank Waste Management Area B-BX-BY*).

2.3 Waste Characteristics

During the period of Hanford Site operations, wastes routed to tanks in the B/BX/BY Tank Farms were derived from several production processes. Section 2.1.2 discusses the process chemistry, and the documents identified below provide an evaluation of the chemical and radioactive species derived from the processes at B Plant, U Plant, PUREX Plant, REDOX Plant, and the Hot Semiworks Facility:

- HNF-SD-WM-TI-740, *Standard Inventories of Chemicals and Radionuclides in Hanford Site Tank Wastes*
- LA-UR-96-3860, *Hanford Tank Chemical and Radionuclide Inventories: HDW Model, Rev. 4*
- RPP-19822, *Hanford Defined Waste Model – Rev. 5*
- RPP-26744, *Hanford Soil Inventory Model, Rev. 1*
- WHC-MR-0132, *A History of the 200 Area Tank Farms*

WHC-MR-0132 provides the approximate waste stream types sent to the SSTs, and RPP-26744 includes detailed estimates for chemical and radioisotope concentrations for several tank leaks and UPRs in WMA B-BX-BY. Table 2-1 lists the dangerous wastes specified in the Dangerous Waste Permit Application Part A Form (WA7890008967).

The contaminants of potential concern associated with the SSTs have been derived through various Hanford Site documents. Previous groundwater monitoring was derived from LA-UR-96-3860 for chemical and radiological species resulting from process wastes sent to WMA B-BX-BY. A more recent analytical strategy was based on an analysis of major constituent categories associated with specific SST constituents to address risk assessment and performance criteria (RPP-23403, *Single-Shell Tank Component Closure Data Quality Objectives*). By comparison, the more recent list from RPP-23403 is significantly more extensive. Thus, the monitoring strategy for this plan includes a common subset of constituents from two sources to determine if dangerous waste or dangerous waste constituents have impacted the groundwater: (1) RPP-23403; and (2) 40 CFR 264 (“Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities”), Appendix IX (“Ground-Water Monitoring List”). The common subset of these constituents is discussed in Section 3.1 (Tables 3-2 through 3-4). The lists of constituents will be used to determine the concentration and extent of potential dangerous waste or dangerous waste constituents in the groundwater. Any dangerous waste or dangerous waste constituent determined to have impacted the groundwater will be retained for subsequent analyses.

Table 2-1. Dangerous Wastes in the SST System
(Dangerous Waste Permit Application Part A Form)

Dangerous Waste Code	Contaminant Description	Dangerous Waste Code	Contaminant Description
D001	Ignitable waste	D034	Hexachloroethane
D002	Corrosive waste	D035	Methyl ethyl ketone
D003	Reactive waste	D036	Nitrobenzene
D004	Arsenic	D038	Pyridine
D005	Barium	D039	Tetrachloroethylene
D006	Cadmium	D040	Trichloroethene (TCE)
D007	Chromium	D041	2,4,5-Trichlorophenol
D008	Lead	D043	Vinyl chloride
D009	Mercury	F001	1,1,1-Trichloroethane
D010	Selenium	F002	Methylene chloride
D011	Silver	F003	Acetone, methyl isobutyl ketone
D018	Benzene	F004	Cresol-m, -o, -p
D019	Carbon tetrachloride	F005	Methyl ethyl ketone (MEK)
D022	Chloroform	WT01	Extremely hazardous waste/ toxic dangerous waste
D028	1,2-Dichloroethane	WT02	Dangerous waste/toxic dangerous waste
D029	1,1-Dichloroethylene	WP01	Extremely hazardous waste/ persistent dangerous waste
D030	2,4-Dinitrotoluene	WP02	Dangerous waste/persistent dangerous waste
D033	Hexachlorobutadiene		

Notes:

WA7890008967, *Hanford Facility Dangerous Waste Permit Application for Single-Shell Tank Farm Systems.*

Analytes associated with the F001 through F005 waste codes are from WHC-MR-0517, *Listed Waste History at Hanford Facility TSD Units.*

It is likely that only the more mobile dangerous waste or dangerous waste constituents may be determined as impacting groundwater from WMA B-BX-BY. This is based on the conclusion that not all of the chemical species in tank waste are mobile. Depending on solubility and concentration, some species are more likely to have leaked from a tank and migrated through the subsurface to the groundwater. Thus, it is important to consider the chemistry and fate of the waste routed to the SSTs in WMA B-BX-BY. Nitrate, sulfate, and chloride are the most likely anionic constituents to be detected in the groundwater, although these constituents are not dangerous constituents identified in 40 CFR 264, Appendix IX.

Inorganic complexes (i.e., the ferrocyanide complex associated with in-farm scavenging) and organic complexing agents (e.g., ethylene diamine tetraacetic acid, hydroxyethyl ethylenediamine triacetic acid, etc.) are the most significant complexes associated with WMA B-BX-BY. Cyanide, various metals, and TOC are the most obvious constituents associated with these types of complexes, and cyanide present in the groundwater at well 299-E33-47 is likely associated with scavenging process waste stored at WMA B-BX-BY.

Some of organic components, if not completely degraded, should be detected by the analyses described in Section 3.1. However, complexing agents such as ethylene diamine tetraacetic acid and hydroxyethyl ethylenediamine triacetic acid are difficult to analyze for and will be interpreted by the presence of increased TOC. Because of the lack of organics reported in groundwater monitoring results for the 200-BP-5 Operable Unit (OU), it seems unlikely that any organics would be detected other than common laboratory contaminants (e.g., acetone, 2-butanone, methylene chloride, bis[2-ethylhexyl]phthalate, and 2-butoxyethanol).

2.4 Geology and Hydrogeology

The geology and hydrology of the 200 East Area, including the WMA B-BX-BY, have been described in detail in several reports over the past 20 years, such as the following:

- BHI-00184, *Miocene- to Pliocene-Aged Suprabasalt Sediments of the Hanford Site, South-Central Washington*
- HNF-5507, *Subsurface Conditions Description of the B-BX-BY Waste Management Area*
- PNL-6820, *Hydrogeology of the 200 Areas Low-Level Burial Grounds: An Interim Report*
- WHC-SD-EN-AP-012, *Interim-Status Groundwater Monitoring Plan for the Single-Shell Tanks*
- WHC-SD-EN-TI-012, *Geologic Setting of the 200 East Area*
- WHC-SD-EN-TI-290, *Geologic Setting of the Low-Level Burial Grounds*

Interpretative discussion of the geologic history is further provided in *Paleodrainage of the Columbia River System on the Columbia Plateau of Washington State: A Summary* (RHO-BW-SA-318 P) and *Hydrogeologic Model for the Gable Gap Area, Hanford Site* (PNNL-19702). As investigations continued to analyze and review borehole log cuttings, sediment sample mineralogy, geophysical logs, and regional cross sections, further refinement occurred of the hydrogeology defined in *Revised Hydrogeology for the Suprabasalt Aquifer System, 200-East Area and Vicinity, Hanford Site, Washington* (PNNL-12261). In addition, investigations have resulted in refinement of the contacts between the Ringold Formation, CCU, and Hanford formation. The revised criteria for differentiating these stratigraphic units are provided in WHC-SD-EN-TI-012, HNF-5507, PNNL-19702, and PNNL-19277. Based on the most recent interpretation, the geologic profile and sediment description beneath the WMA B-BX-BY are presented in Section 2.4.1. The primary tools used for the interpretations included geologic descriptions from geologist logs, sediment photographs, and stratigraphic horizon thickness. The primary data in the geologist logs were sediment descriptions (e.g., basalt content, unconsolidated, sediment shape, and color) and lithology changes. Because a thick silt horizon (greater than 1 m [3.3 ft] thick) is present overlying the basal gravel unit through most of the WMA B-BX-BY, the underlying gravel unit was defined as the ancestral Columbia River Cold Creek gravel unit.

2.4.1 Geology

A total of six stratigraphic units are recognized in WMA B-BX-BY:

- Recent backfill material
- Hanford formation gravel-dominated sequence (H1 unit)
- Hanford formation sand-dominated sequence (H2 unit)
- CCU (fine-grained)
- CCU (coarse-grained)
- Columbia River Basalt Group

The WMA B-BX-BY was constructed in the near-surface sediments that overlie the Columbia River Basalt Group (i.e., bedrock) on the northern limb of the Cold Creek syncline. Plio-Pleistocene-age fluvial and perhaps some eolian deposits lay between Columbia River basalt and the overlying cataclysmic Ice Age flood deposits (i.e., Hanford formation). Suprabasalt sediments in the vicinity are unconsolidated and include two facies of the CCU: (1) the deeper facies, which is coarse-grained (gravel-dominated); and (2) the shallower facies, which is generally fine-grained mud with sand. The suprabasalt sediments in this area also include sand, gravel, and lesser amounts of silt-dominated deposits from Pleistocene cataclysmic floods, collectively referred to as the Hanford formation. In the vicinity of WMA B-BX-BY, the Hanford formation is subdivided into a gravel sequence (H1 unit) and an underlying sequence composed of predominantly sand (H2 unit), which contains several thin, fine-grained silty lenses. The three thin, fine-grained H2 lenses and the fine-grained mud with sand of the CCU may have played a significant role in horizontal spreading of waste liquids disposed or accidentally leaked at the various facilities, respectively.

2.4.1.1 Columbia River Basalt Group

The surface of the Columbia River Basalt Group forms the bedrock base of the unconfined aquifer under the B Complex. The Elephant Mountain Member of the Saddle Mountains Basalt is the youngest flow, ranging from 83 to 86.4 m (272.3 to 283.5 ft) bgs. The top of basalt dips northeast in the eastern half of the B Complex area and to the southwest in the western half of the B Complex (Figure 2-1). Up to 6 m (19.7 ft) of topographic relief exists on the basalt surface as a result of tectonic deformation and/or erosion that occurred in this area prior to cataclysmic flooding (Figure 2-2). A northwest-southeast-trending basalt high lies just north of the B Tank Farm, and the region between the BX/BY Tank Farms is consistent with the trend of other eroded and/or deformed basalt highs in the region. In general, lavas of the Saddle Mountains Basalt and the overlying suprabasalt sediments thicken to the south toward the axis of the Cold Creek syncline.

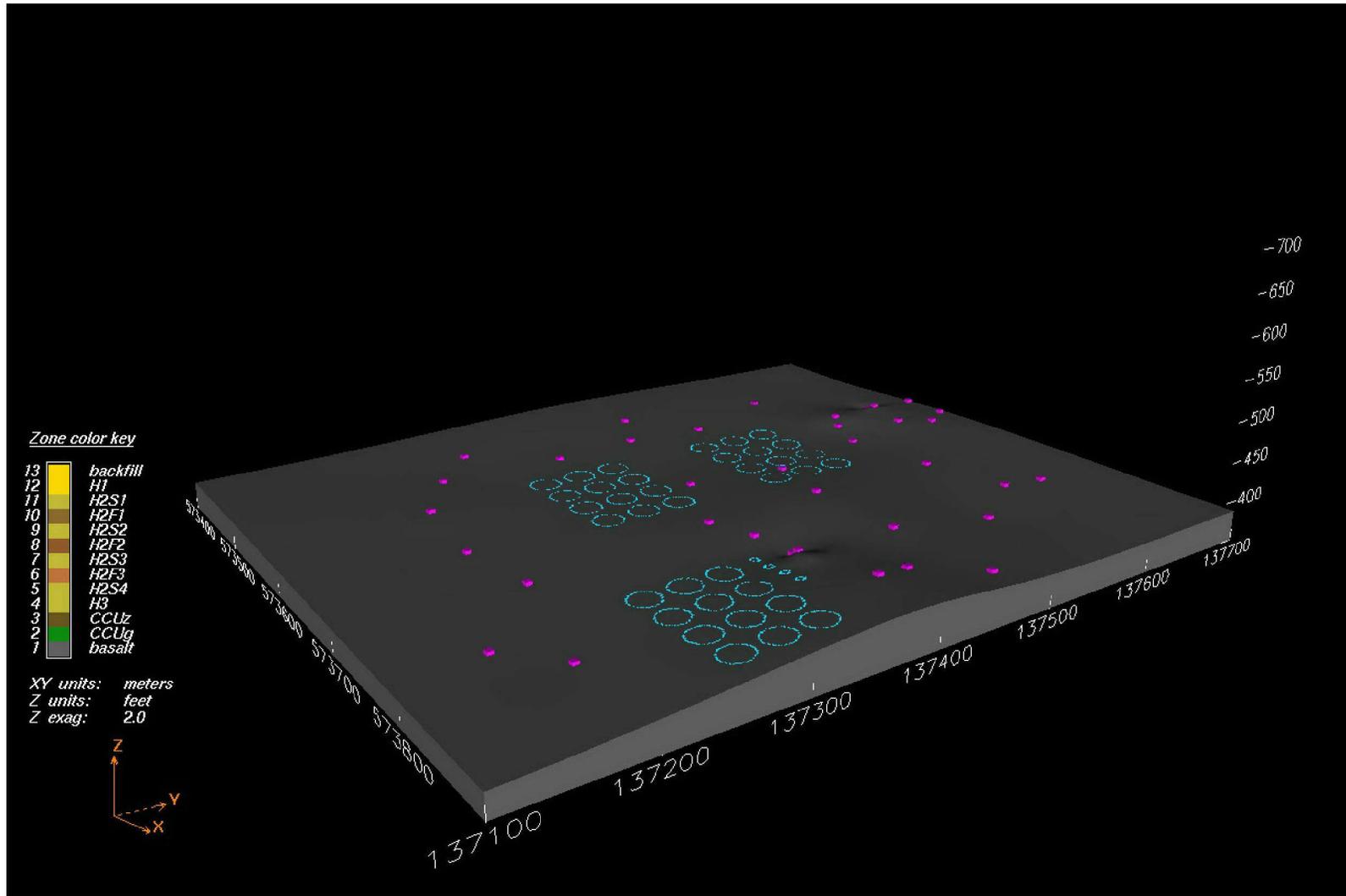


Figure 2-1. Top of Basalt (Looking from Southwest to Northeast, with B Tank Farm in Foreground and BX/BY Tank Farms in Background)

The Elephant Mountain Member is medium- to fine-grained tholeiitic basalt with abundant microphenocrysts of plagioclase. The Elephant Mountain Member has been dated by the K/Ar method to be about 10.5 million years before present (“Duration and Volume of Columbia River Basalt Volcanism; Washington, Oregon, and Idaho” [McKee et al., 1977]) and consists of two flows beneath the 200 East Area. Because the water table is near the top of basalt bedrock, most boreholes beneath the B Complex were drilled until they intersected basalt. Prior to the recent 200-BP-5 OU borehole characterization effort, only two boreholes penetrated the Elephant Mountain Member: borehole 299-E33-40 terminated within the first interbed (Rattlesnake Ridge Interbed of the Ellensburg Formation), and borehole 299-E33-12 advanced through the first interbed into the underlying Pomona Member of the Columbia River Basalt Group. Other boreholes were recently drilled into the basalt to investigate contamination in the confined aquifer (e.g., 299-E33-50, 299-E33-340, and 699-52-55B), but only the upper portions of 299-E33-50 and 299-E33-340 were used in creation of the geology conceptual model presented herein. The deeper portions of the boreholes that penetrated deep into the basalt bedrock will be important in addressing the Gable Mountain/Gable Butte Gap and confined aquifer issues for other reporting purposes.

2.4.1.2 Cold Creek Unit

Two facies of the CCU are present beneath WMA B-BX-BY (Figures 2-3 and 2-4). The lower facies is the gravel-dominated CCU, which is described as coarse-grained, gravel-dominated, unconsolidated, sandy gravel to gravelly sand. The unit overlies the Elephant Mountain Basalt and ranges from 5 to 15 m (20 to 50 ft) in thickness (Figure 2-5). A depression exists at the top of this unit centered over the northwest corner of the B Tank Farm, which appears to be filled with the overlying CCU silt layer. PNNL-19277 defined the mean bulk density, porosity, and effective porosity of this unit as 2.15 g/cm³, 0.121 cm³/cm³, and 0.11 cm³/cm³, respectively. The longitudinal and transverse dispersivity were also provided in PNNL-19277, and the ratio is 0.1.

Overlying the gravel-dominated facies is the CCU silt-dominated facies. The silt layer is present throughout the B/BX Tank Farms (Figure 2-6); elsewhere, it was either subsequently eroded or not deposited. Based on drilling logs and an examination of drill cuttings, this unit consists of olive-brown to olive-gray, well-sorted, calcareous silt and/or fine sand. Both laminations and pedogenic structures (i.e., mottling and root traces) are present in the larger intact pieces recovered with a drive barrel (HNF-5507). The silt layer is up to approximately 6.1 m (20 ft) thick. PNNL-19277 defined the mean bulk density, porosity, and effective porosity of this unit as 1.65 g/cm³, 0.3763 cm³/cm³, and 0.3514 cm³/cm³. Field capacity provided in PNNL-19277 was 0.2644 cm³/cm³. The longitudinal and transverse dispersivity were also provided, and the ratio is 0.1.

2.4.1.3 Hanford Formation

The Hanford formation is the informal name for the glacio-fluvial deposits from cataclysmic Ice Age floods. Sources for floodwaters included Glacial Lake Missoula, pluvial Lake Bonneville, and ice-margin lakes that formed around the margins of the Columbia Plateau (“Quaternary Geology of the Columbia Plateau” [Baker et al., 1991]). The last Ice Age floods occurred about 15,000 calendar years ago; the earliest may have been 1 to 2 million years ago (*On the Trail of the Ice Age Floods: A Geological Field Guide to the Mid-Columbia Basin* [Bjornstad, 2006]). The Hanford formation consists of mostly unconsolidated sediments that cover a wide range in grain size, from pebble- to boulder-size gravel, fine- to coarse-grained sand, silty sand, and silt. The Hanford formation is further subdivided into gravel-, sand-, and silt-dominated facies, which transition into one another laterally with distance from the main, high-energy flood currents (PNNL-19277).

Top of Basalt Structure Map: B-BX-BY Tank Farms

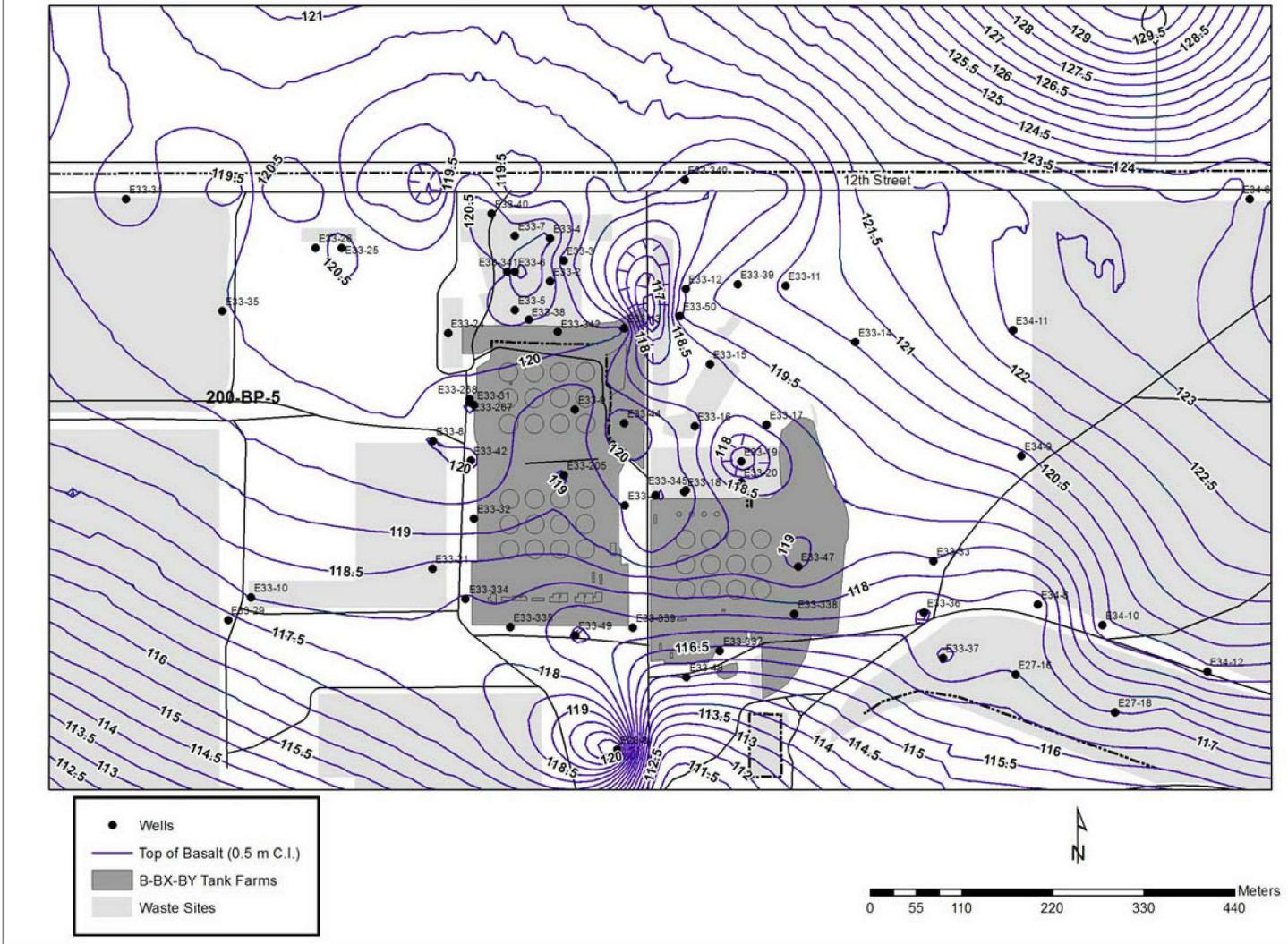


Figure 2-2. Contour Map for Top of Basalt at WMA B-BX-BY

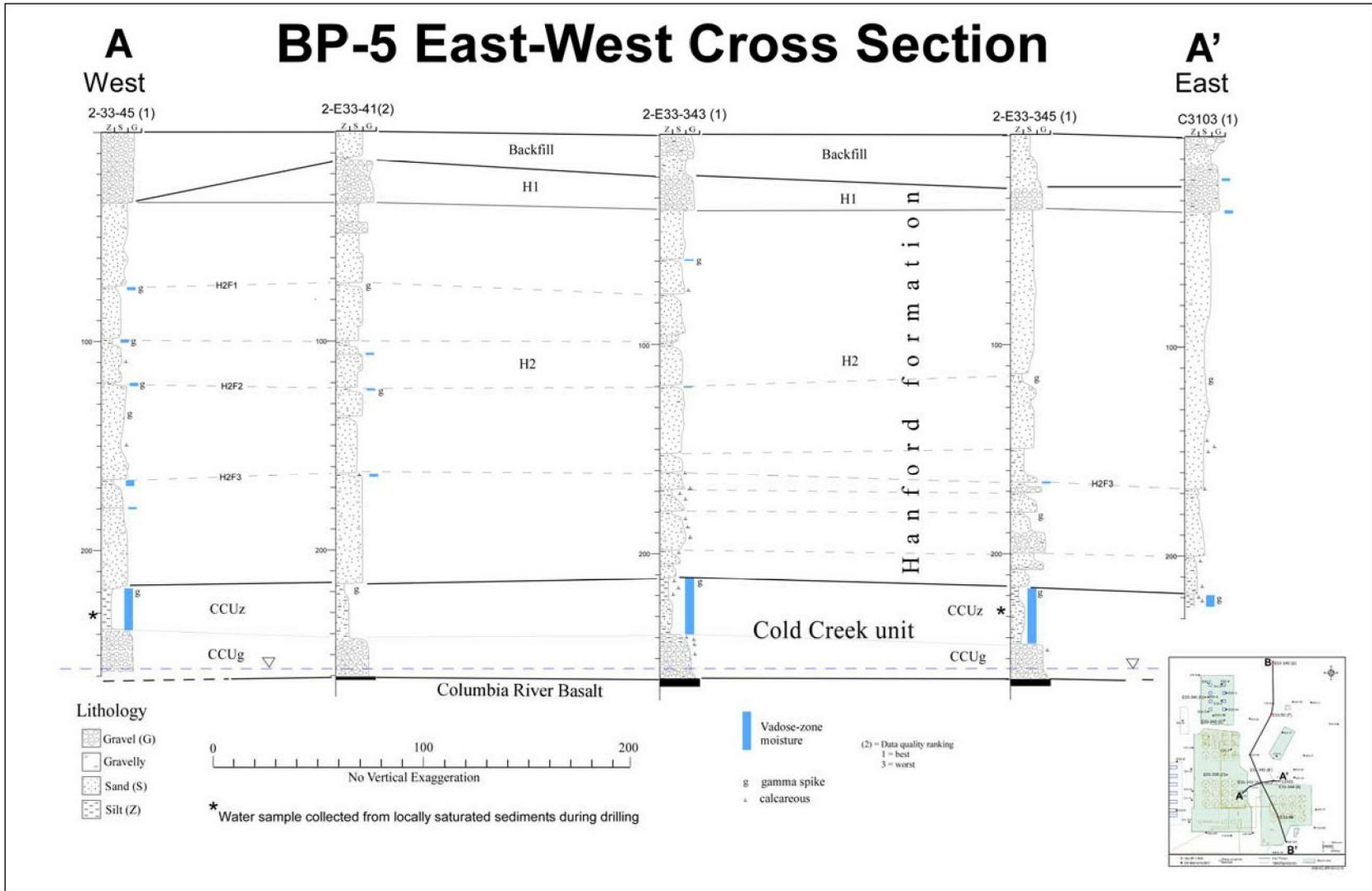


Figure 2-3. Geologic Cross Section A-A' in B Complex Region

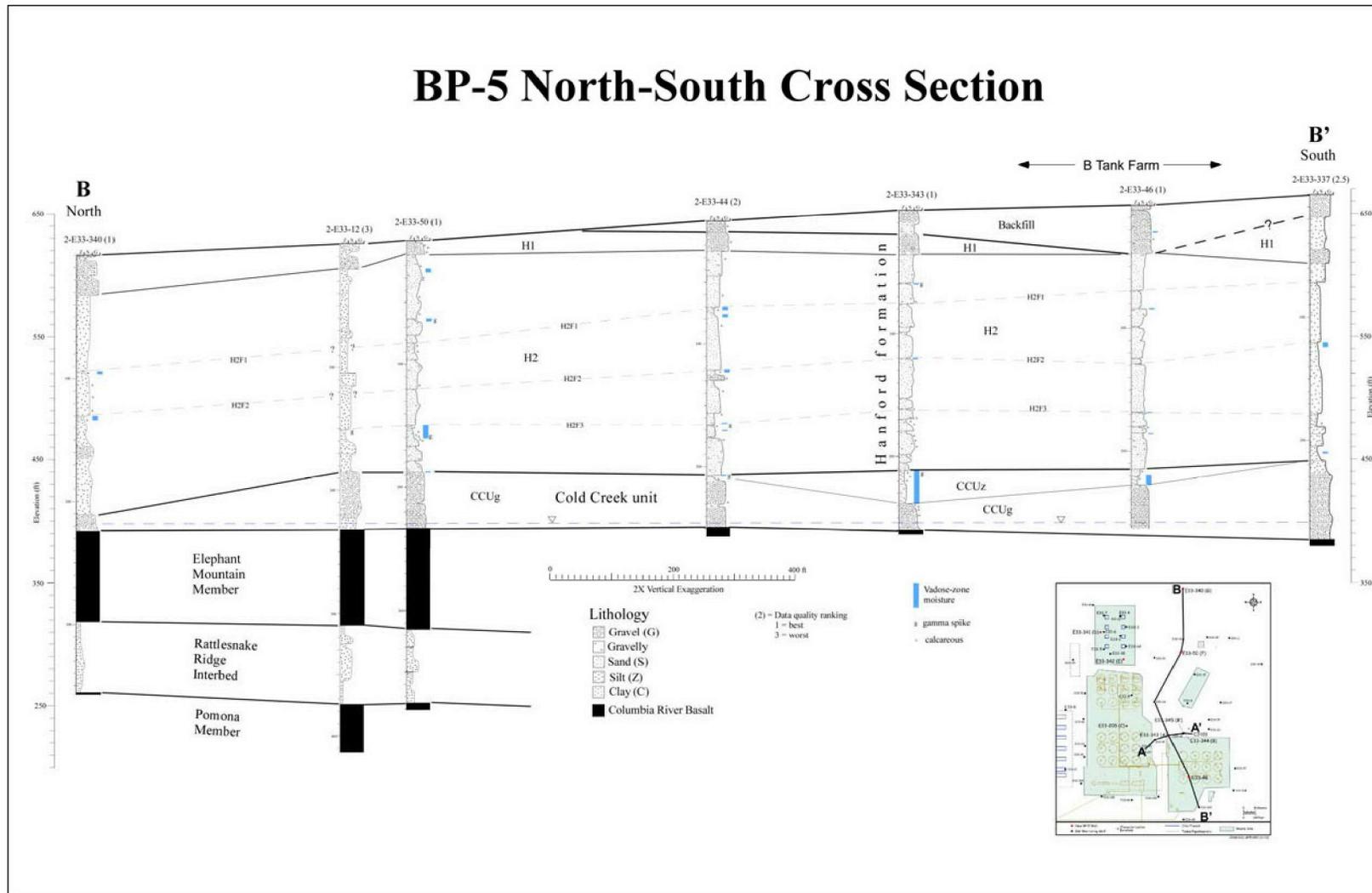


Figure 2-4. Geologic Cross Section in B Complex Region

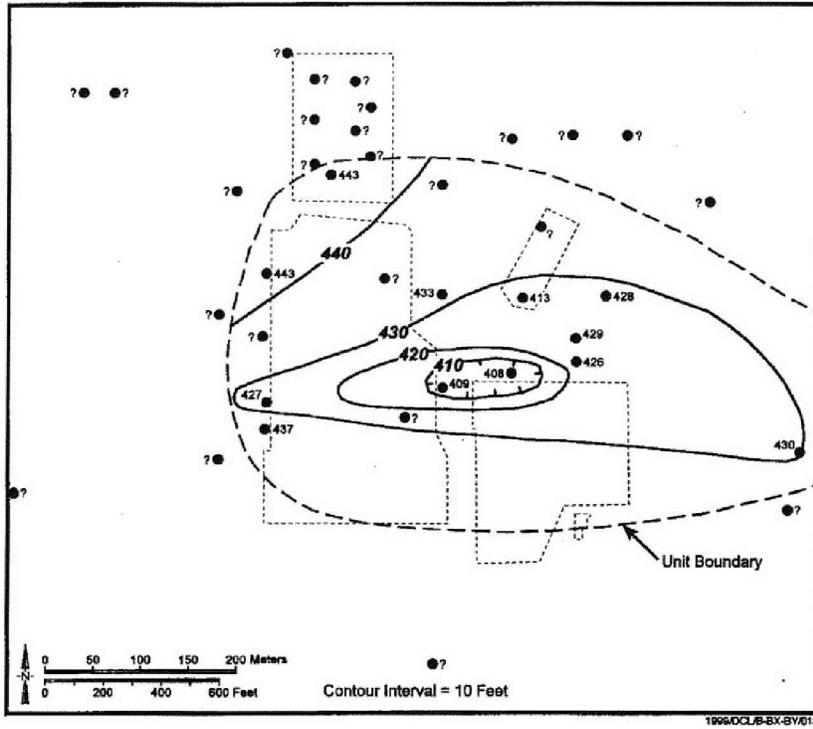


Figure 2-5. Areal Extent and Thickness of Cold Creek Gravel-Dominated Unit

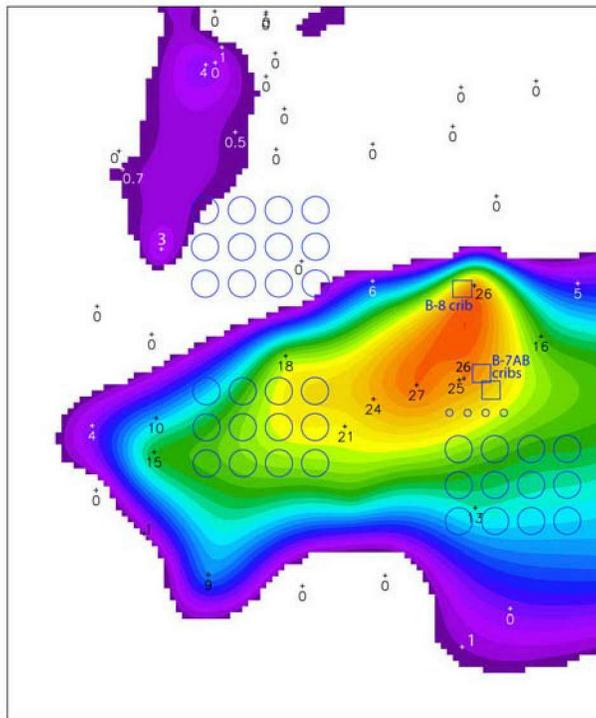


Figure 2-6. Areal Extent of Cold Creek Silt-Dominated Facies at WMA B-BX-BY

Hanford formation sand-dominated sequence (H2) overlies the CCU silt-dominated unit at WMA B-BX-BY. The H2 unit is predominantly sand-dominated with graded plane- to foreset-bedded sequences of sand or gravelly sand several meters or more thick. Silty sand or silt is occasionally observed near the top of the graded sand to gravelly sand sequences. Cementation is very minor or absent in the H2 unit, and total calcium carbonate content is generally a few weight percent or less. This facies thickens from north to south ranging, from 30 to 60 m (110 to 200 ft, respectively). Three apparent, continuous, thin, fine-grained lenses occur across WMA B-BX-BY at 21.3, 30.5, and 51.8 m (70, 120, and 170 ft) bgs (Figures 2-3 and 2-4). PNNL-19277 defined the mean bulk density, porosity, and effective porosity of this unit as 1.77 g/cm^3 , $0.2515 \text{ cm}^3/\text{cm}^3$, and $0.2207 \text{ cm}^3/\text{cm}^3$. Field capacity provided in PNNL-19277 was $0.0842 \text{ cm}^3/\text{cm}^3$. The longitudinal and transverse dispersivity were also provided, and the ratio is 0.1.

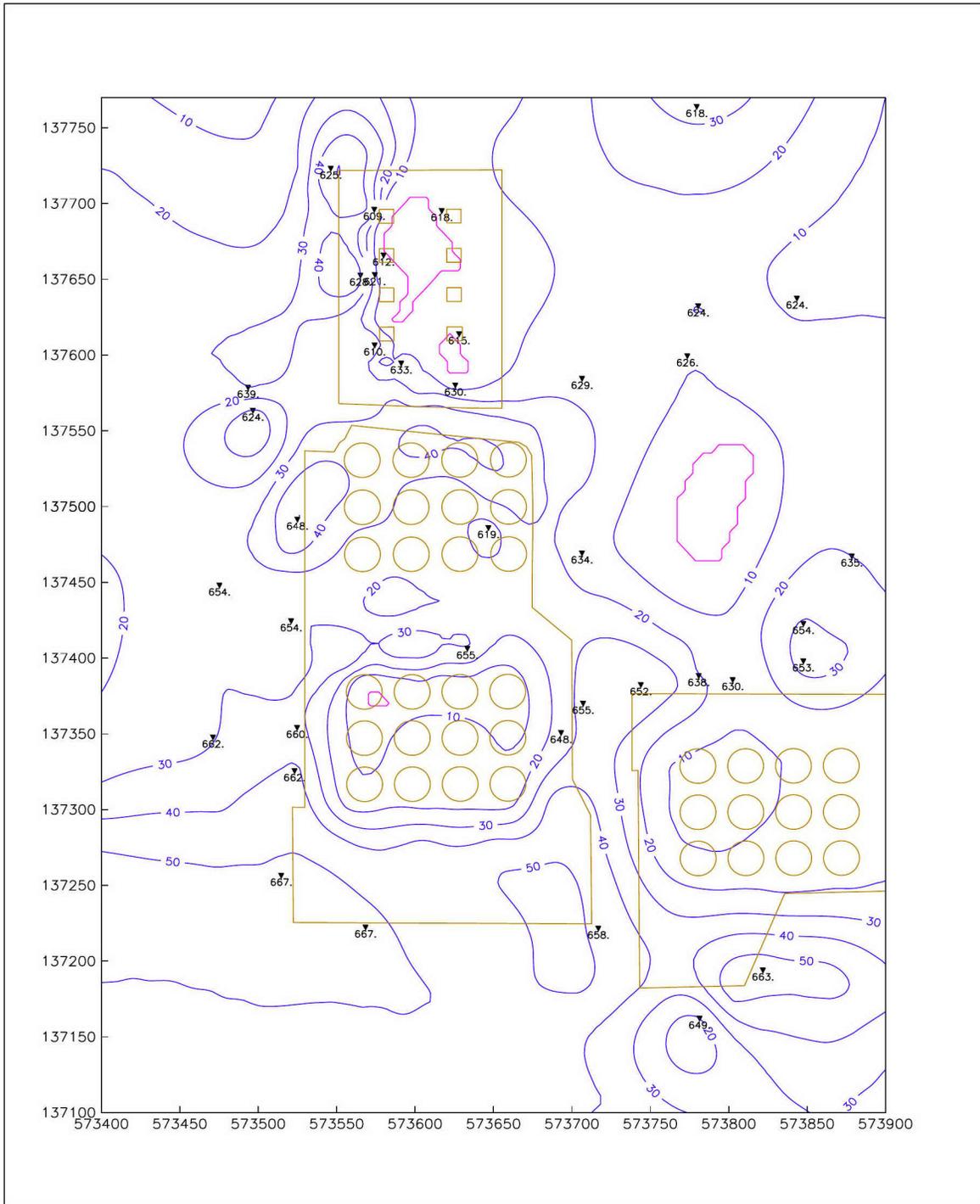
The Hanford formation gravel-dominated sequence (H1) overlies the sand-dominated sequence. The gravel-dominated sequence consists of the high-energy gravels with subordinate lenticular and discontinuous layers of the sand and silt-dominated facies. The maximum thickness of the H1 unit reflects a north-south-trending trough (i.e., channel) that trends beneath the BX/BY Tank Farms; the maximum thickness of the H1 unit in this trough is about 15 m (50 ft) (Figure 2-7). PNNL-19277 defined the mean bulk density, porosity, and effective porosity of this unit as 2.07 g/cm^3 , $0.1207 \text{ cm}^3/\text{cm}^3$, and $0.1027 \text{ cm}^3/\text{cm}^3$. Field capacity and longitudinal to transverse dispersivity was also provided in PNNL-19277 at $0.0741 \text{ cm}^3/\text{cm}^3$, with a ratio of 0.1.

Overlaying the Hanford gravel dominated facies is approximately 13.7 m (45 ft) of backfill.

2.4.2 Hydrogeology

The uppermost aquifer beneath WMA B-BX-BY is unconfined, and it occurs within the gravel-dominated CCU. The water table elevation beneath WMA B-BX-BY is approximately 122 m (400 ft) above mean sea level. The base of the unconfined aquifer is defined as the top of the Elephant Mountain Member of the Saddle Mountains Basalt, which dips to the south-southeast and ranges between 120.2 and 116.8 m (394.5 to 383.3 ft) above mean sea level. The unconfined aquifer thickness ranges from 1.7 to 5.09 m (5.5 to 16.7 ft). The screen interval across the aquifer for the WMA B-BX-BY wells is presented in Section 3.2, Table 3-5. The top of the Elephant Mountain basalt is considered to create an impermeable barrier beneath WMA B-BX-BY based on the lack of vesicles in basalt chips (PNL-6820).

During defense operation efforts at the Hanford Site from 1943 to 1995, the groundwater flow direction in most of the 200 East Area was influenced by the hydraulic mounding associated with discharges to the 216-B-3 Ponds, located to the east of WMA B-BX-BY. This groundwater mound is evident in water table maps through the 1990s and acted as a hydraulic dam along with other waste sites and ponds, slowing groundwater flow to the southeast or diverting it to the northwest from the 200 East Area (Figure 2-8).



Notes: Units presented are in feet.

Figure 2-7. Thickness Map for Hanford Formation Gravel-Dominated Sequence at B Complex

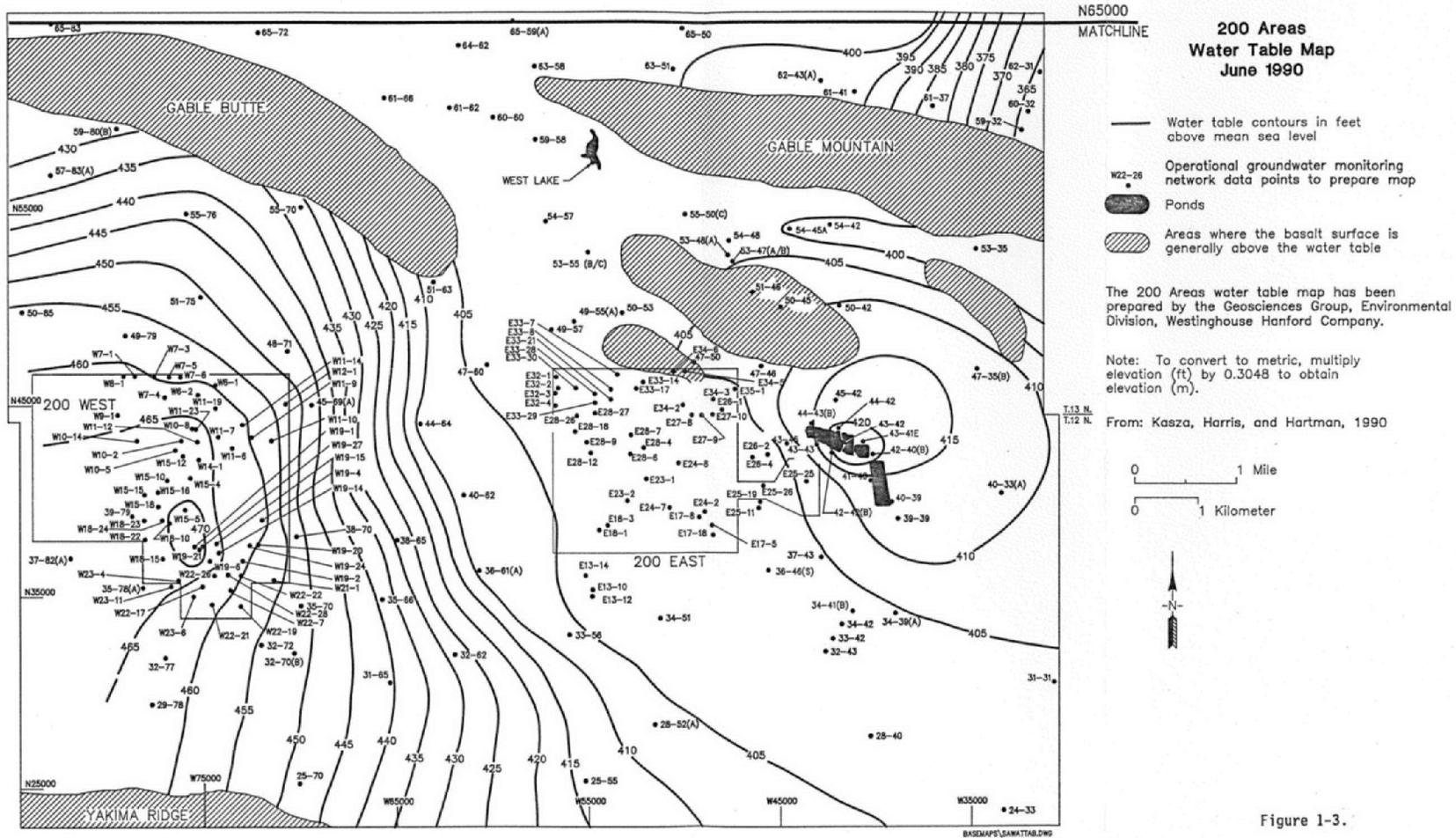


Figure 2-8. 1990 Water Table Map

Figure 1-3.

Groundwater flow after the termination of waste discharges to Gable Mountain Pond in 1985 and prior to termination of the 216-B-3 Ponds in 1997 was considered generally to the west-northwest beneath WMA B-BX-BY (Figure 2-9). The termination of discharges to the 216-B-3 Ponds resulted in the groundwater mound dissipation with decreasing head differences. As groundwater elevation continued to decline, differentiating a flow direction and gradient beneath WMA B-BX-BY became increasingly more uncertain. A low-level groundwater monitoring network was employed in 1999 at the 216-B-63 Trench using existing monitoring wells and multiple-regression deconvolution method for barometric responses (PNNL-13078, *Evaluation of Barometric Fluctuations on Well Water-Level Measurements and Aquifer Test Data*). The results of this effort produced a southwest flow direction beneath the 216-B-63 Trench, which did not match the anticipated west to northwest response. However, the effort illustrated good predictive/removal capabilities by multiple-regression deconvolution methods for well water-level and aquifer total head values.

In 2000, an in situ flow meter (colloidal borescope) was used to determine local groundwater flow directions at WMA B-BX-BY. The results indicated a general south to southeast flow direction; however, considerable variation was observed in flow directions between wells (PNNL-13788, *Hanford Site Groundwater Monitoring for Fiscal Year 2001*). In addition, a low-level, water-level, trend-surface analysis at Low-Level Waste Management Area 1, located west of WMA B-BX-BY, returned a northwest flow direction. The inconsistencies led to continued improvements of the low-level groundwater trend-surface analysis over the next several years. In 2008, highly accurate casing surveys to a common datum and borehole deviation corrections confirmed statistically significant flow directions to the northwest over the past years. This information, combined with the observation of uranium migration from WMA B-BX-BY, provided strong evidence of a northwest flow direction until the mid-2008.

High Columbia River spring stages were determined to cause a flow reversal at WMA B-BX-BY in the summer of 2008. It was nearly a year before the flow returned to the north, based on statistically significant low-level groundwater trend-surface analysis (Figure 2-10).

In 2010, it was realized that large discharges to the Treated Effluent Disposal Facility (TEDF) also played a role in the flow direction at WMA B-BX-BY. A figure was presented in *Hanford Site Groundwater Monitoring Report for 2010* (DOE/RL-2011-01) showing the relationship between large discharges at TEDF and the groundwater elevation increases in the 200 East Area. Figure 2-11 shows the time relationship between the TEDF discharges and the groundwater level increases in the 200 East Area. As can be seen in Figure 2-11, the relationship between the discharges and the elevation increases was short, on the order of weeks.

In 2011, another large Columbia River spring runoff was attributed to a groundwater flow reversal at WMA B-BX-BY. The flow reversal continued through 2012. The low-level groundwater trend-surface analysis (Table 2-2) shows how the groundwater gradient increased and decreased between the summer of 2011 and 2012. The gradient peaked in November 2011 at $3.3827\text{E-}05$, which indicates increased flow rates over this time period. From November through April, the gradient decreased, indicating decreasing flow rates. In May 2012, the gradient began to increase again and significantly increased between June and July, resulting from the high Columbia River spring stages in 2012. Based on the 2011 influence of the Columbia River through April 2012, and the larger spring runoff in 2012, it is anticipated that a northwest flow direction in this area will not return until at least the spring of 2014 (if at all). This forecast is based, in part, on no large discharges being planned at TEDF in the next few years.

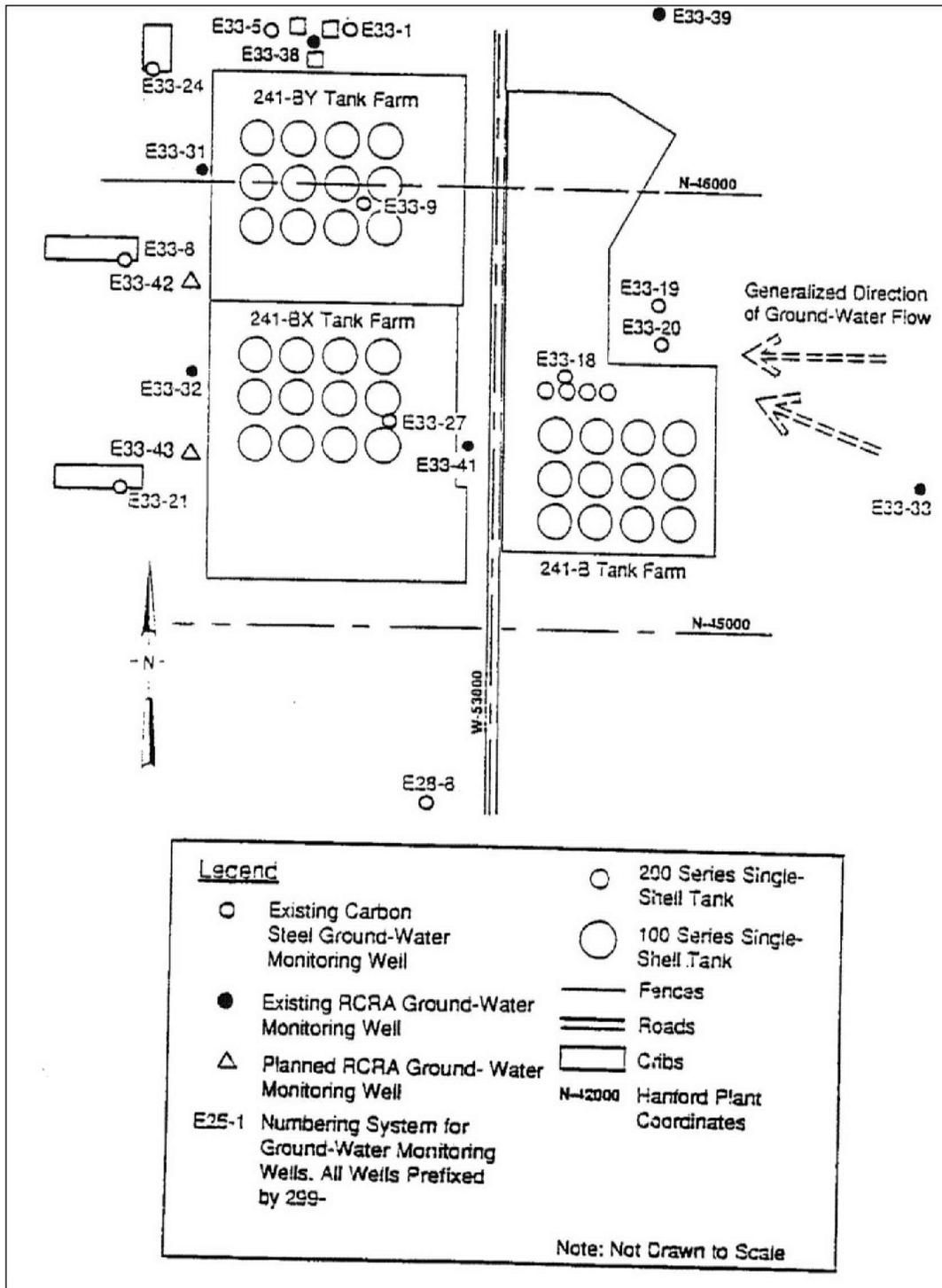


Figure 2-9. 1990 Groundwater Flow Direction

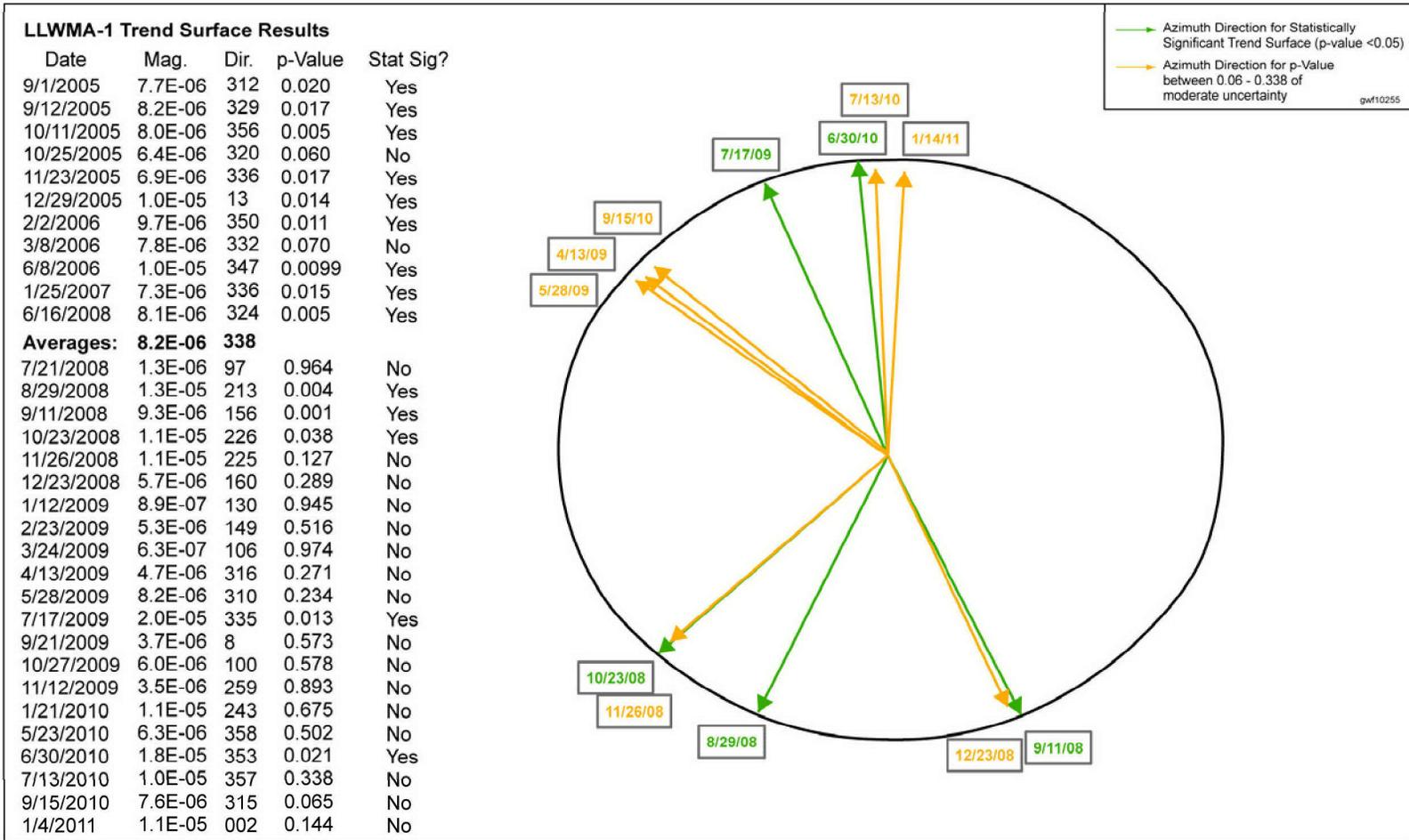


Figure 2-10. Statistical Measurements of Low-Level Groundwater Trend-Surface Analysis

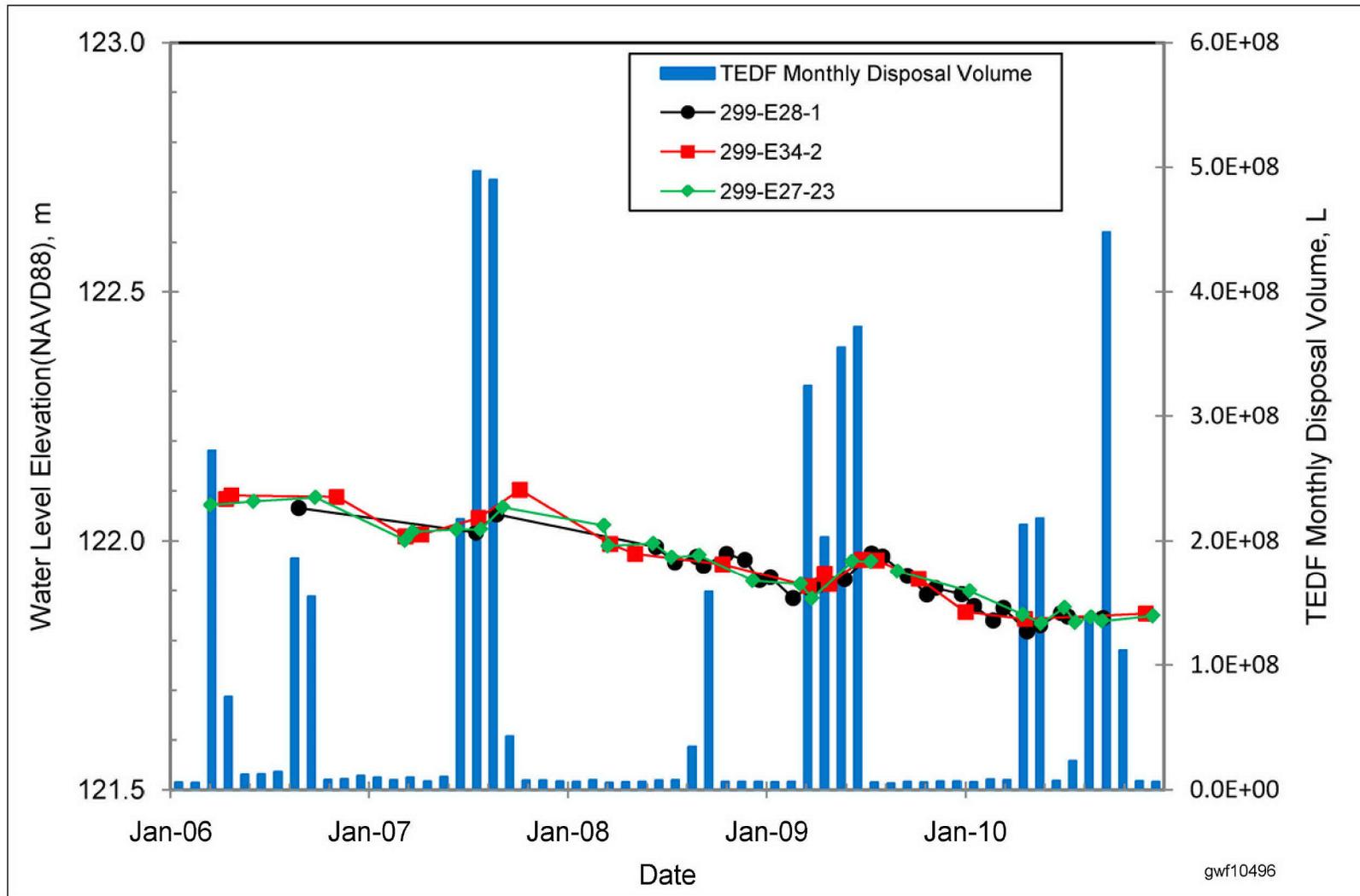


Figure 2-11. Comparison of TEDF Discharges with 200 East Area Groundwater Elevations

Table 2-2. Hydraulic Head – Gyro Corrections and Precision Elevation Survey

Well Name	7/14/2011	8/15/2011	8/29/2011	11/30/2011	12/29/2011	1/25/2012	2/28/2012	4/18/2012	5/15/2012	6/14/2012	7/24/2012	8/16/2012
299-E28-1	121.808	NM	121.808	121.794	121.813	121.781	121.832	--	121.802	121.785	121.791	121.781
299-E28-17	NM	121.804	121.799	121.798	NM	121.736	121.815	121.79	121.793	121.779	121.774	121.773
299-E28-18	121.815	121.831	121.824	121.84	121.838	121.825	121.823	--	121.803	121.794	121.793	121.805
299-E28-27	121.793	NM	121.821	121.835	121.832	121.816	121.818	121.804	121.806	121.79	121.797	121.8
299-E32-5	121.808	121.826	121.829	121.841	121.839	121.83	121.824	121.811	121.809	121.788	121.804	121.809
299-E32-6	121.804	121.826	121.828	121.844	121.841	121.608	121.822	121.802	121.803	121.79	121.802	121.81
299-E32-8	121.811	121.833	121.834	121.852	121.846	121.84	121.823	121.81	121.811	121.795	121.812	121.818
299-E33-28	121.802	NM	121.825	121.839	121.835	121.793	121.82	121.807	121.801	121.792	121.799	121.802
299-E33-339	121.807	121.82	121.822	121.829	121.827	121.817	121.817	121.8	121.802	121.794	121.797	121.797
299-E33-34	121.807	121.822	121.827	121.838	121.84	121.82	121.827	121.807	121.804	121.791	--	121.807
299-E33-38	121.806	121.82	NM	121.837	121.832	121.81	121.846	121.806	--	121.795	121.798	121.8
699-49-55A	121.824	121.841	121.849	121.859	121.865	121.83	121.847	121.8	121.826	121.813	121.827	121.83
699-49-57A	121.812	NM	121.863	121.859	121.855	121.834	121.829	121.813	121.819	121.809	121.827	121.829
699-50-56	121.829	121.868	121.886	121.913	121.897	121.882	121.872	121.837	121.843	121.832	121.871	121.885

Table 2-2. Hydraulic Head – Gyro Corrections and Precision Elevation Survey

Well Name	7/14/2011	8/15/2011	8/29/2011	11/30/2011	12/29/2011	1/25/2012	2/28/2012	4/18/2012	5/15/2012	6/14/2012	7/24/2012	8/16/2012
Trend Surface Results												
Range (m)	0.036	0.064	0.087	0.119	0.084	0.274	0.057	0.047	0.05	0.053	0.097	0.112
Gradient (m/m)	1.085E-05	1.978E-05	2.848E-05	3.3827E-05	2.7142E-05	6.606E-05	2.539E-05	1.173E-05	1.742E-05	1.924E-05	3.051E-05	3.213E-05
Dir. (azimuth)	193.60881	154.32019	171.36162	153.055674	162.624304	218.43696	213.45638	148.68192	189.31966	192.81071	178.3178	162.97256
R ²	0.446628	0.751564	0.891175	0.81747364	0.81239377	0.2156321	0.6334268	0.5956832	0.7934959	0.8051409	0.8596672	0.8133414
p-value	0.0519	0.0076	0	0.0001	0.0002	0.2629	0.004	0.017	0.0004	0.0001	0.0001	0.0001
Stat. significant?	No	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes

Notes: Hydraulic head is measured in m NAVD88.

2.5 Summary of Previous Groundwater Monitoring and Results

In 1996, the groundwater monitoring program for WMA B-BX-BY was changed from indicator parameter evaluation to groundwater quality assessment because specific conductance exceeded the critical mean value in well 299-E33-32. Accompanying the increased specific conductance were increased nitrate and chloride concentrations. Well 299-E33-32 is located on the west side of the BX Tank Farm, and the groundwater flow was considered to be west-northwest at the time (Figure 2-9). The *Assessment Groundwater Monitoring Plan for the Single Shell Tank Waste Management Area B-BX-BY* (WHC-SD-ENV-AP-002) provided a list of the mobile constituents expected in groundwater, if the SSTs were the source. The report also provided rules on how to determine the flow direction. It was determined that conclusive evidence was needed to differentiate possible tank waste from similar waste at the nearby cribs, trenches, and french drains.

In 1998, *Results of Phase I Groundwater Quality Assessment for Single-Shell Tank Waste Management Areas B-BX-BY at the Hanford Site* (PNNL-11826) concluded that the WMA had impacted groundwater quality; however, it did not identify any dangerous waste or dangerous waste constituents. The main reason for determining that the WMA had impacted the groundwater was the increased specific conductance at well 299-E33-41 and the elevated anion and radionuclide analytical results from this well. During drilling of this well in 1991, gamma-log results indicated elevated radionuclide levels in a perched water horizon located approximately 3 m (10 ft) above the water table. It was assumed that the elevated anions and radionuclide levels at this well (versus much lower concentrations at other nearby groundwater wells) was evidence of infiltration from past tank leaks and migration through the vadose zone to the groundwater. However, the samples confirming groundwater contamination did not include RCRA dangerous waste or dangerous waste constituents. PNNL-11826 also presented requirements for a Phase II assessment. The Phase II requirements included constructing local contaminant plume maps to determine temporal and spatial trends of contaminant movement, evaluating vadose zone contamination, and evaluating groundwater chemistry.

In 2000, the *Groundwater Quality Assessment Plan for Single-Shell Waste Management Area B-BX-BY at the Hanford Site* (PNNL-13022) was issued, stating that WMA B-BX-BY has likely impacted groundwater quality based on elevated nitrate and technetium-99 at well 299-E33-41. This plan was not able to determine the groundwater flow in the area because the water table was too flat; thus, requirements were provided in an attempt to determine the flow direction. The plan pointed out the following issues with current attempt to determine the flow direction: elevation variability associated with past well casing surveys, variability in groundwater tape measurements, vertical borehole deviations, and barometric effects. PNNL-13022 also included the following:

- Recommended actions to minimize the potential error with groundwater measurements
- Recommended construction of spatial contaminant maps for evaluation of plume movement
- Discussion that contaminant plumes beneath the BY Cribs appeared to be migrating to the northwest, and that there were no wells south of WMA B-BX-BY, so at least two wells were recommended to be installed
- Expanded the groundwater network, using both RCRA-compliant and non-RCRA wells to complete the spatial contaminant elevation
- Increased the frequency of sampling, including strategies for evaluating the groundwater chemistry to the source sites
- Stated that assessment progress reporting was to be included in annual reports.

In 2001, *Hanford Site Groundwater Monitoring for Fiscal Year 2000* (PNNL-13404) provided contaminant relationships (as required by the PNNL-13022) for specific waste sites, including WMA B-BX-BY. The contaminant relationships were based on spatial relationships, historic plume movement, knowledge of process chemistry, and characteristic chemical ratios. The notable difference between the WMA B-BX-BY and other waste sites was the presence of uranium. PNNL-13404 also determined that cyanide was a characteristic contaminant for the BY Cribs and that chromium was a characteristic contaminant for the 216-B-8 Crib. As part of the WMA B-BX-BY assessment, two new wells (299-E33-334 and 299-E33-335) were installed in early 2000, and three additional wells (299-E33-337, 299-E33-338, and 299-E33-339) were added in 2001. Also part of the assessment, an in situ flow meter (colloidal borescope) was used to determine local groundwater flow directions at WMA B-BX-BY. The results indicated a general south to southeast flow direction; however, considerable variation was observed in the flow directions between wells (PNNL-13788). In addition, a low-level, water-level, trend-surface analysis at Low-Level Waste Management Area 1 (located to the west of WMA B-BX-BY) returned a northwest flow direction. Because of these differences, it was realized that additional efforts were necessary to better understand the flow regime in these areas.

In May 2002, an interim change notice was issued (PNNL-13022-ICN-1), changing the flow direction interpretation to southwest under the BY Tank Farm and south-southeast beneath the southern portion of the B Tank Farm. Changes were also made to the well network, sampling frequency, and required constituents to be sampled.

In November 2003, a second interim change notice was issued (PNNL-13022-ICN-2), changing the well network and constituents and frequencies. In 2005, *Hanford Site Groundwater Monitoring for Fiscal Year 2004* (PNNL-15076) added three additional wells (299-E33-47, 299-E33-48, and 299-E33-49) as part of the assessment. In May 2006, a third interim change notice was released (PNNL-13022-ICN-3) to change the well network and frequency, and in September 2006, PNNL-13022, Rev. 1 was issued to again change the well network and sampling frequency.

In July 2010, PNNL-19277 was issued, which provided time-series snapshots of plume migration for cyanide and chromium. The cyanide time series included the years 2000, 2003, 2006, and 2009 (Figure 2-12 through 2-15). The isopleths increased over time beneath the BY Cribs, showing preferential migration to the northwest. The cyanide mass increased in the unconfined aquifer from 15.1 to 38.5 kg between 2000 and 2009 near the BY Cribs. The chromium time series included spring and fall snapshots from 2000 to 2009. The chromium isopleths originated beneath the 216-B-8 Crib (Figure 2-16). As with cyanide, the general flow direction was determined to be to the northwest; however, there were indications of intermittent flow fluctuations, possibly causing south flow during certain years. During 2008, a groundwater flow reversal was statistically determined for the low-gradient monitoring network (see Section 2.4.2 for further discussion).

In 2011, another groundwater flow reversal occurred resulting in chromium migration through the unconfined aquifer, past well 299-E33-47 (Figure 2-17). This flow reversal has continued to produce statistically significant flow gradients to the south-southeast since July/August 2011.

The earlier groundwater flow fluctuations noted in the chromium time series (PNNL-19277) may have been precursors to the statistically derived flow reversal in 2008. After the flow reversal in 2008, numerous nonstatistical determinations were observed between late 2008 and 2011, when the flow reversal became longer term.; This period of time may have been an indication of a flow transition period. The recent southeast flow direction in this area has persisted for over one year (Table 2-2). Observations of the statistical low-gradient groundwater measurements indicated that the south flow direction will continue for at least another year (until spring 2014), if not longer.

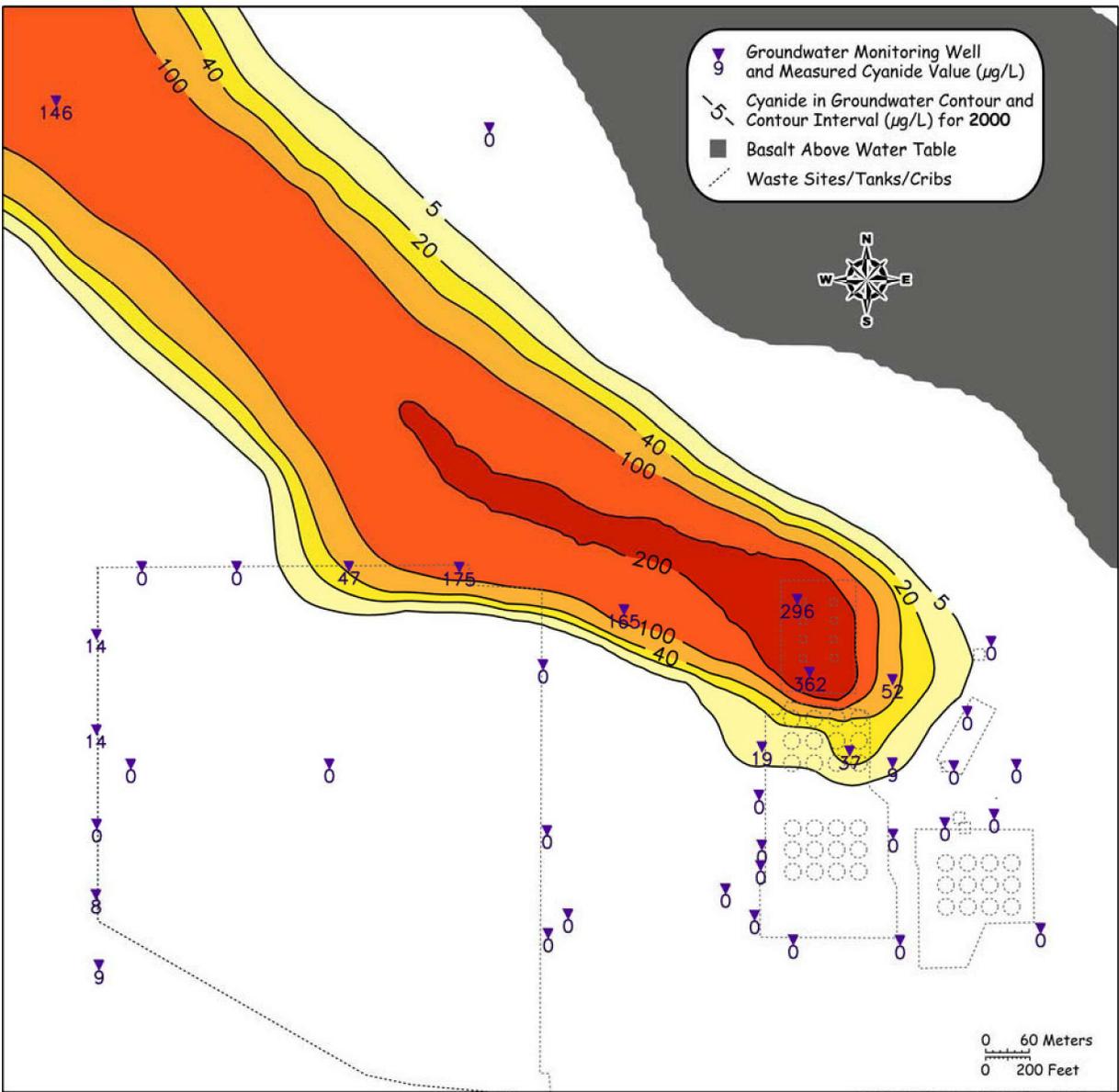


Figure 2-12. Cyanide Groundwater Plume for B Complex and to the North, Calendar Year 2000

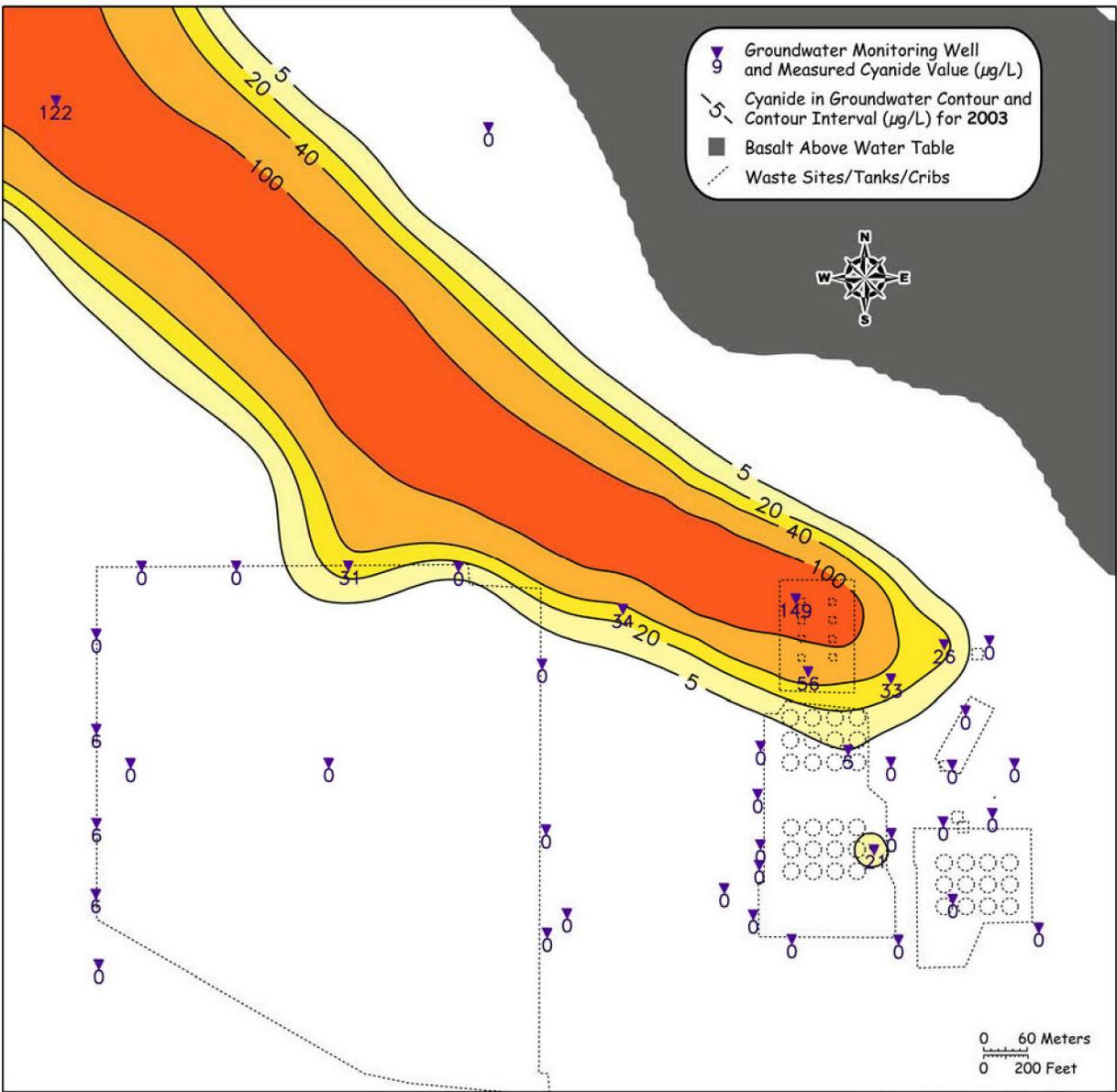


Figure 2-13. Cyanide Groundwater Plume for B Complex and to the North, Calendar Year 2003

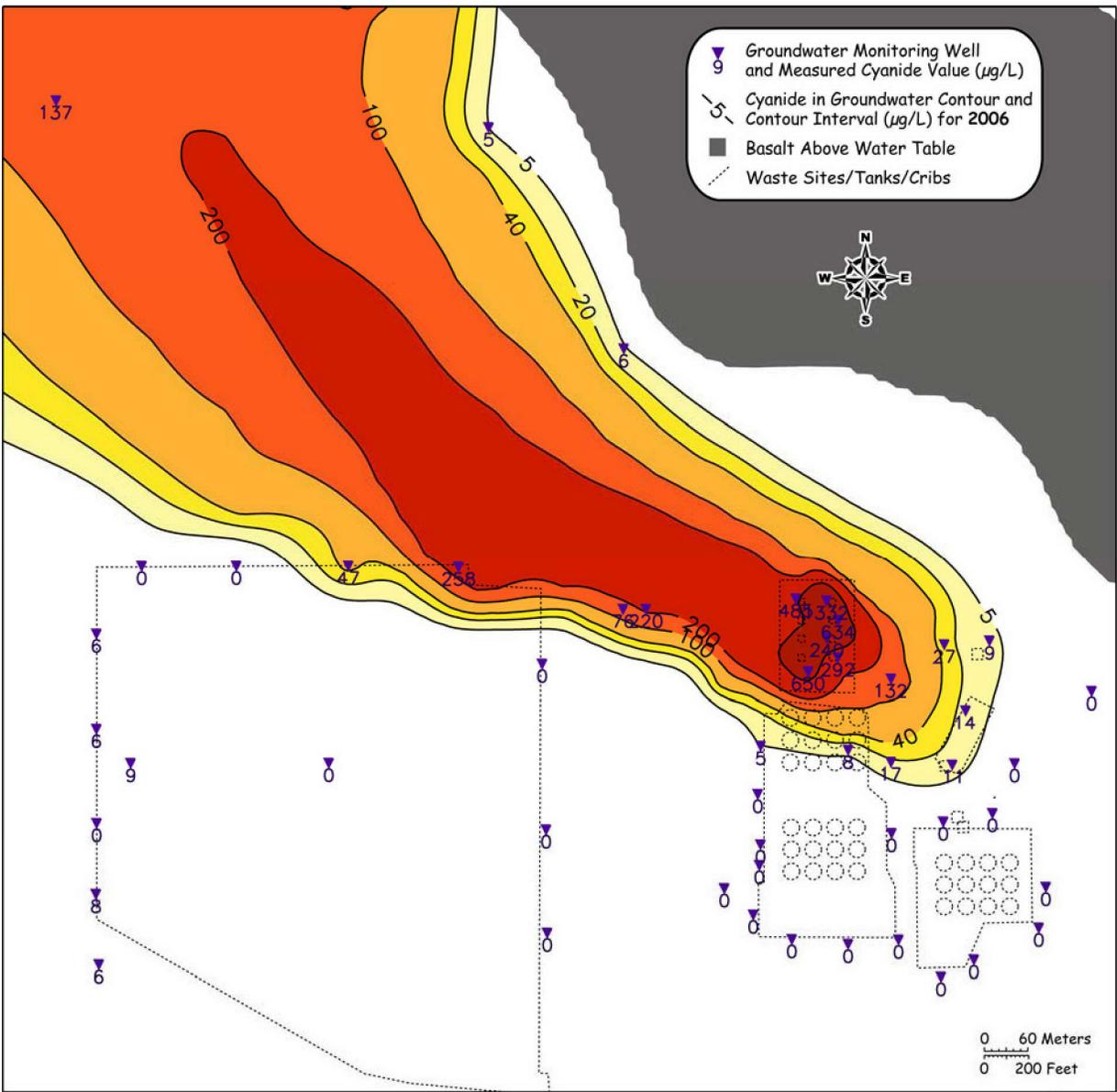


Figure 2-14. Cyanide Groundwater Plume for B Complex and to the North, Calendar Year 2006

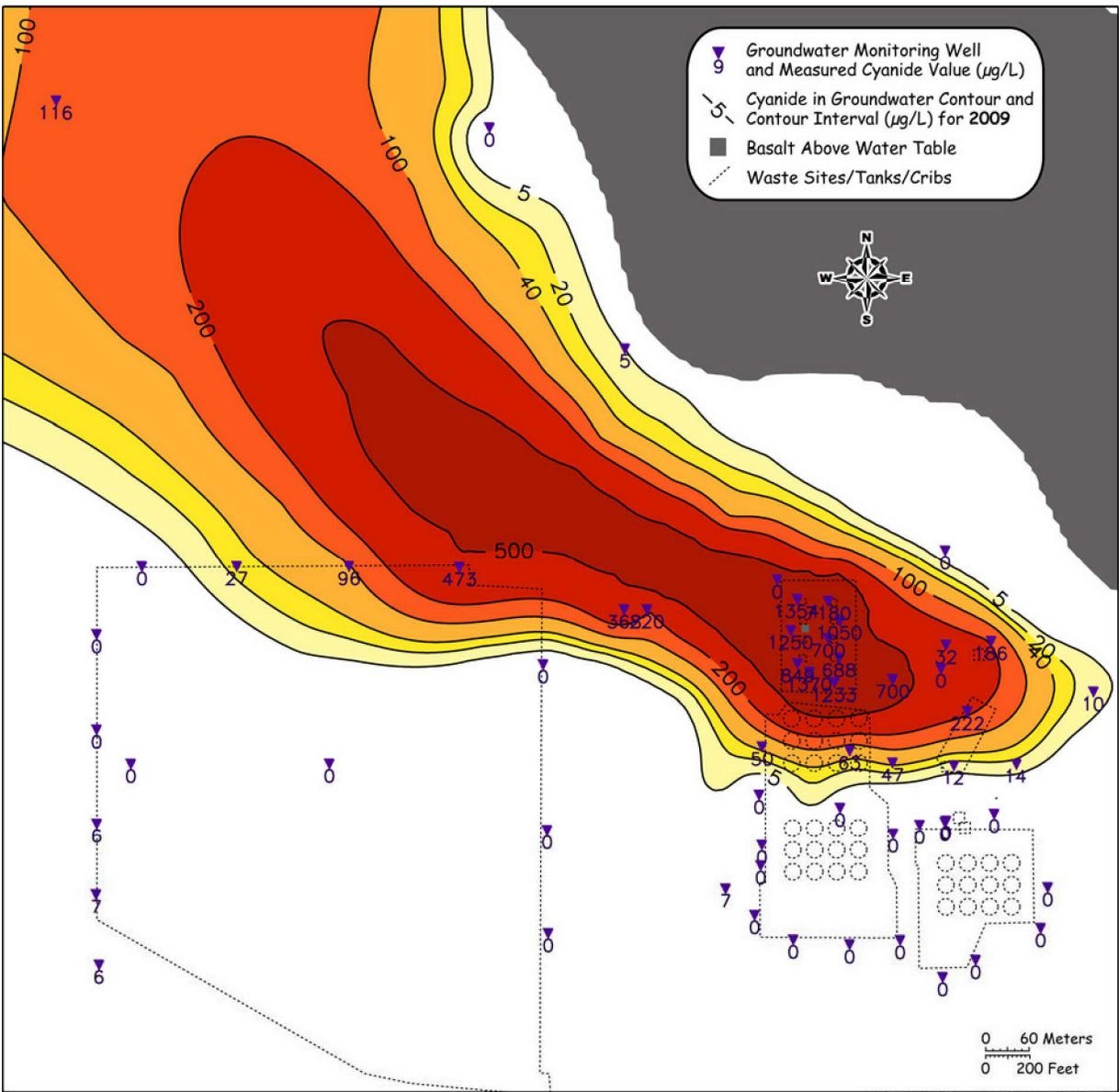


Figure 2-15. Cyanide Groundwater Plume for B Complex and to the North, Calendar Year 2009

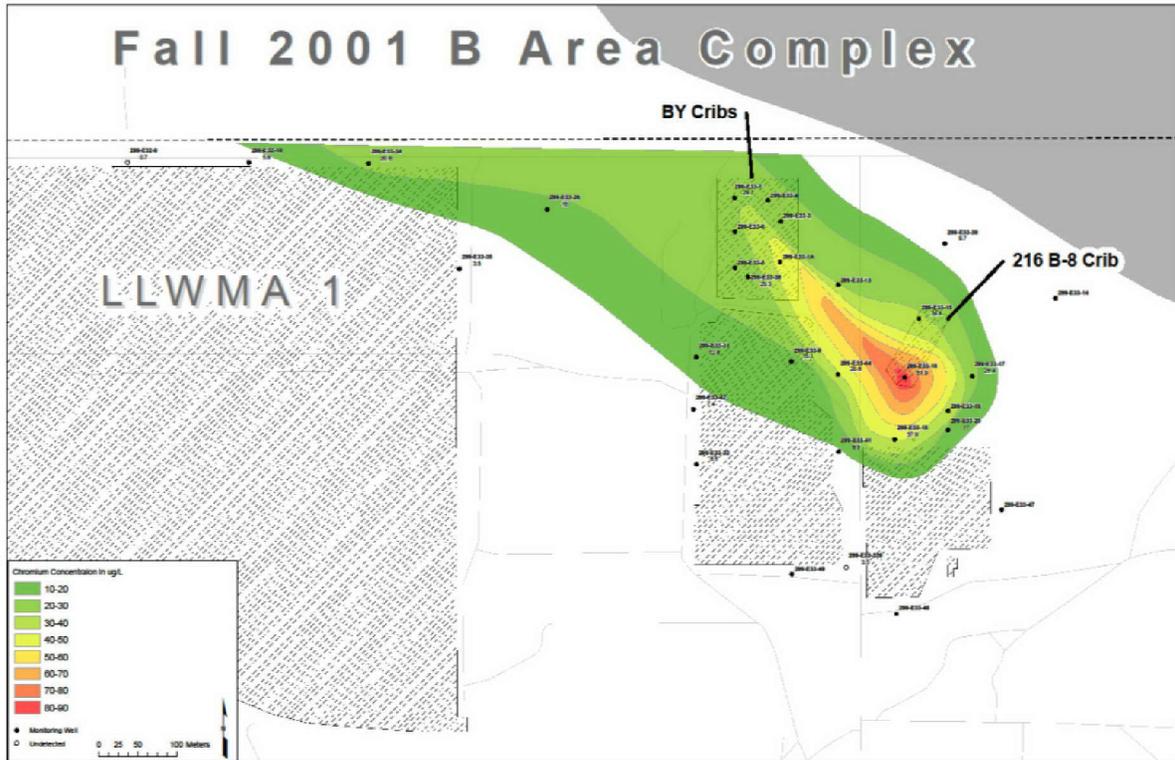


Figure 2-16. Chromium Groundwater Plume for Fall 2001

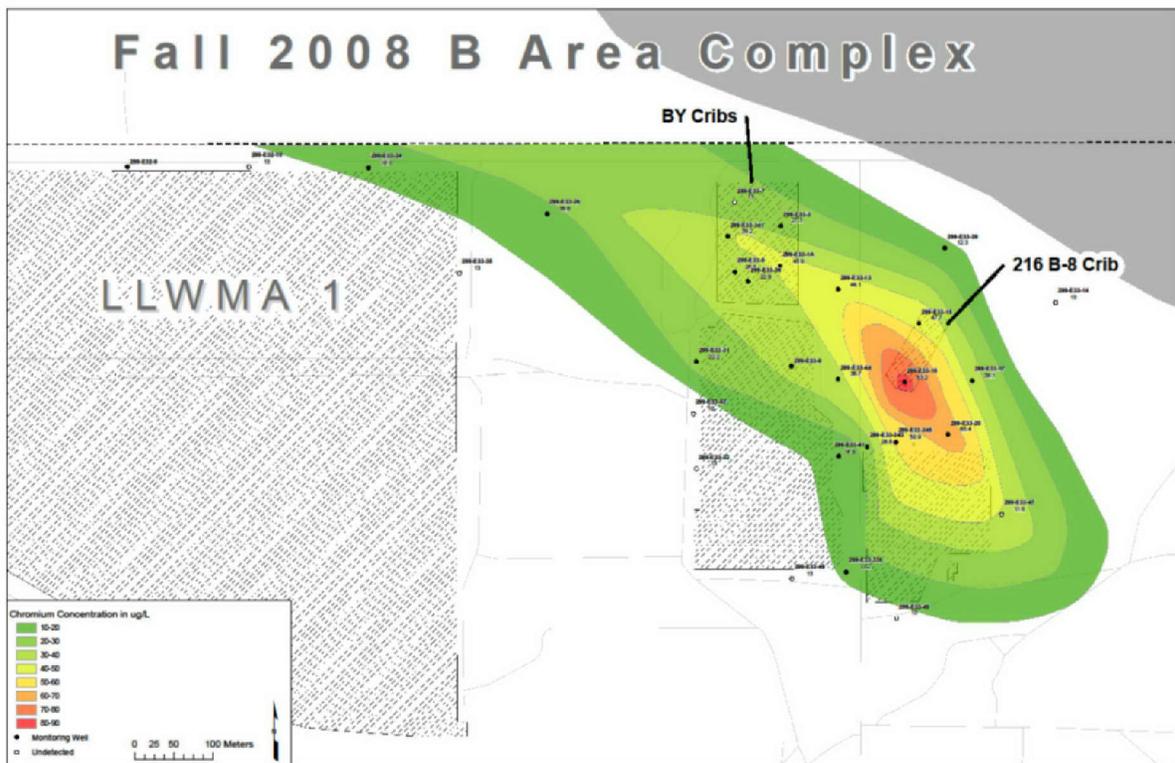


Figure 2-17. Chromium Groundwater Plume for Fall 2008

Based on the migration of chromium from the north, it is not possible to differentiate possible infiltration of chromium from the vadose zone. Although upgradient wells to the north of well 299-E33-47 (299-E33-17, 299-E33-18, and 299-E33-20) have not shown as high of chromium concentrations in the recent past (as currently seen at well 299-E33-47), spatial and temporal variability within the aquifer may account for the small concentration difference (Figures 2-18 and 2-19).

Alternatively, cyanide migration via the unconfined aquifer does not appear to be associated with the elevated concentrations at well 299-E33-47 (Figures 2-20 and 2-21). As shown in Figures 2-20 and 2-21, neither the wells to the north nor to the northwest have significant groundwater cyanide concentrations. This indicates that the cyanide at well 299-E33-47 is from the vadose zone south of wells 299-E33-17, 299-E33-18, and 299-E33-20. Because none of the waste sites just north of the B Tank Farm (i.e., 216-B-7A&B, 216-B-8, and 216-B-11A&B) received cyanide waste, it is determined that the cyanide is from the B Tank Farm.

Further assessment is required at wells 299-E33-337 and 299-E33-339 because TOC analyses were not associated with the prior assessment plan. Thus, a comparison cannot be evaluated between possible complexing agents and the elevated nickel and manganese. In addition, it should be determined why chromium is not as elevated as nickel and manganese based on the release inventory for tank 241-B-110. If TOC does not appear to be elevated, then the initial determination of well casing degradation will be confirmed.

2.6 Conceptual Model

Based on the findings presented in Section 2.1.3 and the groundwater results discussed in Section 2.5, only one constituent, cyanide, was found that confirmed the presence of a RCRA dangerous waste or dangerous waste constituent from the B/BX/BY Tank Farms. A conceptual transport model for cyanide is provided below for its association with the elevated groundwater results at well 299-E33-47.

Another source of groundwater contamination is also present within WMA B-BX-BY (the tank 241-BX-102 release[s]); however, no dangerous wastes are associated with this release. The conceptual model for this release is presented in PNNL-19277. This conceptual model is not provided herein because there were no dangerous wastes or dangerous waste constituents associated with this release.

Three other tank farm releases were also evaluated as possible causes for the elevated chromium, nickel, and manganese at wells 299-E33-337 and 299-E33-339 as part of this assessment. It was determined that additional sampling is required to determine if the elevated metals are dangerous waste/dangerous waste constituents or if they are the product of well degradation. The three sites are the 241-B-110, 241-BX-110, and 241-BX-111 releases. Although the additional analyses associated with this assessment may determine whether the constituents are associated with RCRA-regulated releases, sufficient data will not be available to confirm the source. Upon receipt of additional information, a determination will be made and reported as described in Chapter 4.

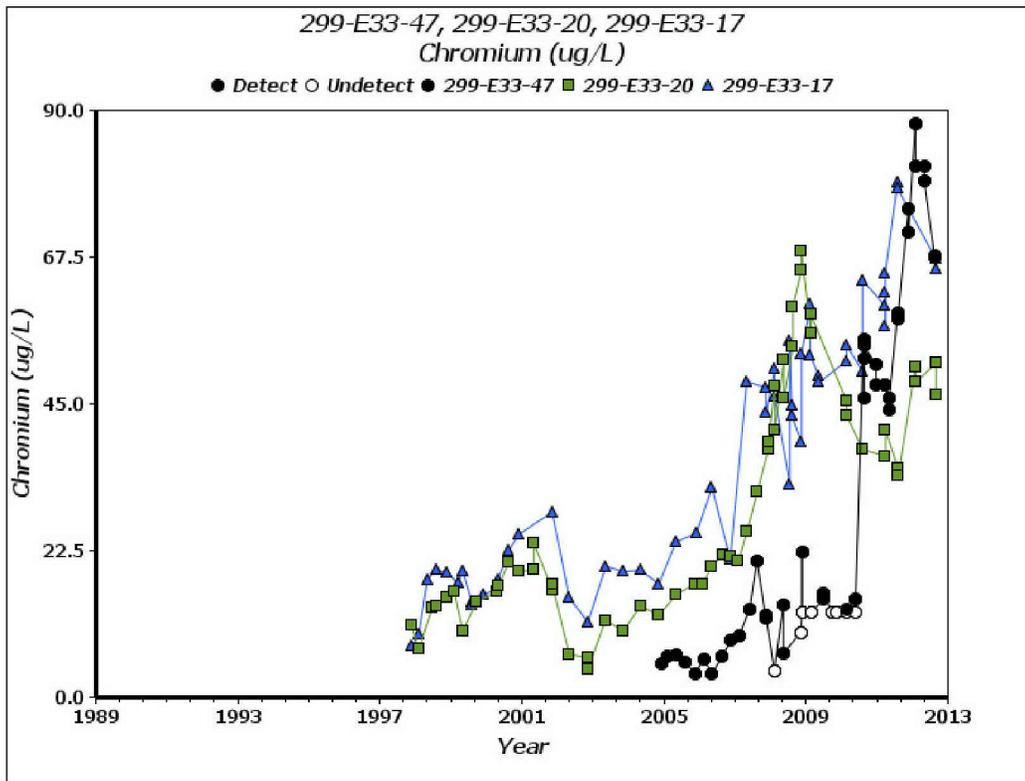


Figure 2-18. Groundwater Chromium Comparison Between Wells 299-E33-47, 299-E33-17, and 299-E33-20

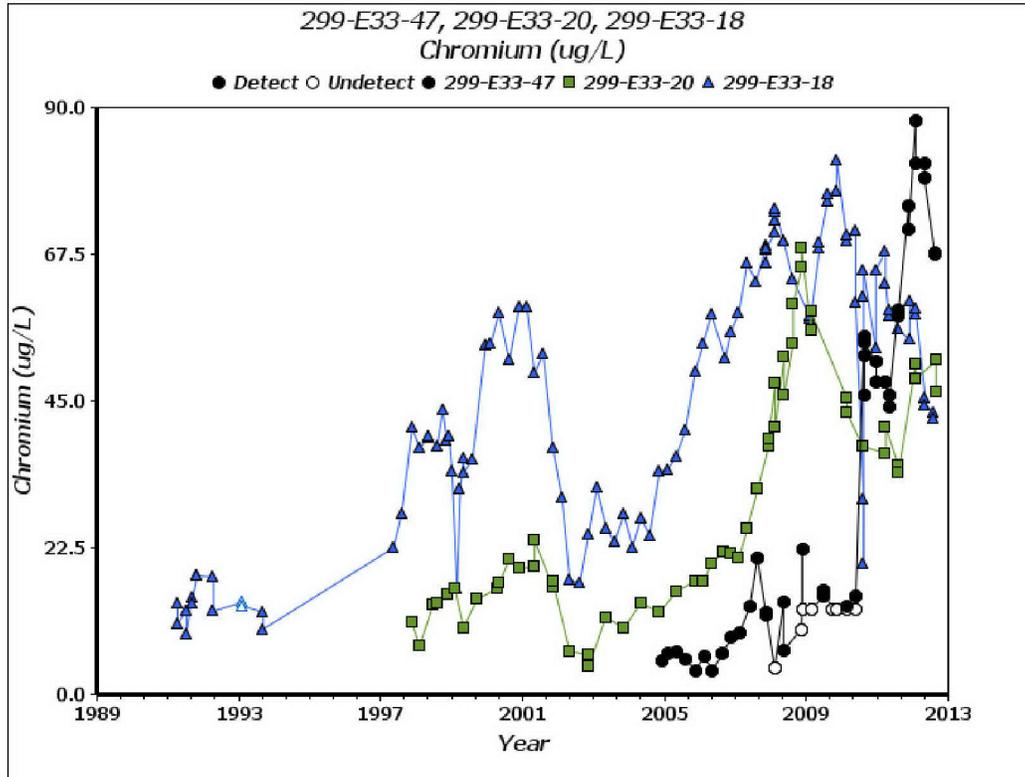


Figure 2-19. Groundwater Chromium Comparison Between Wells 299-E33-47, 299-E33-18, and 299-E33-20

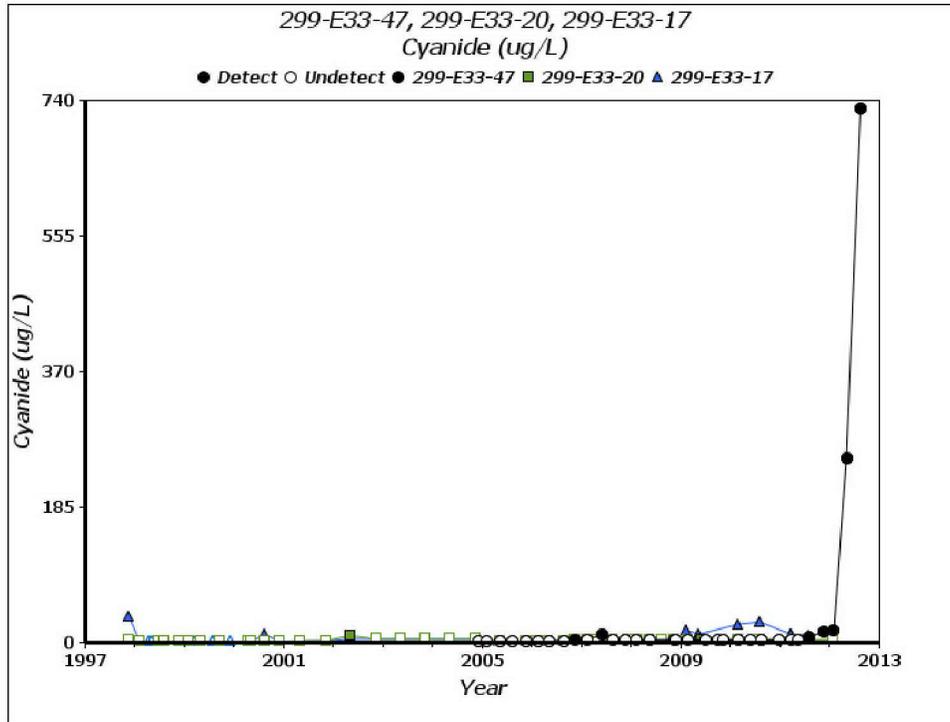


Figure 2-20. Groundwater Cyanide Comparison Between Wells 299-E33-47, 299-E33-17, and 299-E33-20

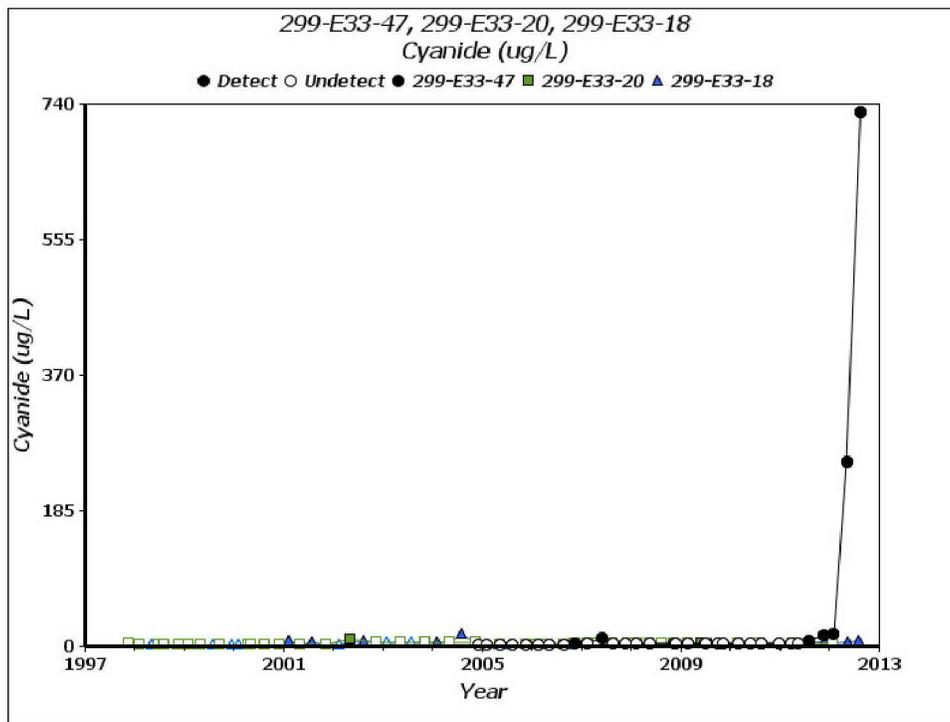


Figure 2-21. Groundwater Cyanide Comparison Between Wells 299-E33-47, 299-E33-18, and 299-E33-20

The conceptual model for the cyanide dangerous waste/dangerous waste constituent is provided as follows. The tributyl phosphate release near tank 241-B-106 was reported in June 1954 (RPP-RPT-49089). The releases between this tank and tank 241-B-105 were calculated at 140,060 L (37,000 gal) based on the cesium-137 distribution. Based on a narrow, radial contaminant plume of 4.6 m (15 ft), defined by the cesium-137 and the distance to the adjacent drywells, as well as the mean effective porosities provided in PNNL-19277, approximately 16 percent of the available effective pore space is filled throughout the vadose zone by a release of this size. Theoretically, since this value is larger than the field capacity, a dense saline solution (e.g., ferrocyanide) could reach the groundwater. According to PNNL-13679, a contaminant plume of this type would have less lateral spreading compared to water and may have a propensity to finger by displacing less dense fluids. It is important to note that an east-west, 10.2 cm (4 in.) raw water line was present just north of tank 241-B-106. Past experience indicates that these water lines are susceptible to leaking. A significant perching horizon is also located within the silt-dominated CCU north of this location. Therefore, it appears that cyanide migrated down through the vadose zone and laterally within the silt-dominated CCU, to an area just north-northwest of well 299-E33-47 before entering the groundwater. As the groundwater flow reversed, the cyanide came into contact with well 299-E33-47. Migration from the BY Cribs, an upgradient source site for cyanide, was ruled out because of the nondetect and small cyanide concentrations from groundwater samples at wells located north to northwest (299-E33-17, 299-E33-18, and 299-E33-20). These wells are considered to be in the prevailing upgradient groundwater flow direction. Thus, cyanide is considered a dangerous waste constituent associated with the B Tank Farm.

It should be noted that groundwater chromium contamination, which is also mainly from a source to the north, is dispersed and present in the upgradient wells (mentioned above) at concentrations similar to that of well 299-E33-47. Thus, for cyanide to take some tortuous path around the upgradient wells does not seem feasible. Also, note that the upgradient cyanide source (BY Cribs) is further north than the chromium source (216-B-8 Crib) and has, therefore, not migrated to well 299-E33-47 as seen by the concentration levels at the upgradient wells. Furthermore, the cyanide plume associated with the BY Cribs is much more concentrated and laterally extensive than the chromium plume, indicating that a tortuous path to well 299-E33-47 is unrealistic.

2.7 Data Quality Objectives

To define the required information for groundwater quality assessment, the data quality objective (DQO) process is used to ensure that data gathered during the assessment are of the appropriate quantity and quality to meet specific objectives. The DQO decision statements listed below are based on the requirements of 40 CFR 265.93(d)(7):

- If dangerous waste or dangerous waste constituents are suspected to be in the groundwater, then determine the appropriate constituents and analytical methods for determining which dangerous waste or dangerous waste constituents are present in the unconfined aquifer beneath WMA B-BX-BY.
- If dangerous waste or dangerous waste constituents are determined to be in the groundwater, determine the concentration.
- If dangerous waste or dangerous waste constituents are determined to be in the groundwater, then determine if the number, location, and depth of network monitoring wells are appropriate to determine the extent and rate of migration of the dangerous waste or dangerous waste constituents in groundwater.

The DQO parameters, regulatory interim status requirements, and associated reports supporting the regulatory requirements are outlined in Table 2-3.

Table 2-3. Matrix of DQO Parameters, Associated Regulatory Requirements, and Documentation for WMA B-BX-BY

DQO Parameter	Related Requirements	Plan Criteria and Associated Historical Documentation
Scope	<p>40 CFR 265, Subpart F, incorporated by reference in WAC 173-303-400(3)(a), as modified by WAC 173-303-400(3)(b) and WAC 173-303-400(3)(c)(v)</p> <p>40 CFR 265.93, “Preparation, Evaluation, and Response.”</p> <p>(a) Within one year after the effective date of these regulations, the owner or operator must prepare an outline of a ground-water quality assessment program. The outline must describe a more comprehensive groundwater monitoring program capable of determining: (1) whether dangerous waste or dangerous waste constituents have entered the ground-water; (2) the rate and extent of migration of dangerous waste or dangerous waste constituents in the ground-water; and (3) the concentration of dangerous waste or dangerous waste constituents in the ground-water.</p> <p>(d)(3) The plan...must specify (i) the number, location, and depth of wells; (ii) sampling and analytical methods for those dangerous waste or dangerous waste constituents in the facility; (iii) evaluation procedures, including any use of previously gathered ground-water quality information; and (iv) a schedule of implementation.</p> <p>(d)(4) The owner or operator must implement the ground-water quality assessment plan which...at a minimum, determine: (i) the rate and extent of migration of dangerous waste or dangerous waste constituents in the ground-water; (ii) the concentration of the dangerous waste constituents in the ground-water.</p> <p>(d)(5) The owner or operator must make his first determination under paragraph (d)(4) of this section as soon as technically feasible, and prepare a report containing an assessment of ground-water quality. This report must be placed in the facility operating record and be maintained until closure of the facility. A copy of the report must be submitted to the department within 15 days.</p>	<p>This plan; Chapters 3 and 4, Appendix A</p> <p>WHC-SD-ENV-AP-002, <i>Assessment Groundwater Monitoring Plan for Single Shell Tank Waste Management Area B-BX-BY</i></p> <p>PNNL-11826, <i>Results of Phase I Groundwater Quality Assessment for Single-Shell Tank Waste Management Areas B-BX-BY at the Hanford Site</i></p> <p>PNNL-13022, <i>Groundwater Quality Assessment Plan for Single-Shell Waste Management Area B-BX-BY at the Hanford Site</i> (as modified by revision and interim change notices)</p>

Table 2-3. Matrix of DQO Parameters, Associated Regulatory Requirements, and Documentation for WMA B-BX-BY

DQO Parameter	Related Requirements	Plan Criteria and Associated Historical Documentation
	<p>40 CFR 265.93, “Preparation, Evaluation, and Response.” (cont’d.) (d)(7) If the owner or operator determines, based on the first determination...that hazardous waste or hazardous waste constituents from the facility have entered the ground-water, then the owner or operator: (1) must continue to make the determinations...on a quarterly basis until final closure of the facility, of the ground-water quality (i) Must continue to make the determinations required under paragraph (d)(4) of this section...</p>	<p>Summarized in annual report or other future reports, as required</p>
<p>Number and location of wells</p>	<p>40 CFR 265, Subpart F, incorporated by reference in WAC 173-303-400(3)(a), as modified by WAC 173-303-400(3)(b) and WAC 173-303-400(3)(c)(v) 40 CFR 265.93, “Preparation, Evaluation, and Response.” (d)(4) The owner or operator must implement the ground-water quality assessment plan which satisfies the requirements of paragraph (d)(3) of this section, and, at a minimum, determine: (i) The rate and extent of migration of the dangerous waste or dangerous waste constituents in the ground-water; and (ii) The concentrations of the dangerous waste or dangerous waste constituents in the ground-water.</p>	<p>This plan; Chapters 3 and 4</p>
<p>Well configuration (depth and length of screened interval, well construction)</p>	<p>40 CFR 265.91, “Ground-Water Monitoring System.” (c) All monitoring wells must be cased in a manner that maintains the integrity of the monitoring well borehole. This casing must be screened or perforated, and packed with gravel or sand where necessary; to enable sample collection at depths where appropriate aquifer flow zones exist. The annular space (i.e., the space between the borehole and well casing) above the sampling depth must be sealed with a suitable material (e.g., cement grout or bentonite slurry) to prevent contamination of samples and the ground-water.</p>	<p>This plan; Section 3.2 PNNL-13022, <i>Groundwater Quality Assessment Plan for Single-Shell Waste Management Area B-BX-BY at the Hanford Site</i> (as modified by revision and interim change notices)</p>

Table 2-3. Matrix of DQO Parameters, Associated Regulatory Requirements, and Documentation for WMA B-BX-BY

DQO Parameter	Related Requirements	Plan Criteria and Associated Historical Documentation
Frequency of sampling Types of analysis or measurement Method detection limits or accuracy and precision Methods used to evaluate the collected data	<p>40 CFR 265.93, “Preparation, Evaluation, and Response.”</p> <p>(d)(4) The owner or operator must implement the ground-water quality assessment plan which satisfies the requirements of paragraph (d)(3) <i>[see Scope in first row of this table]</i> of this section, and, at a minimum, determine:</p> <p>(i) The rate and extent of migration of the dangerous waste or dangerous waste constituents in the ground-water; and</p> <p>(ii) The concentrations of the dangerous waste or dangerous waste constituents in the ground-water</p> <p>(d)(7) If the owner or operator determines ... that dangerous waste or dangerous waste constituents from the facility have entered the ground-water, then the owner or operator:</p> <p>(i) Must continue to make the determinations required under paragraph (d)(4) of this section <u>on a quarterly basis</u> until final closure of the facility, if the ground-water quality assessment plan was implemented prior to final closure of the facility...</p>	This plan; Chapter3 Future reports (annual report or other reports, as required)

Notes: The references cited in this table are listed in the reference section (Chapter 5) of this plan.

DQO = data quality objective

An initial determination regarding WMA B-BX-BY is that the groundwater has been impacted by dangerous waste and dangerous waste constituents based on the following:

- Presence of cyanide in well 299-E33-47
- History of cyanide (a constituent appearing on the 40 CFR 264, Appendix IX groundwater monitoring list), which is linked with scavenging waste at the B Tank Farm
- Lack of cyanide inventory in upgradient wells and past-practice waste sites along the north side of the B Tank Farm.

The dangerous waste or dangerous waste constituent selection and associated analytical methods are discussed in Section 3.1, and the initial well monitoring network is discussed in Section 3.2. Chapter 4 provides a discussion on the evaluation process.

Any dangerous waste or dangerous waste constituent determined to have impacted groundwater will be retained for subsequent analyses on a quarterly basis in accordance with 40 CFR 265.93(d)(7)(i). Subsequent to this determination, the well monitoring network will be evaluated to determine if additional wells are required to establish the extent and rate of migration for any dangerous waste or dangerous waste constituent from WMA B-BX-BY. Annual reports will provide the results of the groundwater quality assessment program until final closure in accordance with 40 CFR 265.94(b)(2) (“Recordkeeping and Reporting”).

3 Groundwater Monitoring

This chapter lists the wells, constituents, and sampling frequency for the revised RCRA assessment program. The quality assurance and quality control requirements are provided in the QAPjP (Appendix A).

3.1 Constituent List and Sampling Frequency

The WMA B-BX-BY will be monitored in accordance with this groundwater quality assessment plan. Monitoring wells and parameters to be sampled quarterly for this assessment are listed in Table 3-1. In addition (as described in Section 2.2), a common subset of constituents from two requirements is used to determine if dangerous waste or dangerous waste constituents have impacted the groundwater (RPP-23403; 40 CFR 264, Appendix IX), and the lists are provided in Tables 3-2, 3-3, and 3-4. Initial groundwater samples for this assessment will be collected during the November 2012 quarterly sampling event. In accordance with 40 CFR 265.93(d)(7), if through the evaluation process (Sections 4.1 and 4.2) dangerous waste or dangerous waste constituents are determined to have impacted the groundwater, the constituents will be retained for quarterly sample collection. Because sample results may not be available in time for planning the February 2013 sampling event, the same list of constituents will be sampled during February 2013. Based on the evaluation process described in Section 4.1, constituents will be either retained or excluded.

Table 3-1. Groundwater Monitoring Schedule for WMA B-BX-BY

Well Name	Purpose	Construction Standard	pH	Specific Conductance	TOC	Alkalinity	Anions ^a	Cyanide	Metals ^b	Water Level
299-E33-18	Upgradient; B Tank Farm	N	Q	Q	Q	Q	Q	Q	Q	Q
299-E33-20	Upgradient; B Tank Farm	N	Q	Q	Q	Q	Q	Q	Q	Q
299-E33-31	Upgradient; BY Tank Farm	C	Q	Q	Q	Q	Q	Q	Q	Q
299-E33-32	Upgradient; BX Tank Farm	C	Q	Q	Q	Q	Q	Q	Q	Q
299-E33-38	Upgradient; BY Tank Farm	C	Q	Q	Q	Q	Q	Q	Q	Q
299-E33-41	Downgradient; BY/BX Tank Farms	C	Q	Q	Q	Q	Q	Q	Q	Q
299-E33-42	Upgradient; BX Tank Farm	C	Q	Q	Q	Q	Q	Q	Q	Q
299-E33-44	Downgradient; BY Tank Farm	C	Q	Q	Q	Q	Q	Q	Q	Q

Table 3-1. Groundwater Monitoring Schedule for WMA B-BX-BY

Well Name	Purpose	Construction Standard	pH	Specific Conductance	TOC	Alkalinity	Anions ^a	Cyanide	Metals ^b	Water Level
299-E33-47	Downgradient; B Tank Farm	C	Q	Q	Q	Q	Q	Q	Q	Q
299-E33-48	Downgradient; B/BX Tank Farms	C	Q	Q	Q	Q	Q	Q	Q	Q
299-E33-49	Downgradient; BX Tank Farm	C	Q	Q	Q	Q	Q	Q	Q	Q
299-E33-334	Upgradient; BX Tank Farm	C	Q	Q	Q	Q	Q	Q	Q	Q
299-E33-335	Downgradient; BX Tank Farm	C	Q	Q	Q	Q	Q	Q	Q	Q
299-E33-337	Downgradient; B Tank Farm	C	Q	Q	Q	Q	Q	Q	Q	Q
299-E33-338	Downgradient; B Tank Farm	C	Q	Q	Q	Q	Q	Q	Q	Q
299-E33-339	Downgradient; BX Tank Farm	C	Q	Q	Q	Q	Q	Q	Q	Q

Notes:

Water levels are measured in all wells before sampling. The measurement frequency is provided.

WAC 173-160, "Minimum Standards for Construction and Maintenance of Wells."

a. Anions include, but are not limited to, chloride, nitrate, and sulfate.

b. Metals (filtered and unfiltered) include, but are not limited to, calcium, magnesium, potassium, and sodium.

C = well was constructed as a WAC 173-160 resource protection well

N = well was constructed before the requirements of WAC 173-160 were applicable at the Hanford Site

Q = to be sampled quarterly

TOC = total organic carbon

Table 3-2. Groundwater Assessment Volatile Organic Compound Monitoring at WMA B-BX-BY

Constituent	CAS Number	Constituent	CAS Number
1,1-Dichloroethane	75-34-3	Carbon disulfide	75-15-0
1,1-Dichloroethylene	75-35-4	Carbon tetrachloride	56-23-5
1,1,1-Trichloroethane	71-55-6	Chlorobenzene	108-90-7
1,1,2,2-Tetrachloroethane	79034-5	Chloroethene	75-01-4
1,1,2-Trichloroethane	79-00-5	Chloroform	67-66-3
1,2-Dibromoethane	106-93-4	Chloromethane	74-87-3
1,2-Dichloroethane	107-06-2	cis-1,3-Dichloropropene	10061-01-5
1,2-Dichloropropane	78-87-5	Dichlorodifluoro-methane	75-71-8
1,2,4-Trichlorobenzene	120-82-1	Dichloromethane	75-09-2
1,4-Dichlorobenzene	106-46-7	Ethylbenzene	100-41-4
1,4-Dioxane	123-91-1	Ethyl cyanide	107-12-0
2-Butanone (MEK)	78-93-3	Methacrylonitrile	126-98-7
2-Hexanone	591-78-6	Styrene	100-42-5
2-Propanone (acetone)	67-64-1	Tetrachloroethene	127-18-4
3-Chloropropene	107-05-1	Toluene	108-88-3
4-Methyl-2-pentanone	108-10-1	trans-1,3-Dichloropropene	10061-02-6
Acetonitrile	75-05-8	Trichloroethene	79-01-06
Acrolein	107-02-8	Trichlorofluoro-methane	75-69-4
Acrylonitrile	107-13-1	Xylenes	1330-20-7
Benzene	71-43-2		
Bromomethane	74-83-9		

Notes:

Samples will be analyzed for these constituents at least twice. Constituents considered to be dangerous constituents, as defined in WAC 173-303-645(4) and based on the logic discussed in Section 4.1, will continue to be sampled as required.

WAC 173-303-645, "Dangerous Waste Regulations," "Releases from Regulated Units."

CAS = Chemical Abstract Services

Table 3-3. Groundwater Assessment Semivolatile Organic Compound Monitoring at WMA B-BX-BY

Constituent	CAS Number	Constituent	CAS Number
1,2-Dichlorobenzene	95-50-1	Endrin	72-20-8
1,3-Dichlorobenzene	541-73-1	Fluoranthene	206-44-0
2-Chlorophenol	95-57-8	Gamma-BHC	58-89-9
2-Methylphenol	95-48-7	Heptachlor	76-44-8
2-Nitrophenol	88-75-5	Hexachlorobenzene	118-74-1
2-sec-Butyl-4,6-dinitrophenol	88-85-7	Hexachlorobutadiene	87-68-3
2,4-Dinitrotoluene	121-14-2	Hexachloroethane	67-72-1
2,4,5-Trichlorophenol	95-95-4	Isodrin	465-73-6
2,4,6-Trichlorophenol	88-06-2	Naphthalene	91-20-3
3-Methylphenol	108-39-4	Nitrobenzene	98-95-3
4-Methylphenol	106-44-5	N-Nitrosodi-methylamine	62-75-9
Acenaphthene	83-32-9	N-Nitrosodi-propylamine	62164-7
Acetophenone	98-86-2	n-Nitrosomorpholine	59-89-2
Aldrin	309-00-2	p-Chorol-m-cresol	59-50-7
Alpha-BHC	319-84-6	Pentachloronitro-benzene	82-68-8
Benzo[a]pyrene	50-32-8	Pentachlorophenol	87-86-5
Beta-BHC	319-85-7	Phenol	108-95-2
Butylbenzylphthalate	85-68-7	Pyrene	129-00-0
Dibenzene[a,h]anthracene	53-70-3	Pyridine	110-86-1
Dieldrin	60-57-1	Toxaphene	8001-35-2
Di-n-butylphthalate	84-74-2		
Diphenylamine	122-39-4		

Notes:

Samples will be analyzed for these constituents at least twice. Constituents considered to be dangerous constituents, as defined in WAC 173-303-645(4) and based on the logic discussed in Section 4.1, will continue to be sampled as required.

WAC 173-303-645, "Dangerous Waste Regulations," "Releases from Regulated Units."

CAS = Chemical Abstract Services

Table 3-4. Groundwater Assessment Inorganic Constituent Monitoring at WMA B-BX-BY

Constituent	CAS Number
Antimony	7440-36-0
Arsenic	7440-38-2
Barium	7440-39-3
Beryllium	7440-41-7
Cadmium	7440-43-9
Chromium	7440-47-3
Cobalt	7440-48-4
Copper	7440-50-8
Cyanide	57-12-5
Lead	7439-92-1
Mercury	7439-97-6
Nickel	7440-02-0
Selenium	7782-49-2
Silver	7440-22-4
Sulfide	18496-25-8
Thallium	7440-28-0
Tin	7440-31-5
Vanadium	7440-62-2
Zinc	7440-66-6

Notes:

Samples will be analyzed for these constituents at least twice. Constituents considered to be dangerous constituents, as defined in WAC 173-303-645(4) and based on the logic discussed in Section 4.2, will continue to be sampled as required.

WAC 173-303-645, "Dangerous Waste Regulations," "Releases from Regulated Units."

CAS = Chemical Abstract Services

3.2 Well Network

PNNL-13022, Rev. 1 provides as-built diagrams for all of the WMA B-BX-BY wells. Figure 3-1 shows the locations of the wells in the WMA B-BX-BY groundwater monitoring network. Table 3-1 lists the wells in the network, provides the functional location for each well, and indicates if the existing wells meet the well construction standards of WAC 173-160, "Minimum Standards for Construction and Maintenance of Wells." Table 3-5 summarizes well construction information and provides the 2011 water measurements, as well as the water column in each well and the depth to basalt.

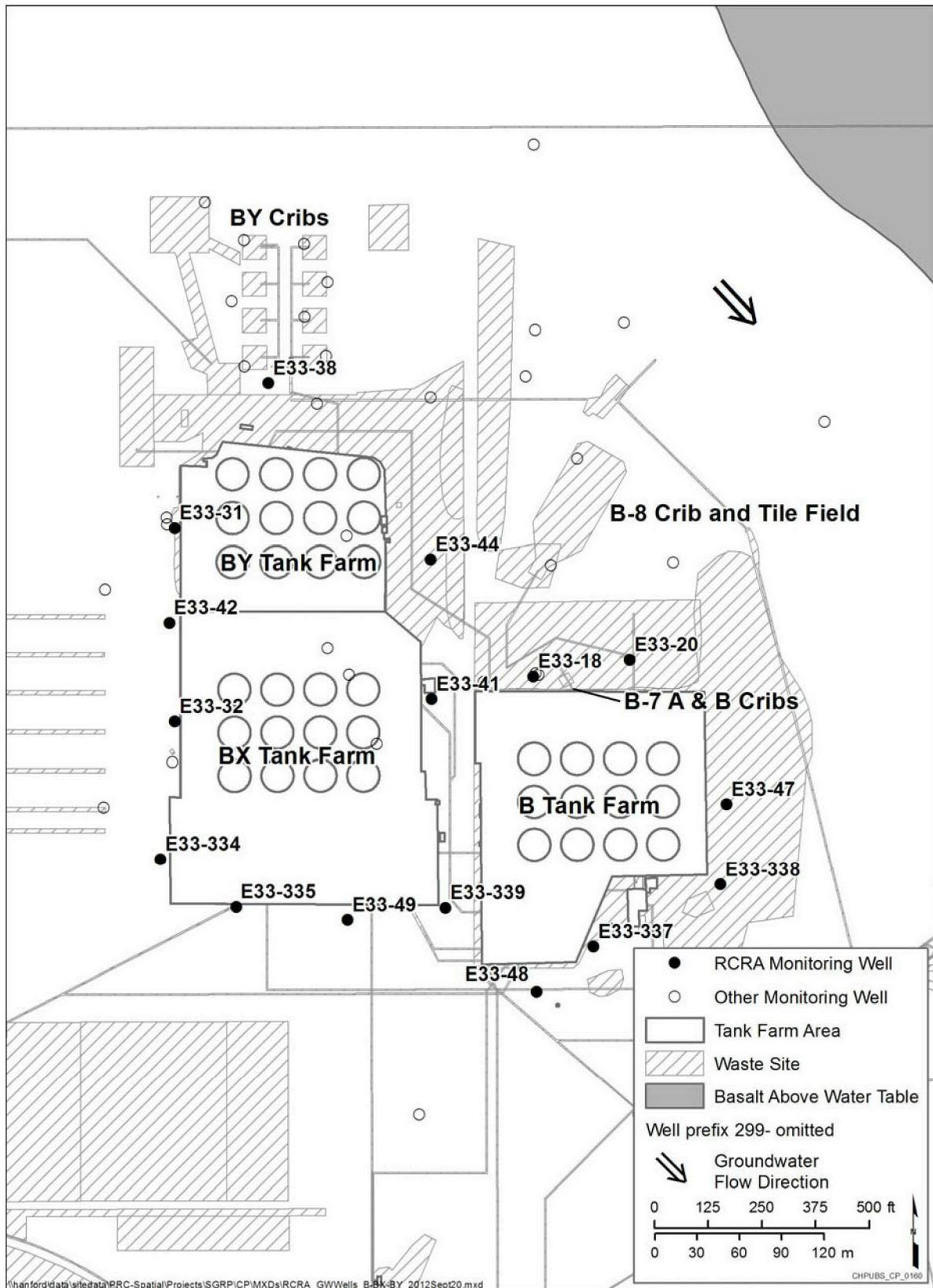


Figure 3-1. Revised Groundwater Monitoring Network for WMA B-BX-BY

Table 3-5. WMA B-BX-BY Groundwater Monitoring Well Attributes

Well Name	Drill Date	Elev. Top of Casing (m)	Elev. Land Surface (m)	Casing Stickup (m)	Depth to Screen (ft bgs)		Depth to Screen (m bgs)		Depth to Water		Water Level		Depth to Basalt	
					Top	Bottom	Top	Bottom	Depth Below Top of Casing (m)	m (bgs)	Date	Water Column (m)	ft (bgs)	m (bgs)
299-E33-18*	1950	199.71	198.94	0.77	246.0	266.0	75.0	81.1	77.89	77.12	3/27/2011	3.96	272.5	83.1
299-E33-20*	1956	199.16	198.24	0.91	234.0	254.0	71.3	77.4	77.34	76.43	3/27/2011	0.99	254.0	77.4
299-E33-31	1989	198.36	197.43	0.93	234.9	255.9	71.6	78.0	76.55	75.62	3/16/2011	2.38	255.6	77.9
299-E33-32	1989	202.18	201.24	0.94	246.4	267.4	75.1	81.5	80.4	79.46	2/9/2011	2.05	271.0	82.6
299-E33-38	1991	193.63	193.03	0.61	218.6	239.6	66.6	73.0	71.87	71.26	3/21/2011	1.77	238.0	72.5
299-E33-41	1991	200.64	199.59	1.05	244.9	262.0	74.6	79.9	78.84	77.79	2/9/2011	2.06	262.7	80.1
299-E33-42	1991	200.43	199.39	1.04	238.5	259.2	72.7	79.0	78.64	77.60	2/9/2011	1.41	NDE	NDE
299-E33-44	1998	196.77	196.03	0.75	238.0	253.0	72.5	77.1	75.03	74.29	3/27/2011	2.83	247.4	75.4
299-E33-47	2004	198.53	197.75	0.78	244.1	264.1	74.4	80.5	76.88	76.10	3/27/2011	4.39	264.0	80.5
299-E33-48	2004	203.36	202.59	0.77	260.2	285.2	79.3	86.9	81.57	80.80	3/25/2011	6.12	285.5	87.0
299-E33-49	2004	204.00	203.24	0.77	235.5	283.5	71.8	86.4	82.17	81.40	3/25/2011	5.01	283.5	86.4
299-E33-334	2000	204.21	203.29	0.92	257.7	282.7	78.5	86.2	82.38	81.46	3/31/2011	4.71	NDE	NDE
299-E33-335	2000	204.2.6	203.42	0.85	260.0	280.0	79.3	85.4	82.43	81.58	2/9/2011	3.77	280.5	85.5
299-E33-337	2001	202.72	201.99	0.73	255.4	280.4	77.8	85.5	80.9	80.17	3/29/2011	5.29	281.0	85.6
299-E33-338	2001	201.11	200.26	0.85	250.9	270.9	76.5	82.6	79.32	78.47	3/28/2011	4.10	271.0	82.6
299-E33-339	2001	203.03	202.30	0.73	259.4	279.3	79.1	85.1	81.21	80.48	3/27/2011	4.65	NDE	NDE

* Well not constructed as a WAC 173-160 resource protection well.

bgs = below ground surface

NDE = not deep enough (did not reach basalt)

Wells installed since the promulgation of WAC 173-160 have stainless-steel casings and screen, sand pack in the screened interval, and full annular seal above (including surface seal). Wells 299-E33-18 and 299-E33-20, which were installed before implementation the WAC 173-160 requirements, have carbon-steel casings and perforated intervals rather than screens. The use of these older wells permits continuity with historical data.

The WMA B-BX-BY monitoring well network includes seven upgradient and nine downgradient wells. Based on current trends in water table elevation, none of these wells are expected to go dry in the near future.

3.3 Water-Level Measurements

Water levels are measured in each well prior to sampling and at other times as needed to create consistent data sets. These values are corrected for borehole deviation from vertical and for barometric pressure effects to improve accuracy (Section 4.1)

3.4 Sampling and Analysis Protocol

Sampling and analysis protocols follow the conventions of the project and are further addressed in the QAPjP (Appendix A).

4 Data Evaluation and Reporting

This chapter addresses the data evaluation and reporting requirements for WMA B-BX-BY. Data review, validation, and verification are discussed in the QAPjP (Appendix A).

4.1 Evaluation of Dangerous Waste Constituents

The RCRA groundwater assessment monitoring requirements include quarterly determinations of the extent and rate of migration of the dangerous waste or dangerous waste constituents in accordance with 40 CFR 265.93(d)(4). The results will be discussed in annual reports that will provide the basis for the extent of contamination.

All potential dangerous waste or dangerous waste constituents will be evaluated by the process outlined in the steps below and as shown in Figure 4-1.

- A. Is the upgradient concentration higher than the downgradient concentration?
 - i. If yes, do not consider the reported constituent to be associated with WMA B-BX-BY; however, proceed as follows:
 - Is the groundwater flow direction such that the upgradient well is representative of the downgradient well in which the constituent was detected?
 - If so, exclude the constituent from further consideration.
 - If not, retain the constituent and re-evaluate the monitoring network.
 - ii. If no, proceed to step B.
- B. Is the downgradient concentration higher or equal to the upgradient concentration? If yes, proceed to step i below. If no, proceed to step C.
 - i. Are there any laboratory issues with the analysis?
 - If yes, do not consider the constituent to be associated with WMA B-BX-BY; however, include the constituent for the next quarterly sampling event.
 - If no, proceed to step ii below.
 - ii. Is the result below Hanford Site background concentrations (DOE/RL-96-61, *Hanford Site Background: Part 3, Groundwater Background*)?
 - If yes, exclude the constituent from further consideration.
 - If no, proceed to step iii below.
 - If DOE/RL-96-61 does not provide a background concentration for the constituent, proceed to step iii.
 - iii. Are there similar characteristics of the groundwater quality that indicate the same plume with the major source of contamination now past the upgradient well?
 - If yes, do not consider the constituent to be associated with WMA B-BX-BY; however, retain the constituent for further analysis. If three consecutive results concur with migration of a plume through the well, then exclude the constituent.
 - If no, consider the reported constituent to be associated with WMA B-BX-BY.

- C. Is the result for the constituent nondetect?
- i. If yes, excluded from further analyses.
 - ii. If no, start the logic process again.

It is likely that only a few (if any) dangerous waste or dangerous waste constituents will be determined to be impacting groundwater from WMA B-BX-BY. Constituents that are excluded based on the evaluation process will be listed in the annual report. Conversely, the constituents determined to be dangerous waste or dangerous waste constituents will also be defined in the annual report and will be retained for further evaluation. Finally, any constituent that is undetermined will be retained for further evaluation and will be reported as such in the annual report.

Based on the results of the assessment, further activities may be required to determine the full extent of dangerous waste or dangerous waste constituents in groundwater from WMA B-BX-BY.

4.2 Interpretation

The following techniques may be used to interpret WMA B-BX-BY groundwater data.

- Water level elevations may be used to (1) construct contour maps, (2) calculate hydraulic gradients, or (c) track water-table variations. Water-level measurements are corrected, if needed, to account for borehole deviation from vertical and barometric effects. Hydraulic gradients are used to estimate groundwater flow rate using Darcy's Law. If the groundwater gradient is too small to be determined, then contaminant trends, stiff diagrams, and contaminant contouring are compared with past results to derive the estimated groundwater flow rate and direction.
- Trend plots (i.e., graphs of concentrations versus time) are used to depict increases, decreases, and fluctuations. These may be used in tandem with hydrographs and/or water table maps to determine if concentrations relate to changes in water level or in groundwater flow directions.
- Plume maps illustrate the distribution of chemical or radiological constituents in the aquifer to determine the extent of contamination. Changes in plume distribution over time assist in determining plume movement and flow direction.
- Stiff diagrams depict the general chemistry of water in terms of major cations and anions. These diagrams can be helpful in differentiating between background and contaminated groundwater or multiple groundwater sources.
- Contaminant ratios in groundwater samples can be compared to ratios in releases from various sources to detect the likely origin of contamination.

Records of the analyses and evaluations discussed in this section will be maintained throughout the active lifetime of the facility. The results of laboratory analyses are stored in the Hanford Environmental Information System (HEIS) database.

The adequacy of the monitoring network to meet the objectives of this plan will be reviewed annually. If the monitoring network is not adequate to provide the extent and concentration of dangerous waste or dangerous waste constituents, then additional well(s) will be considered.

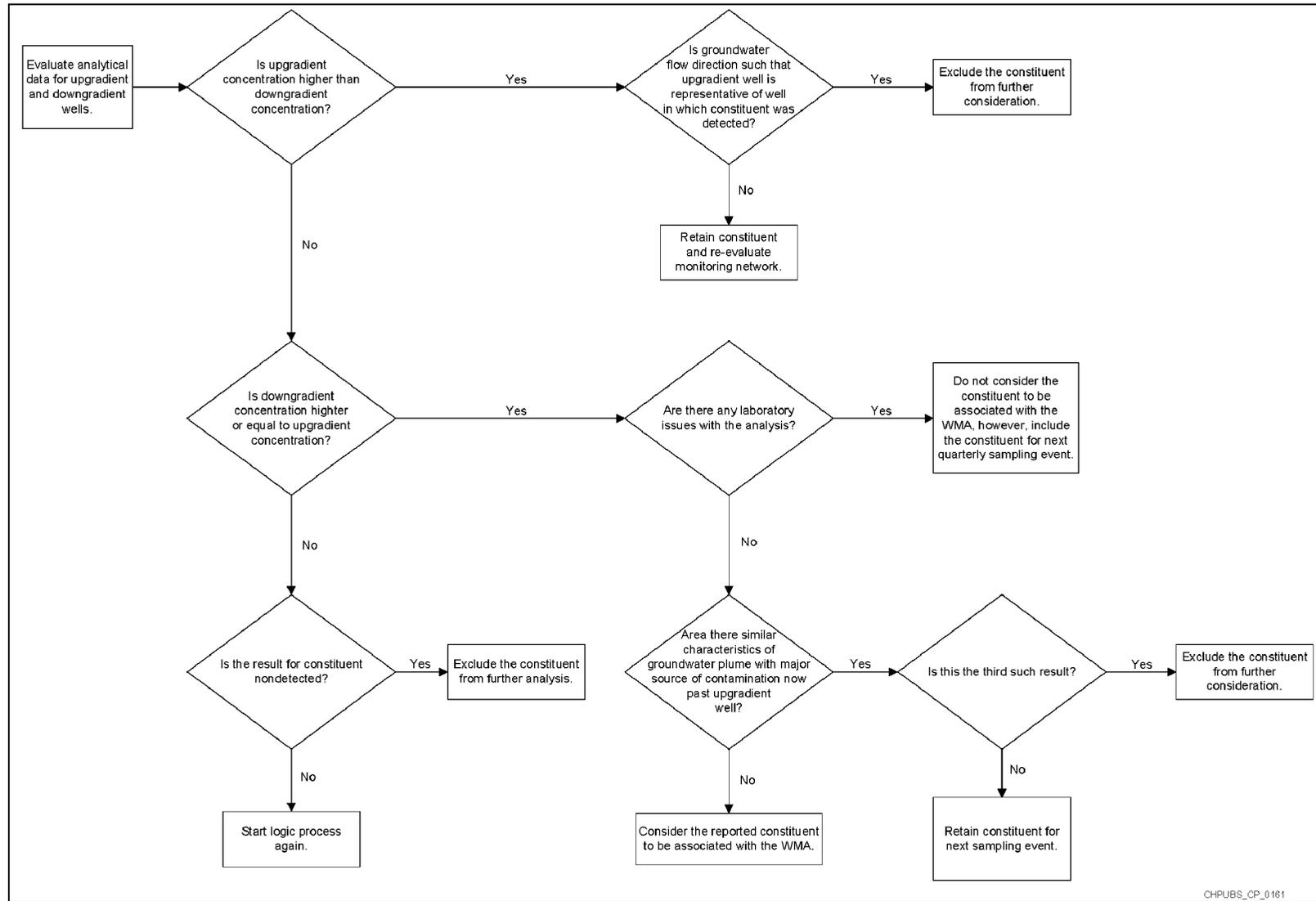


Figure 4-1. Groundwater Sample Result Evaluation Flow Chart

4.3 Reporting and Notification

Assessment monitoring results are reported annually, in accordance with the requirements of 40 CFR 265.94(b), in annual Hanford Site groundwater monitoring reports (e.g., DOE/RL-2011-118). The annual report will provide results and identify proposed constituents to be excluded, constituents to be retained for further evaluation, and constituents determined to be dangerous waste or dangerous waste constituents based on the evaluation process discussed in Section 4.1. As required by 40 CFR 265.94(b), the extent and rate of migration will also be described.

4.4 Corrective Action and Change Control

Changing groundwater conditions, unexpected events, or errors may necessitate changes to the groundwater monitoring program. Table 4-1 summarizes the general types of conditions, suitable actions, and documentation, which include the following:

- A. **Adding constituents, wells, or sampling events:** The technical lead may elect to increase sampling frequency, add wells, or add constituents to investigate changing conditions. For example, abrupt changes in chemical trends may result in more frequent sampling. Because this is an addition to the planned monitoring, no formal approval or notification of the regulatory agency is required. However, if the change becomes permanent, a revision of this assessment plan may be appropriate.
- B. **Deleting constituents, wells, or sampling events:** Conditions may warrant a planned decrease in sampling. For example, a well may be inaccessible due to nearby construction or remediation activities. These planned changes should be documented in correspondence. If the change becomes permanent, this assessment plan will be revised.
- C. **Unavoidable changes:**
 - a. **Well not sampled as planned:** Sampling may be delayed because of broken equipment, access restrictions, or other issues. In most cases, sampling operations staff will resolve the problem and sample the well later. If the delay is significant (e.g., a quarterly sampling event is missed), DOE or the technical lead will notify the regulatory agency via the RCRA monthly report or correspondence. If the problem cannot be fixed (e.g., well goes dry), DOE will notify the regulatory agency and the parties will determine the corrective action, which may range from no action to installing a replacement well.
 - b. **All samples not collected:** This problem may result from errors in paperwork or bottle preparation. The technical lead will work with the Sample Management and Reporting organization to determine if water from another sample bottle can be used to perform the missing analysis. If that is not possible, the technical lead will schedule the well for the missing analyses the following quarter and the deviation will be noted in the next annual report.
 - c. **Constituents not all analyzed:** This problem may result from a broken samples bottle or laboratory error. Corrective action is the same as for that for samples that are not all collected.
- D. **Revision to assessment plan:** When conditions warrant permanent changes to the monitoring program, this assessment plan will be revised and released in accordance with normal document control practices.
- E. **Anomalous data:** The technical lead will review data and submit requests for data review for anomalous data (see QAPjP in Appendix A). The corrective action may be simply to flag the data as suspect or rejected in the HEIS database. In some cases, the technical lead may recommend re-analyzing the sample or resampling the well. No special notification of DOE or the regulatory agency is required.

Table 4-1. Change Control for WMA B-BX-BY Groundwater Monitoring

Condition		Action	Documentation
A	Adding constituents, wells, or sampling events	Project management approval. Revise assessment plan if the changes are permanent (see condition D).	Project's schedule tracking system.
B	Deleting constituents, wells, or sampling events	Notify regulatory agency. If the change is permanent, revise assessment plan.	Initial notification may be verbal or e-mail. Formal notification via correspondence. Revised assessment plan, if needed.
C	Unavoidable changes (e.g., drywells; delayed samples, one-time missed samples due to broken pump, lost bottle, etc.)	Document the condition; notify regulatory agency.	Project's schedule tracking system; notification via report or correspondence (see text discussion).
D	Revision to assessment plan	Revise and distribute plan.	Revision of this document.
E	Anomalous data	Submit request for data review and flag data. Additional actions may include laboratory check, re-analysis, or resampling (Appendix A).	Project's request for data review files; data flags in HEIS database.

HEIS = Hanford Environmental Information System

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5 References

- 40 CFR 264, “Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities,” Appendix IX, “Ground-Water Monitoring List,” *Code of Federal Regulations*. Available at: <http://www.gpo.gov/fdsys/pkg/CFR-2010-title40-vol25/pdf/CFR-2010-title40-vol25-part264-appIX.pdf>.
- 40 CFR 265, “Interim Status Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities,” *Code of Federal Regulations*. Available at: http://www.access.gpo.gov/nara/cfr/waisidx_10/40cfr265_10.html.
- 40 CFR 265.91, “Ground-Water Monitoring System.”
- 40 CFR 265.92, “Sampling and Analysis.”
- 40 CFR 265.93, “Preparation, Evaluation, and Response.”
- 40 CFR 265.94, “Recordkeeping and Reporting.”
- 40 CFR 265, Subpart F, “Ground-Water Monitoring.”
- ARH-CD-691, 1976, *Strontium Recovery from PUREX Acidified Sludge*, Atlantic Richfield Hanford, Richland, Washington.
- Atomic Energy Act of 1954*, 42 USC 2011, et seq. Available at: <http://www.nrc.gov/reading-rm/doc-collections/nuregs/staff/sr0980/v1/sr0980v1.pdf#page=13>.
- Baker, V.R., B.N. Bjornstad, A.J. Busacca, K.R. Fecht, E.P. Kiver, U.L. Moody, J.G. Rigby, D.F. Stradling, and A.M. Tallman, 1991, “Quaternary Geology of the Columbia Plateau,” *Quaternary Nonglacial Geology; Conterminous U.S.*, Vol. K-2, R.B. Morrison, ed., Geological Society of America, Boulder, Colorado, pp. 215-250.
- BHI-00184, 1995, *Miocene- to Pliocene-Aged Suprabasalt Sediments of the Hanford Site, South-Central Washington*, Rev. 0, Bechtel Hanford, Inc., Richland, Washington.
- Bjornstad, B. N., 2006, *On the Trail of the Ice Age Floods: A Geological Field Guide to the Mid-Columbia Basin*, Kokee Books, Sandpoint, Idaho.
- Comprehensive Environmental Response, Compensation, and Liability Act of 1980*, 42 USC 9601, et seq., Pub. L. 107-377, December 31, 2002. Available at: <http://epw.senate.gov/cercla.pdf>.
- DOE/RL-89-16, 1996, *Single-Shell Tanks System Closure Work Plan*, Rev. 1, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: <http://www5.hanford.gov/arpir/?content=findpage&AKey=D196148631>.
- DOE/RL-96-61, 1997, *Hanford Site Background: Part 3, Groundwater Background*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: <http://www5.hanford.gov/arpir/?content=findpage&AKey=D197226378>.
- DOE/RL-2010-11, 2010, *Hanford Site Groundwater Monitoring and Performance Report for 2009*, Volumes 1 and 2, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: <http://www5.hanford.gov/arpir/?content=findpage&AKey=0084237>.

- DOE/RL-2011-01, 2011, *Hanford Site Groundwater Monitoring Report for 2010*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://www.hanford.gov/c.cfm/sgrp/GWRep10/html/gw10_Title_Pages.pdf.
- DOE/RL-2011-118, 2012, *Hanford Site Groundwater Monitoring for 2011*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: <http://www5.hanford.gov/arpir/?content=findpage&AKey=0091795>.
- Ecology Publication 97-407, 2009, *Chemical Testing Methods for Designating Dangerous Waste: WAC 173-303-090 & -100*, Appendix 5, "Appendix IX of 40 CFR 264," Washington State Department of Ecology, Olympia, Washington. Available at: <http://www.ecy.wa.gov/pubs/97407.pdf>.
- Ecology, EPA, and DOE, 1989, *Hanford Federal Facility Agreement and Consent Order*, 2 vols., as amended, Washington State Department of Ecology, U.S. Environmental Protection Agency, and U.S. Department of Energy, Olympia, Washington. Available at: <http://www.hanford.gov/?page=81>.
- GJO-98-40-TARA, 2000, *Hanford Tank Farms Vadose Zone: Addendum to the BX Tank Farm Report*, GJO-HAN-19, U.S. Department of Energy, Grand Junction Office, Grand Junction, Colorado. Available at: http://www.osti.gov/bridge/product.biblio.jsp?query_id=1&page=0&osti_id=765840&Row=0&formname=advancedsearch.jsp
- GJO-99-113-TAR, 1999, *Vadose Zone Characterization Project at the Hanford Tank Farms: B Tank Farm Report*, GJO-HAN-28, U.S. Department of Energy, Grand Junction Office, Grand Junction, Colorado. Available at: <http://environet.hanford.gov/env/attach//703/data/htfvz/BReport/report.cfm>.
- HNF-5507, 2000, *Subsurface Conditions Description of the B-BX-BY Waste Management Area*, Rev. 0A, CH2M HILL Hanford Group, Inc., Richland, Washington. Available at: <http://www5.hanford.gov/arpir/?content=findpage&AKey=0911240519>.
- HNF-SD-WM-TI-740, 1999, *Standard Inventories of Chemical and Radionuclides in Hanford Site Tank Wastes*, Rev. 0C, Lockheed Martin Hanford Corporation, Richland, Washington. Available at: <http://www5.hanford.gov/arpir/?content=findpage&AKey=0911300003>.
- HW-31000-DEL, 1955, *PUREX Technical Manual*, Hanford Atomic Works, Richland, Washington.
- HW-56933, 1958, *Process Specifications for Operational Control: PUREX Plant*, Rev. 1, General Electric Company, Hanford Atomic Products Operation, Richland, Washington. Available at: <http://www.osti.gov/bridge/servlets/purl/10151723-i3oxhp/native/>.
- ISO-986, 1967, *B-Plant Phase III Flowsheets*, ISOCHEM Inc., Richland, Washington. Available at: <http://www5.hanford.gov/arpir/?content=findpage&AKey=D196129100>.
- LA-UR-96-3860, 1997, *Hanford Tank Chemical and Radionuclide Inventories: HDW Model*, Rev. 4, Los Alamos National Laboratory, Los Alamos, New Mexico.
- McKee, E.H., D.A. Swanson, and T.L. Wright, 1977, "Duration and Volume of Columbia River Basalt Volcanism; Washington, Oregon, and Idaho," *Geological Society of America, Abstracts with Programs*, 9(4):364-463.

- PNL-4389, 1982, *Effect of Organic Complexants on the Mobility of Nickel and Cobalt in Soils: Status Report*, Pacific Northwest Laboratory, Richland, Washington. Available at: <http://www.osti.gov/energycitations/servlets/purl/6814818-bCoAsY/>.
- PNL-6456, 1988, *Hazard Ranking System Evaluation of CERCLA Inactive Waste Sites at Hanford*, Pacific Northwest Laboratory, Richland, Washington. Available at: <http://www5.hanford.gov/arpir/?content=findpage&AKey=D196006954>.
<http://www5.hanford.gov/arpir/?content=findpage&AKey=D196006996>.
<http://www5.hanford.gov/arpir/?content=findpage&AKey=D196007000>.
- PNL-6820, 1989, *Hydrogeology of the 200 Areas Low-Level Burial Grounds: An Interim Report*, 2 vols., Pacific Northwest Laboratory, Richland, Washington. Available at: <http://www5.hanford.gov/arpir/?content=findpage&AKey=D195066506>.
<http://www5.hanford.gov/arpir/?content=findpage&AKey=D195066592>.
<http://www5.hanford.gov/arpir/?content=findpage&AKey=D195066599>.
- PNL-7297, 1990, *Hanford Waste-Form Release and Sediment Interaction: A Status Report with Rationale and Recommendations for Additional Studies*, Pacific Northwest Laboratory, Richland, Washington. Available at: http://www.osti.gov/energycitations/product.biblio.jsp?query_id=1&page=0&osti_id=7045797.
- PNNL-11826, 1998, *Results of Phase I Groundwater Quality Assessment for Single-Shell Tank Waste Management Areas B-BX-BY at the Hanford Site*, Pacific Northwest National Laboratory, Richland, Washington. Available at: <http://www5.hanford.gov/arpir/?content=findpage&AKey=D198175185>.
- PNNL-12261, 2000, *Revised Hydrogeology for the Suprabasalt Aquifer System, 200-East Area and Vicinity, Hanford Site, Washington*, Pacific Northwest National Laboratory, Richland, Washington. Available at: <http://www5.hanford.gov/arpir/?content=findpage&AKey=0906180659>.
- PNNL-13022, 1999, *Groundwater Quality Assessment Plan for Single-Shell Waste Management Area B-BX-BY at the Hanford Site*, Pacific Northwest National Laboratory, Richland, Washington. Available at: http://www.pnl.gov/main/publications/external/technical_reports/PNNL-13022.pdf.
- PNNL-13022-ICN-1, 2002, *Groundwater Quality Assessment Plan for Single-Shell Waste Management Area B-BX-BY at the Hanford Site*, Interim Change Notice 1, Pacific Northwest National Laboratory, Richland, Washington. Available at: http://www.pnl.gov/main/publications/external/technical_reports/PNNL-13022ICN1.pdf.
- PNNL-13022-ICN-2, 2003, *Groundwater Quality Assessment Plan for Single-Shell Waste Management Area B-BX-BY at the Hanford Site*, Interim Change Notice 2, Pacific Northwest National Laboratory, Richland, Washington. Available at: http://www.pnl.gov/main/publications/external/technical_reports/PNNL-13022-ICN-2.pdf.
- PNNL-13022-ICN-3, 2006, *Groundwater Quality Assessment Plan for Single-Shell Tank Waste Management Area B-BX-BY at the Hanford Site*, Interim Change Notice 3, Pacific Northwest National Laboratory, Richland, Washington. Available at: http://www.pnl.gov/main/publications/external/technical_reports/PNNL-13022-ICN-3.pdf.

- PNNL-13022, 2006, *RCRA Assessment Plan for Single-Shell Tank Waste Management Area B-BX-BY at the Hanford Site*, Rev. 1, Pacific Northwest National Laboratory, Richland, Washington. Available at: http://www.pnl.gov/main/publications/external/technical_reports/PNNL-13022rev1.pdf.
- PNNL-13078, 1999, *Evaluation of Barometric Fluctuations on Well Water-Level Measurements and Aquifer Test Data*, Pacific Northwest National Laboratory, Richland, Washington. Available at: <http://www5.hanford.gov/arpir/?content=findpage&AKey=0906160166>.
- PNNL-13404, 2001, *Hanford Site Groundwater Monitoring for Fiscal Year 2000*, Pacific Northwest National Laboratory, Richland, Washington. Available at: http://www.pnl.gov/main/publications/external/technical_reports/PNNL-13404.pdf.
- PNNL-13679, 2001, *Vadose Zone Transport Field Study: Status Report*, Pacific Northwest National Laboratory, Richland, Washington. Available at: http://www.pnl.gov/main/publications/external/technical_reports/pnnl-13679.pdf.
- PNNL-13788, 2002, *Hanford Site Groundwater Monitoring for Fiscal Year 2001*, Pacific Northwest National Laboratory, Richland, Washington. Available at: http://www.pnl.gov/main/publications/external/technical_reports/PNNL-13788.pdf.
- PNNL-16663, 2007, *Geochemical Processes Data Package for the Vadose Zone in the Single-Shell Tank Waste Management Areas at the Hanford Site*, Pacific Northwest National Laboratory, Richland, Washington. Available at: <http://www5.hanford.gov/arpir/?content=findpage&AKey=0911240118>.
- PNNL-19277, 2010, *Conceptual Models for Migration of Key Groundwater Contaminants Through the Vadose Zone and Into the Upper Unconfined Aquifer Below the B-Complex*, Pacific Northwest National Laboratory, Richland, Washington. Available at: http://www.pnl.gov/main/publications/external/technical_reports/PNNL-19277.pdf.
- PNNL-19702, 2010, *Hydrogeologic Model for the Gable Gap Area, Hanford Site*, Pacific Northwest National Laboratory, Richland, Washington. Available at: http://www.pnl.gov/main/publications/external/technical_reports/PNNL-19702.pdf.
- Resource Conservation and Recovery Act of 1976*, 42 USC 6901, et seq. Available at: <http://epw.senate.gov/rcra.pdf>.
- RHO-BW-SA-318 P, 1985, *Paleodrainage of the Columbia River System on the Columbia Plateau of Washington State: A Summary*, Rockwell Hanford Operations, Richland, Washington. Available at: <http://www5.hanford.gov/arpir/?content=findpage&AKey=D196044988>.
- RPP-10098, 2002, *Field Investigation Report for Waste Management Area B-BX-BY*, Vols. 1 and 2, Rev. 0, CH2M HILL Hanford Group, Inc., Richland, Washington. Available at: <http://www5.hanford.gov/arpir/?content=findpage&AKey=1001051152>, <http://www5.hanford.gov/arpir/?content=findpage&AKey=1001051153>, <http://www5.hanford.gov/arpir/?content=findpage&AKey=1001051154>, <http://www5.hanford.gov/arpir/?content=findpage&AKey=1001051155>, <http://www5.hanford.gov/arpir/?content=findpage&AKey=0911240515>.

- RPP-10435, 2002, *Single-Shell Tank System Integrity Assessment Report*, Rev. 0, CH2M HILL Hanford Group, Inc., Richland, Washington. Available at:
<http://www5.hanford.gov/arpir/?content=findpage&AKey=D9090983>.
<http://www5.hanford.gov/arpir/?content=findpage&AKey=D9091082>.
- RPP-16015, 2004, *Origin of Wastes in Single-Shell Tanks 241-B-110 and 241-B-111*, Rev. 1, CH2M HILL Hanford Group, Inc., Richland, Washington.
- RPP-19822, 2004, *Hanford Defined Waste Model – Rev. 5*, CH2M HILL Hanford Group, Inc., Richland, Washington.
- RPP-23403, 2006, *Single-Shell Tank Component Closure Data Quality Objectives*, Rev. 3, CH2M HILL Hanford Group, Inc., Richland, Washington.
- RPP-26744, 2005, *Hanford Soil Inventory Model, Rev. 1*, Rev. 0, CH2M HILL Hanford Group, Inc., Richland, Washington.
- RPP-36315, 2008, *Completion Report for 241-B Tank Farm Hydraulic Rotary Hammer Direct Push Drilling, Probe Installation, and Sampling*, Rev. 0, Energy Solutions Federal Services, Inc., Richland, Washington.
- RPP-RPT-47562, 2011, *Hanford BX-Farm Leak Assessments Report*, Rev. 0, Washington River Protection Solutions, LLC, Richland, Washington. Available at:
http://www.hanford.gov/files.cfm/RPP-RPT-47562_-_Rev_00.pdf.
- RPP-RPT-49089, 2011, *Hanford B-Farm Leak Inventory Assessments Report*, Rev. 0, Washington River Protection Solutions, LLC, Richland, Washington.
- SD-WM-TI-302, 1987, *Hanford Waste Tank Sluicing History*, Rev. 0, Westinghouse Hanford Company, Richland, Washington. Available at:
<http://www5.hanford.gov/arpir/?content=findpage&AKey=E0027566>.
- USGS, 1997, *Geochemistry and Microbiology of Iron-Related Well-Screen Encrustation and Aquifer Biofouling in Suffolk County, Long Island, New York*, Water-Resources Investigation Report 97-4032, U.S. Geological Survey, Denver, Colorado. Available at:
<http://ny.water.usgs.gov/pubs/wri/wri974032/WRIR97-4032.pdf>.
- WA7890008967, 2009, *Hanford Facility Resource Conservation and Recovery Act Permit, Dangerous Waste Portion, Revision 8C, for the Treatment, Storage, and Disposal of Dangerous Waste, Class 1 Modification*, Washington State Department of Ecology, Richland, Washington. Available at: <http://www7.rl.gov/rapidweb/ENVPRO-RCRA/index.cfm?PageNum=129>.
- WAC 173-160, “Minimum Standards for Construction and Maintenance of Wells,” *Washington Administrative Code*, Olympia, Washington. Available at:
<http://apps.leg.wa.gov/WAC/default.aspx?cite=173-160>.

- WAC 173-303, "Dangerous Waste Regulations," *Washington Administrative Code*, Olympia, Washington. Available at: <http://apps.leg.wa.gov/WAC/default.aspx?cite=173-303>.
- WAC 173-303-400, "Interim Status Facility Standards."
- WAC 173-303-645, "Releases from Regulated Units."
- WHC-MR-0132, 1990, *A History of the 200 Area Tank Farms*, Rev. 0, Westinghouse Hanford Company, Richland, Washington. Available at:
<http://www5.hanford.gov/arpir/?content=findpage&AKey=D196015712>.
<http://www5.hanford.gov/arpir/?content=findpage&AKey=D196015715>.
- WHC-MR-0517, 1996, *Listed Waste History at Hanford Facility TSD Units*, Rev. 0, Westinghouse Hanford Company, Richland, Washington. Available at:
<http://www.osti.gov/bridge/purl.cover.jsp?purl=/341253-znDhFj/webviewable/>.
- WHC-SD-ENV-AP-002, 1996, *Assessment Groundwater Monitoring Plan for Single Shell Tank Waste Management Area B-BX-BY*, Rev. 0, Westinghouse Hanford Company, Richland, Washington. Available at: <http://www5.hanford.gov/arpir/?content=findpage&AKey=0093515>.
- WHC-SD-EN-AP-012, 1989, *40 CFR 265 Interim Status Groundwater Monitoring Plan for the Single-Shell Tanks*, Rev. 0, Westinghouse Hanford Company, Richland, Washington. Available at: <http://www5.hanford.gov/arpir/?content=findpage&AKey=D195063122>.
- WHC-SD-EN-AP-012, 1991, *Interim-Status Groundwater Monitoring Plan for the Single-Shell Tanks*, Rev. 1, Westinghouse Hanford Company, Richland, Washington. Available at:
<http://www5.hanford.gov/arpir/?content=findpage&AKey=D196071250>.
- WHC-SD-EN-TI-012, 1992, *Geologic Setting of the 200 East Area: An Update*, Rev. 0, Westinghouse Hanford Company, Richland, Washington.
- WHC-SD-EN-TI-290, 1990, *Geologic Setting of the Low-Level Burial Grounds*, Rev. 0, Westinghouse Hanford Company, Richland, Washington.
- WHC-SD-ENV-AP-002, 1996, *Assessment Groundwater Monitoring Plan for the Single Shell Tank Waste Management Area B-BX-BY*, Rev. 0, Westinghouse Hanford Company, Richland, Washington. Available at: <http://www.osti.gov/bridge/servlets/purl/326402-TWvymI/webviewable/326402.pdf>.
- WMP-28945, 2007, *Data Quality Objective Summary Report in Support of the 200-BP-5 Groundwater Operable Unit Remedial Investigation/Feasibility Study Process*, Rev. 0, Fluor Hanford, Inc., Richland, Washington.

Appendix A
Quality Assurance Project Plan

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Terms

CRDL	contract-required detection limit
DOE	U.S. Department of Energy
DQO	data quality objective
DUP	laboratory matrix duplicate
EB	equipment blank
Ecology	Washington State Department of Ecology
EPA	U.S. Environmental Protection Agency
FTB	full trip blank
FXR	field transfer blank
GC	gas chromatography
HASQARD	<i>Hanford Analytical Services Quality Assurance Requirements Documents</i>
HEIS	Hanford Environmental Information System
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
NTU	nephelometric turbidity unit
PCB	polychlorinated biphenyl
QA	quality assurance
QAPjP	quality assurance project plan
QC	quality control
RCRA	<i>Resource Conservation and Recovery Act of 1976</i>
RL	U.S. Department of Energy, Richland Operations Office
RPD	relative percent difference
RSD	relative standard deviation

SUR	surrogate
Tri-Party Agreement	<i>Hanford Federal Facility Agreement and Consent Order</i>
TSD	treatment, storage, and disposal
VOC	volatile organic compound

A Quality Assurance Project Plan

The contractor's quality assurance (QA) program describes the contractor's QA structure, requirements, implementation methods, and responsibilities. The contractor's environmental QA program plan provides the requirements for collecting and assessing environmental data in accordance with the following:

- 10 CFR 830, "Nuclear Safety Management," Subpart A, "Quality Assurance Requirements"
- DOE O 414.1D, *Quality Assurance*
- DOE/RL-96-68, *Hanford Analytical Services Quality Assurance Requirements Documents* (HASQARD)
- EPA/240/B-01/003, *EPA Requirements for Quality Assurance Project Plans*

This quality assurance project plan (QAPjP) establishes the quality requirements for environmental data collection including the planning, implementation, and assessment of sampling, field measurements, and laboratory analyses. Sections 6.5 and 7.8 of the *Hanford Federal Facility Agreement and Consent Order* (Tri-Party Agreement) (Ecology et al., 1989a), Attachment 2, "Action Plan," require that QA/quality control (QC) and sampling and analysis activities specify the QA requirements for treatment, storage, and disposal (TSD) units, as well as for past-practice processes. The HASQARD requirements (DOE/RL-96-68) also apply to this work.

The content of this QAPjP is patterned after the QA elements of EPA/240/B-01/003. The QAPjP demonstrates conformance to the Part B requirements of *Quality Systems for Environmental Data and Technology Programs: Requirements with Guidance for Use* (ANSI/ASQ E4-2004). This QAPjP is divided into four sections (as designated in EPA/240/B-01/003) that describe the quality requirements and controls applicable to this investigation. This QAPjP is intended to supplement the contractor's environmental QA program plan.

A1 Project Management

This section addresses the basic aspects of project management and will ensure that the project has defined goals, the participants understand the goals and the approaches used, and the planned outputs are appropriately documented.

A1.1 Project/Task Organization

The project organization in regard to planning, sampling, analysis, and data assessment is described in the following subsections and is shown in Figure A-1. For each functional primary contractor role, there is a corresponding oversight role within the U.S. Department of Energy (DOE).

A1.1.1 Regulatory Project Manager

The Washington State Department of Ecology (Ecology) project manager is responsible for oversight of the work being performed under this groundwater monitoring plan. Ecology will work with the DOE Richland Operations Office (RL) to resolve concerns regarding the work as described in this QAPjP. Ecology can request this plan during a regulatory compliance inspection for review.

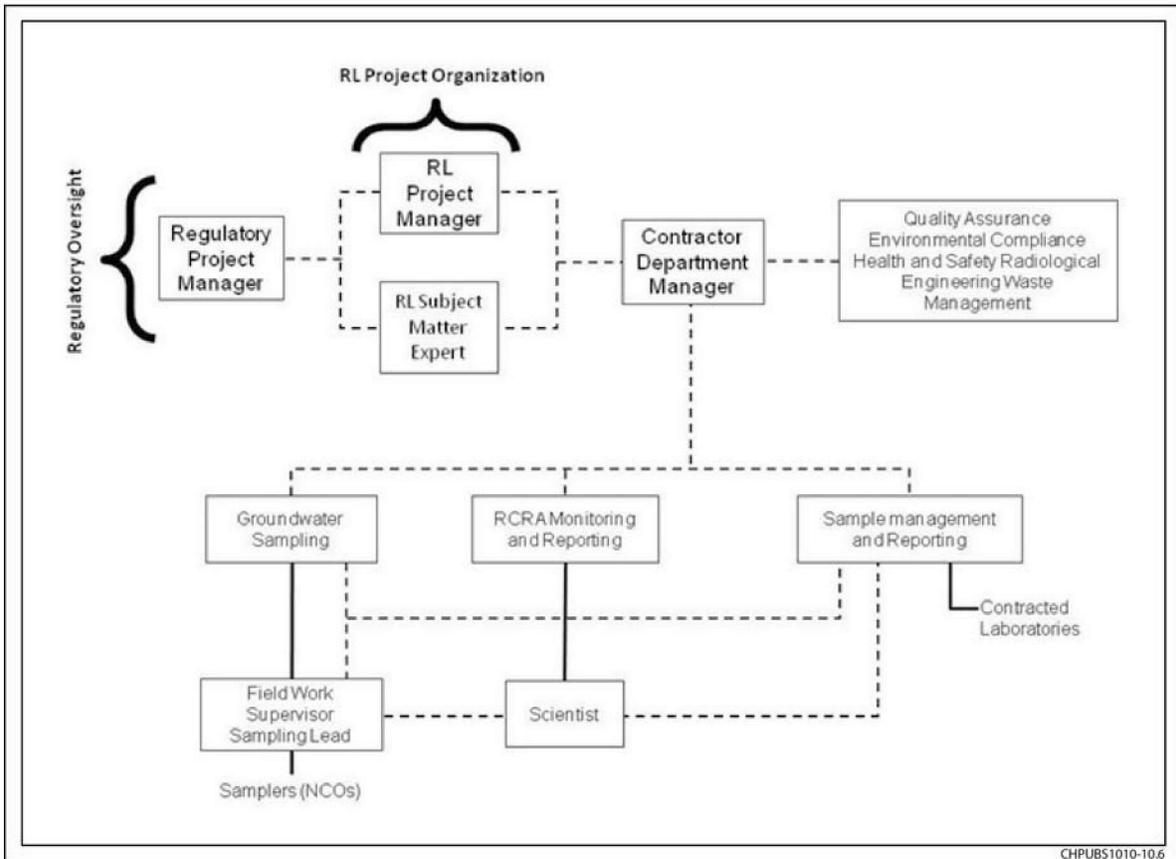


Figure A-1. Project Organization

A1.1.2 U.S. Department of Energy, Richland Operations Office Project Manager

Hanford Site cleanup is the responsibility of RL. The RL project manager is responsible for authorizing the contractor to perform activities under the *Comprehensive Environmental Response, Compensation, and Liability Act of 1980*; the *Resource Conservation and Recovery Act of 1976 (RCRA)*; the *Atomic Energy Act of 1954*; and the Tri-Party Agreement (Ecology et al., 1989a) for the Hanford Site.

A1.1.3 U.S. Department of Energy, Richland Operations Office Subject Matter Expert

The RL subject matter expert is responsible for providing day-to-day oversight of the contractor's performance of workscope, working with the contractor and the regulatory agencies to identify and work through issues, and providing technical input to the RL project manager.

A1.1.4 Contractor Groundwater Remediation Department Manager

The contractor groundwater remediation department manager provides oversight for all activities and coordinates with DOE, the regulatory agencies, and primary contractor management in support of sampling and reporting activities. The remediation department manager also provides support to the RCRA Monitoring and Reporting manager to ensure that work is performed safely and cost effectively.

A1.1.5 Groundwater Sampling Operations

Groundwater sampling operations is responsible for planning and coordinating field sampling resources and provides the field work supervisor for routine groundwater sampling operations. The field work supervisor directs the samplers, who collect groundwater samples in accordance with the sampling

and analysis plan, and in accordance with corresponding standard procedures and work packages. The samplers also complete field logbooks and chain-of-custody forms, including any shipping paperwork, and ensure delivery of the samples to the analytical laboratory.

A1.1.6 RCRA Monitoring and Reporting

The RCRA Monitoring and Reporting manager is responsible for direct management of activities performed to meet RCRA TSD monitoring requirements. The RCRA Monitoring and Reporting manager coordinates with and reports to DOE and primary contractor management regarding RCRA TSD monitoring requirements. The RCRA Monitoring and Reporting manager assigns scientists to provide technical expertise.

A1.1.7 Sample Management and Reporting Organization

The Sample Management and Reporting organization coordinates laboratory analytical work to ensure that laboratories conform to HASQARD requirements (or their equivalent), as approved by DOE, the U.S. Environmental Protection Agency (EPA), and Ecology. Sample Management and Reporting receives analytical data from the laboratories, performs data entry into the Hanford Environmental Information System (HEIS) database, and arranges for data validation. Sample Management and Reporting is responsible for informing the RCRA Monitoring and Reporting manager of any issues reported by the analytical laboratories.

A1.1.8 Contract Laboratories

The contract laboratories analyze samples in accordance with established procedures and provide necessary sample reports and explanations of results to support data validation. The laboratories must meet site-specific QA requirements and must have an approved QA plan in place.

A1.1.9 Quality Assurance

The QA point of contact is matrixed to the subject matter expert and is responsible for QA issues on the project. Responsibilities include overseeing implementation of project QA requirements; reviewing project documents, including data quality objective (DQO) summary reports, sampling and analysis plans, and the QAPjP; and participating in QA assessments on sample collection and analysis activities, as appropriate. The QA point of contact must be independent of the unit generating the data.

A1.1.10 Environmental Compliance Officer

The environmental compliance officer provides technical oversight, direction, and acceptance of project and subcontracted environmental work, and also develops appropriate mitigation measures with the goal of minimizing adverse environmental impacts.

A1.1.11 Health and Safety

The Health and Safety organization is responsible for coordinating industrial safety and health support within the project as carried out through health and safety plans, job hazard analyses, and other pertinent safety documents required by federal regulations or by internal primary contractor work requirements.

A1.1.12 Waste Management

Waste Management communicates policies and procedures and ensures project compliance for storage, transportation, disposal, and waste tracking in a safe and cost-effective manner.

A1.2 Problem Definition/Background

The problem definition, as required by WAC 173-303-400 (“Dangerous Waste Regulations,” “Interim Status Facility Standards”) and 40 CFR 265, Subpart F (“Interim Status Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities,” “Ground-Water Monitoring”), is outlined in the main text discussion of this monitoring plan. The background is also provided in the monitoring plan.

A1.3 Project/Task Description

The project description is provided in Chapters 3 and 4 of this monitoring plan and includes the selection of appropriate dangerous waste or dangerous waste constituents, collection and analyses of groundwater from the monitoring network, interpretation of analytical results, evaluation of the monitoring network, and reporting.

The target analytes, along with the monitoring wells and frequency of sampling, are provided in Chapter 3.

A1.4 Quality Objectives and Criteria

The quality objectives and criteria for groundwater monitoring are defined in the tables provided in this QAPjP in order to meet the evaluation requirements stated in the monitoring plan.

A1.5 Special Training/Certification

Workers receive a level of training that is commensurate with their responsibility for collecting and transporting groundwater samples according to the dangerous waste training plan maintained for the TSD unit to meet the requirements of WAC 173-303-330, “Personnel Training.” The field work supervisor, in coordination with line management, will ensure that all field personnel meet training requirements.

A1.6 Documents and Records

The project scientist is responsible for ensuring that the current version of the groundwater monitoring plan is used and for providing any updates to field personnel. Version control is maintained by the administrative document control process. Significant changes to the plan that affect DQOs will be reviewed and approved by DOE and the regulatory agency prior to implementation. Table A-1 defines the types of changes that may be made to the sampling design and documentation requirements.

Logbooks and data forms are required for field activities. The logbook must be identified with a unique project name and number. Individuals responsible for the logbooks shall be identified in the front of the logbook, and only authorized individuals may make entries into the logbooks. Logbooks will be controlled in accordance with internal work requirements and processes.

The HEIS database will be identified as a data repository for the Hanford Facility Operating Record unit file. Records may be stored in either electronic or hardcopy format. Documentation and records, regardless of medium or format, are controlled in accordance with internal work requirements and processes that ensure accuracy and retrievability of stored records. Records required by the Tri-Party Agreement (Ecology et al., 1989a) will be managed in accordance with the requirements therein.

Table A-1. Actions and Documentation for Regulatory Notification

Type of Change	Action	Documentation
Temporary addition of wells or constituents, or increased sampling frequency	RCRA Monitoring and Reporting manager approval; notify regulatory agency, if appropriate	Project's schedule tracking system
Unintentional impact to groundwater monitoring plan including one-time missed well sampling due to operational constraints, delayed sample collection, broken pump, lost bottle set, missed sampling of indicator parameters, loss of samples in transit, etc.	Electronic notification	RCRA annual report
Planned change to groundwater monitoring activities, including addition or deletion of constituents or wells, change of sampling frequency, etc.	Revise monitoring plan	Revised RCRA groundwater monitoring plan
Anticipated unavoidable changes (e.g., dry wells)	Electronic notification; revise monitoring plan	RCRA annual report and revised groundwater monitoring plan

RCRA = *Resource Conservation and Recovery Act of 1976*

The results of groundwater monitoring are reported annually in accordance with the requirements of 40 CFR 265.94, "Recordkeeping and Reporting." Reporting will be made in annual Hanford Site groundwater monitoring reports (e.g., DOE/RL-2011-118, *Hanford Site Groundwater Monitoring for 2011*).

A2 Data Generation and Acquisition

This section addresses data generation and acquisition to ensure that the project's methods for sampling, measurement and analysis, data collection or generation, data handling, and QC activities are appropriate and documented.

A2.1 Sampling Process Design (Experimental Design)

The sampling design is based on regulatory requirements and judgmental sampling.

A2.1.1 Regulatory Requirements

The groundwater protection regulations of WAC 173-303-400 dictate the groundwater sampling and analysis requirements applicable to interim status TSD units.

A2.1.2 Judgmental Sampling

The selection of sampling and analysis requirements is based on knowledge of the feature or condition under investigation and is also based on professional judgment. The TSD unit monitoring is based on professional judgment. Conclusions depend on the validity and accuracy of professional judgment.

A2.2 Sampling Methods

Sampling is described in the contractor's environmental QA program plan, including the following:

- Field sampling methods
- Sample preservation, containers, and holding times
- Corrective actions for sampling activities
- Decontamination of sampling equipment

The groundwater sampling operations supervisor must ensure that situations that may impair the usability of samples and/or data are documented in field logbooks or on nonconformance report forms in accordance with internal corrective action procedures, as appropriate. The groundwater sampling operations supervisor will note any deviations that occur from the standard procedures for sample collection, contaminants of potential concern, sample transport, or monitoring. The groundwater sampling operations supervisor is also responsible for coordinating all activities related to the use of field monitoring equipment (e.g., dosimeters and industrial hygiene equipment). Field personnel will document in the logbook all noncompliant measurements taken during field sampling. Ultimately, the groundwater sampling operations supervisor is responsible for developing, implementing, and communicating corrective action procedures; for documenting all deviations from procedure; and for ensuring that immediate corrective actions are applied to field activities. Problems with sample collection, custody, or data acquisition that adversely impact data quality or impair the ability to acquire data or failure to follow procedure will be documented in accordance with internal corrective action procedures, as appropriate.

A2.3 Sample Handling and Custody

A sampling and data tracking database is used to track samples from the point of collection through the laboratory analysis process. Laboratory analytical results are entered and maintained in the HEIS database. Each sample is identified and labeled with a unique HEIS sample number. The contractor's environmental QA program plan specifies sample handling information, including the following:

- Container requirements
- Container labeling and tracking process
- Sample custody requirements
- Shipping and transportation

Sample custody during laboratory analysis is addressed in the applicable laboratory's standard operating procedures. Laboratory custody procedures will ensure that sample integrity and identification are maintained throughout the analytical process. Storage of samples at the laboratory will be consistent with laboratory instructions prepared by the Sample Management and Reporting organization.

A2.4 Analytical Methods

Information on analytical methods is provided in Tables A-2 and A-3. These analytical methods are controlled in accordance with the laboratory's QA plan and the requirements of this QAPjP. The primary contractor participates in oversight of offsite analytical laboratories to qualify the laboratories for performing Hanford Site analytical work.

Table A-2. Preservation Techniques, Analytical Methods Used, and Current Method Quantitation Limits for Continuing Constituents

Constituent	Collection and Preservation ^a	Analysis Methods ^b	Method Quantitation Limit (µg/L) ^c
Metals Analyzed by ICP Method – Unfiltered/Filtered			
Calcium	P, HNO ₃ to pH <2	SW-846 ^d Method 6010B/C, SW-846 Method 6020 ^e , or EPA/600 Method 200.8 ^e	1,000
Chromium			10
Magnesium			750
Potassium			4,000
Sodium			500
Anions by IC			
Chloride	P	EPA/600 Method 300.0 ^f	200
Nitrate			250
Sulfate			500
Other			
Alkalinity	G/P	Standard Method ^g 2320, EPA/600 Method 310.1 EPA/600 Method 310.2	5,000
Conductivity, field	Field measurement	Instrument/meter	1 µohm
pH, field measurement	Field measurement	Instrument/meter	0.1
Temperature	Field measurement	Instrument/meter	
Turbidity, field measurement	Field measurement	Instrument/meter	0.1 NTU

a. All samples will be collected in plastic (P) or glass (G) containers and will be cooled to 4°C upon collection.

b. Constituents grouped together are analyzed by the same method, unless otherwise indicated.

c. Detection limit units, unless otherwise indicated.

d. SW-846, *Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, Third Edition; Final Update IV-B*.

e. SW-846 Method 6010 is the preferred method; however, Method 6020 or EPA/600 Method 200.8 may be used, as long as the method quantitation limit listed is met.

f. Analytical method adapted from Method 300.0 (EPA/600/4-84-017, *Test Methods for Determination of Inorganic Anions in Water by Ion Chromatography*).

g. *Standard Methods for the Examination of Water and Wastewater* (AWWA et al., 2005).

EPA = U.S. Environmental Protection Agency

IC = ion chromatography

ICP = inductively coupled plasma

NTU = nephelometric turbidity unit

Table A-3. Preservation Techniques, Analytical Methods Used, and Current Method Quantitation Limits for Listed Assessment Constituents

Constituent	Collection and Preservation ^a	Analysis Methods ^b	Method Quantitation Limit (µg/L) ^c
Metals Analyzed by ICP Method – Unfiltered/Filtered			
Barium	P, HNO ₃ to pH <2	SW-846 ^d Method 6010B/C, SW-846 Method 6020 ^e , or EPA/600 Method 200.8 ^e	20
Beryllium			5
Cadmium			5
Cobalt			20
Copper			10
Nickel			40
Silver			10
Vanadium			25
Zinc			10
Trace Metals – Unfiltered/Filtered			
Antimony	P, HNO ₃ to pH <2	SW-846 Method 6020 or EPA/600 Method 200.8	6
Arsenic			10
Lead			5
Mercury	G, HNO ₃ to pH <2	SW-846 Method 7470A, EPA/600 Method 200.8	0.5
Selenium	P, HNO ₃ to pH <2	SW-846 Method 6020 or EPA/600 Method 200.8	10
Thallium			5
Volatile by GC/MS			
1,1-Dichloroethene	G, no headspace	SW-846 Method 8260B	10
1, 2-Dichloroethane			5
1,1,1-Trichloroethane			5
1,1,2-Trichloroethane			5
1,1,2,2-Tetrachloroethane			5
Acetone (2-propanone)			20
Benzene			5
Carbon disulfide			5
Carbon tetrachloride			5
Chlorobenzene			5

Table A-3. Preservation Techniques, Analytical Methods Used, and Current Method Quantitation Limits for Listed Assessment Constituents

Constituent	Collection and Preservation ^a	Analysis Methods ^b	Method Quantitation Limit (µg/L) ^c
Chloroform			5
Ethylbenzene			5
Isobutanol			500
Methylene chloride			5
Methyl ethyl ketone (2-butanone)			10
Methyl isobutyl ketone (4-methyl-2-pentanone) (MIBK)			10
Tetrachloroethene			5
Toluene			5
trans-1,3-Dichloropropene			5
Trichloroethene			5
Trichlorofluoromethane			10
Vinyl chloride (chloroethene)			10
Xylenes			10
Semivolatiles by GC/MS			
1,2-Dichlorobenzene (o-Dichlorobenzene)	Amber glass	SW-846 Method 8270D	10
1,2,4-Trichlorobenzene			10
2-Chlorophenol			10
2-Methylphenol (o-cresol)			10
2-Nitrophenol (o-Nitrophenol)			20
2,4-Dinitrotoluene			10
2,4,5-Trichlorophenol			10
2,4,6-Trichlorophenol			10
3-Methylphenol (m-cresol)			20
4-Chloro-3-methylphenol (p-Chloro-m-cresol)			10
4-Methylphenol (p-cresol)			10
Acenaphthene			10

Table A-3. Preservation Techniques, Analytical Methods Used, and Current Method Quantitation Limits for Listed Assessment Constituents

Constituent	Collection and Preservation ^a	Analysis Methods ^b	Method Quantitation Limit (µg/L) ^c
Butylbenzylphthalate			10
Di-n-butylphthalate			10
Di-n-octylphthalate			10
Fluoranthene			10
Hexachlorobutadiene			10
Hexachloroethane			10
n-Nitroso-di-n-propylamine			10
n-Nitrosomorpholine			10
Naphthalene			10
Nitrobenzene			10
Pyrene			10
Pyridine			20
PCBs			
Aroclor 1016	G	SW-846 Method 8082	0.5
Aroclor 1221			0.5
Aroclor 1232			0.5
Aroclor 1242			0.5
Aroclor 1248			0.5
Aroclor 1254			0.5
Aroclor 1260			0.5
Other			
Cyanide	P, NaOH to pH >12	SW-846 Method 9012, Standard Method ^f 4500, EPA/600 Method 335.2	5
Sulfide	G/P, 2 mL 2N zinc acetate and NaOH pH >9, cool 4°C	Sulfides – 9030	500
TOC	G, HCL or H ₂ SO ₄ to pH <2	SW-846 Method 9060	1,000

Table A-3. Preservation Techniques, Analytical Methods Used, and Current Method Quantitation Limits for Listed Assessment Constituents

Constituent	Collection and Preservation ^a	Analysis Methods ^b	Method Quantitation Limit (µg/L) ^c
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a. All samples will be collected in glass (G) or plastic (P) containers and samples and will be cooled to 4°C upon collection.

b. Constituents grouped together are analyzed by the same method, unless otherwise indicated.

c. Detection limit units.

d. SW-846, *Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, Third Edition; Final Update IV-B*.

e. SW-846 Method 6010 is the preferred method; however, Method 6020 or EPA/600 Method 200.8 may be used, as long as the method quantitation limit listed is met.

f. *Standard Methods for the Examination of Water and Wastewater* (AWWA et al., 2005).

EPA = U.S. Environmental Protection Agency

GC/MS = gas chromatography/mass spectrometry

ICP = inductively coupled plasma

PCB = polychlorinated biphenyl

Laboratories providing analytical services in support of this QAPjP will report errors to the Sample Management and Reporting project coordinator, who will then initiate a sample disposition record. The error-reporting process is intended to document analytical errors and the resolution of those errors with the project scientist. The corrective action program addresses the following:

- Evaluation of impacts of laboratory QC failures on data quality
- Root-cause analysis of QC failures
- Evaluation of recurring conditions that are adverse to quality
- Trend analysis of quality-affecting problems
- Implementation of a quality improvement process
- Control of nonconforming materials that may affect quality

A2.5 Quality Control

The QC procedures must be followed in the field and laboratory to ensure that reliable data are obtained. Field QC samples will be collected to evaluate the potential for cross-contamination and to provide information pertinent to field variability. Field QC for sampling will require the collection of field replicates (duplicates), trip or field blanks, and equipment blanks (EBs). Laboratory QC samples estimate the precision and bias of the analytical data. Field and laboratory QC samples are summarized in Table A-4.

Table A-4. QC Samples

Sample Type	Primary Characteristics Evaluated	Frequency
Field QC		
Full trip blank (FTB)	Contamination from containers or transportation	One per 20 well trips
Field transfer blank (FXR)	Contamination from sampling site	One each day; VOCs sampled
Equipment blank (EB)	Contamination from non-dedicated equipment	As needed ^a
Replicate/duplicate sample	Reproducibility	One per 20 well trips
Laboratory QC		
Method blank (MB)	Laboratory contamination	One per batch
Laboratory duplicate	Laboratory reproducibility	See footnote b
Matrix spike (MS)	Matrix effect and laboratory accuracy	See footnote b
Matrix spike duplicate (MSD)	Laboratory reproducibility/accuracy	See footnote b
Surrogate (SUR)	Recovery/yield	See footnote b
Laboratory control sample (LCS)	Method accuracy	One per batch

a. For portable Grundfos® (registered trademark of Grundfos Pumps Corporation, Colorado Springs, Colorado) pumps, EBs are collected one per 10 well trips. Whenever a new type of nondedicated equipment is used, an EB shall be collected every time sampling occurs until it can be shown that less frequent collection of EBs is adequate to monitor the decontamination procedure for the nondedicated equipment.

b. As defined in the laboratory contract or quality assurance plan, and/or analysis procedures.

QC = quality control

VOC = volatile organic compound

A2.5.1 Field Quality Control Samples

Field QC samples will be collected to evaluate the potential for cross-contamination and field sampling performance. The QC samples and the required frequency for collection are described in this section.

Full trip blanks (FTBs) are prepared by the sampling team prior to traveling to the sampling site. The FTB is filled with high-purity reagent water. The bottles are sealed and transported, unopened, to the field in the same storage containers used for samples collected that day. Collected FTBs are analyzed for the same constituents as the samples. The FTBs are used to evaluate potential contamination of the samples due to the sample bottles, preservative, handling, storage, or transportation.

Field transfer blanks (FXRs) are preserved volatile organic analysis sample bottles that are filled at the sample collection site with high-purity reagent water that has been transported to the field. After collection, FXR bottles are sealed and placed in the same storage containers with the samples from the associated sampling event. The FXR samples are analyzed for volatile organic compounds (VOCs) only. The FXRs are used to evaluate potential contamination caused by conditions in the field.

The EBs are samples in which high-purity reagent water is passed through the pump or placed in contact with the sampling surfaces of the equipment to collect blank samples identical to the sample set that will be collected. The EB bottles are placed in the same storage containers with the samples from the

associated sampling event. The EB samples are analyzed for the same constituents as the samples from the associated sampling event. The EBs are used to evaluate the effectiveness of the cleaning process to ensure that samples are not cross-contaminated from previous sampling events.

For the field blanks (i.e., FTBs, FXRs, and EBs), results above two times the method detection limit (MDL) are identified as suspected contamination. However, for common laboratory contaminants such as acetone, methylene chloride, 2-butanone, toluene, and phthalate esters, the limit is five times the MDL.

Field duplicates, also known as replicates, are two samples that are collected as close as possible to the same time and same location, and they are intended to be identical. Field duplicates are stored and transported together and are analyzed for the same constituents. The field duplicates are used to determine precision for both sampling and laboratory measurements. The results of the field duplicates must have precision within 20 percent, as measured by the relative percent difference (RPD). Only field duplicates with at least one result greater than five times the MDL or minimum detectable activity (MDA) are evaluated.

Double-blind samples contain a concentration of analyte known to the supplier but unknown to the analyzing laboratory. The laboratory is not informed that the samples are QC samples. The project submits double-blind samples to assess analytical precision and accuracy.

A2.5.2 Laboratory Quality Control Samples

The laboratory QC samples (e.g., method blanks [MBs], laboratory control samples [LCSs]/blank spikes, and matrix spikes [MSs]) are defined in Chapter 1 of SW-846, *Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, Third Edition; Final Update IV-B*, and will be run at the frequency specified in that reference, unless superseded by agreement.

A2.5.3 Quality Control Requirements

Table A-5 lists the acceptance criteria for QC samples, and Table A-6 lists the acceptable recovery limits for the double-blind standards. These samples are prepared by spiking Hanford Site background well water with known concentrations of constituents of interest. Spiking concentrations range from the detection limit to the upper concentration limit determined for Hanford Site groundwater. Investigations shall be conducted for double-blind standards that are outside of acceptance limits. The results from these standards are used to determine the acceptability of the associated parameter data.

Table A-5. Field and Laboratory QC Elements and Acceptance Criteria

Method ^a	QC Element	Acceptance Criteria	Corrective Action
General Chemical Parameters			
Alkalinity Conductivity pH	MB ^b	<MDL	Flagged with "C"
	LCS	80-120% recovery ^c	Data reviewed ^d
	DUP	≤20% RPD ^c	Data reviewed ^d
	MS ^e	75-125% recovery ^c	Flagged with "N"
	EB, FTB	<2 times MDL	Flagged with "Q"
	Field duplicate	≤20% RPD ^f	Flagged with "Q"

Table A-5. Field and Laboratory QC Elements and Acceptance Criteria

Method ^a	QC Element	Acceptance Criteria	Corrective Action
Ammonia and Anions			
Anions by IC Cyanide Sulfide	MB	<MDL	Flagged with "C"
	LCS	80-120% recovery ^c	Data reviewed ^d
	DUP	≤20% RPD ^c	Data reviewed ^d
	MS	75-125% recovery ^c	Flagged with "N"
	EB, FTB	<2 times MDL	Flagged with "Q"
	Field duplicate	≤20% RPD ^f	Flagged with "Q"
Metals			
Arsenic Cadmium Chromium Lead Mercury Selenium Thallium ICP metals ICP/MS metals	MB	<CRDL	Flagged with "C"
	LCS	80-120% recovery ^c	Data reviewed ^d
	MS	75-125% recovery ^c	Flagged with "N"
	MSD	≤20% RPD ^c	Data reviewed ^d
	EB, FTB	<2 times MDL	Flagged with "Q"
	Field duplicate	≤20% RPD ^f	Flagged with "Q"
	VOCs		
Volatiles by GC/MS	MB	<MDL	Flagged with "B"
	LCS	Statistically derived ^g	Data reviewed
	MS	Statistically derived ^g	Flagged with "N"
	MSD	Statistically derived ^g	Data reviewed ^d
	SUR	Statistically derived ^g	Data reviewed ^d
	EB, FTB, FXR	<2 times MDL ^h	Flagged with "Q"
	Field duplicate	≤20% RPD ^f	Flagged with "Q"

Table A-5. Field and Laboratory QC Elements and Acceptance Criteria

Method ^a	QC Element	Acceptance Criteria	Corrective Action
Semi-VOCs			
PCBs by GC Phenols by GC Semivolatiles by GC/MS	MB	<2 times MDL	Flagged with “B”
	LCS	Statistically derived ^g	Data reviewed ^d
	MS	Statistically derived ^g	Flagged with “N”
	MSD	Statistically derived ^g	Data reviewed ^d
	SUR	Statistically derived ^g	Data reviewed ^d
	EB, FTB	<2 times MDL ^h	Flagged with “Q”
	Field duplicate	≤20% RPD ^f	Flagged with “Q”

a. Refer to Tables A-2 and A-3 for specific analytical methods.

b. Does not apply to pH.

c. Laboratory-determined, statistically derived control limits may also be used. Such limits are reported with the data.

d. After review, corrective actions are determined on a case-by-case basis. Corrective actions may include a laboratory recheck or flagging the data as suspect (“Y” flag) or rejected (“R” flag).

e. Applies to total organic carbon and total organic halides only.

f. Applies only in cases where one or both results are greater than five times the detection limit.

g. Determined by the laboratory based on historical data. Control limits are reported with the data.

h. For common laboratory contaminants such as acetone, methylene chloride, 2-butanone, toluene, and phthalate esters, the acceptance criteria is less than five times the MDL.

CRDL = contract-required detection limit

MB = method blank

DUP = duplicate

MDL = method detection limit

EB = equipment blank

MS = matrix spike

FTB = full trip blank

PCB = polychlorinated biphenyl

GC/MS = gas chromatography/mass spectrometry

QC = quality control

IC = ion chromatography

RPD = relative percent difference

LCS = laboratory control sample

VOC = volatile organic compound

Data flags:

B, C = possible laboratory contamination (analyte was detected in the associated MB)

N = result may be biased (associated MS result was outside the acceptance limits)

Q = problem with associated field QC sample (blank and/or duplicate results were out of limits)

Holding time is the elapsed time period between sample collection and analysis. The contractor’s environmental QA program plan provides a table with holding times. Exceeding the required holding times could result in changes in constituent concentrations due to volatilization, decomposition, or other chemical alterations. Recommended holding times depend on the analytical method, as specified in SW-846 or *Methods of Chemical Analysis of Water and Wastes* (EPA/600/4-79/020). Data associated with exceeded holding times are flagged with an “H” in the HEIS database. Data that exceed the holding time shall be maintained but potentially may not be used in statistical analyses.

Table A-6. Blind Standard Constituents and Schedule

Constituents	Frequency	Accuracy (%)	Precision (% RSD)*
Nitrate	Quarterly	±25%	≤25%
Chromium	Annually	±20%	≤25%

* If the results are less than five times the required detection limit, then the criterion is that the difference of the results of the replicates is less than the required detection limit.

RSD = relative standard deviation

Additional QC measures include laboratory audits and participation in nationally based performance evaluation studies. The contract laboratories participate in national studies such as the EPA-sanctioned Water Pollution and Water Supply Performance Evaluation studies. The Groundwater Project periodically audits the analytical laboratories to identify and solve quality problems, or to prevent such problems from occurring. Audit results are used to improve performance, and the summaries of audit results and performance evaluation studies are presented in the annual Hanford Site groundwater monitoring report.

Failure of QC will be determined and evaluated during the data validation and the data quality assessment process. Data will be qualified, as appropriate.

A2.6 Instrument/Equipment Testing, Inspection, and Maintenance

Measurement and testing equipment used in the field or in the laboratory that directly affects the quality of analytical data will be subject to preventive maintenance measures to minimize measurement system downtime. Laboratories and onsite measurement organizations must maintain and calibrate their equipment. Maintenance requirements (e.g., documentation of routine maintenance) will be included in the individual laboratory and the onsite organization's QA plan or operating procedures, as appropriate. Maintenance of laboratory instruments will be performed in a manner consistent with SW-846, or with auditable HASQARD and contractual requirements. Consumables, supplies, and reagents will be reviewed in accordance with SW-846 requirements and will be appropriate for their use.

A2.7 Instrument/Equipment Calibration and Frequency

Specific field equipment calibration information is provided in the environmental QA program plan. Standards used for calibration will be certified and traceable to nationally recognized performance standards. Analytical laboratory instruments and measuring equipment are calibrated in accordance with the laboratory's QA plan.

A2.8 Inspection/Acceptance of Supplies and Consumables

Supplies and consumables used to support sampling and analysis activities are procured in accordance with internal work requirements and processes that describe the contractor's acquisition system and the responsibilities and interfaces necessary to ensure that items procured/acquired for contractor meet the specific technical and quality requirements. The procurement system ensures that purchased items comply with applicable procurement specifications. Supplies and consumables are checked and accepted by users prior to use.

Supplies and consumables that are procured by the analytical laboratories are procured, checked, and used in accordance with the laboratory's QA plan.

A2.9 Nondirect Measurements

Nondirect measurements include data obtained from sources such as computer databases, programs, literature files, and historical databases. If evaluation includes data from historical sources, whenever possible such data will be validated to the same extent as the data generated as part of this effort. All data used in evaluations will be identified by source.

A2.10 Data Management

The Sample Management and Reporting organization, in coordination with the RCRA Monitoring and Reporting manager, is responsible for ensuring that analytical data are appropriately reviewed, managed, and stored in accordance with applicable programmatic requirements that govern data management procedures. Electronic data access, when appropriate, will be via a database (e.g., HEIS or a project-specific database). Where electronic data are not available, hardcopies will be provided in accordance with Section 9.6 of the *Hanford Federal Facility Agreement and Consent Order Action Plan* (Ecology et al., 1989b). The HEIS database will be identified as a data repository for the Hanford Facility Operating Record unit file.

All field activities will be recorded in the field logbook.

Laboratory errors are reported to the Sample Management and Reporting organization on a routine basis. For reported laboratory errors, a sample disposition record will be initiated in accordance with contractor procedures. This process is used to document analytical errors and to establish resolution of the errors with the RCRA Monitoring and Reporting manager. Sample disposition records become a permanent part of the analytical data package for future reference and for records management.

A3 Assessment and Oversight

The elements discussed in this section address the activities for assessing the effectiveness of project implementation and the associated QA and QC activities. The purpose of the assessment is to ensure that the QAPjP is implemented as prescribed.

A3.1 Assessments and Response Actions

The contractor management, Regulatory Compliance, Quality, and/or Health and Safety organizations may conduct random surveillances and assessments to verify compliance with the requirements outlined in this QAPjP.

Oversight activities in the analytical laboratories, including corrective action management, are conducted in accordance with the laboratory's QA plan. The primary contractor conducts oversight of offsite analytical laboratories to qualify the laboratories for performing Hanford Site analytical work.

A3.2 Reports to Management

Reports to management on data quality issues will be made if and when these issues are identified. Issues reported by the laboratories are communicated to the Sample Management and Reporting organization, which initiates a sample disposition record in accordance with contractor procedures. This process is used to document analytical or sample issues and to establish resolution with the RCRA Monitoring and Reporting manager.

A4 Data Validation and Usability

The elements in this section address the QA activities that occur after the data collection phase of the project is completed. Implementation of these elements determines whether the data conform to the specified criteria, thus satisfying project objectives. These elements are further discussed in the contractor's environmental QA program plan.

A4.1 Data Review, Verification, and Validation

The criteria for verification may include review for completeness (e.g., all samples were analyzed as requested), use of the correct analytical method/procedure, transcription errors, correct application of dilution factors, appropriate reporting of dry weight versus wet weight, and correct application of conversion factors. Laboratory personnel may perform data verification.

A4.2 Verification and Validation Methods

The work activities shall follow documented procedures and processes for data validation and verification, as summarized below. Validation of groundwater data consists of assessing whether the data collected and measured truly reflect aquifer conditions. Verification means assessing data accuracy, completeness, consistency, availability, and internal control practices to determine overall reliability of the data collected. Other DQOs that shall be met include proper chain-of-custody, sample handling, use of proper analytical techniques as applied for each constituent, and the quality and acceptability of the laboratory analyses conducted.

Groundwater monitoring staff perform checks on laboratory electronic data files for formatting, allowed values, data flagging (i.e., qualifiers), and completeness. Hardcopy results are verified to check for (1) completeness, (2) notes on condition of samples upon receipt by the laboratory, (3) notes on problems encountered during analysis of the samples, and (4) correct reporting of results. If data are incomplete or deficient, staff work with the laboratory to correct the problem found during the analysis.

The data validation process provides the requirements and guidance for validating groundwater data that are routinely collected. Validation is a systematic process of reviewing verified data against a set of criteria (provided in Section A2.5) to determine whether the data are acceptable for their intended use.

Results of laboratory and field QC evaluations, double-blind sample results, laboratory performance evaluation samples, and holding-time criteria are considered when determining data usability. Staff review the data to identify whether observed changes reflect changes in groundwater quality or potential data errors, and they may request data reviews of laboratory, field, or water-level data for usability purposes. The laboratory may be asked to check calculations or re-analyze the sample, or the well may be resampled. Results of the data reviews are used to flag the data appropriately in the HEIS database (e.g., "R" for reject, "Y" for suspect, or "G" for good) and/or to add comments.

A4.3 Reconciliation with User Requirements

The data quality assessment 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 data evaluation is to determine if quantitative data are of the correct type and are of adequate quality and quantity to meet project DQOs. The RCRA Monitoring and Reporting manager is responsible for determining if data quality assessment is necessary and for ensuring that, if required, one is performed. The results of the data quality assessment will be used in interpreting the data and determining if the objectives of this activity have been met.

A5 References

- 10 CFR 830, “Nuclear Safety Management,” Subpart A, “Quality Assurance Requirements,” *Code of Federal Regulations*. Available at: <http://ecfr.gpoaccess.gov/cgi/t/text/text-idx?c=ecfr&rgn=div6&view=text&node=10:4.0.2.5.26.1&idno=10>.
- 40 CFR 265, “Interim Status Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities,” *Code of Federal Regulations*. Available at: http://www.access.gpo.gov/nara/cfr/waisidx_10/40cfr265_10.html.
- 40 CFR 265.93, “Preparation, Evaluation, and Response.”
- 40 CFR 265.94, “Recordkeeping and Reporting.”
- 40 CFR 265, Subpart F, “Ground-Water Monitoring.”
- ANSI/ASQ E4-2004, 2004, *Quality Systems for Environmental Data and Technology Programs: Requirements with Guidance for Use*, American National Standards Institute/American Society for Quality, Milwaukee, Wisconsin.
- Atomic Energy Act of 1954*, 42 USC 2011, et seq. Available at: <http://www.nrc.gov/reading-rm/doc-collections/nuregs/staff/sr0980/v1/sr0980v1.pdf#page=13>.
- AWWA, APHA, and WEF, 2005, *Standard Methods for the Examination of Water and Wastewater*, 21st ed., American Water Works Association, Denver, Colorado; American Public Health Association, Washington, D.C.; and Water Environment Federation, Alexandria, Virginia.
- Comprehensive Environmental Response, Compensation, and Liability Act of 1980*, 42 USC 9601, et seq., Pub. L. 107-377, December 31, 2002. Available at: <http://epw.senate.gov/cercla.pdf>.
- DOE O 414.1D, 2011, *Quality Assurance*, U.S. Department of Energy, Washington, D.C. Available at: <https://www.directives.doe.gov/directives/0414.1-BOrder-d>.
- DOE/RL-96-68, 2007, *Hanford Analytical Services Quality Assurance Requirements Documents*, Rev. 3, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: <http://www.hanford.gov/orp/?page=141&parent=14>.
- DOE/RL-2011-118, 2012, *Hanford Site Groundwater Monitoring for 2011*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington.
- Ecology, EPA, and DOE, 1989a, *Hanford Federal Facility Agreement and Consent Order*, 2 vols., as amended, Washington State Department of Ecology, U.S. Environmental Protection Agency, and U.S. Department of Energy, Olympia, Washington. Available at: <http://www.hanford.gov/?page=81>.
- Ecology, EPA, and DOE, 1989b, *Hanford Federal Facility Agreement and Consent Order Action Plan*, Washington State Department of Ecology, U.S. Environmental Protection Agency, and U.S. Department of Energy, Olympia, Washington. Available at: <http://www.hanford.gov/?page=82>.
- EPA/240/B-01/003, 2001, *EPA Requirements for Quality Assurance Project Plans*, EPA QA/R-5, Office of Environmental Information, U.S. Environmental Protection Agency, Washington, D.C. Available at: <http://www.epa.gov/QUALITY/qs-docs/r5-final.pdf>.

EPA/600/4-79/020, *Methods of Chemical Analysis of Water and Wastes*, U.S. Environmental Protection Agency, Office of Research and Development, Cincinnati, Ohio. Available at: <http://www5.hanford.gov/arpir/?content=findpage&AKey=D196018581>.

EPA/600/4-84-017, 1984, *Test Methods for Determination of Inorganic Anions in Water by Ion Chromatography*, Method 300.0, U.S. Environmental Protection Agency, Washington, D.C.

Resource Conservation and Recovery Act of 1976, 42 USC 6901, et seq. Available at: <http://epw.senate.gov/rcra.pdf>.

SW-846, 2007, *Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, Third Edition; Final Update IV-B*, as amended, Office of Solid Waste and Emergency Response, U.S. Environmental Protection Agency, Washington, D.C. Available at: <http://www.epa.gov/epawaste/hazard/testmethods/sw846/online/index.htm>.

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

WAC 173-303-330, "Personal Training."

WAC 173-303-400, "Interim Status Facility Standards."

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