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Site-Specific SST Phase 1 RFI/CMS Work Plan Addendum for WMA B-BX-BY

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Abstract: This site-specific work plan addendum for WMA B-BX-BY addresses vadose zone characterization plans for collecting and analyzing sediment samples.

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SITE-SPECIFIC SST PHASE 1 RFI/CMS WORK PLAN ADDENDUM FOR WMA B-BX-BY

May 15, 2000

Prepared for
U.S. Department of Energy
Office of River Protection

Prepared by
CH2M Hill Hanford Group, Inc.

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LIST OF TERMS

bgs	below ground surface
CMS	corrective measures study
CoCs	contaminants of concern
DOE	U.S. Department of Energy
DQO	data quality objectives
Ecology	Washington State Department of Ecology
HWMA	Hazardous Waste Management Act
ICM	interim corrective measure
ITS	in-tank solidification
RCRA	*Resource Conservation and Recovery Act of 1976*
RFI	RCRA facility investigation
SST	single-shell tank
TSD	treatment, storage, and/or disposal
WMA	waste management area

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1.0 INTRODUCTION

This Site-Specific Single-Shell Tank (SST) Phase 1 *Resource Conservation and Recovery Act of 1976* (RCRA) Facility Investigation/Corrective Measures Study (RFI/CMS) Work Plan Addendum for Waste Management Area (WMA) B-BX-BY has been prepared to collect field characterization data in and near WMA B-BX-BY to support RFI/CMS decision making. This WMA B-BX-BY addendum is necessary to identify and plan characterization efforts as part of an RFI. An RFI is covered under the categorical exclusion for *State Environmental Policy Act* and *National Environmental Policy Act*.

Documented in this WMA B-BX-BY addendum are the agreements made through a data quality objectives (DQO) process except for sediment sampling of proposed RCRA groundwater monitoring wells. These agreements include the tasks, project responsibilities, and schedule for the next characterization effort to fulfill proposed Milestone M-45-53 (Ecology et al. 1999). The field characterization efforts include the collection of vadose zone data from the following:

- Installation and sampling of two vertical boreholes (east-northeast of tank BX-102 and north of tank B-110) to groundwater
- Shallow vadose zone soil investigation in the vicinity of tanks B-110, BX-102, BX-107, and BX-110 and the diversion boxes (241-B-151, -152, and -153) in B tank farm
- Vadose zone sediment sampling of proposed RCRA groundwater monitoring wells south and southwest of BX tank farm.

1.1 BACKGROUND

The Hanford Federal Facility Agreement and Consent Order (Ecology et al. 1998), commonly referred to as the Tri-Party Agreement, that is signed by the Washington State Department of Ecology (Ecology), the U.S. Environmental Protection Agency, and the U.S. Department of Energy (DOE), addresses cleanup at more than 2,000 waste disposal and unplanned release sites on the Hanford Site. Some of these sites are treatment, storage, and/or disposal (TSD) units that have been grouped into WMAs for the purpose of groundwater monitoring. Included in the WMAs are 149 SSTs that are TSD units regulated under the Washington State "Hazardous Waste Management Act" (HWMA) and its implementing requirements (WAC 173-303).

The SSTs currently are operating under interim status pending closure. The tank farms will be closed under the HWMA and Major Milestone series M-45-00 of the Tri-Party Agreement (Ecology et al. 1998). The 149 SSTs are grouped into 12 SST farms, which are in turn grouped into 7 WMAs for purposes of HWMA groundwater assessment and monitoring. To date, tank leaks and past-practice releases of tank waste including dangerous waste and dangerous waste constituents have resulted in groundwater contamination documented at four of the seven SST WMAs (i.e., S-SX, B-BX-BY, T, and TX-TY). DOE has initiated a corrective action program to address the impacts of past and potential future tank waste releases to the environment. A Phase 1 RFI/CMS work plan (DOE/RL-99-36) has been issued that establishes the overall framework and requirements for the program. This addendum presents details specific to WMA B-BX-BY.

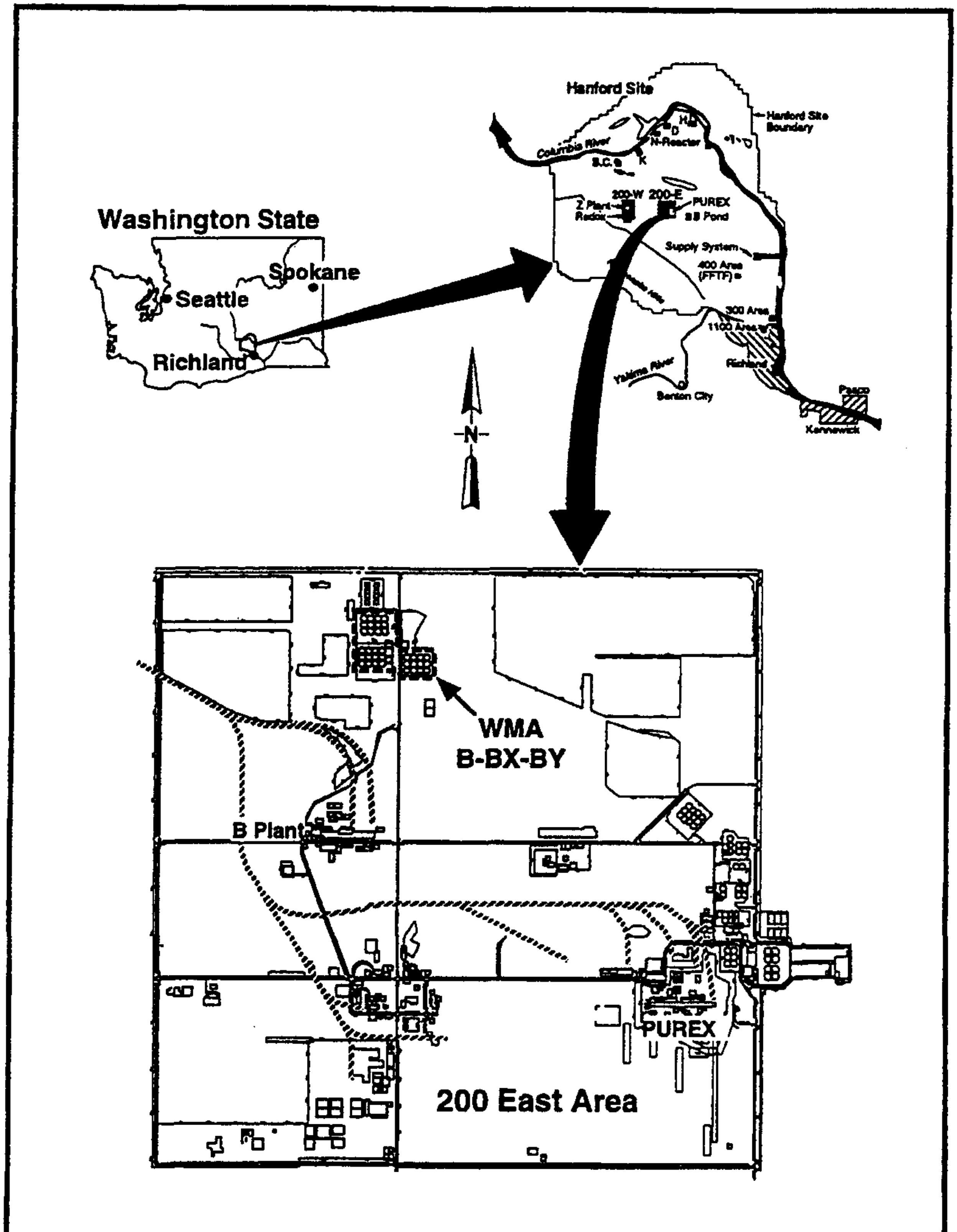
The investigation activities outlined in this WMA B-BX-BY addendum will be managed by the Tank Farm Vadose Zone Project as an integrated function of the Hanford Site Groundwater/Vadose Zone Integration Project. This WMA B-BX-BY addendum is a Tri-Party Agreement primary document submitted to Ecology for review and approval pursuant to proposed Milestone M-45-53 (Ecology et al. 1999).

The B, BX, and BY tank farms are regulated under HWMA interim status regulations (WAC 173-303-400) (Figure 1.1). The B, BX, and BY tank farms comprise WMA B-BX-BY, which was placed in assessment groundwater monitoring in June 1996 because of elevated specific conductance in downgradient monitoring wells (WHC-SD-EN-AP-002). Technetium-99, uranium, and nitrate are the only constituents to have exceeded drinking water standards. The drinking water exceedances in the RCRA-compliant monitoring wells are currently limited to two wells (299-E33-41 and 299-E33-44) located along the east side of the BY tank farm (see Section 3.1.4).

In fiscal year 1997, spectral gamma logging (i.e., collection of baseline gamma-specific radioisotope information in the upper vadose zone) was completed at the BX tank farm. Spectral gamma logging was completed at the BY tank farm in fiscal year 1996. Spectral gamma logging was completed at the B tank farm in fiscal year 1998. The spectral gamma logging program builds on a previous program in which gross gamma data were collected as a means of leak detection from the SSTs. Both programs used the network of drywells installed around each tank in each SST farm. In February 1997, the final report on spectral gamma logging at the BY tank farm (GJO-HAN-6) indicated that the contaminant cesium-137 was present at a maximum depth of 30.5 m (100 ft) below ground surface (bgs) (total depth of borehole) near tank BY-103. Several other high cesium-137 concentrations were detected in the boreholes; however, these concentrations were associated with near-surface contamination resulting from surface spills, pipe leaks, or the proximity of the boreholes to pipes containing contamination. In August 1998, the final report on spectral gamma logging at the BX tank farm (GJO-HAN-19) indicated that contaminants cesium-137, cobalt-60, uranium-235, uranium-238, antimony-125, europium-152 and europium-154 were detected throughout the 45.7-m (150-ft) depths of several of the boreholes in the eastern portion of the tank farm. The March 2000 final report on spectral gamma logging at the B tank farm (GJO-HAN-28) indicated that contaminants cesium-137, cobalt-60, europium-152, europium-154, and uranium-235 were detected in the boreholes. The network of drywells installed around each tank was intended for leak detection and was generally installed between depths of 22.8 m and 45.7 m (75 to 150 ft) bgs, thus the maximum detection depth is limited by the drywell depth.

A groundwater assessment monitoring report that focused on contaminants in the underlying unconfined aquifer has been completed (PNNL-11826). Except for alterations for clarity, major findings summarized in the report are as follows.

Figure 1.1. Location Map of WMA B-BX-BY Single-Shell Tanks and Surrounding Facilities in the 200 East Area



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- In 1997 and 1998, elevated concentration levels of technetium-99, nitrate, chloride, sulfate, and sodium in well 299-E33-41 appear to be related to remobilized tank waste that has reached groundwater from the WMA. The trend plot exhibits characteristics of high-amplitude, high-frequency events that when combined with the well's proximity to a known tank leak vadose zone plume and with documentation of local water driving forces indicate that this WMA contributed to the observed contamination. Data reported in February 1997 showed technetium-99 was 6 times the drinking water standard of 900 pCi/L. Early August 1997 data reported technetium-99 as 13 times the drinking water standard.

- Based on (1) the vadose zone contamination found in 1991 during drilling of well 299-E33-41, (2) the existence of perched water and saturated sediments, (3) the rapid drop in water level shortly after well completion, and (4) the documented events of nearby artificial water releases at the surface, it is likely that the groundwater contamination taken from well 299-E33-41 is remobilized tank waste in the vadose zone from a leak of 340,650 L (90,000 gal) associated with tank BX-102 that occurred in 1951.

- The rising technetium-99 and nitrate concentration levels from 1996 to August 1997 on the west side of the WMA in wells 299-E33-42, 299-E33-31, and 299-E33-32 may be related to release from the WMA or from BX trenches to the west of these wells. As evidenced with the August 1997 data, however, the source is still not determined. Contamination concentrations are still increasing.

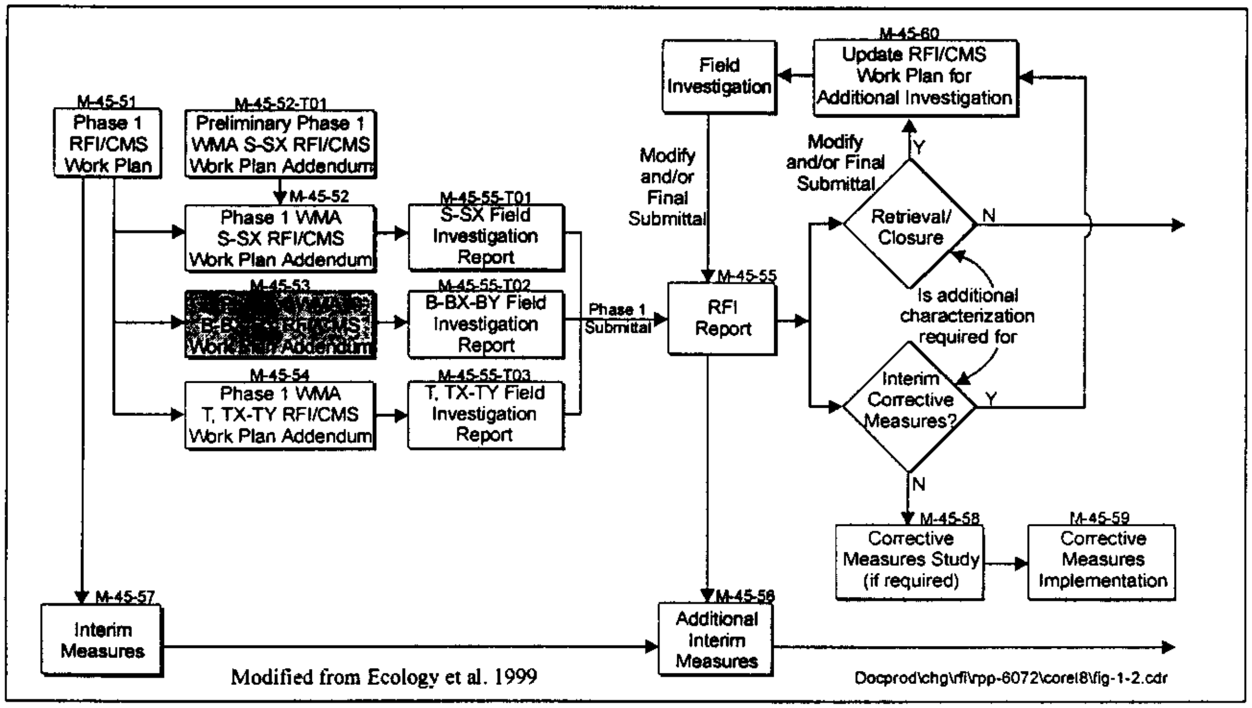
- The contamination observed at well 299-E33-41 appears to have recently (August 1997) entered the groundwater as evidenced by the sudden sharp rise in anions, sodium, and technetium-99. Furthermore, the contamination events are localized and the concentrations are low when compared directly to waste stored in the SSTs. Consequently, the overall impact on groundwater quality may be small, especially when compared to the large regional contaminant plumes that currently exist in the northern portion of the 200 East Area.

Based on the results of the groundwater assessment, on July 10, 1998, Ecology requested that DOE develop and submit a corrective action plan for the four WMAs with documented leaks (i.e., S-SX, B-BX-BY, T, and TX-TY).

Pursuant to the proposed Tri-Party Agreement Change Control Form Number M-45-98-03 (Ecology et al. 1999) and Phase 1 RFI/CMS work plan (DOE/RL-99-36), the RCRA Corrective Action process is used to establish the framework within which vadose zone investigations are planned and carried out.

The initial sequence of investigations included initiation of preliminary characterization efforts in fiscal year 1999 in WMA S-SX based on the preliminary addendum (HNF-4380) and characterization of the remainder of WMA S-SX (HNF-5085) followed by characterization of WMAs B-BX-BY (Figure 1.2), and T, and TX-TY. *All of these efforts will be based on the* Phase 1 RFI/CMS work plan (DOE/RL-99-36) and site-specific SST Phase 1 RFI/CMS work plan addenda for all four WMAs (proposed Milestones M-45-52, M-45-53, and M-45-54).

Figure 1.2. Proposed Tri-Party Agreement Milestones for Corrective Actions



1.2 PURPOSE AND OBJECTIVE

The Phase 1 RFI/CMS work plan (DOE/RL-99-36) established the objectives of the characterization effort for the four WMAs that are a part of the RCRA corrective action process. The objectives of the investigative efforts identified in this WMA B-BX-BY addendum are as follows:

- Collect data to support an improved understanding of the nature and extent of contaminants in the vadose zone from surface to groundwater
- Collect data to support an improved understanding of vadose zone parameters affecting contaminant fate and transport required to perform risk assessments
- Provide WMA-specific information on source, nature, and extent of contamination for the planned activities in Section 1.3
- Provide WMA-specific characterization programs to address information gaps identified through a DQO process
- Support the Phase 1 RFI/CMS work plan objectives.

The DQO process was completed from March through April 2000 (HNF-6020). The DQO process included participation by Ecology and DOE (the decision makers), the Hanford Site Vadose Zone/Groundwater Integration Project, stakeholders, Tribal Nations, Oregon Department of Energy, and Hanford Site contractors. Meetings held as part of the DQO process involved varying levels of involvement by all participants. Meetings were held between the decision makers with input from Site contractors and DQO process participants.

The DQO process (HNF-6020) resulted in identification of activities to collect vadose zone data to support the objectives outlined in Section 1.3 and in this section. The process included meetings to complete a review of existing data, define the problem, identify and prioritize decisions, identify the input required to make decisions, and boundaries for the decisions. The meetings also addressed decision rules and uncertainty and sampling and analysis alternatives. The focus of the DQO process for the WMA B-BX-BY addendum was on sampling and analysis alternatives. These alternatives and the decisions made by Ecology and DOE based on the alternatives are documented in Chapter 4.0 and HNF-6020.

1.3 SCOPE OF ACTIVITIES

The characterization effort at WMA B-BX-BY identified in this addendum will address the following:

- Installation of two new boreholes, one in BX tank farm and one in B tank farm
- Performance of direct pushes in the southern portion of B tank farm, and eastern and southern portion of the BX tank farm for near-surface characterization
- Integration with the Hanford Site Groundwater Monitoring Project to collect vadose zone data from the installation of RCRA groundwater monitoring wells downgradient of WMA B-BX-BY.

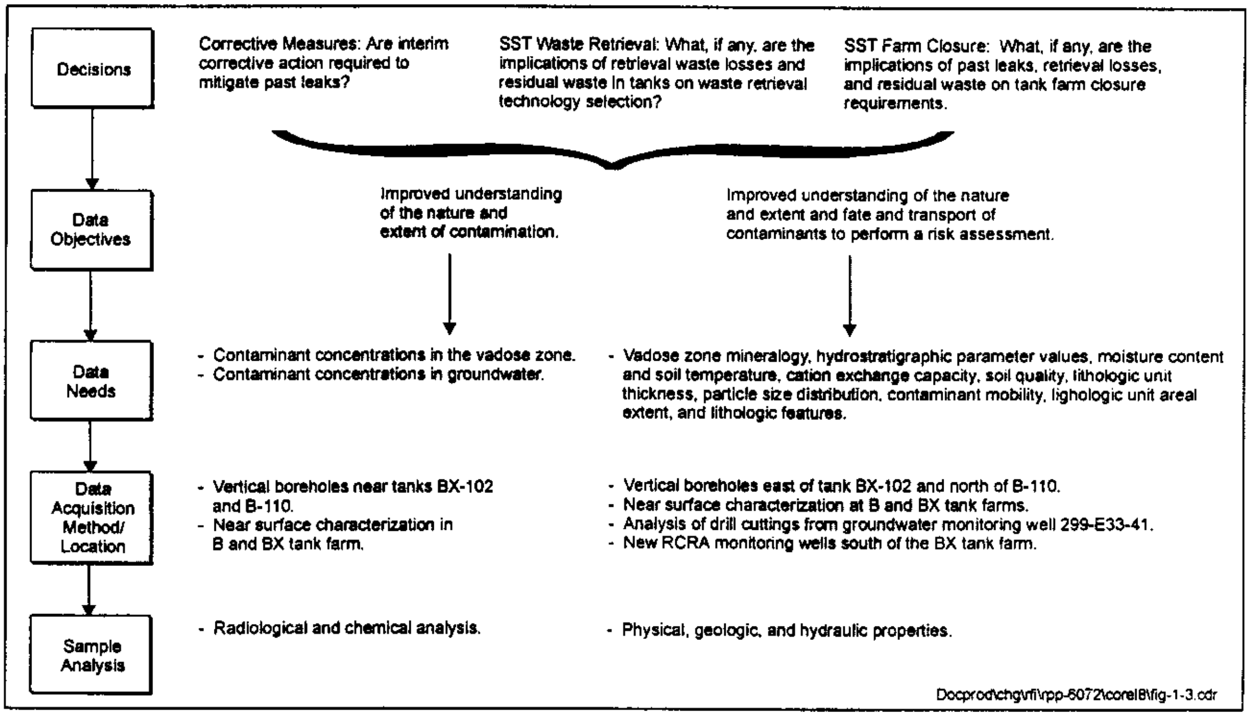
These activities support the following objectives (1) development of a best-estimate of the concentration and distribution of contaminants of concern (CoCs) in WMA B-BX-BY, (2) refinement of a conceptual model for concentration, distribution, and mobility of contaminants in WMA B-BX-BY, (3) quantification of the risks posed by migration of past tank waste releases to the groundwater if no interim corrective measures (ICMs) are implemented, and (4) determination of whether interim measures or ICMs would effectively contribute to the mitigation of contaminant migration to groundwater to levels that would not pose unacceptable risk to human health and the environment before tank farm closure. Risk assessments conducted in support of retrieval and closure decisions will be performed in the future and will include the potential contribution or reduction in risk as a result of ICMs.

In addition to the characterization activities, a separate implementation plan is included as an appendix to the Phase 1 RFI/CMS work plan (DOE/RL-99-36). This implementation plan will bridge the gap between the generalities in DOE/RL-99-36 and the specifics of this addendum. The implementation plan provides the approach to ensuring the availability of data required to complete the analyses and evaluations that would be included in the field investigation report for proposed target milestone M-45-55-T02 as shown in Figure 1.2. A similar plan will be provided for WMAs T and TX-TY as work proceeds. Ecology approval of the implementation plan is not necessary before fieldwork begins.

1.4 SELECTION OF FIELD ACTIVITIES

Based on input from Ecology and DOE and input from the DQO participants, the characterization activities in support of the objectives and data needs identified for this addendum are illustrated in Figure 1.3. The following summarize the decisions reached by Ecology and DOE based on the DQO process:

Figure 1.3. DQOs and Data Needs



- **Shallow vadose zone soil investigation** – This investigation will collect sediment samples via direct-push technology (1) in the southern portion of B tank farm, (2) between tanks B-110 and B-111 in the B tank farm, (3) two transects in the eastern portion of BX tank farm, and (4) between tanks BX-110 and BX-107 in the BX tank farm. The shallow investigation will comprise collecting sediment samples at approximately 31 areal locations between ground surface and the base of the tanks. Base of the tanks are approximately 11.2 m (37 ft) for B and BX tank farms. The main emphasis will be on characterizing unplanned releases within these areas of concern. For the investigation at tank B-110, the shallow vadose zone soil investigation will be used to delineate the optimal location for the new vertical borehole.

- **Installation of new vertical exploratory boreholes east of tank BX-102 and north of tank B-110** – The DQO process resulted in the identification of several potential locations for the proposed new boreholes. Locations north-northeast of tank BX-102 and north of tank B-110 were selected based on spectral gamma data, groundwater quality data, and historical process knowledge. These locations are near past leak events either from the tank or a transfer line. The new boreholes will be installed using a drive-and-sample technique to reduce the likelihood of cross-contamination resulting from penetration through the highly contaminated zones. Collection of sediment samples will be attempted from about 3 m (10 ft) bgs to just below the water table on 3-m (10-ft) intervals. The water table is expected to be encountered at a depth of 78 m (256 ft) bgs. Selected portions of the samples will be analyzed for chemical, radiological, and physical characteristics. A suite of geophysical surveys will be performed, and groundwater samples will be collected for chemical and radiological analysis. The new boreholes may be completed as RCRA-compliant groundwater monitoring wells if technetium-99 is detected at concentrations exceeding 5 times (4,500 pCi/L) the drinking water standard (900 pCi/L). If so, the new wells will be included in the RCRA groundwater monitoring network for routine groundwater sampling and analysis. If not completed as RCRA-compliant groundwater wells, then the boreholes will be decommissioned in accordance with WAC 173-160.

- **Collection of vadose zone characterization data from proposed RCRA groundwater monitoring wells** – Vadose zone samples will be collected during the installation of proposed RCRA groundwater monitoring wells planned in support of the ongoing RCRA groundwater monitoring effort. The RCRA groundwater monitoring wells are to aid in determining groundwater flow direction in the WMA B-BX-BY area. Continuous drill cuttings will be collected and geologically described from these proposed wells. Selected portions of the drill cuttings will be analyzed for physical, hydraulic, and chemical properties. A detailed description of the work associated with the installation of these monitoring wells is being developed by the Hanford Site Groundwater Monitoring Project. Only details associated with the collection and analysis of drill cuttings are provided in this addendum (Sections 4.3.4 and 5.2.1.3).

The rationale and approach to these decisions are addressed in Section 4.0 of this work plan and in HNF-6020. At this time, no vadose zone characterization is planned for the BY tank farm based on the lack of supporting data from process history knowledge and spectral gamma data. However, future vadose zone characterization planning activities will address the need for data from the BY tank farm.

1.5 ORGANIZATION OF THE WMA B-BX-BY ADDENDUM

Nine chapters and one appendix are included in this WMA B-BX-BY addendum. The addendum is structured to provide information necessary to initiate the field investigations at WMA B-BX-BY in fiscal year 2000. The chapters and appendix include the following:

- **Chapter 1.0** – Introduction to the WMA B-BX-BY addendum that provides an overview of the issues and technical approach detailed in the remainder of the addendum
- **Chapter 2.0** – Overview of the physical and environmental setting of WMA B-BX-BY
- **Chapter 3.0** – Summary of the available data on potential contaminant exposure pathways that will be used to develop a conceptual exposure pathway model for WMA B-BX-BY needed to assess compliance with Federal and state environmental

standards, requirements, criteria, or limitations that may be considered potential corrective action requirements, and potential impacts to human health and the environment

- **Chapter 4.0** – Presentation of the rationale and approach for the field investigations
- **Chapter 5.0** – Presentation of the tasks and activities necessary to conduct field investigations
- **Chapter 6.0** – The schedule for the site-specific investigations focused on vadose zone-related aspects of WMA B-BX-BY in accordance with the tasks and activities discussed in Chapter 5.0
- **Chapter 7.0** – Description of the project management tasks necessary to implement the field investigation activities, including responsibilities, organizational structure, and project tracking and reporting procedures. Interfaces with tank farm operations activities and other DOE or contractor activities planned in or surrounding the tank farm addressed in this addendum
- **Chapter 8.0** – References used to develop the WMA B-BX-BY addendum
- **Chapter 9.0** – Glossary of terms that are used in this addendum
- **Appendix A** – Sampling and Analysis Plan.

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2.0 BACKGROUND AND SETTING

The B, BX, and BY tank farm SSTs are HWMA TSD units located in the northern portion of the 200 East Area. Waste in the SSTs consists of liquid, sludges, and salt cake (i.e., crystallized salts). Over the years, much of the liquid stored in the SSTs has been evaporated or pumped to double-shell tanks.

The B, BX, and BY tank farms comprise WMA B-BX-BY. The tanks are interim status TSD units pending closure that must be operated, permitted, and maintained in compliance with the following:

- RCRA
- Washington State dangerous waste program regulations (WAC 173-303)
- Tri-Party Agreement Milestones M-45-00 and M-24-00 (Ecology et al. 1998)
- Proposed Tri-Party Agreement Milestones M-45-51, and M-45-53 (Ecology et al. 1999).

WMA B-BX-BY historically received hazardous or dangerous waste, but SSTs in WMA B-BX-BY are out of service (i.e., no additional waste has been added) and will be closed in accordance with Tri-Party Agreement Milestone M-45-00, which specifies WAC 173-303-610 (Closure and Postclosure). An SST closure work plan (DOE/RL-89-16) has been prepared but is scheduled for revision and resubmittal to Ecology. Sampling and analysis plans for closure are not included in the closure work plan. Post-closure permit applications would be required to support the closure plans submitted to Ecology. Post-closure permit applications may be required if dangerous waste is left in place (e.g., closure as a landfill) or if modified closure is required (Ecology 1998). The procedures are consistent with the Tri-Party Agreement (Ecology et al. 1998).

2.1 SITE DESCRIPTION

Information and data relevant to the RFI/CMS investigations at the B, BX, and BY tank farm facilities were largely obtained from the historical tank content estimate for the northeast quadrant of the Hanford Site 200 East Area (WHC-SD-WM-ER-349). This work plan updates and augments information from the subsurface condition description of WMA B-BX-BY (HNF-5507). The location, history of operations, leak detection systems, and interaction of WMA B-BX-BY with other surrounding past-practice facilities are discussed in the following subsections.

2.1.1 Location

The B, BX, and BY tank farms are located in the northern portion of the 200 East Area near B Plant (Figure 1.1). The SSTs in these tank farms are 23 m (75 ft) in diameter, except for 4 SSTs in B tank farm that are 6.1 m (20 ft) in diameter. The B tank farm contains 12 SSTs each with 2,006,050-L (530,000-gal) capacity, 4 SSTs each with 208,175-L (55,000-gal) capacity, waste transfer lines, leak detection systems, and tank ancillary equipment. The BX tank farm contains 12 SSTs each with 2,006,050-L (530,000-gal) capacity, waste transfer lines, leak detection systems, and tank ancillary equipment. The BY tank farm contains 12 SSTs each with 2,869,030-L (758,000-gal) capacity, waste transfer lines, leak detection systems, and tank ancillary equipment. The B and BX tank farm SSTs are approximately 9.07 m (29.75 ft) tall from base to dome. The SSTs in BY tank farm and the small SSTs in B tank farm are approximately 11.4 m (37.25 ft) tall from base to dome (HNF-EP-0182-141).

The sediment cover from the apex of the dome to ground surface is 2.5 m (8.1 ft) at the BY tank farm, and 2.2 m (7.3 ft) at the B and BX tank farms (HNF-EP-0182-141). The smaller SSTs in B tank farm are approximately 0.3 m (1 ft) above ground surface (HNF-EP-0182-141). All of the tanks have a dish-shaped bottom (Figure 2.1). The 23 m (75 ft) diameter SSTs were constructed with cascade overflow lines in a three-tank series that allowed gravity flow of liquid waste between the tanks. The end of the cascade series in the BX tank farm is hooked to the first cascade tank in the BY tank farm (WHC-SD-WM-ER-349). The cascade overflow height for B and BX tank farm SSTs is 4.78 m (15.67 ft) from the tank bottom, while the cascade overflow height for BY tank farm SSTs is 6.91 m (22.67 ft) from the tank bottom (WHC-SD-WM-ER-349). Figures 2.2, 2.3, and 2.4 show B, BX, and BY tank farm SSTs and associated drywells.

2.1.2 History of Operations

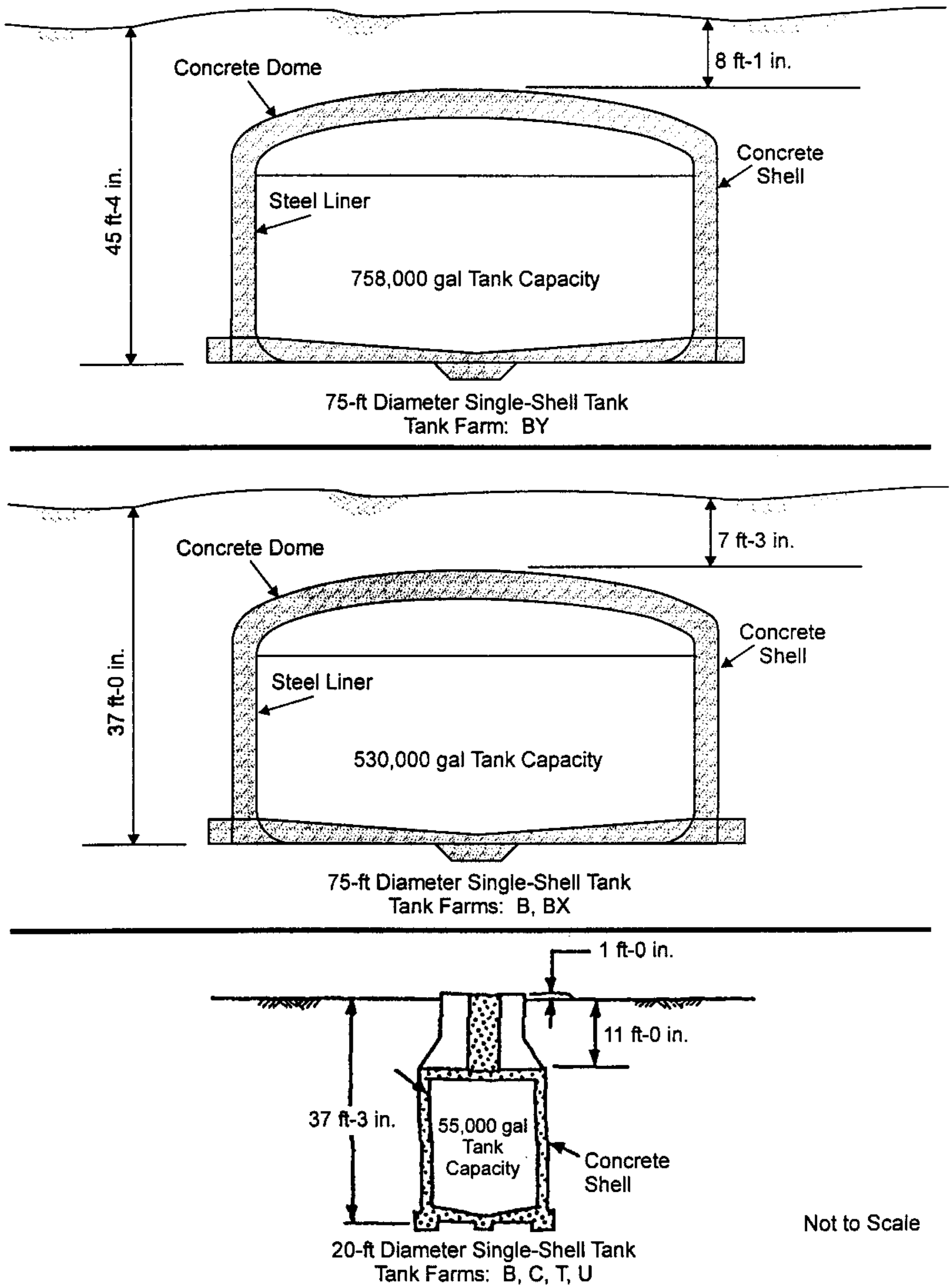
The B tank farm was built from 1943 to 1944. The BX tank farm was built from 1946 to 1947. BY tank farm was constructed during 1948 and 1949 (WHC-SD-WM-ER-349). From 1947 through 1949, BX and BY tank farms and other cribs, notably crib 216-B-8, were constructed to handle the large volumes of generated waste. Each tank farm contains 12 tanks except for B tank farm, which contains 16 tanks. The B-BX-BY tank farm complex has received waste generated by a variety of major chemical processing operations.

In 1945, the B tank farm tanks began receiving bismuth phosphate wastes from B Plant. Because of limited tank space, intentional discharge of bismuth phosphate wastes to the soil column began in 1946 in reverse well 216-B-5 and then to 216-B-7A and B-7B cribs. The initial processing operation was bismuth phosphate plutonium extraction, which generated large amounts of waste requiring storage and, frequently, disposal.

From 1948 through 1951, the 216-B-8 crib was the primary discharge facility, receiving approximately 2.7×10^7 L (7.13×10^6 gal) of waste. To improve liquid reduction, evaporator 242-B was built in 1951 and began shipping condensate to reverse wells 216-B-11A and -11B. However, the evaporator process was diverted to a different waste stream and the last large-scale disposal (1.33 million L [3.51×10^5 gal]) of bismuth phosphate waste into the BX trenches occurred in 1954.

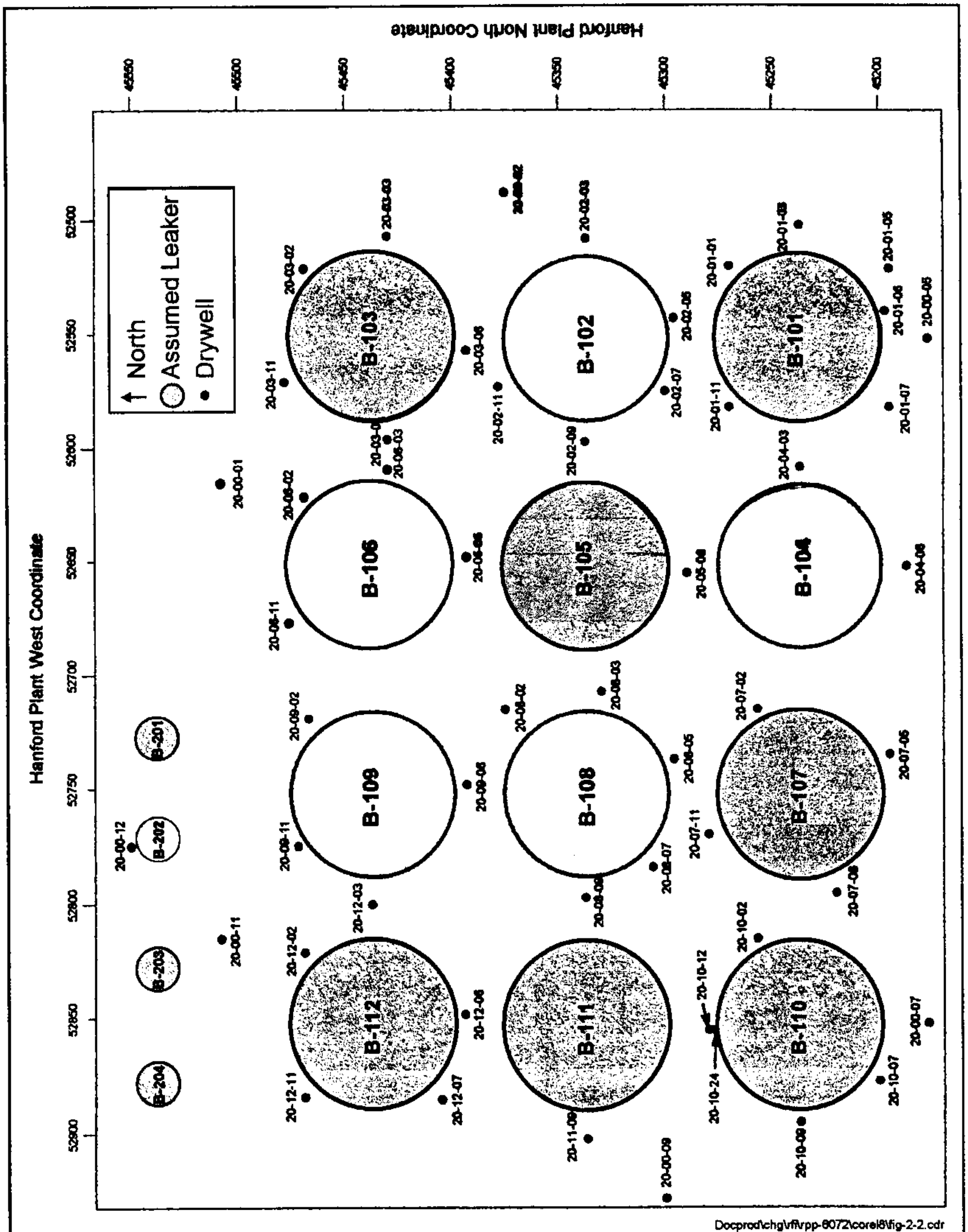
Substantial amounts of uranium were present in the B, BX, and BY tanks from the initial waste, produced by the bismuth phosphate process. This waste was called metal waste. The metal waste consisted of all the uranium from the bismuth phosphate process, approximately 90% of the original fission products activity, and approximately 1% of the original product from the process. The metal waste was brought just to the neutral point with 50% caustic and then treated with an excess of sodium carbonate as part of the bismuth phosphate process at the tank farms. The procedure yielded almost completely soluble waste at a minimum volume. The exact composition of the carbonate complex is unknown but was assumed to be a uranium phosphate-carbonate mixture.

Figure 2.1. General Configuration of Tanks in WMA B-BX-BY



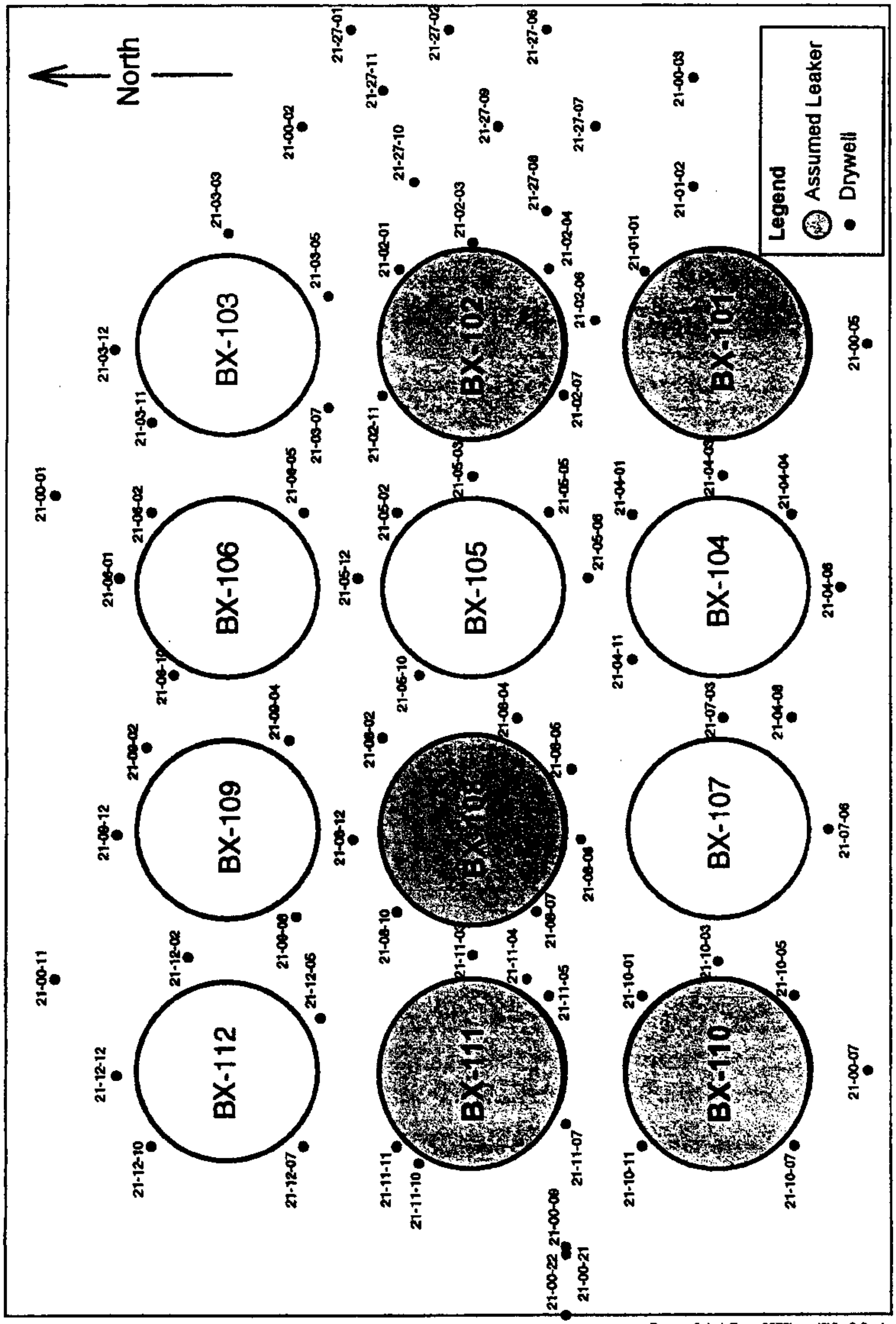
(Adapted from HNF-EP-0182-141)

Figure 2.2. Plan View of the Tanks and Boreholes in the B Tank Farm



Source: GJO-HAN-28

Figure 2.3. Plan View of the Tanks and Boreholes in the BX Tank Farm



Source: GJO-HAN-19

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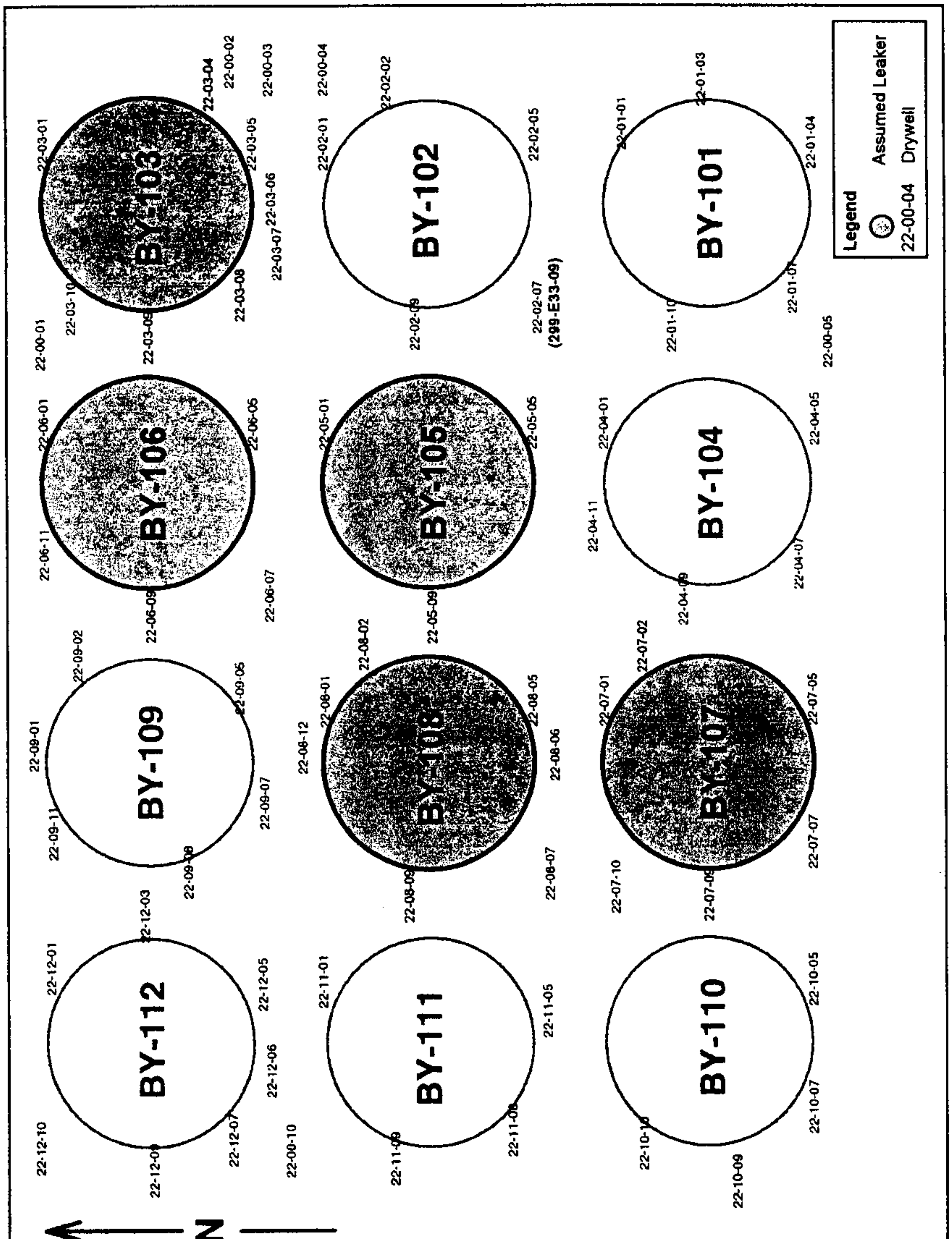
Figure 2.4. Plan View of the Tanks and Boreholes in the BY Tank Farm



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A need arose for uranium and the most readily available source was the metal waste in the tanks. Beginning in 1952, metal waste was sluiced from the tanks and sent to U Plant where uranium was extracted. Tributyl phosphate waste generated from the uranium removal process was returned to evaporator 242-B to reduce waste volume. A ferrocyanide treatment also was used to remove excess cesium-137 and strontium-90 from the liquid waste by precipitation. The liquid waste ultimately was disposed of in the BY cribs and BX trench 216-B-42 in 1954 and 1955. In all, about 34 million L (9 million gal) of liquid waste was discharged to the BY cribs and 1.5 million L (400,000 gal) of liquid waste were discharged to BX trench 216-B-42.

Following completion of the uranium recovery program, concern about potential tank leakage grew and a decision was made to remove excess liquid from the tanks. Consequently, the in-tank solidification (ITS) program was initiated. The ITS program comprised heating the air inside the tanks to promote evaporation. The first ITS program, ITS#1, used heated air circulated through tanks BY-101 and BY-102 beginning in 1965. As modification ITS#2, heaters were installed in the tanks beginning in 1968. This program lasted until 1974 when a decision was made to use salt well pumping, a more efficient method of reducing liquid. Condensate from ITS#1 (5.9×10^7 L [1.56×10^7 gal]) was sent to crib 216-B-50 and condensate from ITS#2 (8.4×10^7 L [2.22×10^7 gal]) was sent to crib 216-B-57.

The salt well pumping program replaced the ITS program in 1975 to accelerate removal of all excess liquid in the tanks as the first step in achieving a condition known as interim stabilization. Initially, pumped tank liquid passed through tank BX-104 through diversion box 241-ER-151 to evaporators 242-S and 242-A. In 1983, double-contained receiver tank 244-BX was constructed to replace tank BX-104 as the receiver for pumped tank liquids.

From 1967 to 1979, the B Plant was reactivated as an isotope recovery and storage facility. The primary focus was on recovering cesium-137 and strontium-90 from tank waste and plutonium-uranium extraction and reduction-oxidation process streams. Several waste streams were generated during this phase of B Plant operations (LA-UR-96-3860). Some of the B Plant isotope recovery programs used organic complexing agents extensively to facilitate specific radionuclide separations (LA-UR-96-3860). Many of the organic complexing agents ended up in the high-level waste stream coming from the B Plant. The B Plant high-level waste stream and low-activity waste streams were routed to tanks in the B, BX, and BY tank farms.

All of the tanks were removed from service (i.e., no new additions of waste) in the late 1970s through 1980 (WHC-SD-WM-ER-349) and have been interim isolated or partially interim isolated. All tanks except for BY-105 and BY-106 have been interim stabilized. Tanks BY-105 and BY-106 are scheduled to be interim stabilized in 2003 (HNF-EP-0182-141). Table 2.1 lists the volume of waste currently stored in the B, BX, and BY tanks (HNF-EP-0182-141). Previous evaluations have screened the universe of radiological and chemical constituents in the tanks and identified those constituents potentially associated with the SST system. The results of those screenings are provided in Section 3.0 of the Phase 1 RFI/CMS work plan for SST WMAs (DOE/RL-99-36). That document includes tables listing the radiological and chemical constituents that are contaminants of potential concern for the SST system. Those tables served as the starting point for defining WMA B-BX-BY-specific contaminants of potential concern and are discussed in greater detail in Chapter 3.0 of this addendum and in HNF-6020, which contains a summary of the WMA B-BX-BY DQO.

Table 2.1. Current Waste Volume in B, BX, and BY Tank Farm Tanks

Tank Number	Total Waste Volume KL (Kgal)	Supernate KL (Kgal)	Salt Cake KL (Kgal)	Sludge KL (Kgal)
B-101	428 (113)	0 (0)	428 (113)	0 (0)
B-102	121 (32)	15 (4)	106 (28)	0 (0)
B-103	223 (59)	0 (0)	223 (59)	0 (0)
B-104	1404 (371)	4 (1)	231 (61)	1170 (309)
B-105	598 (158)	0 (0)	492 (130)	106 (28)
B-106	443 (117)	4 (1)	0 (0)	439 (116)
B-107	625 (165)	4 (1)	269 (71)	352 (93)
B-108	356 (94)	0 (0)	155 (41)	201 (53)
B-109	481 (127)	0 (0)	242 (64)	238 (63)
B-110	931 (246)	4 (1)	0 (0)	927 (245)
B-111	897 (237)	4 (1)	0 (0)	893 (236)
B-112	125 (33)	11 (3)	0 (0)	114 (30)
B-201	110 (29)	4 (1)	0 (0)	106 (28)
B-202	102 (27)	0 (0)	0 (0)	102 (27)
B-203	193 (51)	4 (1)	0 (0)	189 (50)
B-204	189 (50)	4 (1)	0 (0)	185 (49)
BX-101	163 (43)	4 (1)	0 (0)	159 (42)
BX-102	363 (96)	0 (0)	0 (0)	363 (96)
BX-103	269 (71)	34 (9)	0 (0)	235 (62)
BX-104	375 (99)	11 (3)	0 (0)	363 (96)
BX-105	193 (51)	19 (5)	0 (0)	174 (46)
BX-106	144 (38)	0 (0)	0 (0)	144 (38)
BX-107	1306 (345)	4 (1)	0 (0)	1302 (344)
BX-108	98 (26)	0 (0)	0 (0)	98 (26)
BX-109	731 (193)	0 (0)	0 (0)	731 (193)
BX-110	783 (207)	11 (3)	269 (71)	503 (133)
BX-111	613 (162)	4 (1)	515 (136)	95 (25)
BX-112	625 (165)	4 (1)	0 (0)	621 (164)
BY-101	1465 (387)	0 (0)	1052 (278)	413 (109)
BY-102	1048 (277)	0 (0)	1048 (277)	0 (0)
BY-103	1514 (400)	0 (0)	1480 (391)	34 (9)
BY-104	1234 (326)	0 (0)	666 (176)	568 (150)
BY-105	1904 (503)	0 (0)	1722 (455)	182 (48)

Table 2.1. Current Waste Volume in B, BX, and BY Tank Farm Tanks

Tank Number	Total Waste Volume KL (Kgal)	Supernate KL (Kgal)	Salt Cake KL (Kgal)	Sludge KL (Kgal)
BY-106	2127 (562)	0 (0)	1809 (478)	318 (84)
BY-107	1007 (266)	0 (0)	855 (226)	151 (40)
BY-108	863 (228)	0 (0)	280 (74)	583 (154)
BY-109	1098 (290)	0 (0)	882 (233)	216 (57)
BY-110	1506 (398)	0 (0)	1117 (295)	390 (103)
BY-111	1737 (459)	0 (0)	1737 (459)	0 (0)
BY-112	1101 (291)	0 (0)	1101 (291)	0 (0)

2.1.3 Description of the Leak Detection System

The B tank farm has 52 leak detection drywells currently available for leak detection monitoring. These drywells were drilled from 1944 to 1974. The depth ranges for these drywells are between 18.6 m (61 ft) and 45.7 m (150 ft) bgs. Gamma logging data from the drywells were used during this time to ascertain the integrity of the tank. The B tank farm layout in Figure 2.2 shows drywell locations in reference to tanks.

The BX tank farm has 76 leak detection drywells currently available for leak detection monitoring. These drywells were drilled from 1947 to 1977. The depth ranges for these drywells are between 22.9 m (75 ft) and 45.7 m (150 ft) bgs, except for drywell 21-02-04 which extends to 71.6 m (235 ft). The BX tank farm layout in Figure 2.3 shows drywell locations in reference to tanks.

The BY tank farm has 70 leak detection wells currently available for leak detection monitoring. These drywells were drilled from 1949 to 1974. The depth ranges for these drywells are between 30.5 m (100 ft) and 45.7 m (150 ft) bgs. The BY tank farm layout in Figure 2.4 shows drywell locations in reference to tanks.

2.1.4 Relationship to Other Facilities

Various cribs, trenches, french drains, reverse wells, evaporator 242-B, and B pond that comprise associated facilities are located in the vicinity of the B, BX, and BY tank farms. These associated facilities, used during B, BX, and BY tank farm operations, are located just outside WMA B-BX-BY boundaries. The large additions of water to B pond significantly altered groundwater flow patterns under WMA B-BX-BY. Waste discharged to or stored at these facilities may have had an effect on the groundwater contamination at WMA B-BX-BY. These sites are not RCRA TSD units except for B pond and, therefore, are not part of the SST RCRA Groundwater Monitoring Program. These TSD units are monitored under the Hanford Site Groundwater Monitoring Program (DOE/RL-99-36 and PNNL-12086). The following are the associated facilities.

- Evaporator 216-242-B
- Cribs 216-B-7A, -7B, -8, -43, -44, -45, -46, -47, -48, -49, -50, and -57
- Tile fields 216-B-8TF and 216-E9
- Reverse wells 216-11A and -11B
- Trenches 216-B-35, -36, -37, -38, -39, -40, -41, -41A, -41B, -41C, -41D, and -42
- French drain 216-B-51.

The following facilities are located inside WMA B-BX-BY and are TSD units as defined by the Tri-Party Agreement (Ecology et al. 1998).

- Diversion boxes 241-B-151, -152, -153, and -252; 241-BR-152; 241-BX-153; 241-BXR-151, -152, and -153; 241-BYR-152, -153, and -154; 242-B-151
- Catch tanks 241-B-301B and 241-BX-302A
- Receiving vault 244-BXR
- Septic tank 2607-EB.

Figure 2.5 shows the location of these facilities (except the B pond, which is located 3.5 km [2.2 mi.] east of WMA B-BX-BY) with respect to WMA B-BX-BY.

A number of raw and potable water lines are also present in and around WMA B-BX-BY. Leaks from these lines could have contributed to tank waste migration in the vadose zone. It appears that leaks from these lines were not considered to have any adverse impacts to tank farm operations. Thus, historical records are likely to be incomplete.

A summary of the operation, vadose zone contamination, and groundwater contamination history for each of these associated facilities is described in HNF-2603, HNF-5507, and other documents.

2.2 PHYSICAL SETTING

The following subsections summarize the topography, geology, hydrogeology, and surface water hydrology of WMA B-BX-BY. More detail is provided in the geology and hydrogeology summaries because of their more direct relationship to the WMA B-BX-BY field investigation. Because the meteorology, environmental resources, and human resources associated with WMA B-BX-BY are the same as the 200 Areas at the Hanford Site, the reader is referred to Section 3.0 of DOE/RL-99-36 for related information. Sections 2.2.2 and 2.2.3 are taken directly from HNF-5507.

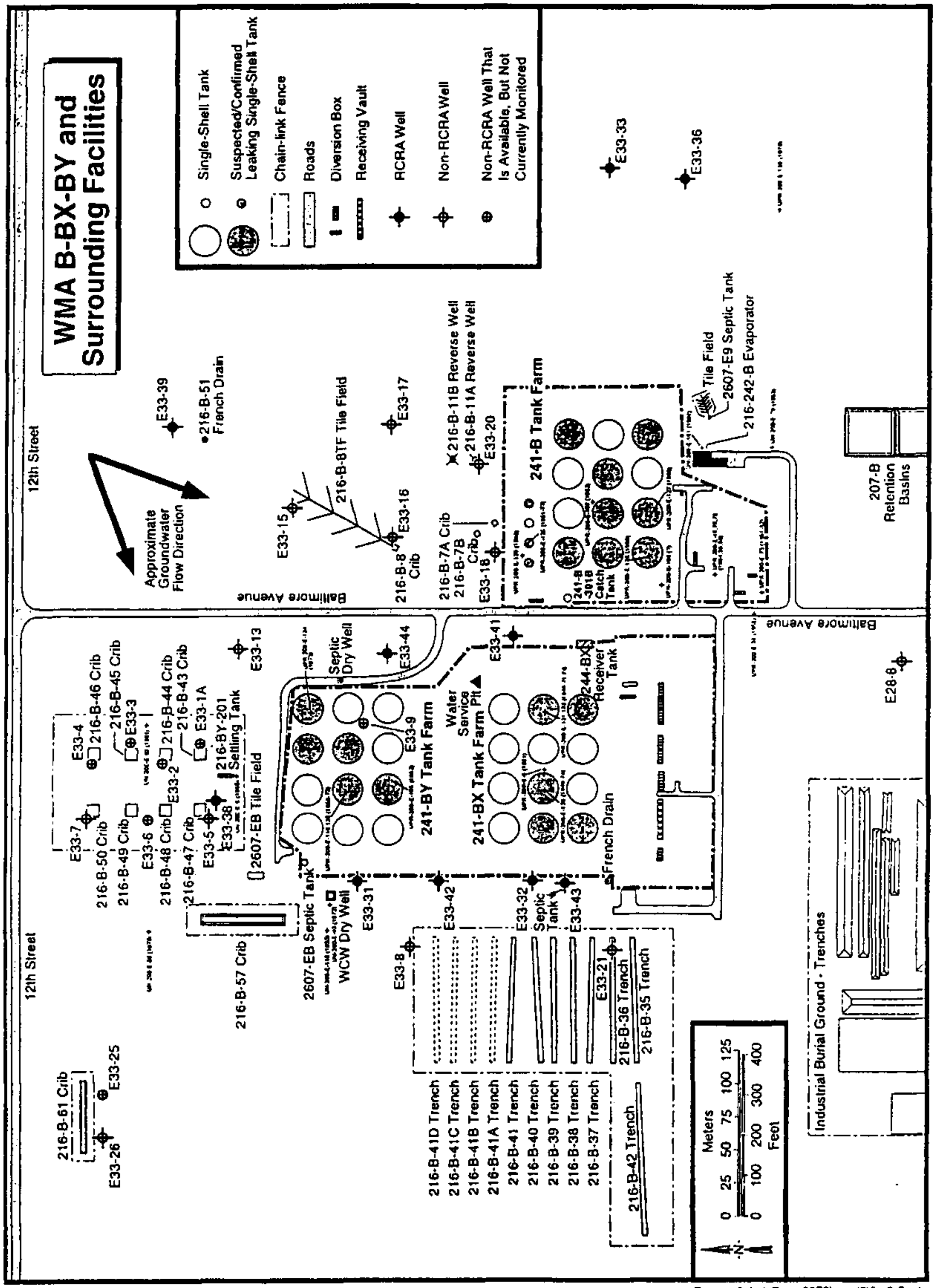
2.2.1 Topography

WMA B-BX-BY lies along the northern flank of the Cold Creek bar, a large compound flood bar formed during Pleistocene ice-age floods. The upper surface of the bar in the 200 East Area forms a broad plain at about the 210 m (700 ft) elevation. The bar extends westward for several kilometers; the northern boundary of the bar is defined by a series of northwest-southeast-trending flood channels (DOE/RW-0164). WMA B-BX-BY is located on the grade that slopes gently (about 0.085 m/m [0,026 ft/ft]) to the northeast from the Cold Creek bar into the uppermost flood channel. HNF-5507 provides more information.

2.2.2 Geology

The tank farms that constitute WMA B-BX-BY (see Figure 2.5) were constructed in excavations into the near-surface sediments that overlie the Columbia River Basalt Group (i.e., bedrock) on the northern limb of the Cold Creek syncline. Suprabasalt sediments in the vicinity of WMA B BX BY are unconsolidated and include probable facies of the Plio-Pleistocene unit and sand, gravel, and lesser amounts of silt-dominated deposits from Pleistocene cataclysmic floods, collectively referred to as the Hanford formation (see Figure 2.6). The fluvial-lacustrine Ringold Formation, which overlies basalt over most of the Hanford Site, is not present beneath the WMA, having been completely eroded away since Ringold time. Plio-Pleistocene-age fluvial, and perhaps some eolian, deposits lie between the Columbia River Basalt Group and the overlying cataclysmic ice-age flood deposits (i.e., the Hanford formation). In the vicinity of WMA B-BX-BY, the Hanford formation is subdivided into an upper and lower gravel sequence (the H1 and H3 units, respectively) and an intervening sequence composed predominantly of sand (H2 unit).

Figure 2.5. WMA B-BX-BY and Surrounding Facilities



Source: HNF-6020

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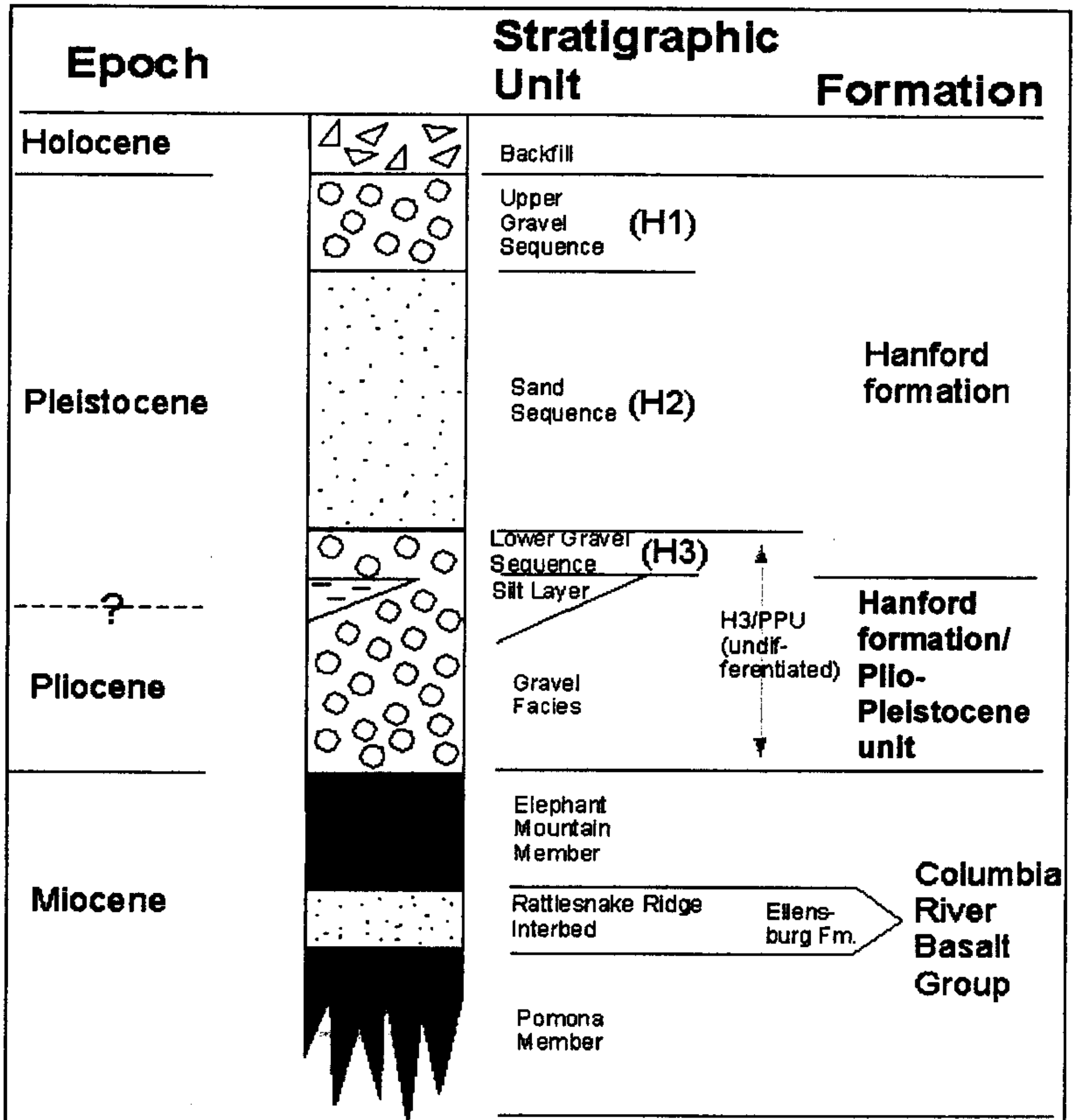
Figure 2.6. General Stratigraphy of the WMA B-BX-BY



Source: HNF-5507

The vadose zone beneath WMA B-BX-BY is as much as 83-m (273-ft) thick and consists of the Pleistocene-aged Hanford formation and the Hanford formation/Plio-Pleistocene unit (?). The unconfined aquifer beneath the WMA is generally only a few meters thick and, in places, the top of basalt extends above the water table (see Section 2.2.3). The saturated zone lies within the H3/Plio-Pleistocene units (undifferentiated). The vadose zone stratigraphy of the B, BX, and BY tank farms is discussed in HNF-5507.

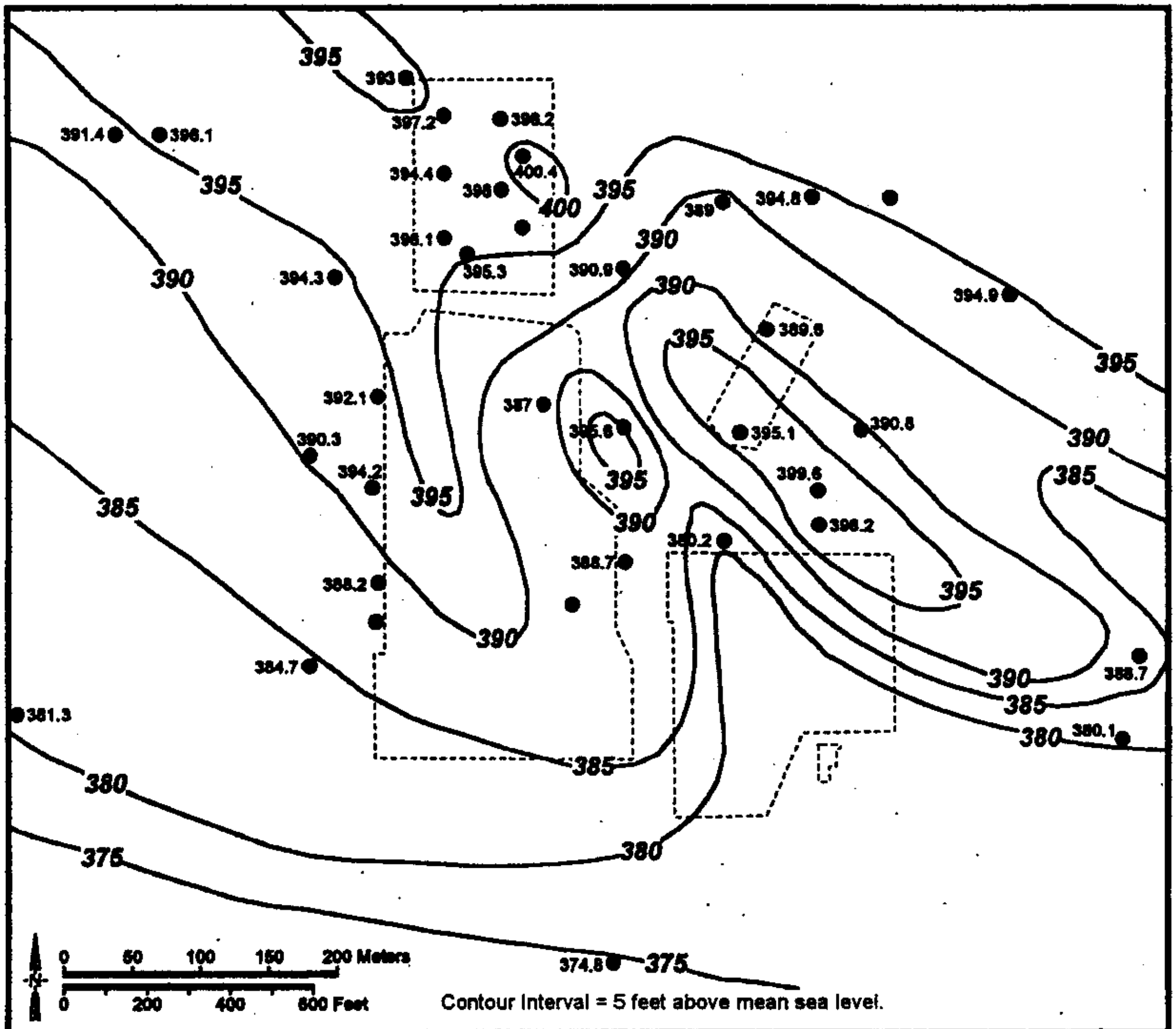
2.2.2.1 Columbia River Basalt Group. The surface of the Columbia River Basalt Group forms the bedrock base of the unconfined aquifer under WMA B-BX-BY. The Elephant Mountain Member of the Saddle Mountains Basalt is the youngest flow and ranges from 70 m to 100 m (230 to 320 ft) bgs. The top of the basalt dips southwest toward the axis of the Cold Creek syncline (Figure 2.7). Up to 8 m (25 ft) of topographic relief exists on the basalt surface. Based on the topography on top of the basalt (Figure 2.7) some of this relief appears caused by post-basalt channeling into the basalt probably during late Pleistocene time. The predominant northwest-southeast structural trend on the top of the basalt 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.

2.2.2.2 Ringold Formation. The fluvial-lacustrine Ringold Formation, which overlies basalt over most of the central Pasco Basin, is not present beneath WMA B-BX-BY (BHI-00184). The Ringold Formation was present at one time and probably filled the basin with sediments to at least 724 m (900 ft) in elevation (Lindsey 1996) during the late-Miocene to Pliocene time (10.5 to 3.4 Ma). However, in the vicinity of WMA B-BX-BY, the Ringold Formation since has been effectively removed by fluvial downcutting of the ancestral Columbia River, cataclysmic ice-age flooding, or both.

2.2.2.3 Hanford Formation/Plio-Pleistocene Unit (?). A geologic unit of questionable origin locally overlies basalt within WMA B-BX-BY. This unit may be equivalent or partially equivalent to the Plio-Pleistocene unit or it may represent the earliest ice-age flood deposits overlain by a locally thick sequence of fine-grained non-flood deposits. This unit is referred to as the Hanford formation/Plio-Pleistocene unit (?) (Figure 2.6).

Since Ringold time, approximately 3.4 million years ago, base level within the Pasco Basin dropped approximately 182.9 m (600 ft), leading to incision and erosion of the preexisting Ringold Formation deposits by the ancestral Columbia River system. Once the new base level was established, erosion stopped allowing local deposition and partial backfilling of the eroded landscape by fluvial deposits toward the center of the basin and eolian/floodplain deposits distally, while paleosols formed in low-relief uplands and interfluvial areas. Beginning about 2 million years ago, ice-age floods from ice-dammed lakes north and east of the Columbia Plateau inundated the region. In some places within the Pasco Basin, ice-age floodwaters scoured further into basalt bedrock, while in other places flood deposits blanketed older Ringold or post-Ringold deposits.

Figure 2.7. Top of Basalt Surface



Source: HNF-5507

Deposits in the Pasco Basin that post-date the Ringold Formation and predate the ice-age floods are referred to as the Plio-Pleistocene unit (DOE/RW-0164, Lindsey et al. 1994). Several facies of the Plio-Pleistocene unit include the well-defined calcic paleosol (caliche) facies reported at the 200 West Area (DOE/RW-0164, Slate 1996); a sidestream alluvial facies (DOE/RW-0164, PNL-7336, Slate 1996); and recently, an eolian facies (Slate 1996) that was originally described as a separate unit (i.e., early Palouse soil). A mainstream facies of the Plio-Pleistocene unit also reported across the basin associated with deposition by the ancestral Yakima, Snake, and Columbia Rivers (WHC-SD-EN-TI-290).

Post-Ringold age late Pliocene to early-Pleistocene deposits 2.0 to 3.4 million years before present or less may be present beneath WMA B-BX-BY. Two facies of the Hanford formation/Plio-Pleistocene unit (?) represented beneath the WMA B-BX-BY are eolian/overbank silt and sandy gravel to gravelly sand of uncertain origin.

2.2.2.3.1 Silt Facies. This unit is indicated by a thick layer of well-sorted calcareous silt and/or fine sand that lies several meters above the top of the basalt. This layer is up to 10 m (35 ft) in well 299-E33-18 (HNF-5507). Cataclysmic flood deposits of the Hanford formation typically do not contain silt beds more than 1 m (3 ft) thick; therefore this silt layer is believed to be a pre-ice-age flood deposit consisting of either overbank-floodplain alluvium from the ancestral Columbia River or eolian loess. The silt layer could be equivalent or partially equivalent to the early Palouse soil, a distinctive, massive, eolian unit beneath the 200 West Area (DOE/RW-0164) and recently included with the Plio-Pleistocene unit (Slate 1996, Lindsey et al. 1994).

The silt layer is present only locally in an area centered over the northwest portion of the B tank farm (HNF-5507); elsewhere, it was either subsequently eroded or not deposited. The top of the Hanford formation/Plio-Pleistocene unit (?) silt layer appears to dip slightly toward the northeast (HNF-5507). Where the silt layer is missing, which is over most of the WMA, the Hanford formation/Plio-Pleistocene unit (?) cannot be distinguished from the overlying Hanford formation.

2.2.2.3.2 Sandy Gravel to Gravelly Sand Facies. The loose, unconsolidated nature of the sandy gravels to gravelly sands suggests the sediments below the Hanford formation/Plio-Pleistocene unit (?) silt layer are post-Ringold in age. However, sands and gravels beneath the silt layer are compositionally similar to the basaltic sands and gravels above the silt layer, suggesting this facies represents either flood gravels (Hanford formation) or pre-ice age floodplain alluvium with perhaps a significant sidestream component (mixed mainstream and sidestream facies of the Plio-Pleistocene unit.

The upper surface of the Hanford formation/Plio-Pleistocene unit (?) sandy gravel to gravelly sand facies shows approximately 10 m (30 ft) of relief. A depression, centered over the northwestern corner of the B tank farm, exists at the top of this unit. The depression appears to be filled with the overlying Hanford formation/Plio-Pleistocene unit (?) silt layer (HNF-5507). The thickness of the gravel ranges from 5 to 15 m (20 to 50 ft) (HNF-5507). The unit is both thinnest and structurally lowest near the same point, suggesting that the top of the Hanford formation/Plio-Pleistocene unit (?) gravel was eroded before the depression was backfilled with Hanford formation/Plio-Pleistocene unit (?) silt facies (HNF-5507).

A single hydraulic conductivity value, reported for gravel facies of the Plio-Pleistocene unit in well 299-E33-33 (WHC-SD-EN-TI-147) is 98 m/day (320 ft/day). This value is between those normally reported for the Hanford formation (450 m/day to 27,000 m/day [1,500 to 90,000 ft/day]) and the Ringold Formation gravel facies (3 m/day to 70 m/day [9 to 230 ft/day]) (PNL-7336).

Within the Hanford formation/Plio-Pleistocene unit (?) gravels, a distinctive sudden shift occurs in the calcium carbonate content from 0% in the lower part to 2% to 3% in the upper part. This marker horizon is only apparent in a string of wells trending east-west, located in the northern portion of the WMA (HNF-5507). The cause and significance of this marker horizon are not clear but may represent a transition in climate to more arid conditions, which are known to have occurred during Pliocene to Pleistocene times.

2.2.2.4 Hanford Formation. The Hanford formation is the informal name given to all glaciofluvial 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 (Baker et al. 1991). Cataclysmic floods were released during at least four major glacial events that occurred between about 1 million and 13 thousand years ago (early- to late-Pleistocene time). The Hanford formation consists of mostly unconsolidated sediments that cover grain sizes from pebble to boulder gravel, fine- to coarse-grained sand, silty sand, and silt. The 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. Gravel-, sand-, and silt-dominated facies are also referred to as the coarse-grained, transitional, and rhythmite facies of the Hanford formation, respectively (Baker et al. 1991).

- Gravel-dominated facies — This facies generally consists of coarse-grained basaltic sand and granule to boulder gravel. These deposits display an open framework texture, massive bedding, plane to low-angle bedding, and large-scale planar cross-bedding in outcrop. Gravel-dominated beds sometimes grade upward into sand- and silt-dominated facies. Gravel clasts are predominantly basalt, with lesser amounts of Ringold Formation clasts, granite, quartzite, and gneiss (WHC-SD-EN-TI-012). The gravel-dominated facies was deposited by high-energy floodwaters in or immediately adjacent to the main cataclysmic flood channelways.

- Sand-dominated facies — This facies consists of fine- to coarse-grained sand and granule gravel. The sands typically have a high-basalt content and are commonly referred to as black, gray, or "salt-and-pepper" sands. They may contain small pebbles, rip-up clasts, and pebble-gravel interbeds and often grade upward into thin (less than 1 m [less than 3 ft]) zones of silt-dominated facies. This facies commonly displays plane lamination and bedding and less commonly channel cut-and-fill sequences. The sand-dominated facies was deposited adjacent to main flood channelways during the waning stages of flooding. The facies is transitional between the gravel-dominated facies and the silt-dominated facies.

- Silt-dominated facies — This facies consists of thin-bedded, plane-laminated, and ripple cross-laminated silt and fine- to coarse-grained sand. Beds are typically a few to several tens of centimeters thick and commonly display normally graded bedding

(WHC-SD-EN-TI-012). Sediments of this facies were deposited under slackwater conditions and in back-flooded areas (DOE/RW-0164, Baker et al. 1991).

The sand and gravel fractions of the Hanford formation generally consist of about 50% basalt and 50% felsic material (RHO-ST-23). This mineral assemblage gives the Hanford formation the characteristic "salt and pepper" appearance often noted in drillers' and geologists' logs. The felsic material is composed of primarily quartz and feldspar, with some samples containing more than 10% pyroxene, amphibole, mica, chlorite, ilmenite, and magnetite. The silt- and clay-sized fractions consist of quartz, feldspar, mica, and smectite.

The Hanford formation makes up the majority of the suprabasalt sedimentary sequence beneath WMA B-BX-BY, ranging in thickness from 43 m to 73 m (140 to 240 ft). Based on lithologies observed at this WMA, the Hanford formation can be divided into three informal units (H1, H2, and H3). The H1 and H3 units consist of mostly coarse-grained gravel or sandy gravel; the H2 unit is predominantly sand or gravelly sand, with occasional beds of sandy gravel. The H1 and H3 units belong to the gravel-dominated facies of the Hanford formation, associated with deposition within and along the main ice-age flood channelways. Sand-dominated H2 unit was deposited under less-energetic currents, perhaps further away from the main channelway. The third facies of the Hanford formation, the silt-dominated facies, is occasionally present at the top of some beds, but it is a minor component in these overall higher energy flood deposits.

2.2.2.4.1 Lower Gravel Sequence (H3 Unit). The Hanford formation H3 unit locally overlies basalt bedrock or the Hanford formation/Plio-Pleistocene unit (?). This sequence is equivalent to the lower gravel sequence of the Hanford formation described in PNL-6820 and WHC-SD-EN-TI-012, to the Hanford formation H3 sequence described in WHC-SD-EN-TI-290, and to the Quaternary flood gravels deposits documented in Reidel and Fecht (1994).

Based on observations of outcrop and intact core, the lower gravel sequence is interpreted to belong to the gravel-dominated facies of the Hanford formation. Lenticular and discontinuous units of sand-dominated facies are sometimes interbedded with the gravel-dominated facies.

The H3 unit is not continuous beneath WMA B-BX-BY; it generally is missing from the central portion of the waste site, where, in its place, lies the Hanford formation/Plio-Pleistocene unit (?). Where the Hanford formation/Plio-Pleistocene unit (?) silt layer is missing, the H3 and Hanford formation/Plio-Pleistocene unit (?) are undifferentiated. The H3/Plio-Pleistocene unit (undifferentiated) averages about 15-m (50-ft) thick over most of WMA B-BX-BY (HNF-5507), except to the northwest, where it is up to 30-m (100-ft) thick, and to the northeast, where it thins to about 10 m (30 ft).

2.2.2.4.2 Sand Sequence (H2 Unit). The Hanford formation H2 unit overlies the H3 unit and directly overlies the Hanford formation/Plio-Pleistocene unit (?) silt layer locally. The H2 unit is equivalent to the sandy sequence of the Hanford formation discussed in PNL-6820 and WHC-SD-EN-TI-012, to the Hanford formation H2 sequence discussed in WHC-SD-EN-TI-290, and to Quaternary flood sands documented in Reidel and Fecht (1994).

The H2 unit consists predominantly of the sand-dominated facies of the Hanford formation. Internally, this sequence probably contains multiple graded beds of plane- to foreset-bedded sand or gravelly sand several meters or more thick, which sometimes grade upward into silty sand or silt. Cementation is very minor or absent, and total calcium carbonate content is generally only a few weight percent or less.

The H2 unit is ubiquitous beneath WMA B-BX-BY. The base of the H2 unit lies at the top of the gravel-dominated sequence or at the top of the fine-grained Hanford formation/Plio-Pleistocene unit (?), whichever is higher and shows approximately 20 m (60 ft) of relief on the surface of the sand sequence beneath WMA B-BX-BY. This sand sequence is thickest (60 m [200 ft]) in the central and southern portions of the WMA and thins to as little as (30 m [110 ft]) to the north (HNF-5507).

2.2.2.4.3 Upper Gravel Sequence (H1 Unit). The Hanford formation H1 unit overlies the H2 unit. The H1 unit is equivalent to the upper gravel sequence of the Hanford formation discussed in PNL-6820 and WHC-SD-EN-TI-012, to the Hanford formation H1 sequence discussed in WHC-SD-EN-TI-290, and to the Quaternary flood sands documented in Reidel and Fecht (1994).

Based on observations of outcrop and intact core samples, the H1 unit is interpreted to consist of the high-energy, gravel-dominated facies interbedded with lenticular and discontinuous layers of the sand-dominated facies. Silt-dominated facies may also be present, though they probably constitute a relatively small percentage of the total.

The maximum thickness of the H1 unit reflects a north-south-trending trough (i.e., channel) that lies beneath the BX and BY tank farms. The maximum thickness of the H1 unit in this trough is about 20 m (60 ft) (HNF-5507).

2.2.2.5 Holocene Deposits. Up to 10 m (35 ft) of backfill material is present above the Hanford formation in many of the boreholes drilled in WMA B-BX-BY.

2.2.2.5.1 Clastic Dikes. Clastic dikes are vertical to subvertical sedimentary structures that cross-cut normal sedimentary layering. Clastic dikes are a common geologic feature of the Hanford formation in the 200 Areas, especially in the sand- and silt-dominated facies. Clastic dikes are much less common in the gravel-dominated facies of the Hanford formation. No clastic dikes were observed in the excavated walls of the 218-E-12B burial ground, located about 1,000 m (3,000 ft) east of WMA B-BX-BY. However, clastic dikes are occasionally observed elsewhere within the gravel-dominated facies of the Hanford formation.

Clastic dikes occur in swarms and form four types of networks (BHI-01103):

- Regular-shaped polygonal patterns
- Irregular-shaped, polygonal patterns
- Preexisting fissure fillings
- Random occurrences.

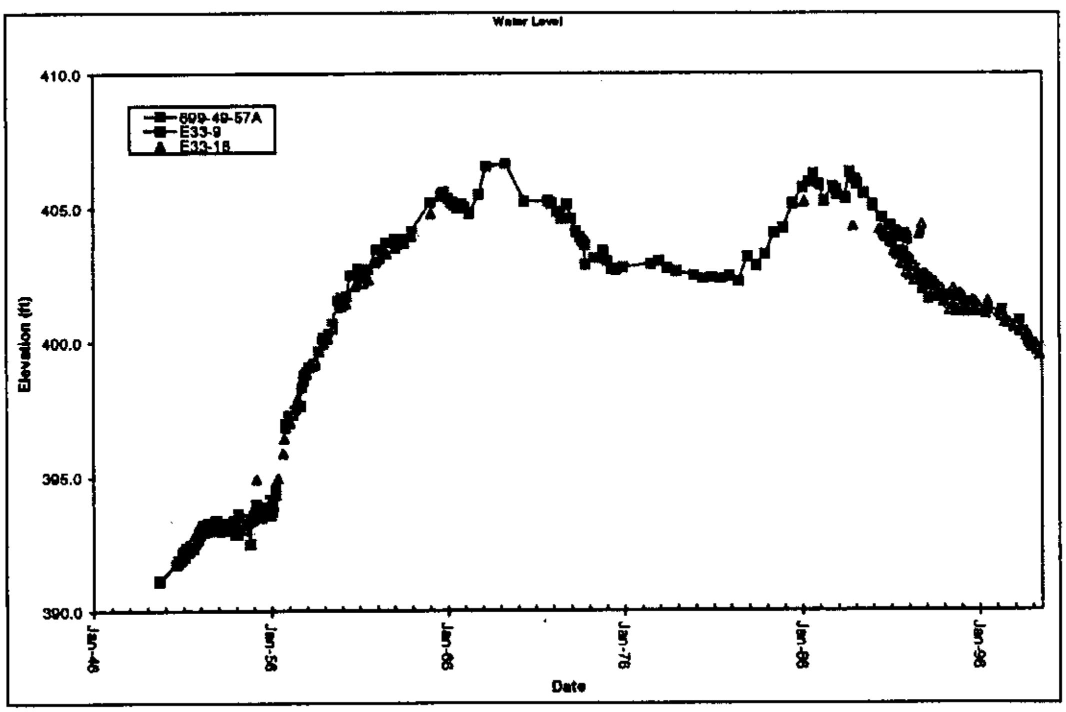
Clastic dikes near WMA B-BX-BY probably occur randomly in the gravel-dominated facies (the Hanford formation H1 and H3 units) and as regular-shaped polygons in the sand facies (the Hanford formation H2 unit). Regular-shaped polygonal networks resemble 4- to 8-sided polygons and typically range from 3-cm to 1-m (1-in. to 3-ft) wide, from 2- to more than 20-m (6- to more than 65-ft) deep, and from 1.5 to 100 m (5 to 325 ft) along their strike. Smaller dikelets, sills, and small-scale faults and shears are commonly associated with master dikes that form the polygons.

In general, a clastic dike has an outer skin of clay with coarser infilling material. Clay linings are commonly 0.03- to 1.0-mm (0.001- to 0.04-in.) thick, but linings up to about 10-mm (0.4-in.) thick are known. The width of individual in-filling layers ranges from as little as 0.01 to more than 30 cm (0.0004 to more than 12 in.) and their length can vary from about 0.2 to more than 20 m (8 in. to more than 65 ft). In-filling sediments are typically poorly to well-sorted sand, but may contain clay, silt, and gravel (HNF-4936).

2.2.3 Hydrogeology

The water table has changed significantly since tank farm operations began in the early 1950s. The discharge of large volumes of wastewater beginning in the early 1950s raised the water table in the vicinity of WMA B-BX-BY to over 4.9 m (16 ft) above conditions before Hanford Site operations (Figure 2.8). The flow direction should be turning back to the original pre-Hanford direction, which is assumed to be to the southeast. This expected flow-direction change would be in response to the diminishing B Pond mound located about 3.5 km (2.2 mi) east of WMA B-BX-BY. Water levels are declining rapidly, as shown in Figure 2.8. As a result, in 5 to 8 years from now (March 2000), some existing wells will contain little water.

Figure 2.8. Historical Water Levels Near WMA B-BX-BY

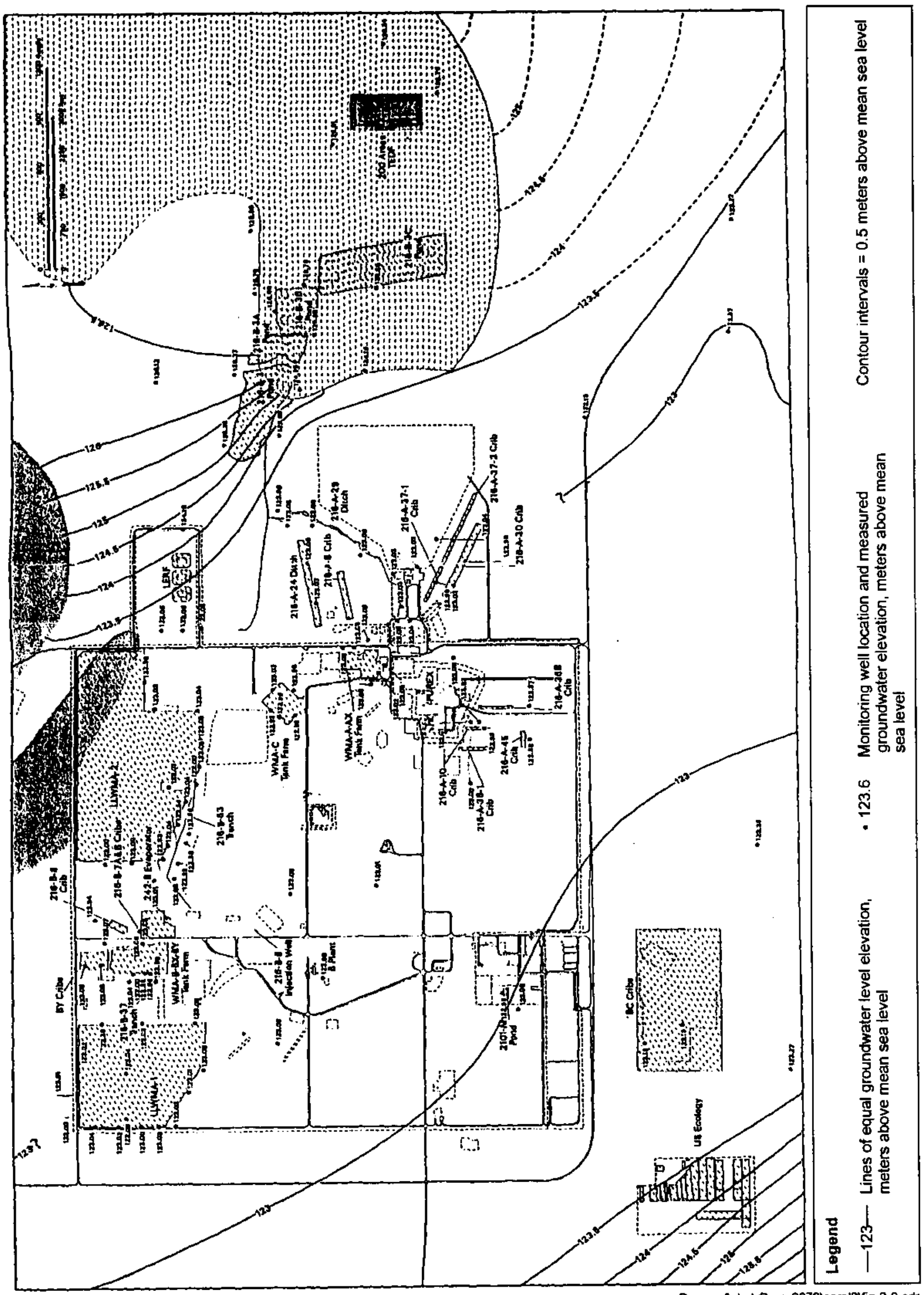


Water level measurements (June 1998) indicated that the water table in the unconfined aquifer was at approximately 123-m (403-ft) above mean sea level (Figure 2.9). The unconfined aquifer is found in the basal gravels interpreted as fluvial pre-Missoula sediments and extends upward at places into the Hanford formation H3 unit and is between 1.9- and 4.3-m (6.2- and 14-ft) thick (HNF-5507 and PNNL-12086). The aquifer appears to be thicker where the basalt surface is lower, correlating with the structure on the top of the basalt.

The hydraulic gradient is flat across the 200 East Area (Figure 2.9). With about 10 cm (4 in.) of change across WMA B-BX-BY, the use of discrete water elevations to determine flow direction is complicated. In this region, making comparisons of data between individual wells to determine the upgradient versus downgradient locations is difficult. This difficulty is related to the fact that the total error in water elevations can be a significant portion of the actual differences in water elevation between two wells. The local hydraulic conductivity of 1,600 m/day (5,300 ft/day), based on pumping test results, was reported in Newcomb et al. (1992) and WHC-SD-EN-TI-019. Porosity is estimated as 30% or greater for the unconsolidated gravels that made up the aquifer. Unfortunately, collecting in-tact core in sufficient quantity from the aquifer is difficult because of large grain size. Consequently, direct methods of determining porosity have not been used. Given the lack of direct measurements, combined with the cobble-to-boulder nature of the aquifer, 30% may be a low estimate.

Groundwater flow historically has been to the northwest with a hydraulic gradient on the order of 0.061/305 m (0.2/1,000 ft) (PNNL-12086). Recent data, however, indicate a possible shift to the southwest between 200 and 250 degrees azimuth (HNF-5507). The local hydraulic gradient across WMA B-BX-BY is approximately 0.00017, based on September 1999 water levels (HNF-5507). Water table elevations in the vicinity of WMA B-BX-BY declined approximately 0.16 m (0.5 ft) between 1997 and 1998 (PNNL-12086). The effective flow rate, using these parameters, is calculated to be 0.9 m/day (3 ft/day). This equates to 324 m (1,064 ft) of effective groundwater movement per year. If discrete, high-permeability flow channels are considered as the prime avenues of contaminant transport, a flow rate of 0.9 m/day (3 ft/day) may be low. Because WMA B-BX-BY is approximately 400 m (1,300 ft) long from north to south and 300 m (985 ft) from east to west across the BY tank farm, contamination related to leakage of tank waste might move through the area in less than 1 year. Given the pulse-type events seen in the past at well 299-E33-41 and the high frequency of contamination documented at other WMAs, semi-annual or even quarterly sampling may not be sufficient to clearly identify and differentiate tank-related waste from background contamination left from discharges to the surrounding cribs, trenches, and reverse wells (PNNL-11810; PNNL-11826). As part of the RCRA WMA B-BX-BY assessment, a study is currently being conducted to determine the best sampling frequency for monitoring WMA B-BX-BY. Table 2.2 provides well construction and water-level data for the RCRA monitoring wells in WMA B-BX-BY. Numerous non-RCRA wells exist near the B, BX, and BY tank farms.

Figure 2.9. 200 East Area Water Table Map, June 1998



Source: PNNL-12086

Table 2.2. RCRA Well Information for WMA B-BX-BY

Well Number	Completion Date	Location	Surface Elevation m (ft)	Depth of Bottom of Screen m (ft)	Depth of Top of Screen m (ft)	Depth to Water 1991 m (ft)	Depth to Water 1999 m (ft)
299-E33-31	1989	Downgradient	197.47 (647.71)	78.05 (256)	71.65 (235)	74.39 (244)	75.58 (247.91)
299-E33-32	1989	Downgradient	200.37 (657.20)	81.4 (267)	75.00 (246)	78.35 (257)	79.44 (260.56)
299-E33-33	1989	Upgradient	195.34 (640.74)	75.61 (248)	69.21 (227)	72.26 (237)	73.35 (240.58)
299-E33-36	1990	Upgradient	196.30 (643.85)	77.74 (255)	71.34 (234)	74.70 (245)	75.85 (248.79)
299-E33-38	1991	Downgradient	193.07 (633.27)	73.17 (240)	66.77 (219)	69.82 (229)	70.57 (231.48)
299-E33-39	1991	Downgradient	190.17 (623.76)	69.82 (229)	63.41 (208)	67.07 (220)	68.29 (223.99)
299-E33-40	1991	Downgradient	189.33 (621.00)	92.99 (305)	89.63 (294))	NA (NA)	NA (NA)
299-E33-41	1991	Downgradient	198.60 (651.40)	79.57 (261)	74.39 (244)	76.83 (252)	77.86 (255.39)
299-E33-42	1991	Downgradient	199.44 (654.16)	79.27 (260)	72.87 (239)	76.52 (251)	77.66 (254.73)
299-E33-43	1991	Downgradient	201.97 (662.47)	82.62 (271)	76.22 (250)	79.26 (260)	75.43 (247.42)
299-E33-44	1998	Downgradient	199.09 (653.00)	77.13 (253)	72.56 (238)	NA (NA)	73.05 (239.60)

2.2.3.1 Recharge. Recharge through the vadose zone is primarily controlled by the surface sediment type, vegetation type, topography, and spatial and temporal variations in seasonal precipitation at WMA B-BX-BY. As used here, the recharge rate is the amount of precipitation that enters the sediment, is not removed by evaporation or transpiration, and eventually reaches the groundwater table. The recharge to the unconfined aquifer beneath these tank farms from infiltrating precipitation is an important parameter for calculating groundwater impacts from past tank leaks, future tank waste retrieval losses, and residual tank waste currently in the SSTs (Jacobs 1998). The tank farm surface characteristics and infrastructure create an environment conducive to enhanced general recharge and transient, high-intensity events.

Most of the precipitation at the Hanford Site occurs from September through February when little to no evaporation or transpiration occurs. Recharge varies temporally and spatially. The temporal variation occurs with changes in temperature, plant activity, and precipitation. Both seasonal and long-term variations, as a result of climatic change, are important. The spatial variation occurs with changes in vegetation type, surficial sediment type, and human-made structures (e.g., paved parking lots). A lag time exists between a change in recharge rate from infiltration at the surface and a change in the flow field in the vadose zone as the water infiltrates through the ground.

2.2.3.1.1 Natural Infiltration. No direct measurements of the natural infiltration rate under WMA B-BX-BY have been made. However, observations from similar, disturbed, gravel-covered areas at the Hanford Site indicate that as much as 10 cm/yr (3.9 in./yr) can infiltrate a vegetation-free coarse gravel surface (Gee et al. 1992; PNL-10285, Fayer et al. 1996). This represents about 60% of the average annual meteoric precipitation (rainfall plus snowmelt). PNL-10285 indicates that WMA B-BX-BY is in an area estimated *to have about 2 to 5 cm/yr (0.8 to 1.97 in./yr) of infiltration based on soil type, vegetation,* and land use and infiltration rates of 5 to 10 cm/year (1.97 to 3.9 in./yr) immediately south of the tanks. Actual recharge is significantly different and not uniform because of the presence of the tanks and the disturbed soil surrounding the tanks and no vegetative cover. Recharge is intercepted and "shed" by the tank domes and flows into the disturbed soil near the tanks. Thus, infiltration rates near tank edges and between rows of tanks are likely manifold higher than average areal infiltration rates.

Lysimeter data from the Field Lysimeter Test Facility located between the 200 West and 200 East Areas show that the recharge rate ranges from 24 to 66% of the annual precipitation for years 1990 to 1994 for lysimeters with gravel over sand and bare vegetation conditions, which are typical of current tank farm ground conditions (PNL-10508). This is equivalent to approximately 4 to 11.1 cm/yr (1.57 to 4.37 in./yr) of recharge based on the long-term annual precipitation rate of 16.8 cm/yr (6.61 in./yr) (PNNL-11107). However, more recent lysimeter field measurements acquired during August 1995 to August 1996 from the Field Lysimeter Test Facility resulted in 16.06 cm/yr (6.32 in./yr) drainage, which is 66% of the actual precipitation over that period. These lysimeters were designed to simulate tank farm conditions in the 200 Area.

2.2.3.1.2 Artificial Infiltration. Artificial recharge in the 200 East Area is associated with trenches, cribs, ditches, and drains that were used to dispose of approximately 1.0×10^{12} L (3.0×10^{11} gal) of waste water (DOE/RL-92-19). Leaking water lines are another source of artificial recharge in the tank farms. Waterline ruptures, such as the one in September 1996 at the S tank farm, demonstrate that surface water could enter and collect in low spots (PNNL-11810). One topographical low at WMA B-BX-BY is located at the junction of the northwestern corner of the BY tank farm and the elevated soil barrier over crib 216-B-57. Within the boundaries of the tank farms, ponding can be controlled by the berms constructed over electrical lines. These barriers provide potential locations for water to collect during unusual runoff events. As-built diagrams show 10-and 15-cm (4- and 6-in.) raw water lines and 3.8-cm (1.5-in.) sanitary water lines running north-south along Baltimore Avenue and along the farm fence lines. These lines run past double-contained receiver tank 244-BX and next to well 299-E33-41. Also, until recently, the BY tank farm had pressurized water lines inside the tank farm fence lines. Near-surface concentrations of contaminants close to water line leaks could be another source of groundwater contamination. Although rarely documented as important events, water-line leaks have occurred, as is common with any water system. The lack of records makes determining or documenting any significant effect on contaminant mobilization or transport difficult. HNF-5507 provides more information on artificial recharge related to WMA B-BX-BY.

Discharges within WMA B-BX-BY were unplanned releases. Quantities are not known for many of the identified releases. Reported releases are primarily leaks from transfer pipelines, diversion boxes, and tanks. The most significant release, in terms of quantity and degree of contamination is the loss of metal waste from tank BX-102 in 1951. Approximately 346,700 L (91,598 gal) of waste were released. The second largest reported release (265,000 L [70,000 gal]) is a tank leak from BX-102. However, evidence documenting this release is questionable (see Section 3.0). Smaller leaks from an overground pipe (87,000 L [22,985 gal] of first decontamination waste cycle (1C) bismuth phosphate waste), a flush tank overflow (41,600 L [10,990 gal] of tributyl phosphate waste), another pipe leak (20,441 L [5,400 gal]), and leaks from various single-shell and auxiliary tanks (31,500 L [8,322 gal] or less) also are recorded (HNF-5507).

In the months before well 299-E33-41 was drilled, several flooding events occurred just south of this well's location at double-contained receiver tank 244-BX. The migration through the vadose zone of water from these floods while well 299-E33-41 was being drilled would explain the series of high-radiation concentrations in a series of silt lenses from 22.3 to 73.2 m (73 to 240 ft) and the contaminated perched water zone at 68.3 m (224 ft) bgs (PNNL 11826). The actual water-table surface at this time was 75.3 m (247 ft) from the ground surface. Well 299-E33-41 is close to the site of the 113,562- to 340,687-L (30,000- to 90,000-gal) overflow or spill between tanks BX-103 and BX-102 in 1951 (DOE/RL-92-05). This tank leak is most likely the cause of the contamination and creation of the perched zone because it is only 11.3 m (37 ft) from the well (HNF-5507). The nearest crib is 216-B-7B, 91.4 m (300 ft) from the well (PNNL 11826). Information in HNF-5507 addresses surface infiltration sources and events, subsurface discharges, and saturated zone response; hydrologic properties of the vadose zone and saturated zone also are discussed.

2.2.4 Surface Water Hydrology

No flood plains exist in or between the 200 Areas. Floods in Cold Creek and Dry Creek have occurred historically; however, there have been no observed flood events, nor is there evidence that flooding has reached the 200 East Area. Based on a probable maximum flood evaluation, no impact would occur at WMA B-BX-BY. Natural runoff generated onsite or from offsite upgradient sources is not known to occur in the 200 Areas (Newcomb et al. 1972 and PNNL-6415).

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3.0 INITIAL CONDITIONS AND CORRECTIVE ACTION REQUIREMENTS AND OBJECTIVES

The information on known and suspected contamination is presented in Section 3.1 and HNF-5507. A summary of this information is also provided in Section 3.0 of the Phase 1 RFI/CMS work plan (DOE/RL-99-36). This information was used to develop the Section 3.3 discussion on the potential impacts to the public health and the environment. Additional data to support improved understanding of the nature and extent of contamination at WMA B-BX-BY will be collected during the field investigation described in this addendum.

3.1 KNOWN AND SUSPECTED CONTAMINATION

A summary of available data and conditions is needed to effectively develop a characterization plan designed to collect data to support a determination of the presence and extent of contamination at a site caused by a given event or activity. A summary of available WMA B-BX-BY data regarding source, sediments, and groundwater contamination is presented in the following subsections and in HNF-5507.

When interpreting the data in the following subsections, it is important to note the amount of radioactive decay that has taken place since the data were gathered. For example, the half-life of cesium-137 is 30.2 years, approximately the time between 1968 and 1998. Thus, cesium-137 levels would, in 1998, have been approximately half their 1968 values. Where possible, the dates for radionuclide inventories have been given, but calculations of the decayed inventories through the present time have not been made.

3.1.1 Sources

The source term for WMA B-BX-BY is dependent upon nuclear and chemical aspects of the process that generated the waste. There were four main processing operations that generated the waste present in WMA B-BX-BY:

- Bismuth phosphate plutonium extraction,
- Uranium recovery operations,
- In-tank solidification (ITS), and
- Cesium-137 and stronium-90 recovery.

WHC-MR-0132 provides some information about the material in the tanks, which could be in the sediments.

The bismuth phosphate process generated the following waste types: alkaline coating removal waste, metal waste, byproduct cake solution, and waste solution from the first decontamination waste cycle (1C) and second decontamination waste cycle (2C) (WHC-MR-0132). Metal waste consisted of all the uranium, approximately 90% of the original fission products activity (including technetium-99), and approximately 1% of the original product from the process. This waste was brought just to the neutral point with 50% caustic and then treated with an excess of sodium carbonate as part of the bismuth phosphate process at the tank farms. The procedure yielded almost completely soluble waste at a minimum waste volume. The exact composition of the carbonate complex was not known but was assumed to be a uranium phosphate-carbonate mixture. The composition was estimated to contain 0.5 lb/gal of uranium, 2.7 Molar nitrate, 4.8 Molar sodium, and a specific gravity of 1.86.

Sources of releases include fluid discharges; tank waste through tank leaks; ancillary equipment leaks and failures; and trenches, reverse wells, and cribs. These releases impacted the sediments. These releases are discussed in detail in HNF-5507. Estimated releases or leaks from the tanks in WMA B-BX-BY are indicated in Table 3.1. These estimates were obtained from WHC-MR-0132 and HNF-EP-0182-141. The uncertainty associated with the leak durations is even greater than that for the estimated tank leak volumes.

Table 3.1. Estimated Past Leak Losses from the B-BX-BY SSTs

Tank	WHC-MR-0132 Estimated Leak Volume (gal)	HNF-EP-0182-141 Estimated Leak Volume (gal)
B-101	NA	8,000*
B-103	NA	8,000*
B-105	NA	8,000*
B-107	NA	8,000
B-110	NA	10,000
B-111	NA	8,000*
B-112	NA	2,000
B-201	NA	1,200
B-203	NA	300
B-204	NA	400
BX-101	NA	8,000*
BX-102	70,000	70,000
BX-108	2,500	2,500
BX-110	NA	8,000*
BX-111	NA	8,000*
BY-103	Small	<5,000
BY-105	Small	8,000*
BY-106	NA	8,000*
BY-107	NA	15,100
BY-108	NA	<5,000
Totals	**72,500**	**191,500**

*Based on 19 tanks with cumulative leak volume of 150,000 gallons for an average of 8,000 gallons for each of the 19 tanks.

To convert gallons to liters, multiply by 3.785.

NA = not applicable

Throughout the operational history of the B, BX, and BY tank farms fluids have been discharged, both deliberately and inadvertently. A summary of discharge events is provided in HNF-5507. Three types of fluid discharges associated with B, BX, and BY tank farm operations have occurred numerous times in and around WMA B-BX-BY. These discharges included the following:

- Deliberate collection and routing of cooling water and tank condensate to cribs
- Mechanical failure of tanks and leakage into the underlying soil column
- Periodic failure of ancillary equipment (primarily diversion boxes and valve pits) used to transfer liquids between tanks.

Leaks from ancillary equipment were observed and recorded when sufficient fluid reached the surface from the buried, but near-surface, sources. The primary parts of the ancillary equipment system responsible for the surface spills appear to be the collection points for fluids being transferred around the tank farm (e.g., diversion boxes, valve pits, and catch tanks). Numerous pipes feed into these collection points. The pipes were frequently attached, detached, and reattached as part of normal operations.

Most of the trenches and cribs associated with the B, BX, and BY tank farms operated from the beginning of tank farm operations in 1946 until the early 1970s. HNF-5507 supplies a history of waste and its volume released to these cribs and trenches. HNF-5507 provides more information on surface and near-surface spills.

A detailed discussion of the 20 tanks (10 SSTs in B tank farm, 5 SSTs in BX tank farm, and 5 SSTs in BY tank farm) that are assumed or confirmed leakers is provided in Section 3.3 of HNF-5507. The estimated volume of the leaks is provided in Table 3.1 of this addendum. Based on HNF-EP-0182-141, the three highest-volume releases ranked in descending order are as follows:

- Tank BX-102 with an estimated 264,950 L (70,000 gal) leaked
- Tank BY-107 with an estimated 57,154 L (15,100 gal) leaked
- Tank B-110 with an estimated 37,850 L (10,000 gal) leaked.

3.1.2 Releases to Sediment

Releases of historical fluid discharges to trenches, reverse wells, and cribs to the sediment; tank waste through tank leaks; ancillary equipment leaks; and surface spills, along with evaluation of spectral and gross gamma surveys, are of direct interest to the WMA B-BX-BY field investigation.

Detailed information about the spectral gamma surveying and historical gross gamma surveying conducted at B, BX, and BY tank farms is provided in HNF-5507. Spectral gamma logging data are available in separate reports for the B, BX, and BY tank farms (GJO-HAN-28, GJO-HAN-6, GJO-HAN-19).

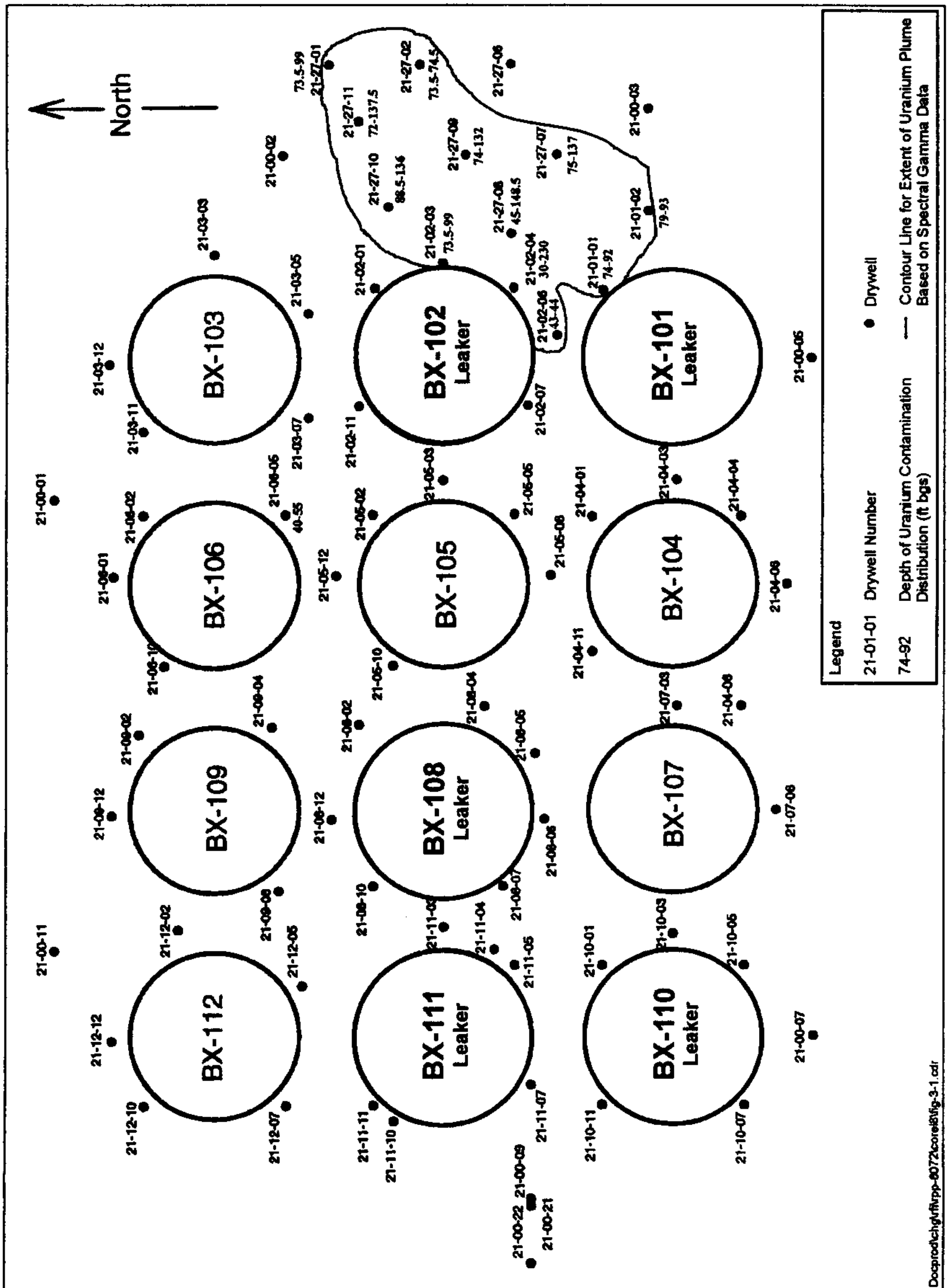
Because SSTs BX-102, BY-107, and B-110 are associated with the largest release volumes, they are discussed in more detail in the following subsections. Tanks BY-103 and BY-107 are also discussed because spectral gamma data indicates leaks may have occurred at these tanks. Information for other tank leaks that affect WMA B-BX-BY are presented in HNF-5507 and HNF-4872.

3.1.2.1 Tank BX-102. Processed uranium containing uranium-235 and uranium-238 occurs throughout the subsurface in the eastern portion of the BX tank farm. Most of the uranium occurs below a depth of 21.3 m (70 ft) and extends laterally 30.5 m (100 ft) to borehole 21-27-01. Because uranium-235 and uranium-238 contamination occurs at the bottoms of several boreholes (at depths of 45.7 m [150 ft]), the total depth extent of the plume cannot be determined (Figure 3.1). However, it has been determined through groundwater monitoring in monitoring well 299-E33-41, which is located 45.7 m (150 ft) northeast of tank BX-102, that contamination resulting from the remobilization of this waste has reached and contaminated groundwater (PNNL-11826). Spectral gamma logging of groundwater monitoring well 299-E33-41 indicated processed uranium from about 66.4 to 71.6 m (215 to 235 ft) (GJ-HAN-89). Drilling at monitoring well 299-E33-41 revealed radioactive contamination in a series of silt lenses in the upper sand-dominated facies at depths of 22.3 m (73 ft), 23.8 m (78 ft), 41.8 m (137 ft), 50 m (164 ft), and 66.4 to 73.2 m (218 to 240 ft). Analysis of soil samples identified potassium-40, uranium-235, uranium-238, and lead-214. Gross alpha content from 66.4 to 73.2 m (218 to 240 ft) ranged from 13.2 to 5 pCi/g. Beta/gamma radiation for the same depth interval ranged from 384.2 to 164.5 pCi/g (PNNL-11826). The observed gross beta concentrations are approximately 10 times higher than the mean gross beta concentration of 20 pCi/g for the Hanford Site (DOE/RL-96-12).

Previous investigation of tank BX-102 revealed that between 1970 and 1971 a vadose zone investigation was conducted as a result of increased gross gamma measurements in drywell 21-27-11, which is located 30.5 m (100 ft) east-northeast of tank BX-102 (Figure 3.1). As part of this investigation, 19 new drywells were installed near tank BX-102 and the tank supernate liquid was analyzed. Drywell 21-02-04 was drilled to groundwater near tank BX-102 and included soil analyses at 0.3-m (1-ft) intervals on many core samples. Soil samples were collected and analyzed for cesium-137. Peak concentration values of cesium-137 occurred at 12.2 m (40 ft) bgs, and was present at levels up to 100 μCi/g in those soil samples. Gross gamma logging of the drywell defined a plume extending to the east from tank BX-102. Based on the estimated plume volume, a 30% soil porosity, and cesium-137 levels measured in tank waste in 1970, an estimated leak volume of 264,950 L (70,000 gal) was developed (ARH-2035). ARH-2035 notes that a 340,650 L (90,000 gal) transfer line UPR-200-E-5 leak had taken place in 1951 between tanks BX-102 and BX-103. Original documentation is associated with Hanford Works Monthly Report (HW-20438). According to the monthly report this release was metal waste and not first-cycle bismuth-phosphate waste as was identified in another letter. ARH-2035 identifies cesium-137 as the gamma constituent; however GJO-HAN-19 shows uranium-238, uranium-235 below the tank base at concentrations ranging from less than 100 to near 1,000 pCi/g.

3.1.2.2 Tanks B-107 and B-110. Decreases in liquid levels between 1963 and 1969 indicate that 30,280 L (8,000 gal) of liquid waste were lost from tank B-107. Drywell 20-07-02 exhibits cesium-137 activity 10.6 to 18.3 m (35 to 60 ft) bgs at levels up to 1,000 pCi/g. Drywells 20-07-11, 20-08-07 and 20-10-02, associated with tank B-110, appear to have strontium–90 activity 21.3 to 24.3 m (70 and 80 ft) bgs. Drywell 20-10-12, associated with tank B-110, has gamma activity beginning at 6.1 m (20 ft) bgs that saturates the detector (greater than 10^3 pCi/g) from 7.6 to 30.5 m (25 to 100 ft) bgs. Between 30.5 to 33.5 m (100 and 110 ft) bgs, both cesium-137 and uranium-235 are reported to be about 1,000 pCi/g. Drilling records and historical gross gamma data indicate that contamination was encountered in the borehole beginning at about 7.6-m (25-ft) bgs when drilled in July 1973 indicating that the leak pre-dates the borehole.

Figure 3.1. Uranium Vadose Zone Plume Map for BX Tank Farm



3.1.2.3 Tanks BY-103 and BY-107. Widespread near-surface contamination exists in the range of 100 pCi/g of cesium-137 in many drywells in the BY tank farm. In most cases, the cesium-137 levels decrease with depth. Drywell 22-03-05, associated with tank BY-103, exhibits cesium-137 activity from 7.6 m (25 ft) bgs to total depth (30.5 m [100 ft]). The cesium-137 activity saturates the detector (greater than 10^3 pCi/g) from 7.6 to 13.7 m (25 to 45 ft) bgs, and maintains a constant activity near 1,000 pCi/g from 13.7 to 27.4 m (45 to 90 ft) bgs. For spectral-gamma activity below 1.8 m (6 ft) bgs, drywell 22-03-05 is the only drywell in the BY tank farm that the detector was saturated. Peaks in drywells 22-07-09 (1,000 pCi/g) and 22-07-10 (100 pCi/g) occur at 10.6 m (35 ft) for tank BY-107. Additional information is presented in HNF-5507.

3.1.3 Intentional Liquid Waste Disposals to Surrounding Cribs and Trenches

As shown in Figure 2.5, numerous cribs and trenches surround WMA B-BX-BY. These facilities received some of the largest quantities of liquid waste ever discharged on the Hanford Site. Most of the more contaminated wastes (first-cycle and tributyl phosphate waste) were discharged before 1956. The most recent large discharge of in-tank solidification condensate occurred from 1968 to 1973. Given the high volume of discharged liquids, particularly to the BY cribs and BX trenches, a saturated column from the surface to the water table likely formed during discharge events. This column would have facilitated rapid transfer of mobile contaminants to the unconfined aquifer. HNF-5507 provides intentional release quantities of 2.91×10^8 L (7.68×10^7 gal) associated with BX trenches; BY cribs; cribs B-7A, B-7B, and B-8; and reverse wells B-11A and B–11B.

Groundwater contamination in the vicinity of WMA B-BX-BY has been ongoing since 1955. Groundwater contamination was identified in May 1955 at crib 216-B-8. In August 1955, groundwater contamination was identified beneath the BY cribs. In October 1955, groundwater contamination was noted at trench 216-B-42. In December 1955, cesium-137 was detected in groundwater under the BY cribs and the tributyl phosphate discharge was rerouted to the BC cribs south of WMA B-BX-BY. Current groundwater contamination is discussed in the next section.

3.1.4 Groundwater

Based on conductivity values that were elevated in 1996 above the critical mean of 365.7 μmhos/cm in downgradient well 299-E33-32 (Figure 2.5), WMA B-BX-BY was placed in a groundwater quality assessment program. The groundwater monitoring frequency was increased from semiannually to quarterly. During 1997, nitrate and technetium-99 were observed above the drinking water standards of 45,000 μg/L and 900 pCi/L, respectively in well 299-E33-41, located between the B and BX tank farms.

A groundwater investigation has indicated that contamination in downgradient RCRA monitoring wells is attributed to WMA B-BX-BY. PNNL-11826 documents the groundwater assessment for WMA B-BX-BY. The findings confirmed contaminants have been released to the groundwater from this WMA. Additional information is provided in PNNL-12086 and HNF-5507. PNNL-11826 findings are outlined below except for modification for clarity.

- Recent (1997 and 1998) elevated concentration levels of technetium-99, nitrate, chloride, sulfate, and sodium in well 299-E33-41 appear to be related to remobilized tank waste that has reached groundwater from WMA B-BX-BY. The trend plot characteristics of high-amplitude, high-frequency events, combined with the well's proximity to a known tank leak vadose zone plume and with documentation of local water driving forces, indicate that WMA B-BX-BY contributed to the observed contamination. Data reported in February 1997 showed technetium-99 was 6 times the drinking water standard of 900 pCi/L. Early August 1997 data reported technetium-99 as 13 times that standard.

- Based on (1) the vadose zone contamination found in 1991 during drilling of well 299-E33-41, (2) the existence of perched water and saturated sediments, (3) the rapid drop in water level shortly after well completion, and (4) the documented events of nearby artificial water releases at the surface, it is likely that the groundwater contamination taken from well 299-E33-41 is remobilized tank waste in the vadose zone from a leak of 340,650 L (90,000 gal) from tank BX-102 that occurred in 1951.

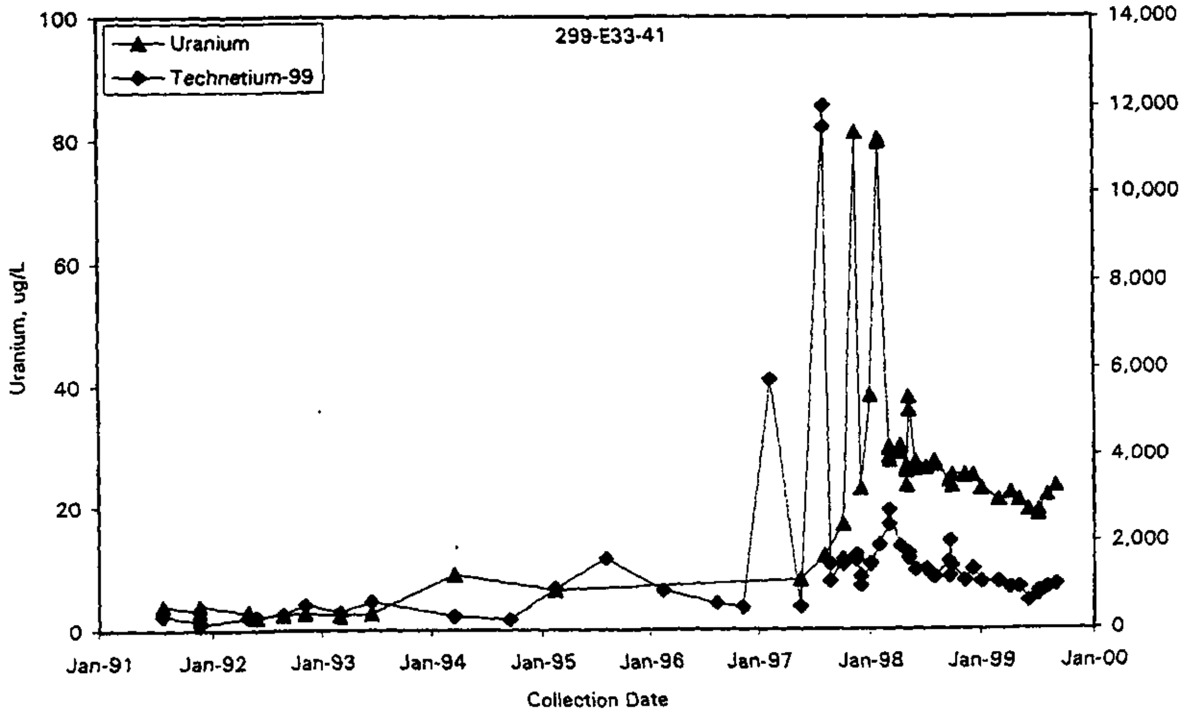
- The rising technetium-99 and nitrate concentration levels seen on the west side of WMA B-BX-BY in wells 299-E33-42, 299-E33-31, and 299-E33-32 may be related to a release from the WMA or from BX trenches to the west of these wells. As evidenced with August 1997 data, however, the source of the contamination along the west side of the WMA is still not determined. Contamination concentrations are still increasing.

- The contamination observed at well 299-E33-41 appears to have recently entered the groundwater as evidenced by the sudden sharp rise in anions, sodium, and technetium-99. Furthermore, the contamination events are localized and the concentrations are low when compared directly to waste stored in the SSTs. Consequently, the overall impact on groundwater quality may be small, especially when compared to the large regional contaminant plumes that currently exist in the northern portion of 200 East Area.

Groundwater data from fiscal year 1998 reveal a unique pattern of uranium changes observed in well 299-E33-41 (see Figure 3.2). The double, high-frequency, high-amplitude spikes observed in technetium-99 data during fiscal year 1997 were repeated for uranium data for fiscal year 1998. No other well has shown this pattern of contamination for any constituents. Based on the time difference between the second peak of technetium-99 to uranium, it appears that uranium is traveling approximately six months behind the technetium-99. The rapid, sharply rising breakthrough curve indicates that contamination has a relatively short travel path in the groundwater and has entered the groundwater near the well (PNNL-12086). Surrounding groundwater monitoring well data for uranium constituent remained unchanged from May 1997 to August 1998.

Groundwater data from fiscal year 1999 reveals three distinct plumes surrounding WMA B-BX-BY related to the constituents of technetium-99, nitrate and associated anions, and uranium. The following discussion centers on those constituents used to track contamination moving through WMA B-BX-BY and to identify groups of contamination that, most likely, have different source histories. Four different wells surrounding WMA B-BX-BY provide these three distinct contamination areas:

Figure 3.2. Technetium-99 versus Uranium in Well 299-E33-41 at WMA B-BX-BY



Source: PNNL-13116

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- Well 299-E33-7, associated with the BY cribs
- Well 299-E33-16, associated with crib B-8
- Wells 299-E33-41 and 299-E33-44, associated with the B and BX tank farms.

Figure 3.3 shows the location of these wells, in bold typeface for emphasis, with respect to WMA B-BX-BY.

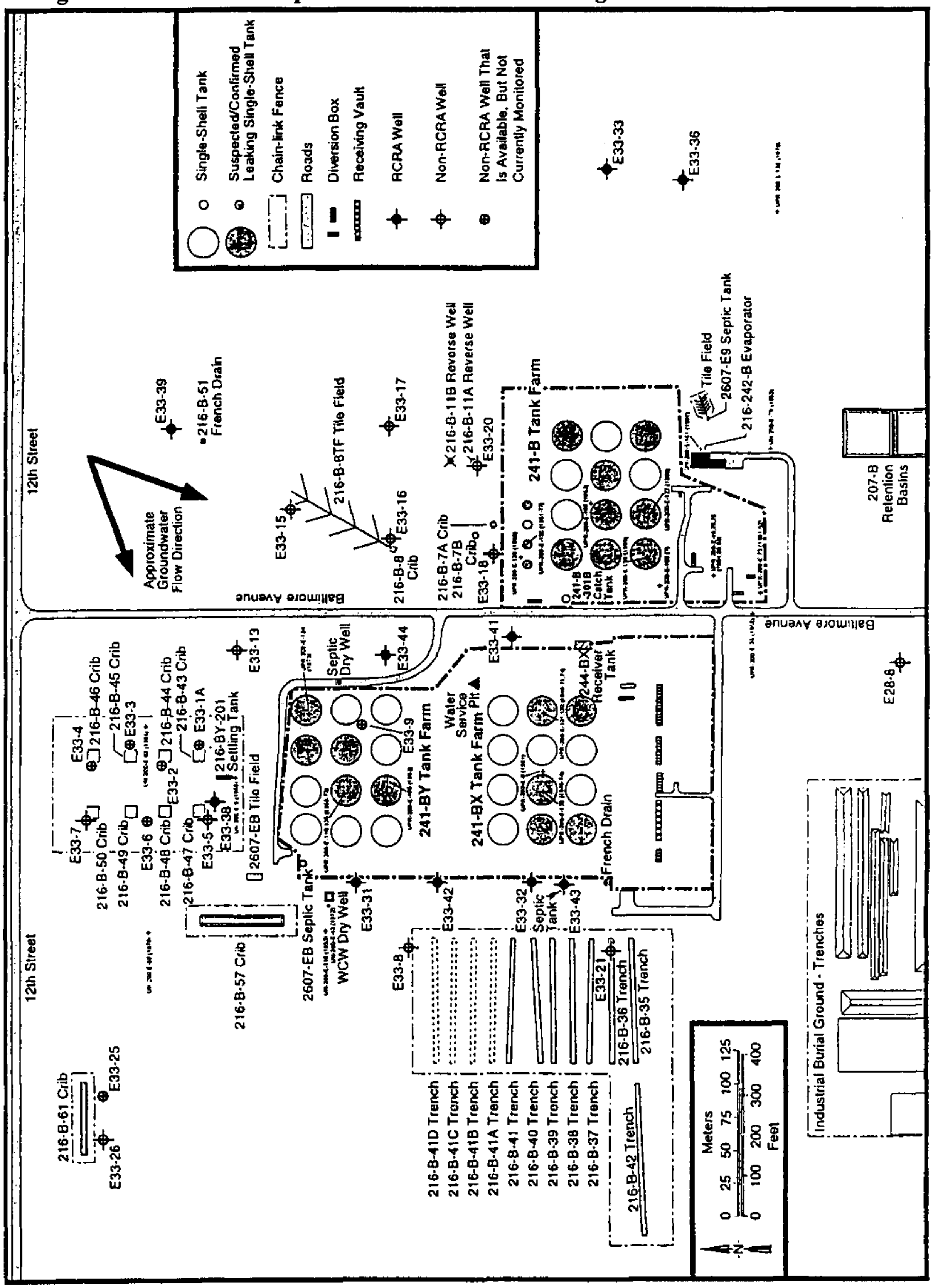
3.1.4.1 Well 299-E33-7. The highest values of technetium-99 (7,030 pCi/L) recently recorded in the northern portion of BY cribs were in well 299-E33-7 (PNNL-13116). Technetium-99 also has risen in wells further south in the BY cribs and along the western side of WMA B-BX-BY. The elevated nitrate apparently migrated with the technetium-99 and was found in wells at the northeastern corner of low-level WMA 1, which is adjacent to WMA B-BX-BY (see Figure 2.10). Nitrate concentrations in all the wells in WMA B-BX-BY are above the 45 mg/L maximum contaminant level. The July 1999 value in well 299-E33-7 was 337 mg/L (PNNL-13116). Technetium-99 is rising in wells near WMA B-BX-BY and appears to be moving southwestward, recently impacting well 299-E33-35 that monitors the low-level WMA 1. High values of tritium (e.g., 10,500 pCi/L at well 299-E33-7) are consistent with the elevated technetium-99.

3.1.4.2 Well 299-E33-16. The contamination detected in the groundwater at well 200-E33-16 had an extremely high nitrate value (i.e., close to 500 mg/L) (PNNL-13116). The maximum contaminant level for nitrate is 45 mg/L. Technetium-99 was also found to be above the drinking water standard at approximately 2,000 pCi/L in June 1999. Chromium is also elevated in well 299-E33-16 at 53.5 µg/L (but below the 100 µg/L maximum contaminant level) (PNNL-13116). Nitrate concentration levels above the maximum contaminant level were also detected at surrounding wells 299-E33-15, -17, and -20. However, elevated technetium-99 and chromium concentration levels were not found in the groundwater at these wells, suggesting that the contamination at well 299-E33-16 is localized.

3.1.4.3 Well 299-E33-44. Well 299-E33-44 was constructed in 1998 to facilitate groundwater sampling between wells 299-E33-41, -13, and -18. High concentration levels of technetium-99 (12,000 pCi/L in August 1997) and uranium (maximum of 81 µg/L in November 1998) were detected at well 299-E33-41 and elevated levels of nitrate, technetium-99, and uranium were found in wells 299-E33-13, and -38. The relationship between technetium-99 and uranium for well 299-E33-41 is shown in Figure 3.2. Similar increases in chloride and sulfate correlated with the high frequency technetium-99 pulses. The associated uranium traveled through the WMA B-BX-BY vicinity at a retarded flow rate, with respect to the more mobile anions, but repeating the same high frequency pattern as shown for technecium-99.

Initial groundwater samples from well 299-E33-44, collected in October 1999, revealed that technetium-99 and nitrate are above the drinking water standard (4,480 pCi/L and 95 mg/L, respectively), but the highest levels of uranium in the area were found between the B and BX tank farms (i.e., at well 299-E33-41) (PNNL-13116). The maximum concentration at well 299-E33-44 was found in April 1999 (350 µg/L). Unlike the technetium-99 and nitrate observed to the north, the groundwater in well 299-E33-44 has neither cyanide nor cobalt-60 in detectable quantities (PNNL-13116).

Figure 3.3. Location Map of Groundwater Monitoring Wells in WMA B-BX-BY



Source: HNF-6020

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Nitrite was detected in the groundwater samples at 299-E33-44 between 400 and 600 µg/L. No coliform was detected. Efforts are underway to sample well 299-E33-9 inside the BY tank farm to ascertain if the nitrite is local to well 299-E33-44 or if there is a small plume located under WMA B-BX-BY.

3.1.5 Surface Water and River Sediment

Surface water and river sediment contamination has not occurred related to contamination releases associated with WMA B-BX-BY.

3.2 POTENTIAL CORRECTIVE ACTION REQUIREMENTS

The purpose of this addendum is to enable field characterization efforts in the vicinity of WMA B-BX-BY beginning fiscal year 2000. The RCRA corrective action process as specified in Section 7 of the Tri-Party Agreement (Ecology et al. 1998) is used to establish the framework within which vadose zone investigations at the WMA B-BX-BY are planned and conducted. Based on Section 7.5 of the Tri-Party Agreement, any required corrective action at WMA B-BX-BY will be conducted to comply with federal and state environmental laws and promulgated standards, requirements, criteria, and limitations that are legally applicable or relevant and appropriate requirements under the circumstances presented by the release or threatened release of dangerous substances, pollutants, or contaminants. Site-specific and plateau-wide potential applicable or relevant and appropriate requirements are identified and discussed in Section 2.0 and Appendix F of the Phase 1 RFI/CMS work plan (DOE/RL 99-36) that was prepared pursuant to proposed Tri-Party Agreement Milestone M-45-51 (Ecology et al. 1999). The Phase 1 RFI/CMS work plan includes identification of potential corrective action standards for protection of human health and the environment.

Only two potentially applicable or relevant and appropriate requirements from the list in Appendix F of the Phase 1 RFI/CMS work plan (DOE/RL-99-36) are not applicable or relevant and appropriate requirements for this addendum. These requirements are related to emissions of asbestos-related material during disposal or demolition and renovation activities (40 CFR 61 Subpart M).

3.3 POTENTIAL IMPACTS TO PUBLIC HEALTH AND THE ENVIRONMENT

This section presents a preliminary conceptual model of the vadose zone portion of the groundwater exposure pathway because the vadose zone is the focus of this addendum. The vadose zone conceptual model is a set of working hypotheses made up of elements of tank waste characteristics, past leak characteristics, geology, hydrogeology, and driving forces that include infiltration from precipitation and human sources of water. The data, both existing and to be collected, will be used to test these hypotheses. If the hypotheses are consistent with the data then that consistency would initially be deemed an endorsement. If the hypotheses are not consistent then the hypotheses will be revised in an effort to refine and improve the conceptual model.

The Phase 1 RFI/CMS work plan (DOE/RL-99-36) focuses on all potential exposure pathways, including groundwater (Ecology et al. 1999). The conclusions in the following subsections are based on preliminary data and are tentative; they will be subject to refinement as data are gathered during the RFI/CMS process.

3.3.1 Conceptual Exposure Pathway Model

This section presents a preliminary vadose zone conceptual model for WMA B-BX-BY. The conceptual model is based on information presented in Chapter 2.0 and Section 3.1 of this addendum and is, therefore, intended to be preliminary. The exposure pathway in this conceptual model is limited to near-surface releases associated with the waste tanks and transport in the vadose zone and is shown conceptually in Figure 3.4. Through the corrective action process, the concepts illustrated in Figure 3.4 must ultimately be confirmed, disproved, or shown to be inconsequential in the context of retrieval and closure, including the WMA B-BX-BY endstate. A generalized conceptual model is provided in Chapter 4.0 of the Phase 1 RFI/CMS work plan (DOE/RL-99-36) and identifies the preliminary conceptual model of this addendum.

The data and evaluations previously discussed are integrated and summarized in this section in the form of a preliminary vadose zone conceptual model. The conceptual model is a preliminary working effort because the data are not complete, not all the data have been evaluated, and in many cases, the data are not validated. The purpose of the vadose zone conceptual model is to help focus the preliminary field data collection. The vadose zone conceptual model will be refined in the site-specific Phase 1 RFI/CMS field investigation report for WMA B-BX-BY based on evaluation of the data collected under the guidelines in this addendum and the continued evaluation of existing data.

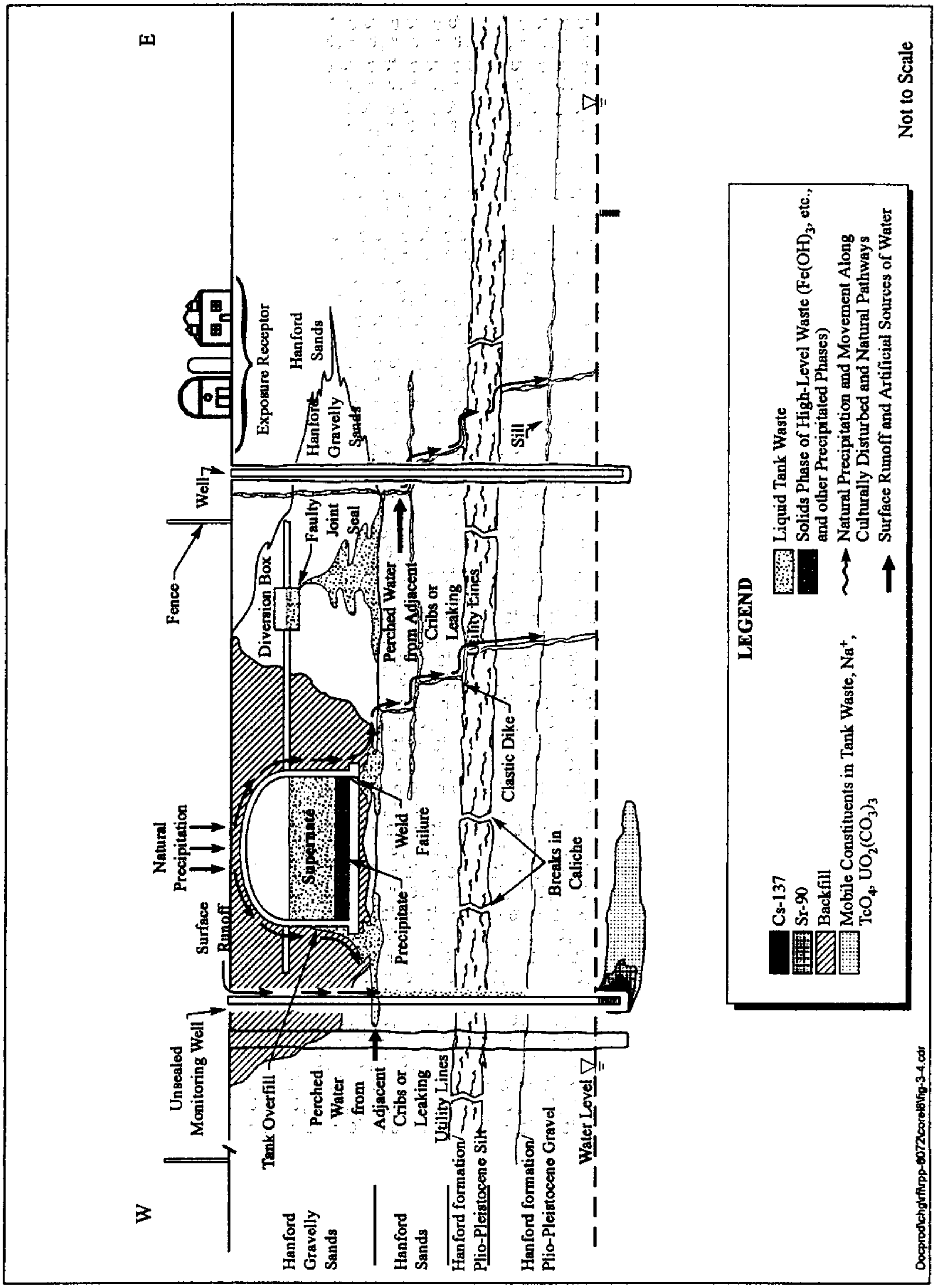
The contaminant sources, mechanisms for these contaminants to be released into other environmental media, potential types of movement through the vadose zone, and one type of potential receptor are shown conceptually in Figure 3.4. The schematic illustrated on Figure 3.4 – together with estimates of values for key parameters (e.g., contaminant concentrations) – are a part of the basis for assessing initial human health risks associated with the various contaminants and receptors.

The results of the human health risk assessment will be provided in the site-specific Phase 1 RFI/CMS field investigation report for WMA B-BX-BY. The vadose zone conceptual model is used in this addendum to qualitatively express the current understanding of the following:

- Pathways that contaminants may follow to the groundwater based on the integration of contaminants, hydrochemical, hydrogeologic, and geologic data (inferences are made on relatively sparse and unevenly distributed data)
- Contaminant sources with most of the available data for source locations for the upper 40 m (130 ft) of the vadose zone (inference is made to the presence of contaminants in the lower vadose zone based on groundwater contamination and historic records of water levels).

Key aspects of the WMA B-BX-BY vadose zone conceptual model required to support this addendum are summarized in the following subsections.

Figure 3.4. Preliminary Generalized Vadose Zone Contaminant Conceptual Model



3.3.1.1 Sources.

3.3.1.1.1 Chemical Processing. Irradiated nuclear fuel from the Hanford Site plutonium production reactors contained fission products and lesser amounts of neutron activation products as well as the unreclaimed uranium and transuranic radionuclides. Plutonium was chemically extracted from the fuel matrix at T Plant and S Plant in the 200 West Area and B Plant and A Plant in the 200 East Area.

The B, BX, and BY tank farms contain aqueous waste generated from five different operations: wartime bismuth phosphate plutonium separations (1943-1945), postwar bismuth phosphate operation (1946-1952), uranium recovery and scavenging (1952-1958), in-tank solidification (1965-1974), and interim stabilization and isolation (1975-present) (HNF-5231).

3.3.1.1.2 Tank-Related Considerations. The SSTs are constructed of a single layer of carbon steel surrounded by a layer of reinforced concrete, which forms the roof and sidewall support. The tanks declared leakers in the B, BX and BY tank farms (Section 3.1.1) apparently failed because of waste transfer leaks and/or accelerated corrosion.

The vadose zone conceptual model for this addendum focuses on those contamination sources in the vicinity of the WMA B-BX-BY SSTs. As discussed in Section 3.1 and HNF-5507, one hypothesis for the observed contaminants in the RCRA groundwater monitoring is that contaminants from tank leaks have migrated downward through the vadose zone and then traveled in a direction consistent with the local groundwater flow. Releases from the WMA B-BX-BY SSTs could represent a significant present contamination source in the vadose zone. It is certain that the leaks from those tanks contained several radioisotopes and chemicals commonly found in tank waste (e.g., cesium-137, technetium-99, sodium, and nitrate). Thus, contaminants (i.e., technetium-99 and nitrate) that are remnants of these past leaks may be still present in the vadose zone, especially within the finer-grained sediments of the Hanford formation. HNF-5507 provides a discussion of the contaminated areas in WMA B-BX-BY.

3.3.1.2 Geologic Conceptual Model. The geology of the B, BX and BY tank farms was documented after the drywell boreholes were completed in the early 1970s (ARH-LD-129, ARH-LD-130 and ARH-LD-131). The major stratigraphic units of the suprabasalt sediments present beneath WMA B-BX-BY are the Hanford formation/Plio-Pleistocene unit (?), and the Hanford formation (in ascending order) (see Chapter 2.0). The sources of data used in evaluating valid conceptual model(s) for the B, BX and BY tank farms geology include ARH-LD-129, ARH-LD-130, ARH-LD-131, BHI-00184, HNF-2603, HNF-5507, PNNL-11826, and WHC-SD-EN-TI-019. Potential structural control or influence on contaminant migration in the vadose zone is of particular interest. Elevation maps of the basalt are presented in Figure 2.7 and HNF-5507 and will be used as a source for this information.

Clastic dikes, illustrated conceptually in Figure 3.4, are lenses or tabular bodies, relatively narrow at 18 to 38 cm (7 to 15 in.) (BHI-00230 and BHI-01103), with textural characteristics typically comprised of clay and sand. The localized effect of the dikes on contaminant movement over the scale of a few meters is an unknown and could account for some observations of relatively immobile contaminants (e.g., cesium-137) deeper in the vadose zone than would be expected under nonpreferential flow conditions. The geologic cross-sections provided in HNF-5507 represent the preliminary working geologic conceptual model for this work plan.

3.3.1.3 Hydrologic Properties. Preliminary hydrologic property values will be provided in the site-specific Phase 1 RFI/CMS field investigation report for WMA B-BX-BY that will be prepared pursuant to proposed Tri-Party Agreement Milestone M-45-55 (Ecology et al. 1999).

3.3.1.4 Receptors. Receptors are organisms with the potential for exposure to the released contaminants and include both biota and humans. A likely point of exposure for terrestrial biota is in the plant root zone where flora could absorb buried contaminants. Terrestrial animals (especially burrowing animals) may be exposed by direct contact, inhalation, and ingestion of contaminated sediment, water, plants, and animals.

For the receptors, the site-specific Phase 1 RFI/CMS field investigation report for WMA B-BX-BY will use modified Model Toxics Control Act (WAC 173-340) Methods B and C exposure scenarios at the WMA boundary to evaluate human health risks.

The modified Model Toxics Control Act Method B residential scenario is a combination of the risk equations specified in WAC 173-340-720 through 173-340-750 and the corresponding exposure pathways for residential use found in the Department of Health's Hanford Guidance for Radiological Cleanup (WDOH/320-015). The modified Model Toxics Control Act Method C industrial scenario is a combination of the risk equations specified in WAC 173-340-720 through 173-340-750 and the corresponding exposure pathways for industrial/commercial use found in WDOH/320-015. WAC 173-340-730 is not applicable to either scenario as it is not expected that WMA B-BX-BY or any remedial activity under consideration will impact surface water. Ecology also asks that the modified Method C scenario specifically include groundwater ingestion at the rate of 500 L/yr (132 gal/yr) and that the soil contaminant transfer to groundwater as specified in WAC 173-340-740 (4)(b) be evaluated. The addition of groundwater intake to the modified Method C scenario represents a change to the WDOH/320-015 pathways that currently does not include this parameter. The soil contaminant transfer to groundwater evaluation is included to ensure consistency with similar scenarios evaluated elsewhere.

3.4 PRELIMINARY CORRECTIVE ACTION OBJECTIVES AND CORRECTIVE ACTION ALTERNATIVES

Interim and final corrective action objectives, general response actions, corrective technologies and process options, and a range of preliminary corrective action alternatives are provided in the Phase 1 RFI/CMS work plan (DOE/RL-99-36). These objectives and alternatives are based on available site data, use of the qualitative risk assessment, and the conceptual exposure pathway model. General interim actions are identified and represent broad classes of corrective actions that may be appropriate to achieve the corrective action objectives in Section 5.0 of the Phase 1 RFI/CMS work plan (DOE/RL-99-36). Corrective action objectives may change or be refined as additional site data are gathered and evaluated during the field investigation and implementation of ICMs.

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4.0 RATIONALE AND APPROACH

The RFI/CMS process is the RCRA-specified method by which risks from releases to the environment are characterized and corrective action alternatives are evaluated and implemented if required to minimize potential risks to human health and the environment. Objectives and data needs must be identified before designing a data collection program to support the RFI/CMS process. The data collected are used as a basis for making an informed risk management decision regarding the most appropriate corrective action(s) to implement. The data needs for field characterization efforts at WMA B-BX-BY were identified through a DQO process that was executed based on the requirements established in the proposed Tri-Party Agreement commitments identified in Change Control Form Number M-45-98-03 (Ecology et al. 1999) and in Section 6.0 of the Phase 1 RFI/CMS work plan (DOE/RL-99-36). The data needs identified in the DQO planning process will be collected in accordance with the Phase 1 RFI/CMS work plan (proposed Milestone M-45-51) and this site-specific WMA B-BX-BY addendum (proposed Milestone M-45-53).

4.1 RATIONALE

An understanding of subsurface conditions and contaminant migration processes is required to support decision making on interim measures and ICMs, SST waste retrieval, and tank farm closure. A comprehensive list of data needs to support these decisions has been developed based on the current level of understanding. However, it is generally recognized on both a technical and regulatory basis that uncertainties regarding existing contaminant inventory, distribution from past leaks, and uncertainties associated with contaminant migration processes are of primary importance to future decision making. The need to reduce these uncertainties through field and laboratory investigations serves as the basis for initiating characterization activities through this addendum.

Characterization objectives and data needs for WMA B-BX-BY were developed during the DQO planning process that was carried out for the Phase 1 RFI/CMS work plan and this addendum for WMA B-BX-BY. A separate DQO process (HNF-6020) was conducted to support the development of this document.

The DQO process is a planning tool to aid in the determination of the type, quantity, and quality of data needed to take the next step in the iterative process of characterizing a contaminated site or area. There are a number of possible approaches to implementing the DQO process. The planning process used to identify data collection activities in this addendum is described in Section 6 of the Phase 1 RFI/CMS work plan (DOE/RL-99-36) and summarized in this section and HNF-6020.

Before initiating meetings to discuss characterization activities to be conducted in the fiscal year 2001 timeframe, the Tank Farm Vadose Zone Project technical team conducted a review of existing information that included published and unpublished reports, interpretations of historical and recent geophysical survey data, and information from previous DQO meetings. To prioritize data needs for inclusion in the fiscal year 2001 effort, a review of the available information on the current state of knowledge of WMA B-BX-BY subsurface contamination was conducted by the Tank Farm Vadose Zone Project technical team. The review results were incorporated into HNF-5507 and summarized in the DQO summary report (HNF-6020).

A series of DQO meetings were held in February and March 2000 that focused specifically on the data needs for the field characterization efforts to be conducted at WMA B-BX-BY. These meetings served to identify the following:

- Existing data and what is currently known about WMA B-BX-BY
- Data needs that will likely be satisfied by fiscal year 2000 characterization activities
- Options for data collection from the additional characterization activities.

The DQO meetings included representatives from Ecology, DOE, Hanford Site contractors, stakeholders, Tribal Nations, Oregon Department of Energy, and Hanford Site Vadose Zone/Groundwater Integration Project as indicated in HNF-6020.

Meetings held as a part of the DQO process involved varying levels of involvement by all participants. The DQO meetings provided a foundation of existing information and identification of characterization options for consideration by the decision makers.

Through the DQO process, it was determined that the primary goal of the WMA B-BX-BY field investigation is to implement vadose zone characterization activities that will support the iterative process of improving the understanding of inventory (i.e., nature and extent of past releases) and contaminant migration processes (fate and transport) necessary to support risk assessments. Additional characterization data are needed to support near-term corrective measures decisions and SST waste retrieval and tank farm closure decisions. The characterization effort will provide data that, when combined with historical data, will improve the ability to make informed corrective measures, waste retrieval, and tank farm closure decisions.

4.2 DATA NEEDS

Current understanding of the nature and extent of contamination at WMA B-BX-BY is based largely on order-of-magnitude estimates of past leak volumes and inventories and on historical information on the distribution of gamma-emitting radionuclides measured to a depth of 30.5 to 45.7 m (100 to 150 ft) in drywells located around the tanks. Historical drywell gross gamma data was collected from the early 1960s through 1994; however, detailed analysis of the gross gamma data has only recently been conducted. Three reports have been issued on this subject, one for the BX tank farm (HNF-3531) one for the BY tank farm (HNF-3532) and one for the B tank farm (HNF-5433).

Comprehensive spectral gamma logging of all drywells in WMA B-BX-BY was completed in the 1997 through 1999 period. Spectral gamma logging reports have been issued for the B, BX, and BY tank farms (GJO-HAN-28, GJO-HAN-6, GJO-HAN-19). Spectral gamma logging data provide greater insight into the distribution and movement of specific gamma-emitting contaminants (e.g., cesium-137). However, limited data exist on the distribution of non-gamma-emitting mobile tank waste contaminants (e.g., technetium-99, iodine-129, hexavalant chromium, and nitrate). While there is emerging data on the distribution and movement of tank waste contamination in the groundwater, the data are not sufficient to support more than qualitative hypotheses on the specific sources of contaminant releases responsible for the observed groundwater contamination.

During the DQO process, the participants determined that the primary focus of the fiscal year 2001 data collection effort at WMA B-BX-BY should be directed toward characterizing the contamination source in the vicinity of the probable largest releases. Potential Phase I characterization efforts at tanks BY-107 and BY-103 are not planned because of the lack of supporting data from process history transfers and spectral gamma information. The primary areas of interest identified were the areas to the east and north of tank BX-102, the area to the north of tank B-110, the area between tanks BX-110 and BX-107, and the area surrounding the 241-B diversion boxes. This effort should improve the understanding of tank leak inventory and distribution to support testing and refining a site-specific conceptual model for tank leaks and contaminant migration processes. A number of characterization technologies, including screening techniques, were considered. Because the current understanding of the distribution of radionuclides in the leak-contaminated vadose zone is still limited and is based primarily on indirect evidence, the focus of the fiscal year 2001 data collection program at WMA B-BX-BY will be on sampling the vadose zone soils in areas of known tank leaks, spills, and overfill events within the tank farms, and analyzing the samples for a range of contaminants of interest.

4.3 CHARACTERIZATION OPTIONS

The Tank Farm Vadose Zone Project technical team plans to use existing information and the characterization data collected during the Phase 1 characterization to develop a best basis or best estimate of the concentration and distribution of CoCs in WMA B-BX-BY. This will involve the integration and synthesis of historical data, process knowledge, in-tank inventory models, as well as the characterization data collected during Phase 1. The integration and synthesis of these data will require extrapolation due to the limitations of collecting samples within the tank farms. This effort will result in a conceptualization of CoC concentrations and distributions that would be used to evaluate human health and environmental risk.

Based on data needs identified in Section 5 of HNF-6020 and the DQO meetings, a number of characterization options were considered for the fiscal year 2001 effort at WMA B-BX-BY. These characterization options included installing new boreholes; decommissioning and/or extending existing boreholes; using direct-push technology (e.g., direct-push technology or geoprobe); using auger drilling; and using nonintrusive geophysical techniques. These options are based on characterization techniques and innovative technologies identified in Section 6.3 of the Phase 1 RFI/CMS work plan (DOE/RL-99-36) for characterizing methods that have been successfully used at the Hanford Site. These options and potential deployment locations were evaluated in terms of the type of information that could be provided, as well as the technical risk associated with deployment during fiscal year 2001. Although all of the options considered could provide valuable data that would serve to improve the understanding of subsurface contamination, a number of the options were considered to be of lesser value or not feasible due to technical risk for the characterization effort to be implemented in fiscal year 2001. The list of characterization options considered during the DQO process, along with the rationale for including or omitting each option from the fiscal year 2001 effort, is provided in HNF-6020.

The characterization options selected for implementation at WMA B-BX-BY during fiscal year 2001 are provided in Table 4.1. The selected options consist of near-surface characterization, vertical borehole installation and RCRA monitoring well characterization.

4.3.1 Near-Surface Characterization

One of the characterization options considered and selected during the DQO process was the collection of sediment samples from the upper portion of the vadose zone using direct-push technology. Direct-push technology is the preferred method for defining the lateral extent of contamination in the upper part of the vadose zone. The near-surface characterization will be implemented in three areas of known spills or leaks indicated by gamma contamination at the B and BX tank farms (Figure 4.1). Near-surface characterization will also be implemented in the largely uncharacterized area surrounding the 241-B diversion boxes, which were reported to have leaked metal waste in 1951.

A two-phased approach will be used for near-surface characterization. Shallow soil characterization will be carried out using a truck-mounted, direct-push based system. At specific sites cleared for access (underground piping and electrical services identified) and for which an excavation permit has been approved, the first phase will be to interrogate with a gross-gamma/spectral gamma probe. The depth of investigation will be determined by the depth to which the direct-push boring can be advanced using a standard deployment truck. The probe will be deployed using the gross gamma mode with the tool lowered or raised at approximately 2 cm/sec (0.8 in./sec). Based on regulatory requirements for direct contact of contaminated soils, the upper 5 m (15 ft) of the vadose zone will use a lower action level than the vadose zone below 5 m (15 ft). If, in the upper 5 m (15 ft) the downhole instrument indicates a potential cesium-137 concentration of 3.7 pCi/g or greater, logging will be shifted to the spectral mode to determine the presence and level of concentration of cesium-137. If the downhole instrument is below 5 m (15 ft) the threshold limit for spectral gamma determinations will be 20 pCi/g. In zones where cesium-137 is present at concentrations greater than 20 pCi/g, spectral gamma readings will be taken at 0.5-m (1.5-ft) intervals.

The second phase will use the graphical log developed using the gross and spectral gamma measurements to select intervals to be sampled. The sampling push is to be made in a location that is no more than 0.7 m (2 ft) from the site of the gamma push. A single point sampler will be used to collect the required samples. Sampling intervals will be selected from those horizons with a cesium-137 concentration of 20 pCi/g or greater. In the event that horizons are penetrated that would yield samples having a greater than 50 mrem/hr dose rate at 30 cm (12 in.) (based on calculations using sampler size and cesium-137 concentration), a sample will be collected from the first interval below the high-rate zone that has a dose rate of less than 50 mrem/hr. No sample will be collected from zones where the gamma instrument exhibits excessive deadtime. The sediment samples collected using direct-push technology may require multiple pushes if sufficient material for analysis of CoCs was not collected from the initial push. Direct-push technology was successfully deployed at nine locations in WMA S-SX in the 200 West area during near-surface characterization activities carried out in early 2000.

Figure 4.1. Shallow Soil, Vadose Zone Soil, and Groundwater Interest Areas in the Vicinity of WMA B-BX-BY

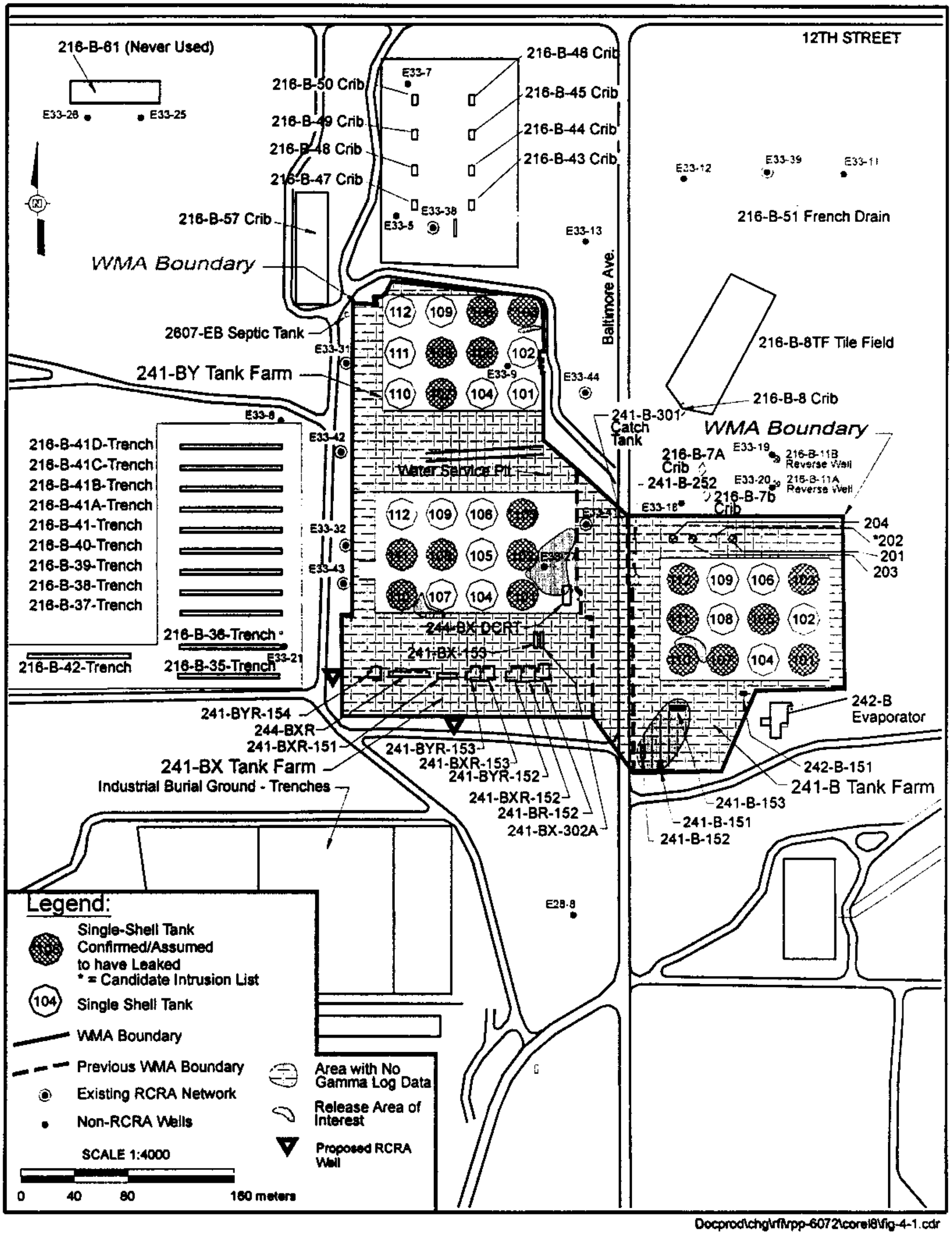


Table 4.1. Proposed WMA B-BX-BY Phase 1 Characterization Design

Area of Interest	Screening Technology	Sampling Method	Implementation Design*	Rationale
Tank BX-102	Gross alpha/beta; gamma spectrometry, soil moisture	Vertical borehole	The vertical borehole would be located near point of highest contaminant concentration based on existing spectral gamma data. Attempt to drill through center of the plume and continue to groundwater (~77.7 m [255 ft]). Continuous collection of drill cuttings. Collect soil samples by split-spoon techniques at 3-m (10-ft) intervals to groundwater (gamma logs indicate low contaminant levels from ground surface to 21 m [70 ft] bgs). Groundwater grab samples would be collected from borehole. All soil and groundwater samples would be conditionally analyzed for the CoCs.	The vertical borehole needed to determine CoC distribution to the water table. Some isotopic uranium analyses required to confirm origin of waste, support risk assessment, and correlate to local groundwater observations.
	Gamma spectrometry	Direct-push technology	Direct-push technology transects (north-south and east-west) if borehole results show Tc-99 in soil <18 m (60 ft) bgs. Six sets of pushes proposed along each transect (i.e., 12 total sets of pushes). Use direct-push technology sampling approach similar to that developed for S tank farm (HNF-5085). Direct-push technology sample volume is limited, soil samples would be conditionally analyzed for gamma emitters and mobile CoCs.	Direct-push technology pushes, if required, would be to refine the conceptual model.

Table 4.1. Proposed WMA B-BX-BY Phase 1 Characterization Design

Area of Interest	Screening Technology	Sampling Method	Implementation Design*	Rationale
Tank B-110	Gamma spectrometry	Direct-push technology	Direct-push technology (3 pushes) to confirm plume location prior to locating vertical borehole. Use direct-push technology sampling approach similar to that developed for S tank farm (HNF-5085). Direct-push technology sample volume is limited, soil samples would be conditionally analyzed for gamma emitters and mobile CoCs.	The direct-push technology pushes are required to increase the chance of locating vertical borehole in an area where contaminants are present and provide indication of continuity or lack of continuity between the gamma contamination observed at dry wells 20-10-12 and 20-10-02.
	Gross alpha/beta; gamma spectrometry, soil moisture	Vertical borehole	Vertical borehole planned to groundwater (i.e., ~77.7 m [255 ft]). Continuous collection of drill cuttings. Collect soil samples by split-spoon techniques at 3-m (10-ft) intervals to groundwater (gamma logs indicate low contaminant levels from ground surface to 21 m [70 ft] bgs). Groundwater grab samples would be collected from borehole. All samples would be conditionally analyzed for the CoCs.	The vertical borehole needed to determine CoC distribution to the water table.

Table 4.1. Proposed WMA B-BX-BY Phase 1 Characterization Design

Area of Interest	Screening Technology	Sampling Method	Implementation Design*	Rationale
Tanks BX-110 and -107	Gamma spectrometry	Direct-push technology	The direct-push technology pushes would be located between dry wells 21-10-03 and 21-10-05 (two pushes) and between dry wells 21-10-05 and 21-07-06 (two pushes) (i.e., a total of four sets of pushes). Several access limitations are expected. Use direct-push technology sampling approach similar to that developed for S tank farm (HNF-5085). Direct-push technology sample volume is limited, soil samples would be conditionally analyzed for gamma emitters and mobile CoCs.	The data would help determine if contaminants detected at 21-10-03, 21-10-05, and 21-07-06 represent a continuous plume or if they are separate discrete "release sites." This data would partially support development of source term.
241-B diversion boxes (i.e., -151, -152, and -153)	Gamma spectrometry	Direct-push technology	The samples would be collected near the corners of each diversion box (12 pushes total). Use direct-push technology sampling approach similar to that developed for S tank farm (HNF-5085). Direct-push technology sample volume is limited, soil samples would be conditionally analyzed for gamma emitters and mobile CoCs.	The data would help establish the effectiveness of past cleanup efforts and partially support development of the source term for vadose zone modeling.

*Figure 4.1 indicates the proposed locations as discussed in the implementation design.

CoC = contaminant of concern.
PNNL = Pacific Northwest National Laboratory.

Deployment of direct-push technology at the proposed locations in WMA B-BX-BY would be expected to begin to address a number of questions related to the concentration and distribution of contaminants, including those listed below.

- What contaminants are present that are routinely identified as CoCs from a groundwater impact standpoint (e.g., technetium-99, nitrates)?
- What are the concentration/inventory correlations between the CoCs and cesium-137 in soil samples and with the tank contents?
- What is the vertical extent of the CoCs in the backfill material?
- What is the horizontal extent of the CoCs across the areas of interest?
- What are the potential drivers (e.g., sediment moisture profile) in the upper portion of the vadose zone that could control the migration of contaminants?

The benefits and uncertainties associated with direct-push technology were identified during the DQO meetings (HNF-6020). Direct-push technology has been previously deployed in the tank farms and is limited to approximately the base of the tank or refusal in geology that is similar to the tank farms. The authorization basis for using one type of direct-push technology, the direct-push technology, has been completed (HNF-SD-WM-HIE-012).

4.3.1.1 Tank BX-102 Near-Surface Characterization. To characterize this area, installation of a vertical borehole to the water table in the vicinity of the highest observed uranium contamination is recommended (see Section 4.3.2). During borehole installation, continuous drill cuttings will be collected to groundwater (77 m [255 ft]). Split-spoon samples will be attempted every 3 m (10 ft) to groundwater. Depending on the findings of the vertical borehole and technical feasibility, several shallow surface samplings down to the base of the tanks or refusal to further define contaminant distribution may be warranted. Direct-push technology pushes would only be performed if technetium-99 were found in the vertical borehole sediments above 18.3 m (60 ft) bgs. Two transects through the plume area would be performed, with 6 pushes on each transect, for a total of 12 pushes. One transect would be oriented north-south and the other east-west. Direct-push sampling techniques may be impeded by the quantity of piping in the area and the high gravel content of the soils.

4.3.1.2 Tank B-110 Near-Surface Characterization. Drywell 20-10-12 shows a large band of contamination from 8 m to 30 m (25 to 100 ft) bgs that includes cesium-137 and cobalt-60, probably strontium-90, and possibly uranium. Drywell 21-10-02 also shows a region of probable strontium-90 contamination. The primary uncertainty to be addressed here is the nature and extent of contaminants in this area. To clear up this uncertainty, a vertical borehole to groundwater is recommended (see Section 4.3.2). To increase the chance of locating the vertical borehole in the area where contaminants are present and provide an indication of continuity or lack of continuity between gamma contamination observed at drywells 20-10-12 and 20-10-02, surface samplings (e.g., direct-push technology) from 3 m to 16.7 m (10 to 55 ft) in this area are recommended. This is estimated to require 3 direct-push technology pushes. In addition to the normal suite of chemical and radiological analyses, some effort should be made to measure the appropriate organic chelating agent species to address the potential impact of these species on contaminant migration.

4.3.1.3 Tanks BX-110 and BX-107 Near-Surface Characterization. Drywells 21-10-03, 21-10-05, and 21-07-06 show multiple sections of high cesium-137 content between 3 m and 30 m (10 and 100 ft) bgs. Cobalt-60 also is present and uranium may be present. The primary uncertainty to be addressed here is the nature and extent of contaminants, particularly mobile constituents, in this area. To clear up this uncertainty, surface samplings (e.g., direct-push technology) from 3 m (10 ft) bgs to the base of the tanks in this area are recommended. This is estimated to require 4 direct-push technology pushes. If mobile constituents are not found, further characterization is not required. If mobile constituents are found, an evaluation of potential impact on groundwater should be made before deciding on additional characterization.

4.3.1.4 241-B Diversion Boxes Near-Surface Characterization. Metal waste leaks from the 241-B diversion boxes were reported in 1951. No gamma logging data or any other kind of characterization data are available for this area. Because the metal waste is the most contaminated waste stream leaked in WMA B-BX-BY, shallow characterization is recommended. The primary uncertainty to be addressed here is the nature and extent of contaminants in this area. Uranium and, possibly, technetium-99 should be present. To clear up this uncertainty, surface samplings (e.g., direct-push technology) from 3 m (10 ft) to the base of the tanks in this area are recommended. This is estimated to require 12 direct-push technology pushes. If mobile constituents are not found, further characterization is not required. If mobile constituents are found, an evaluation of potential impact on groundwater should be made before deciding on additional characterization.

4.3.2 Installation of Vertical Boreholes

In addition to data collection from near-surface characterization, several options were considered for collection of deeper vadose zone data. The preferred option was installation of vertical boreholes at two locations inside the WMA B-BX-BY boundary associated with known past releases (Table 4.1) and sampling of the vadose zone soil down to the water table. This option was selected because vertical boreholes at these locations would provide source characterization along with distribution of contaminants at two primary locations of interest from within WMA B-BX-BY. Source characterization would do the following:

- Provide a basis for estimating contaminant inventories and processes that would control the migration of contaminants
- Support evaluation of the correlations between concentrations of CoCs and existing gamma data, and potentially evaluating the relationship between the CoCs in the soil and the concentrations of CoCs present in the tanks at the time the leaks were believed to occur
- Support assessing contaminant mobility, potential drivers (e.g., moisture content), and the effects of tank leaks on soil properties to support predictive modeling efforts necessary to evaluate potential future groundwater impacts

- Provide information on the single largest source in WMA B-BX-BY via the overfill leak in the BX tank farm from tank BX-102.

Source characterization efforts also would involve identifying what contaminants are present and subsequently the potential CoCs for corrective action, retrieval, and closure decisions. If correlations between the CoCs and available gamma data can be established, there is a potential that the wealth of existing gross gamma and spectral gamma data can be used to better understand the location and distribution of CoCs in the vadose zone.

4.3.2.1 Borehole Locations. Candidate locations for vertical borehole installation considered in the DQO process are presented in HNF-6020. Each option evaluated was identified because samples from these locations would potentially provide data to address source characterization (i.e., nature of contamination), location and distribution (i.e., extent of contamination), and transport pathways and processes (i.e., contaminant fate and transport). An additional consideration was potential programmatic risk (i.e., risk to the program if the characterization effort were unsuccessful) associated with a fiscal year 2001 deployment. Each option would potentially provide data to address a number of different questions and data gaps. However, in terms of source characterization, the potential value of information provided by characterizing the source at tank BX-102 and tank B-110 (Figures 4.2 and 4.3) exceeds the value from other options and makes these two locations primary characterization targets.

The BX-102 and B-110 locations were selected based on historical knowledge of WMA B-BX-BY, such as waste transfer records, leak history, previous vadose zone characterization efforts, historical gross gamma logging data, recent spectral gamma logging data, and RCRA groundwater assessment findings. Based on the information provided in HNF-5507, as summarized in Chapter 3.0, the DQO participants decided that the area just east of tank BX-102 is of interest because it is impacted by the largest documented leak in WMA B-BX-BY (346,700 L [91,600 gal] of metal waste in 1951) and because this plume is postulated to be associated with the observed groundwater contamination in RCRA monitoring wells located just east of the BX tank farm (299-E33-41) and BY tank farm (299-E33-44). The area surrounding tank B-110 is of interest because the gamma data indicate high cesium-137 levels and bremsstrahlung radiation possibly from high probable strontium-90 concentration levels in vadose zone in this area and the waste types stored in tank B-110 are known to have contained organic chelating agents that could be associated with enhanced strontium-90 mobility. The current planning basis is to pursue installation of vertical boreholes to groundwater in the area to the east of tank BX-102 and to the north-northeast of tank B-110.

4.3.2.2 Borehole Construction and Sampling Methodology. The final borehole construction and sampling methodology for the vertical boreholes in WMA B-BX-BY has not been completed. Installation of these boreholes is targeted to intercept tank waste plumes and could potentially encounter highly contaminated sediments. The potential contamination levels raise significant worker safety and air emissions concerns for any drilling or sampling method that brings material to the surface. The proposed sampling methodology to be used during construction of the WMA B-BX-BY boreholes is to collect sediment samples ahead of the casing. There are a number of uncertainties associated with application of this sampling methodology. The primary uncertainty is associated with the potential worker doses resulting from handling highly radioactive samples. Additional uncertainties include sample handling in

Figure 4.2. Vertical Borehole Location East of Tank BX-102

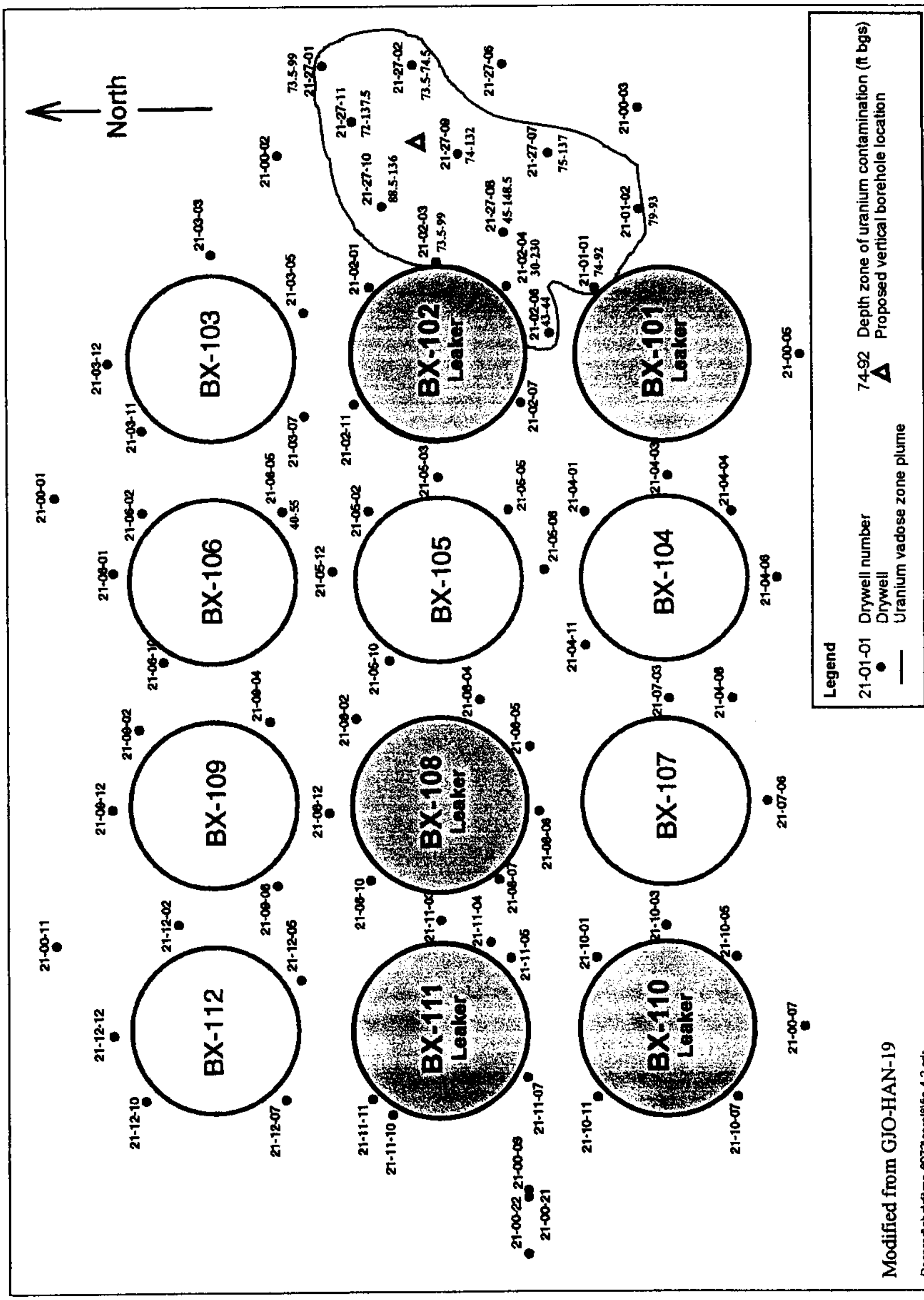
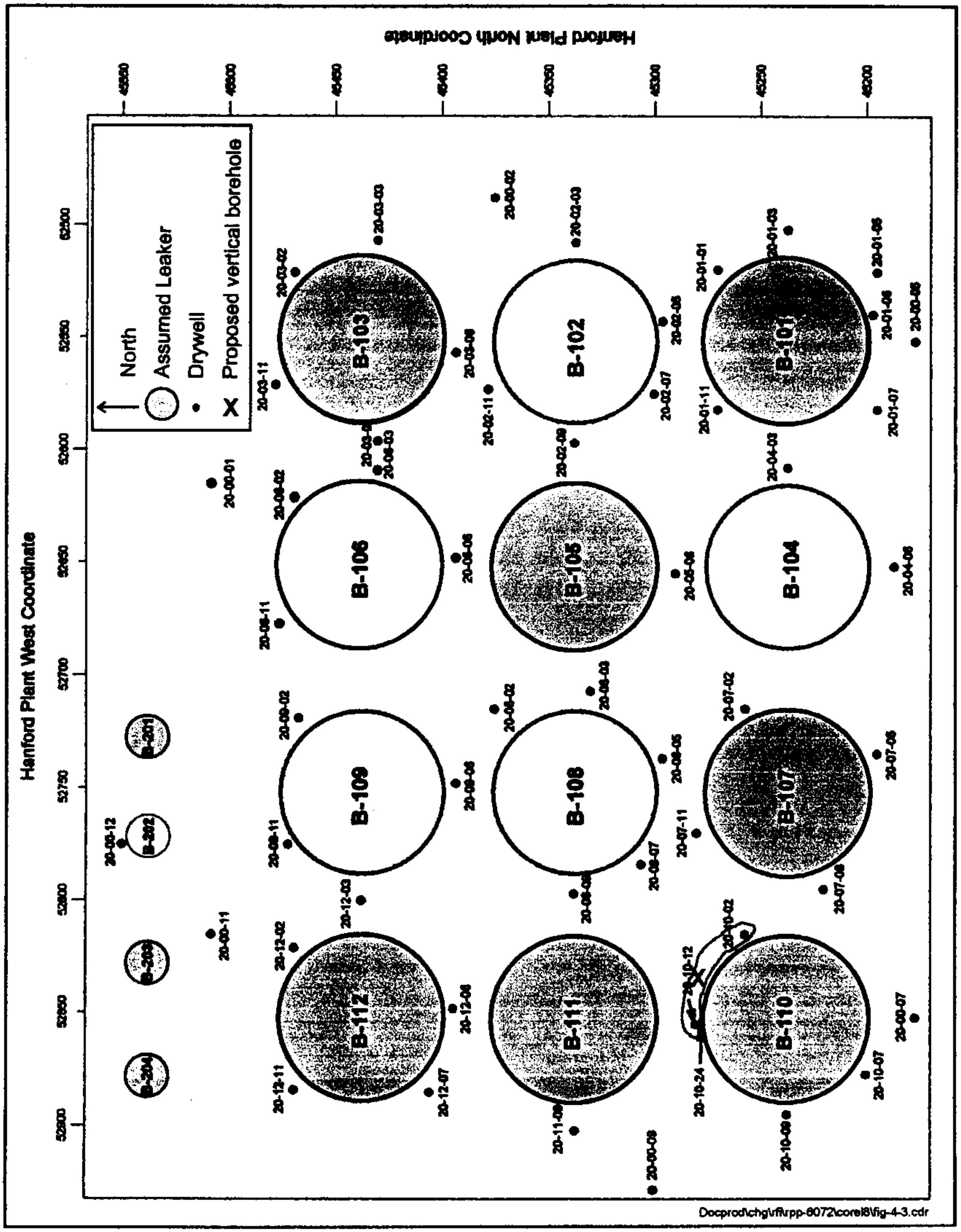


Figure 4.3. Vertical Borehole Location for Tank B-110



Modified from GJO-HAN-28

the laboratory and interfaces between the field and the laboratory. Limitations associated with collecting sediment samples include having to sample without the benefit of gamma ray logging to identify radiation levels. Because of this limitation the details of the sampling plan will be developed assuming that each sample has the potential to be highly contaminated. The final borehole construction and sampling methodology for the two vertical boreholes in WMA B-BX-BY will be designed to maintain compliance with the requirements of the Notice of Construction (ORP-2000-05) for drilling operations inside the tank farms. The following subsections provide the history and rationale for installing boreholes at these two locations.

4.3.2.2.1 Tank BX-102 Borehole. Tank BX-102 was overfilled in 1951, leading to a loss of 340,650 L (91,600 gal) of metal waste. The metal waste, produced at B Plant, was the first waste byproduct associated with the recovery of plutonium from irradiated fuel rods and was 59.9 g/L (0.5 lbs/gal) uranium. Thus, approximately 20.4 metric tons (22.5 tons) of uranium were lost during the tank overfill event. The historical records do not support the assignment of any other significant leak events to this tank.

In 1971, the area east and east-northeast of tank BX-102 was characterized extensively. The 1971 investigation identified an area that would have corresponded to a 264,950 L (70,000 gal) tank leak event. Some geological data were included in the 1971 report.

Spectral gamma-ray logging data collected in the late 1990s identified a large uranium plume to the east of tank BX-102. This uranium plume is undoubtedly related to the metal waste loss in 1951. The gamma logging data indicate the plume is below the maximum depth of a number of the drywells.

The large uranium contamination area occurs at 23 m to 40 m (75 to 130 ft) bgs over a large oval area just south and east of tank BX-102. The 1997 technetium-99 and uranium peaks in monitoring well 299-E33-41 are assumed to have been derived from this contamination area. Thus, the region of potential contamination includes the entire vadose zone below 23 m (75 ft) bgs. The primary question to be answered is the current distribution and total inventory of technetium-99 in this region. Estimates of technetium-99 concentrations in metal waste (LA-UR-96-3860) and the leak volume suggest that about 4 Ci of technetium-99 were initially released. Conceivably, much of the technetium-99 has already reached the unconfined aquifer.

WMA B-BX-BY was initially triggered into RCRA groundwater quality assessment in 1996 based on elevated conductivity observed in downgradient monitoring well 299-E33-32 to the west of the BX tank farm. Since that time, elevated levels of technetium-99, uranium, and other constituents have been observed in well 299-E33-41 located just east of the BX tank farm in close proximity to the tank BX-102 vadose zone plume. Given the information about the 1951 tank BX-102 overfill event, finding technetium-99 and uranium in a nearby monitoring well is expected.

A well drilled to groundwater in the center of the tank BX-102 uranium plume would provide information on the true depth of the plume, soil samples for radionuclide mobility studies, and information about the non-gamma emitting species like technetium-99. Sediment sample collection by split-spoon will be targeted for every 3 m (10 ft), with collection of continuous drill cutting to total depth.

4.3.2.2.2 Tank B-110 Borehole. Tank B-110 is listed in HNF-EP-0182-141 as having leaked 37,850 L (10,000 gal). This leak volume is reported to be based on tank liquid level measurements. However, the tank liquid level data in WHC-SD-WM-TI-615 do not clearly define a 37,850-L (10,000-gal) leak volume. This tank's capacity is nominally 2 million L (530,000 gal) or a fill limit of 4.9 m (16 ft) above the base of the tank. The cascade overflow line begins at that level. However, the inner-steel shell goes up another 0.6 m (2 ft) (or to 5.5 m [18 ft above the base). The waste transfer records indicate that tank B-110 was filled to approximately 12.7 cm (5 in.) above the cascade transfer line in 1961 and again in 1965 and 1968. The last cascade line transfer between tanks B-110 and B-111 was in 1954. The waste transfer records imply that the cascade lines were not functional in the 1960s. If the tank was filled above the cascade line level and the cascade was not functional then the loss of tank wastes around the cascade line port or one of the spare inlet ports would be a reasonable possibility. The spectral gamma logging data from wells around tank B-110 provide strong evidence of a cascade line outlet port leak between tanks B-110 and B-111.

The spectral gamma logging data show very high cesium-137 contamination (>10^3 pCi/g) from near the surface down to 36.6 m (129 ft) bgs in the drywell between tanks B-110 and B-111. The spectral gamma data also suggest that there may be a strontium plume from 18.3 to 36.6 m (60 to 120 ft) bgs. A number of drywells around tanks B-110 and B-111 appear to have high strontium-90 levels indicating this may be a large plume.

The waste types stored in tank B-110 include isotope recovery wastes from B Plant. These B Plant wastes contained organic complexing agents that could be associated with the apparent strontium-90 mobility. Thus, drilling a borehole into the apparent high bremsstrahlung radiation zone would help address questions about the nature and extent of the apparent strontium-90 plume. As at other locations, information about the non-gamma emitting radionuclides and chemicals would also be gained from a borehole sampling and analysis program at tank B-110. Sediment sample collection will be targeted for every 3 m (10 ft) for split-spoon samples and continuous drill cuttings to total depth. Shallow soil sampling will be conducted to optimize the borehole location (see Section 4.3.1).

4.3.3 RCRA Monitoring Well Characterization

The DQO addressed collection of vadose zone data during installation of the planned RCRA groundwater monitoring wells (PNNL-13022). The planned installation of new RCRA groundwater monitoring wells near WMA B-BX-BY provides the opportunity to collect vadose zone sediment samples from a location near the tank farms in a clean or uncontaminated area. The potential benefit of using sediment samples from the RCRA wells is to develop a site-specific representative set of physical property data for the WMA. This representative set of physical property data would then be used in developing and refining conceptual models and in future contaminant fate and transport modeling activities. This is a cost-effective approach to collecting physical property data and eliminates the difficulty of trying to obtain physical property data from contaminated sediment samples obtained from within the tank farms.

4.4 INVESTIGATIVE SAMPLING AND ANALYSIS AND DATA VALIDATION

Samples and data will be collected during the vertical borehole investigation while driving the casing and by conducting geophysical surveying as described in Appendix A. Sediment samples will be collected ahead of the driven casing. Sample lengths will be reduced if necessary when penetrating known hot zones to reduce worker exposure. Continuous drill cuttings will be collected. All samples will be field screened for radiation, sealed, refrigerated, and shipped for analysis. Laboratory analyses will be performed on the sediment samples for radiological and geochemical constituents, as described in the Sampling and Analysis Plan presented in Appendix A. Limited analysis for physical parameters (e.g., moisture retention and hydraulic conductivity) may also be performed on sediments that show visible evidence of being altered by the tank leak chemistry (e.g., cementation, discoloration).

For the near-surface characterization, sediment samples from discrete zones will be collected from the upper vadose zone using direct-push technology. All samples will be field screened for radiation, containerized, and retained for possible analysis. Geophysical logging will be used in conjunction with the direct-push technology to monitor for evidence of gamma contamination and target sample locations prior to sediment sample collection. Samples will be selected for analysis based on the geophysical logs from the initial push or completed borehole and as needed to fill in gaps consistent with the overall objective of identifying the distribution of radiological and chemical species with depth. Laboratory analyses will be performed on the sediment samples for radiological and geochemical constituents and parameters, as described in the SAP (Appendix A). Additionally, physical and hydrological analyses will be performed on selected samples if there is visible or geochemical evidence that the waste has altered the sediments.

Data from the vertical boreholes and near-surface characterization determined by project management to be relevant for the purpose of validation will be made available by the primary laboratory on request. Validation will be performed in accordance with the quality assurance project plan in the Phase 1 RFI/CMS work plan (DOE/RL-99-36).

5.0 RCRA FACILITY INVESTIGATION/CORRECTIVE MEASURES STUDY TASKS AND PROCESS

The primary purpose of Chapter 5.0 of this addendum is to provide a summary of the tasks that will be performed for the field investigation. A detailed description of these tasks is provided in the Sampling and Analysis Plan (Appendix A). Tasks are designed to provide information needed to meet the DQOs identified in Chapter 4.0. Environmental monitoring requirements for protecting the health and safety of onsite investigators are described in the Phase 1 RFI/CMS work plan (DOE/RL-99-36).

Following approval, this addendum will not be modified without approval from Ecology and DOE. Any changes to the scope of work that may be needed will be documented through change requests in accordance with the procedures identified in Appendix A of the Phase 1 RFI/CMS work plan (DOE/RL-99-36).

To satisfy the data needs and DQOs specified in Chapter 4.0, the following tasks will be performed during the RFI field investigation:

- Task 1 Project Management
- Task 2 Geological and Vadose Zone Investigation
- Task 3 Data Evaluation.

The tasks and their component subtasks and activities are outlined in the following subsections. Information about each task is provided to allow estimation of the project schedule (see Chapter 6.0) and costs.

A separate plan will be developed to cover groundwater investigations at WMA B-BX-BY (Narbutovskih 1999). That separate plan will reference back to the Phase 1 RFI/CMS work plan and this addendum.

5.1 TASK 1 – PROJECT MANAGEMENT

The project management objectives throughout the course of the WMA B-BX-BY RFI/CMS are to direct and document project activities so the data and evaluations generated meet the goals and objectives of the work plan and to ensure that the project is kept within budget and on schedule. General project management objectives are addressed in Section 7.0 of the Phase 1 RFI/CMS work plan (DOE/RL-99-36). The project management activity will be to assign individuals to the roles established in Chapter 7.0 of this addendum. Specific subtasks that will occur throughout the RFI and RFI/CMS are addressed in Section 7.0 of the Phase 1 RFI/CMS work plan (DOE/RL-99-36).

5.2 TASK 2 – GEOLOGIC AND VADOSE ZONE INVESTIGATION

The geologic and vadose zone investigation will further characterize the geology of WMA B-BX-BY and provide additional information on the source, nature, and extent of contamination and the potential migration paths of the contamination.

The geologic and vadose zone information will be evaluated to determine the following:

- WMA conceptual vadose zone model
- Release and movement of contaminants
- Development of ICM alternatives
- Initiation of data collection for support of retrieval and closure activities.

The geologic and vadose zone investigation for WMA B-BX-BY will comprise compiling pertinent existing data and collecting data from drilling activities in the vadose zone. The types of data needed from the surface and vadose zone include the following:

- Thickness and areal extent of geologic units
- Lithology, bedding types, facies geometry, particle size, and sorting
- Presence, concentration, and nature of contaminants in sediments.

Subtasks 2a and 2b have been established to gather geologic and vadose zone data.

5.2.1 Subtask 2a – Field Activities

Field activities will include geologic and geophysical logging associated with the following:

- Deep vadose zone characterization in vertical boreholes east-northeast of tank BX-102 and north of tank B-110

- Near-surface characterization by direct pushes (1) in the vicinity of tanks BX-107 and BX-110, (2) at two transects east of tank BX-102 if technetium-99 was detected above 18.3 m (60 ft), (3) north of tank B-110, and (4) in diversion boxes in the B tank farm.

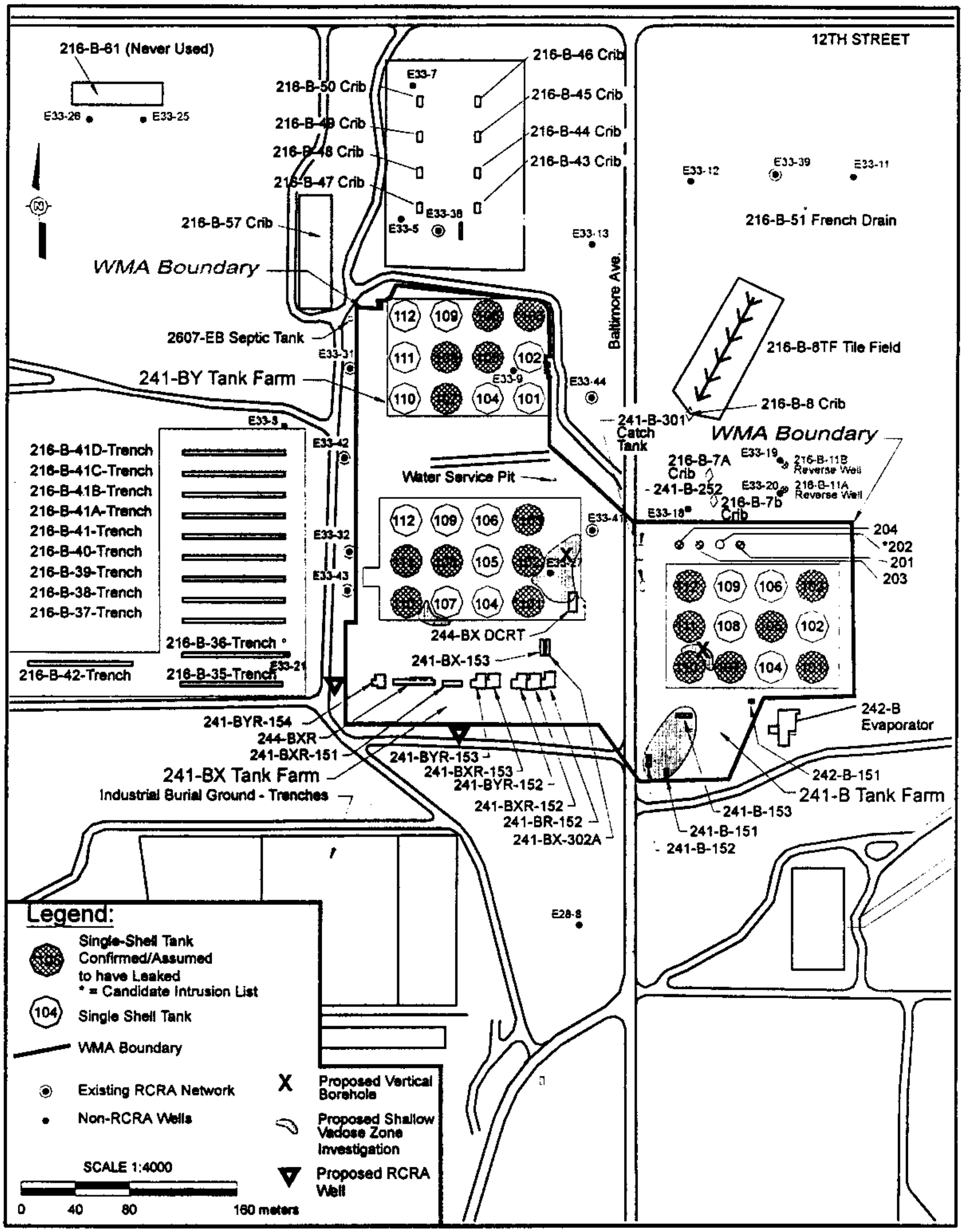
The tentative locations of the planned vertical boreholes, proposed RCRA groundwater monitoring well, and direct pushes are provided in Figure 5.1.

Vadose zone sediment sampling of the proposed RCRA groundwater monitoring wells will also be conducted. The requirements for geologic and geophysical surveying and sediment sampling for physical and laboratory analytical parameters in the vadose zone borings and groundwater monitoring wells are provided in Appendix A. Information and data will be collected from the surface downward to within the unconfined aquifer of the Hanford formation (approximately 77.7 m [255 ft] bgs). Geologic logging will be performed with the drilling operations unless highly radioactive sediments require removal of samples at a separate sample extraction facility.

5.2.1.1 Deep Vadose Zone Characterization. The following activities are planned for the vadose zone characterization in vertical boreholes.

- Conduct borehole geophysical surveying and analysis (i.e., moisture, neutron, gross gamma, spectral gamma and neutron-enhanced spectral gamma analysis).

Figure 5.1. WMA B-BX-BY Proposed Sampling Locations for Vertical Boreholes, Near-Surface Characterization, and Proposed RCRA Groundwater Monitoring Wells



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- Obtain sediment samples to analyze for the presence and concentration of contaminants and to evaluate alterations of the sediments from waste chemistry effects.
- Obtain sediment samples to support preparation of the borehole geologic logs and stratigraphic and lithologic contact correlation with other boreholes and wells in the WMA B-BX-BY vicinity.

The final design for the vertical boreholes has not been completed. One of the primary constraints on sample collection is the potential radiation level which will limit the sample volumes that can be brought to the surface for the borehole at tank B-110.

The current planning basis for the vertical boreholes east-northeast of tank BX-102 and north of tank B-110 includes driven samples that will be collected ahead of the casing. The samples will be transported to the laboratory and analyzed for the CoCs identified in Appendix A. Nominally, 27 horizons will be sampled based on the geophysical surveys or the need to provide depth coverage as identified in Appendix A.

Subsurface conditions are variable and the process of installing the vertical boreholes must be flexible. Some or all of the work described in Appendix A may require modification. This addendum is intended to serve as a guideline and is designed to allow for changes depending on conditions encountered in the field. Any change will be recorded on the appropriated field documentation, memoranda, or letters. A complete documented record of activities will be maintained for preparation of a final summary report.

Appropriate permits and compliance with the Notice of Construction permit (DOE/ORP-2000-05) will be maintained during the drilling operations for inside the tank farm. The selected drilling method will comply with the requirements of the Washington State Department of Health for the Notice of Construction permit and other pertinent requirements and appropriate engineering systems to prevent the possible contaminated air from being released to the environment.

5.2.1.2 Near-Surface Characterization. Four areas have been identified as regions of interest for the Phase 1 characterization of the shallow vadose zone soil. These areas are within the south end of the B tank farm, east of tank BX-102 and east-southeast of tank BX-110. The B tank farm areas of interest include:

- Unplanned release near diversion boxes 241-B-151, -152, and -153
- Unplanned release north of tank B-110.

The BX tank farm areas of interest include:

- Two transects (east-to-west and north-to-south) in the vicinity east of tank BX-102
- Unplanned release east and southeast of tank BX-110.

The vicinity north of tank B-110 and the vicinity east-southeast of tank BX-110 exhibit separate instances of cesium-137 in vadose zone dry wells that may be indicative of near-surface sources.

In addition, metal waste leaks have been recorded in the vicinity of the 241-B diversion boxes. A north-south and east-west transect east of tank BX-102 will be conducted if technetium-99 is detected in the upper 18.3 m (60 ft) of the borehole.

For the purpose of the DQO, the shallow investigation of these areas will comprise collecting sediment samples between the tank farm surface and base of the tanks or refusal using direct-push technology at 31 locations within these four areas. The samples will be transported to the laboratory and analyzed for the CoCs identified in Appendix A. The physical and operational constraints will require evaluation prior to identifying the specific target locations.

Shallow soil characterization will be carried out using a truck-mounted direct-push technology-based system similar to what was conducted in S tank farm. Specific sites cleared for access (i.e., underground piping and electrical services identified) and with an approved excavation permit will be interrogated with a gross-gamma/spectral-gamma probe. The depth of investigation will be determined by the depth to which the direct-push boring can be advanced using a standard deployment truck. The probe will be deployed using the gross gamma mode with the tool lowered or raised at approximately 2 cm/sec (0.8 in./sec). Based on regulatory requirements, if in the upper 5 m (15 ft) the downhole instrument indicates a potential cesium-137 concentration of 3.7 pCi/g or greater, logging will be shifted to the spectral mode to determine the presence and level of concentration of cesium-137. If the downhole instrument is below 5 m (15 ft) the threshold limit for spectral gamma determinations will be 20 pCi/g. In zones where cesium-137 is present at concentrations greater than 20 pCi/g, spectral gamma readings will be taken at 0.5-m (1.5-ft) intervals. No sample will be collected from zones where the gamma instrument exhibits excessive deadtime.

The graphical log developed using the gross and spectral gamma measurements will be used to select intervals to be sampled. The sampling push is to be made in a location that is no more than 0.7 m (2 ft) from the site of the gamma push. A single point sampler will be used to collect the required samples. Sampling intervals will be selected from those horizons with a cesium-137 concentration of 20 pCi/g or greater. In the event that horizons are penetrated that yield samples having a greater that 50 mrem/hr dose rate at 30 cm (12 in.) (based on calculations using sampler size and cesium-137 concentration), a sample will be collected from the first interval below the high-rate zone that has a dose rate of less than 50 mrem/hr. No sample will be collected from zones where the gamma instrument exhibits excessive deadtime.

5.2.1.2.1 Vicinity North and Northeast of Tank B-110. Direct-push technology pushes would be required to increase the chance of making the vertical borehole in an area where contaminants are present and provide indication of continuity or lack of continuity between gamma contamination observed at dry wells 20-10-12 and 20-10-02. The highest recorded levels of cesium-137 contamination associated with this site are in borehole 20-10-12 and 20-10-02 in the northeast quadrant of the tank. Contamination is estimated at about 10^3 pCi/g at a depth of about 7.6 to 30.5 m (25 to 100 ft) bgs. A possible strontium-90 plume exists at depths between 18.3 and 30.5 m (60 and 100 ft) bgs. Up to three sets of gamma probe and sampling pushes may be made to investigate this site for the optimal place to install a vertical borehole. The push locations include the following.

- Adjacent to the 20-10-12 drywell, north of the drywell. This location will be to ascertain if there is a vertical gradient between the push location and the identified elevation of contamination in 20-10-12 and to collect a sample from below the contaminated zone to determine if strontium-90 and mobile contaminants are moving ahead of the cesium-137 hot spot.

- Adjacent to tank B-110 at the one o'clock position. This location is to be as close to the tank as the push-truck can be positioned within dome-load restrictions. The B tank farm tanks are constructed with an outlet port at this position. Experience in other farms has shown that these outlet ports are subject to failure. This push will test the hypothesis that the contamination adjacent to the tank is due to an overfill or transfer event at the outlet port.

- Between the first two pushes for correlation purposes. This location is to be within 3 to 4.5 m (10 to15 ft) of the tank. This location will be used to determine the horizontal and vertical extent of the contamination found in the 20-10-12 borehole.

5.2.1.2.2 Vicinity East-Southeast of Tank BX-110. The direct-push technology pushes will determine if contaminants detected at 21-10-03, 21-10-05, and 21-07-06 represent a continuous plume or if they are separate discrete "hot spots." This supports development of source term. The highest recorded levels of cesium-137 contamination associated with this site are in boreholes 21-10-03 and 21-10-05 in the southeast quadrant of the tank. Contamination is estimated at greater than 10^4 pCi/g at a depth of about 2.4 to 11.6 m (8 to 38 ft) bgs for borehole 21-10-03 and about 11.3 to 14.3 m (37 to 47 ft) bgs for borehole 21-10-05. Four sets of gamma probe and sampling pushes are planned to investigate this site. The push locations include the following.

- Adjacent to tank BX-110, east of drywell 21-10-03. Because little contamination is detected in drywell 21-10-01, this push will be used to determine the extent of contamination other than cesium-137 north-northeast of borehole 21-10-03. The push will be situated as near the tank as safety considerations allow.

- Along the line projected between drywells 21-10-03 and 21-10-05, adjacent to the spare nozzles at approximately the four o'clock position on tank BX-110 between that tank and tank BX-107. This location will provide information on the extent on contamination known to exist between the two boreholes and assess the depth of movement of that contamination.

- Two sets of pushes along the line projected between drywells 21-10-05 and 21-07-06, southeast of tank BX-110. This location will provide information on the extent and general direction of contaminant movement between tanks BX-110 and BX-107. The information obtained will also aid in determining if the contamination is from one leak or multiple leaks and assess whether tank BX-107 or its ancillary equipment is a possible contributor to the contamination.

5.2.1.2.3 Vicinity East of Tank BX-102. Direct-push technology pushes would only be performed if technetium-99 were found in sediments above 18.3 m (60 ft) bgs. Shallow soil investigation at this site would use six direct pushes each in north-to-south and east-to-west transects, depending on results of the vertical borehole. The direct pushes would be made to refusal. Direct-push technology pushes would be for sample collection at intervals determined by split-spoon sample analysis. Direct-push technology pushes, if required, would be done to enable refinement of the constituent concentration model and source term. A total of 12 sets of direct pushes would be conducted.

5.2.1.2.4 Vicinity of the 241-B Diversion Boxes. The direct-push technology pushes would be located near the corner of each diversion box (i.e., 241-B-151, -152, and -153). The direct-push technology pushes would be to determine the effectiveness of the reported past clean up efforts and provide data needed to determine if additional investigations are required in this vicinity. These data would support development of source term. The current plan is to conduct gamma logging with a goal of collecting limited samples if access limitations and ground conditions permit. A total of 12 sets of direct-push technology pushes would be conducted.

5.2.1.3 Vadose Zone Sediment Sampling of the Proposed RCRA Groundwater Monitoring Wells. The following activities are planned for sampling vadose zone sediment in the proposed RCRA groundwater monitoring wells.

- Obtain sediment samples to determine physical properties, including moisture content, that will be used to support development of background and/or baseline conditions
- Obtain sediment samples to support preparation of the borehole geologic logs and stratigraphic and lithologic contact correlation with other boreholes and wells in the WMA B-BX-BY vicinity.

Data expected from sampling at the proposed RCRA groundwater wells (Figure 5.1) will include the following:

- Continuous collection of samples from the cuttings between the surface and groundwater
- Experienced geologist (see Appendix A) logs that detail all cuttings to the finest resolution possible.

Groundwater sampling activities at these RCRA wells will be conducted under the Hanford Site Groundwater Monitoring Project (PNNL-13022).

5.2.2 Subtask 2b – Laboratory Analysis

Laboratory analyses to be conducted for the WMA B-BX-BY geologic and vadose zone investigation are described in Appendix A. These analyses will include radiological and chemical analysis of selected sediment samples. Physical and hydrologic analysis of selected sediment samples will also be performed.

5.3 TASK 3 – DATA EVALUATION

Data generated during the field investigation will be integrated and evaluated, coordinated with RFI activities, and presented in an ongoing manner to allow decisions regarding any necessary rescoping to be made during the course of the project. The results of these evaluations will be made available to project management personnel to keep project staff informed of progress being made. The interpretations developed under this task will be used to refine the conceptual model and to determine whether interim measures or ICMs are warranted for WMA B-BX-BY.

6.0 SCHEDULE

The schedule for developing plans and conducting field activities details the work described in Chapter 5.0 of this WMA B-BX-BY addendum. The schedule, shown in Figure 6.1, is the baseline that will be used to measure progress. The characterization activities described in this addendum were identified during a DQO process to fulfill proposed Tri-Party Agreement Milestone M-45-53 to be completed by May 2000. Activities were planned using the work breakdown structure and project milestones defined in Section 7.0 of the Phase 1 RFI/CMS work plan (DOE/RL-99-36).

Based on DOE guidance for establishing a baseline scope, schedule, and budget document, the use of a multi-year work plan was adopted. The activities identified in Figure 6.1 were taken from the multi-year work plan, which is updated annually and describes the specific details associated with each proposed project. The multi-year work plan incorporates milestones defined in the Tri-Party Agreement (Ecology et al. 1998) and reflects the schedule and commitments made therein. The multi-year work plan defines the scope, schedule, and budget to a level of detail that will be adequate for the planning and management of that project. The work breakdown schedule numbers and activity identification numbers are included in Figure 6.1 to correspond with the schedule maintained by the Tank Farm Vadose Zone Project.

Figure 6.1. Preliminary Characterization Schedule

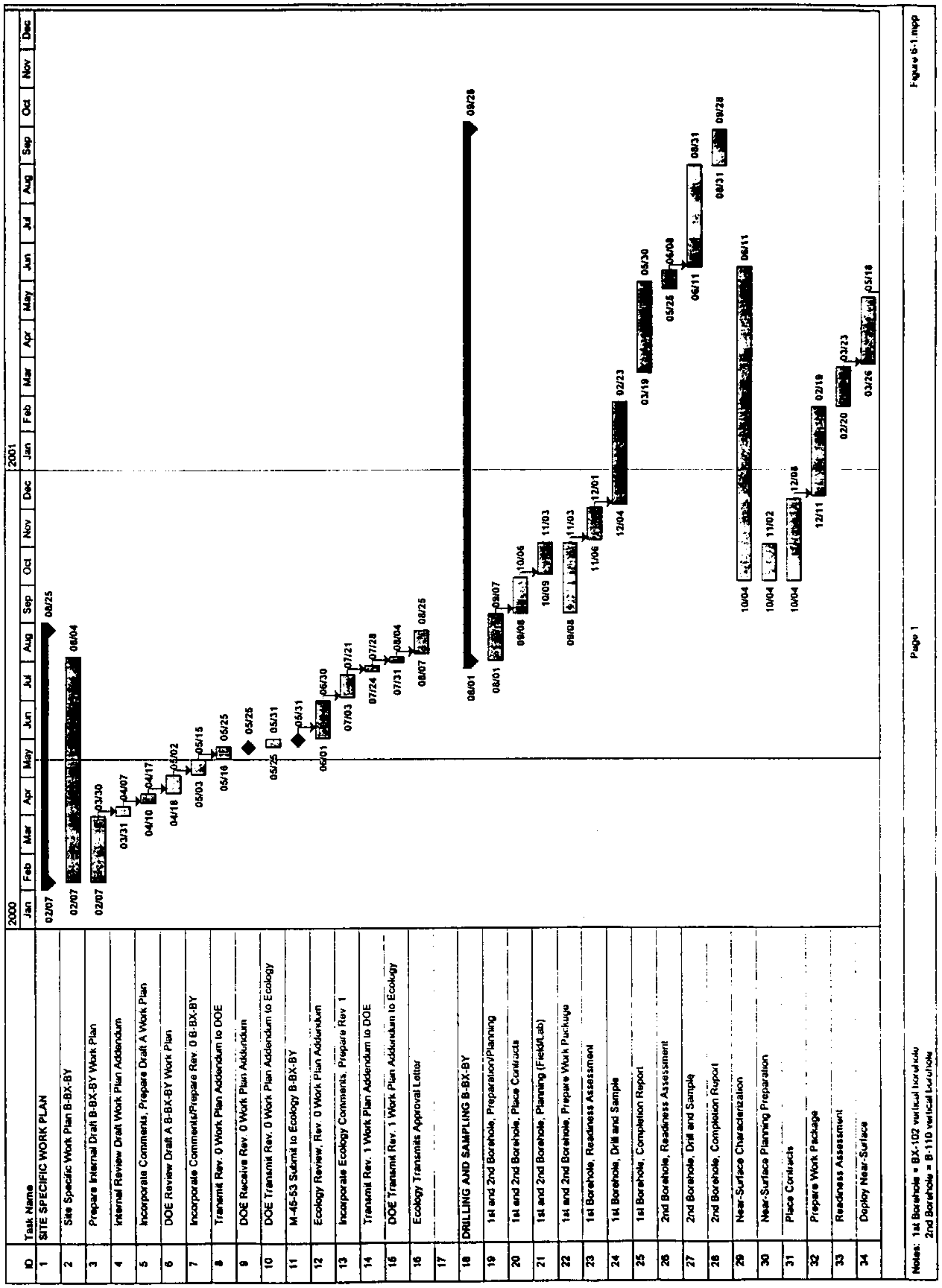
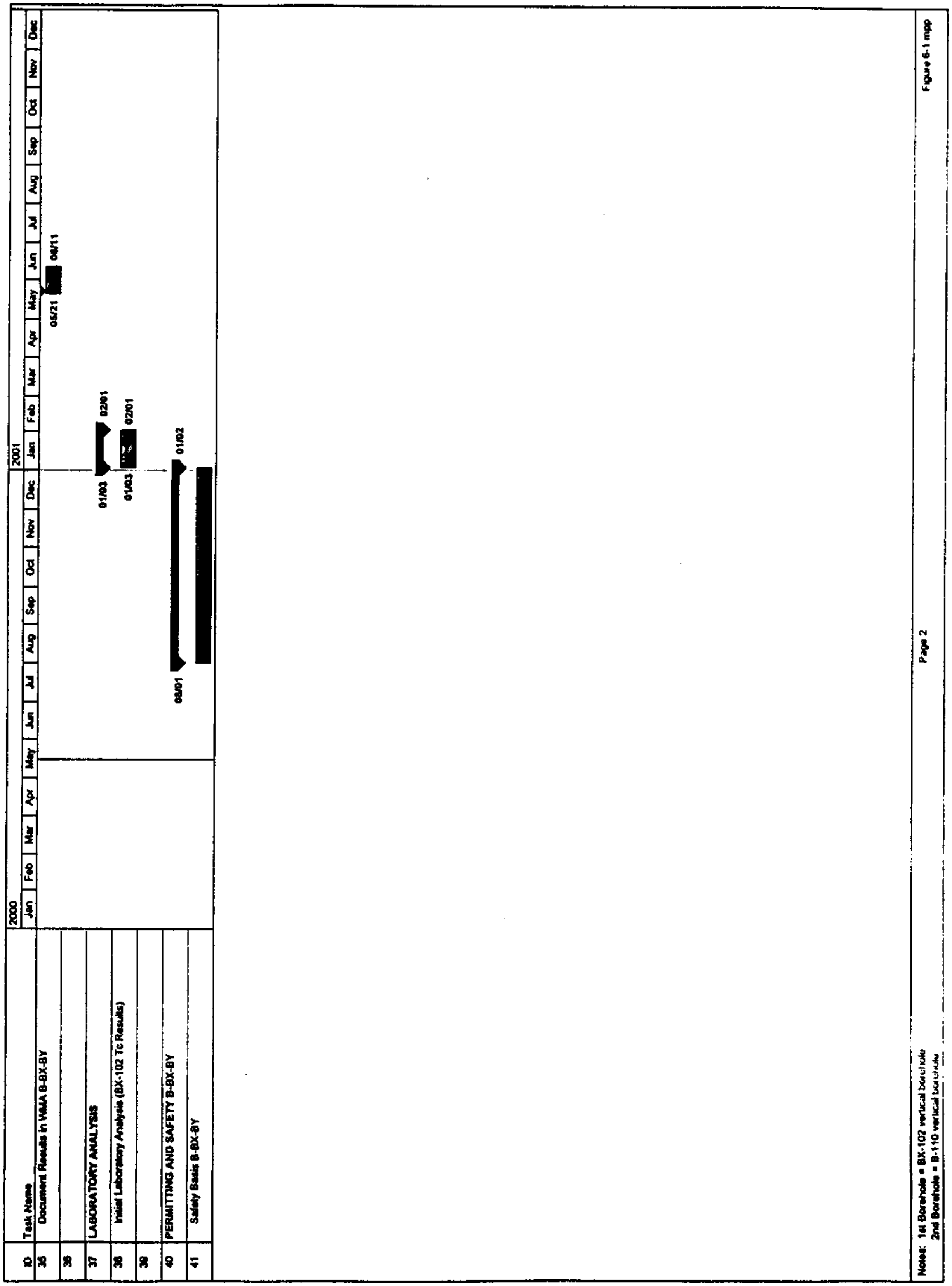


Figure 6.2. Preliminary Characterization Schedule (Cont'd)



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7.0 PROJECT MANAGEMENT

This chapter defines the administrative and institutional tasks necessary to support the RFI/CMS process for WMA B-BX-BY and manage activities described in this WMA B-BX-BY addendum (Chapter 5.0). This chapter also defines the responsibilities of the various participants, organizational structure, and project tracking and reporting procedures. This chapter is in accordance with the provisions of the Tri-Party Agreement action plan (Ecology et al. 1998). Any revisions to the Tri-Party Agreement action plan that would result in changes to the project management requirements would supersede the provisions of this chapter.

7.1 PROJECT ORGANIZATION AND RESPONSIBILITIES

The project organization and responsibilities are described in Section 7.2 of the Phase 1 RFI/CMS work plan (DOE/RL-99-36). Discussion of the roles of SST Program Manager and Tank Farm Vadose Zone Project Manager and of work control, cost control, schedule control, meetings, records management, progress and final reports, quality assurance, health and safety, and community relations are addressed in Section 7.2 of the Phase 1 RFI/CMS work plan (DOE/RL-99-36). This addendum follows the structure outlined in that work plan except where more detail is required. Interfaces with tank farm operations is part of the work control, schedule control, and roles and responsibilities as defined in DOE/RL-99-36. Integration with other organizations, including the Groundwater and Vadose Zone Integration Project, are addressed in Section 7.3 in DOE/RL-99-36.

Detailed information in the form of a work package defining the site-specific activities and instructions needed to carry out the investigative tasks discussed in this chapter will be developed before initiating field work. Where appropriate, the work package will reference the appropriate procedure or standards rather than listing the entire procedure for a task and will be in accordance with the Hanford Analytical Services Quality Assurance Requirements Document (DOE/RL-96-68). Any reference to the quality assurance project plan provided in the Phase 1 RFI/CMS work plan (Appendix A of DOE/RL-99-36) as a source of additional information will be referenced.

The work package shall be prepared in accordance with CH2M HILL Hanford Group, Inc. work control procedures and the procedures listed in Appendix A of DOE/RL-99-36. The work package must satisfy the following requirements:

- Include a scope of work introductory section.
- Include the DQOs (as specified in the work plans) for each type of activity.
- Identify the proposed locations for sampling and the criteria for selecting those locations. A map, at a scale appropriate to locate the sites in the field, should be included.
- Identify any field screening activities not described in the work plan or in the relevant procedures. Identify any field screening equipment to be used that is not described in the relevant procedures.
- Include the frequency of measurement.

- Identify the applicable procedures needed to conduct the work. If a procedure includes several different ways to accomplish the work, the work package should specify the method of choice or reference the specific procedure.
- Identify any calibrating standards and frequencies not included in the relevant procedures.
- Describe any data collection procedures, chain-of-custody procedures, sample container size and preparation, holding times, type of analysis, number of split samples, number of duplicate samples, number of blank samples, and data reporting requirements not included in the relevant procedures.
- Provide an estimate of the proposed field activity schedule, including sampling periods.
- Include provisions to document any field changes using a project change form and submit the form to Ecology within 10 working days of the change.

7.2 DOCUMENTATION AND RECORDS

All RFI/CMS plans and reports will be categorized as primary or secondary documents, as described by Section 9.1 of the Tri-Party Agreement action plan (Ecology et al. 1998). The process for document review and comment will be as described in Section 9.2 of the action plan. If necessary after finalization of any document, revisions will be in accordance with Section 9.3 of the Tri-Party Agreement action plan. Changes in the work schedule, as well as minor field changes, can be made without having to process a formal revision. The process for making these changes will be as stated in Chapter 12.0 of the Tri-Party Agreement action plan.

Administrative records, which must be maintained to support Hanford Site RCRA activities, will be in accordance with Section 9.4 of the Tri-Party Agreement action plan.

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9.0 GLOSSARY

Accuracy: Accuracy may be interpreted as the measure of the bias in a system. Analytical accuracy is normally assessed through the evaluation of matrix-spiked samples, reference samples, and split samples.

Audit: Audits are considered to be systematic checks to verify the quality of operation of one or more elements of the total measurement system. In this sense, audits may be of two types: (1) performance audits, in which quantitative data are independently obtained for comparison with data routinely obtained in a measurement system, or (2) system audits, involving a qualitative onsite evaluation of laboratories or other organizational elements of the measurement system for compliance with established quality assurance program and procedure requirements. For environmental investigations at the Hanford Site, performance audit requirements are fulfilled by periodic submittal of blind samples to the primary laboratory, or the analysis of split samples by an independent laboratory. System audit requirements are implemented through the use of standard surveillance procedures.

Bias: Bias represents a systematic error that contributes to the difference between a population mean of a set of measurements and an accepted reference or true value.

Blind Sample: A blind sample refers to any type of sample routed to the primary laboratory for performance audit purposes, relative to a particular sample matrix and analytical method. Blind samples are not specifically identified as such to the laboratory. They may be made from traceable standards, or may consist of sample material spiked with a known concentration of a known compound. See the glossary entry for Audit.

Borehole: A circular hole made by boring; esp. a deep vertical hole of small diameter, such as a shaft, a well (an exploratory oil well or a water well), or a hole made to ascertain the nature of the underlying formations, to obtain samples of the rocks penetrated, or to gather other kinds of geologic information.

Comparability: Comparability is an expression of the relative confidence with which one data set may be compared with another.

Completeness: Completeness may be interpreted as a measure of the amount of valid data obtained compared to the total data expected under correct normal conditions.

Conceptual Model: A tool designed to represent a simplified version of reality based on a set of working hypotheses. For instance, the vadose zone conceptual model includes the simplified elements of tank waste characteristics, past leak characteristics, geology, hydrogeology, and driving forces that include infiltration from precipitation and human sources of water.

Deviation: Deviation refers to an approved departure from established criteria that may be required as a result of unforeseen field situations or that may be required to correct ambiguities in procedures that may arise in practical applications.

Dip: The angle that a structural surface makes with the horizontal, measured perpendicular to the strike of the structure.

Down Dip: A direction that is downwards and parallel to the dip of a structure or surface.

Drywell: A hollow cylinder of reinforced concrete, steel, timber, or masonry constructed in a pit or hole in the ground that does not reach the water table and is used principally for monitoring in the unsaturated zone.

Equipment Blanks: Equipment blanks consist of pure deionized, distilled water washed through decontaminated sampling equipment and placed in containers identical to those used for actual field samples. They are used to verify the adequacy of sampling equipment decontamination procedures.

Field Duplicate Sample: Field duplicate samples are samples retrieved from the same sampling location using the same equipment and sampling technique, placed in separate, identically prepared and preserved containers, and analyzed independently. Field duplicate samples are generally used to verify the repeatability or reproducibility of the dataset.

Interim-Isolation: The administrative designation reflecting the completion of the physical effort required for interim isolation except for isolation of risers and piping that is required for jet pumping or for other methods of stabilization.

Interim Stabilized: Status term for when a tank that contains less than 189,250 L (50,000 gal) of drainable interstitial liquid and less than 18,925 L (5,000 gal) of supernatant liquid. If the tank was jet pumped to achieve interim stabilization, then the jet pump flow or saltwell screen inflow must also have been at or below 0.19 L (0.05 gal) per minute before interim stabilization criteria is met.

Intrusion Prevention: The administrative designation reflecting the completion of the physical effort required to minimize the addition of liquids into an inactive storage tank, process vault, sump, catch tank, or diversion box. Under no circumstances are electrical or instrumental devices disconnected or disabled during the intrusion prevention process (with the exception of the electrical pump).

Laboratory Duplicate Sample: Laboratory duplicate samples are two aliquots removed from the same sample container in the laboratory and analyzed independently.

Matrix-Spiked Samples: Matrix-spiked samples are a type of laboratory quality control sample. They are prepared by splitting a sample received from the field into two homogenous aliquots (i.e., replicate samples) and adding a known quantity of a representative analyte of interest to one aliquot in order to calculate the percentage of recovery of that analyte.

Maximum Contaminant Level: The maximum permissible level of a contaminant in water that is delivered to any user of a public water system.

Nonconformance: A nonconformance is a deficiency in the characteristic, documentation, or procedure that renders the quality of material, equipment, services, or activities unacceptable or indeterminate. When the deficiency is of a minor nature, does not effect a permanent or significant change in quality if it is not corrected and can be brought into conformance with immediate corrective action, it shall not be categorized as a nonconformance. If the nature of the condition is such that it cannot be immediately and satisfactorily corrected, however, it shall be documented in compliance with approved procedures and brought to the attention of management for disposition and appropriate corrective action.

Operable Unit: A group of land disposal sites placed together for the purposes of doing a Remedial Investigation/Feasibility Study and subsequent cleanup actions. The primary criteria for placement of a site into an operable unit includes geographic proximity, similarity of waste characteristics and site type, and the possibility for economics of scale.

Out of Service: No longer authorized to receive waste.

Partially Interim Isolated: The administrative designation reflecting the completion of the physical effort required to minimize the addition of liquids into an inactive storage tank, process vault, sump, catch tank, or diversion box. In June 1993, interim isolation was replaced by intrusion prevention.

Past-Practice Units (Sites): A waste management unit where waste or substances (intentionally or unintentionally) have been disposed of and that is not subject to regulation as a treatment, storage, and/or disposal unit.

Precision: Precision is a measure of the repeatability or reproducibility of specific measurements under a given set of conditions. The relative percent difference is used to assess the precision of the sampling and analytical method. Relative percent difference is a quantitative measure of the variability. Specifically, precision is a quantitative measure of the variability of a group of measurements compared to their average value. Precision is normally expressed in terms of standard deviation, but may also be expressed as the coefficient of variation (i.e., relative standard deviation) and range (i.e., maximum value minus minimum value). Precision is assessed by means of duplicate/replicate sample analysis.

Quality Assurance: Quality Assurance refers to the total integrated quality planning, quality control, quality assessment, and corrective action activities that collectively ensure that the data from monitoring and analysis meets all end user requirements and/or the intended end use of the data

Quality Assurance Project Plan: The Quality Assurance Project Plan is an orderly assembly of management policies, project objectives, methods and procedures that defines how data of known quality will be produced for a particular project or investigation.

Quality Control: Quality control refers to the routine application of procedures and defined methods to the performance of sampling, measurement and analytical processes.

Range: Range refers to the difference between the largest and smallest reported values in a sample, and is a statistic for describing the spread in a set of data.

Reference Samples: Reference samples (e.g., laboratory control standards, independent calibration verification standard) are a type of laboratory quality control sample prepared from an independent, traceable standard at a concentration other than that used for analytical equipment calibration, but within the calibration range.

Removed from Service: No longer authorized to receive waste.

Representativeness: Representativeness may be interpreted as the degree to which data accurately and precisely represent a characteristic of a population parameter, variations at a sampling point, or an environmental condition. Representativeness is a qualitative parameter that is most concerned with the proper design of a sampling program.

Split Sample: A split sample is produced through homogenizing a field sample and separating the sample material into two equal aliquots. Field split samples are usually routed to separate laboratories for independent analysis, generally for purposes of auditing the performance of the primary laboratory relative to a particular sample matrix and analytical method. See the glossary entry for Audit. In the laboratory, samples are generally split to create matrix-spiked samples (see the glossary entry Matrix-Spiked Samples).

Strike: The direction or trend that a structural surface takes as it intersects the horizontal.

TSD Unit: A unit used for treatment, storage and disposal (TSD) of hazardous waste and is required to be permitted (for operation and/or postclosure care) and /or closed pursuant to *Resource Conservation and Recovery Act of 1976* requirements under the Washington State Dangerous Waste Regulations (WAC 173-303) and the applicable provisions of *Hazardous and Solid Waste Amendment of 1984.*

Up-Dip: A direction that is upwards and parallel to the dip of a structure or surface.

VOA Trip Blanks: Volatile Organics Analysis (VOA) trip blanks are a type of field quality control sample, consisting of pure deionized distilled water in a clean, sealed, sample container, accompanying each batch of containers shipped to the sampling site and returned unopened to the laboratory. Trip blanks are used to identify any possible contamination originating from container preparation methods, shipment, handling, storage or site conditions.

Validation: Validation refers to a systematic process of reviewing data against a set of criteria to provide assurance that the data are acceptable for their intended use. Validation methods may include review of verification activities, editing, screening, cross-checking, or technical review.

Verification: Verification refers to the process of determining whether procedures, processes, data, or documentation conform to specified requirements. Verification activities may include inspections, audits, surveillance, or technical review.

APPENDIX A

SAMPLING AND ANALYSIS PLAN

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LIST OF TERMS

bgs	below ground surface
CMS	corrective measures study
CHG	CH2M HILL Hanford Group, Inc.
DQO	data quality objective
Ecology	Washington State Department of Ecology
HASQARD	Hanford analytical services quality assurance requirements document
RFI	RCRA facility investigation
SAP	sampling and analysis plan
WMA	waste management area

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A.1.0 INTRODUCTION

The focus of this Sampling and Analysis Plan (SAP) is vadose zone investigation of Waste Management Area (WMA) B-BX-BY, which contains the B, BX, and BY tank farms. Sampling and analysis of vadose zone sediments will occur in the vicinity of the B, BX, and BY tank farms to meet the objectives of this investigation.

A.1.1 PURPOSE AND OBJECTIVE

This plan details the field and laboratory activities to be performed in support of the investigation of vadose zone contamination in WMA B-BX-BY and is designed to be used in conjunction with the work plan and referenced procedures. The field investigations at WMA B-BX-BY addressed in this SAP are as follows.

- **Near-surface characterization investigation** – This investigation will collect sediment samples via direct-push technology in the southern portion of B tank farm, between tanks B-110 and B-111 in the B tank farm, at two transects in the eastern portion of BX tank farm, and between tanks BX-107 and BX-110 in the BX tank farm. The shallow investigation will comprise collecting sediment samples at approximately 31 areal (map) locations between ground surface and base of tanks or refusal. Precise sample depths for sediment collection will be determined based on spectral and gross gamma data collected prior to sediment sampling. The main emphasis will be on characterizing unplanned releases within these areas of concern. For the investigation at tank B-110, the shallow vadose zone soil investigation will be used to delineate the optimal location for the new vertical borehole.

- **Installation of new vertical exploratory boreholes east of tank BX-102 and north of tank B-110** – The data quality objective (DQO) process resulted in the identification of several potential locations for proposed new boreholes. Locations north-northeast of tank BX-102 and north of tank B-110 were selected based on spectral gamma data, groundwater quality data, and historical process knowledge. These locations are near past leak events either from a tank or a transfer leak. The new boreholes will be installed using a drive-and-drill drilling technique staged (telescoping) casings may be used to reduce the likelihood of cross-contamination from penetrating through the highly contaminated zones. Collection of spilt-spoon driven samples will be attempted from about 3 m (10 ft) below ground surface (bgs) to just below the water table on 3-m (10-ft) intervals. The water table is expected to be encountered at a depth of 78 m (256 ft) bgs. Selected portions of the samples will be analyzed for chemical, radiological, and physical characteristics. A suite of geophysical surveys will be performed, and groundwater samples will be collected for chemical and radiological analysis. The new boreholes may be completed as a *Resource Conservation and Recovery Act of 1976* (RCRA)-compliant groundwater monitoring wells should technetium-99 concentrations exceed 5 times (4,500 pCi/L) the drinking water standard (900 pCi/L). If so, the new wells will be included in the RCRA groundwater monitoring network for routine groundwater sampling and analysis. If not completed as RCRA-compliant groundwater wells, then the boreholes will be decommissioned in accordance with WAC 173-160.

- **Sediment drill cutting samples collected in conjunction with the installation of proposed RCRA groundwater monitoring wells** – Vadose zone samples will be collected during the installation of proposed RCRA groundwater monitoring wells planned in support of the ongoing RCRA groundwater monitoring effort. Drill cuttings will be collected and described from these wells. Selected portions of cuttings will be analyzed for physical, hydraulic, and chemical properties. A detailed description of the work associated with the installation of these monitoring wells is being developed by the Hanford Site Groundwater Monitoring Project. Only details associated with the collection and analysis of driven samples and cuttings are provided in this work plan addendum.

This SAP describes three distinct field scope elements; thus, it is divided into three parts:

Part I – Installation of new exploratory boreholes (well numbers to be determined)

Part II – Near-surface characterization in B and BX tank farms

Part III – Sediment sampling performed in conjunction with the installation of proposed RCRA groundwater monitoring wells

Technical procedures or specifications that apply to this work include Waste Management Federal Services sampling and geophysical surveying procedures (SML-EP-001), sample and mobile laboratories procedures (SML-EP-001), and vadose zone characterization at the Hanford Site tank farms, high-resolution passive spectral gamma-ray logging procedures (P-GJPO-1783). All field and laboratory work prescribed by this SAP shall also be in conformance with Hanford analytical services quality assurance requirements document (HASQARD) (DOE/RL-96-68). Field and laboratory personnel should be familiar with these documents, as appropriate, and maintain a copy for guidance during work activities.

The field activities related to this investigation comprise vadose zone sampling and sample analysis. This SAP addresses the requirements of the vadose zone sampling and analysis.

The quality assurance project plan, Appendix A of the Phase 1 RCRA facility investigation/corrective measures study (RFI/CMS) work plan (DOE/RL-99-36), is an integral part of the SAP and they must be used jointly. HNF-6020, DQO workbook of WMA B-BX-BY, references the sampling analytical quality assurance and quality control requirements that must be used to obtain representative field samples and measurements. Knowledge of the health and safety plan, Appendix B of DOE/RL-99-36, is required by those involved in the field sampling, because it specifies procedures for the occupational health and safety protection of project field personnel. The data management plan, Appendix C of DOE/RL-99-36, denotes the requirements for field and laboratory data storage. The waste management plan, Appendix D of DOE/RL-99-36, denotes the requirements for the management of waste and the appropriate collection, characterization, and designation of waste produced by the characterization activities.

PART I

INSTALLATION OF VERTICAL BOREHOLES (WELL NUMBER TBD)

The following is a discussion of the field tasks and associated subtasks required for the drilling, sampling, and sample analysis associated with the vertical boreholes.

A.2.0 PROJECT MANAGEMENT (TASK 1 OF CHAPTER 5.0)

Project management will be followed as described in the Phase 1 RFI/CMS work plan (DOE/RL-99-36).

A.3.0 GEOLOGIC AND VADOSE ZONE INVESTIGATION (TASK 2 OF CHAPTER 5.0)

The geologic and vadose zone investigation task has two subtasks relevant to the installation of the new boreholes: Subtask 2a, field activities, and Subtask 2b, laboratory analysis. The following subsections describe each of these subtasks.

A.3.1 FIELD ACTIVITIES (SUBTASK 2A OF CHAPTER 5.0)

The field activities addressed in this subtask required to support the geologic and vadose zone investigation are drilling, geophysical logging, sediment sampling, and reporting activities.

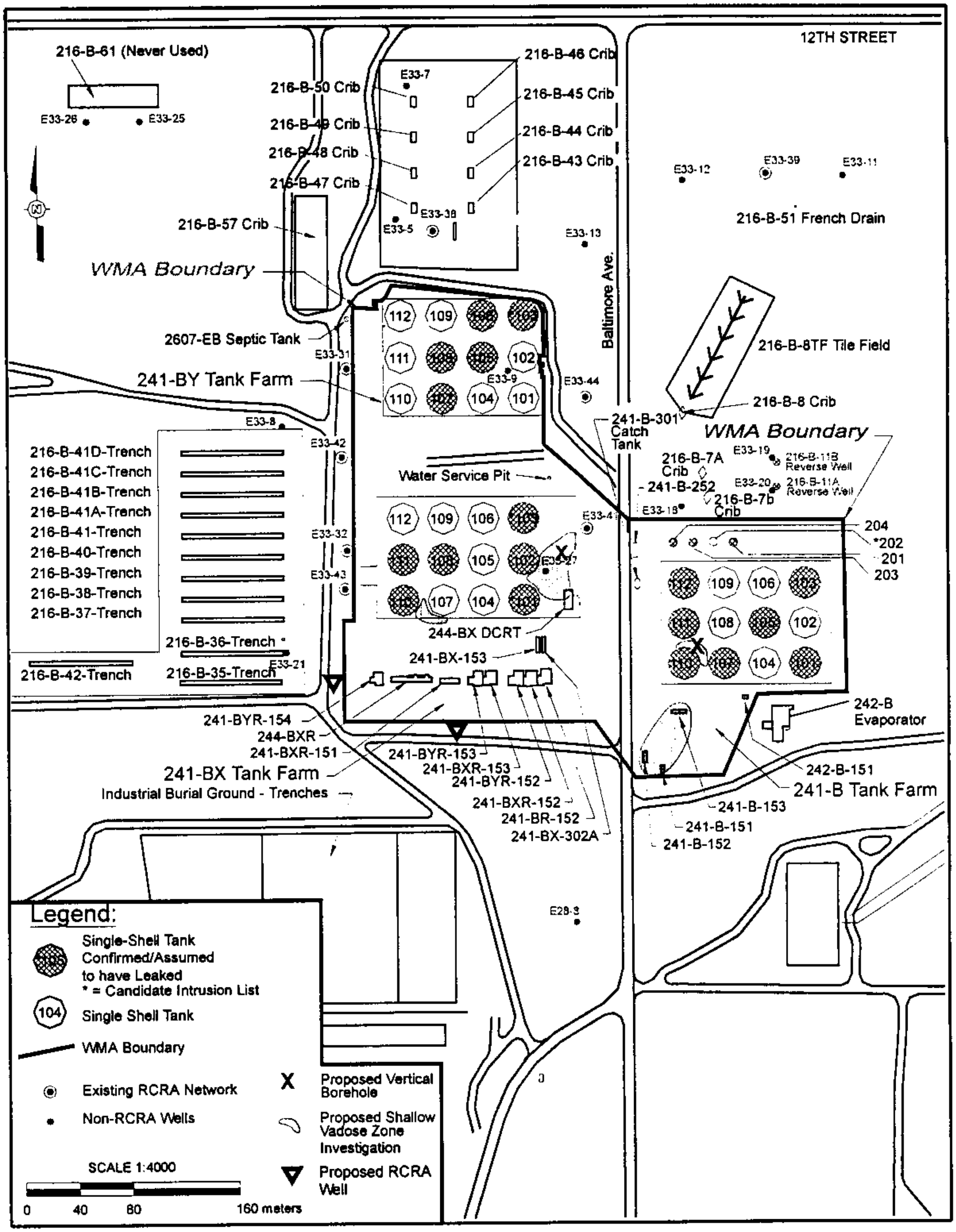
A.3.1.1 Drilling Activities

Drilling will be conducted using specifications and guidance in accordance with WAC 173-160. Drilling operations will also conform to SP 4-1, "Soil and Sediment Sampling"; WP 2-2, "Field Cleaning and/or Decontamination of Equipment"; and the task-specific work package that will be generated for these field activities (ES-SSPM-001). The work package will contain such information as borehole construction, sampling technique, and radiation protection. All waste will be handled in accordance with the requirements of the dangerous waste regulations (WAC 173-303) and/or the site-specific waste control plan. These techniques are based on minimizing the exposure of field personnel to both radiation and chemical pollutants to as low as reasonably achievable and in compliance with regulatory requirements.

Current plans are to drill two vertical boreholes, one northeast of tank BX-102 within the BX tank farm and one north-northeast of tank B-110 in the B tank farm. The locations of the boreholes are shown in Figure A.1. The borings will extend from the surface to just below the water table, approximately 78 m (256 ft) bgs, to allow for groundwater sampling.

The boreholes will be advanced using a drill-and-drive drilling method. The final design for the vertical boreholes has not been completed. One of the primary constraints on sample collection could be the potential of a high radiation level, which will limit the sample volumes from that borehole that can be brought to the surface at tank B-110.

Figure A.1. WMA B-BX-BY Proposed Sampling Locations for Vertical Boreholes, Near-Surface Characterization, and Proposed RCRA Groundwater Monitoring Wells



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Subsurface conditions are variable and the process of installing the vertical boreholes must be flexible. Some or all of the work may require modification. This addendum is intended to serve as a guideline and is designed to allow for changes depending on conditions encountered in the field. Any change will be recorded on the appropriated field documentation, memoranda, or letters. A complete documented record of activities will be maintained for preparation of a final summary report.

Appropriate permits and compliance with the Notice of Construction permit (DOE/ORP-2000-05) will be maintained during the drilling operations for inside the tank farm. The selected drilling method will comply with the requirements of the Washington State Department of Health for the Notice of Construction permit and other pertinent requirements and appropriate engineering systems to prevent contaminated air from being released to the environment.

Continuous drill cuttings will be collected beginning after the first split-spoon sample is attempted. All split-spoon samples will be collected in advance of the casing being driven. Driven split-spoon samples will be attempted at 3 m (10 ft) intervals beginning at 3 m (10 ft) bgs. Standard techniques will be used to remove that portion of the sediment column that remains in the drill casing once it is driven to the sample depth. From the depth of 74.4 m (242 ft) to total depth of the borehole, the drill pipe and conductor casing will be advanced while collecting drill cuttings, except at the capillary fringe zone (approximately 77.1 m [253 ft] bgs) because of the nature of the geology (large gravels to boulders). The casing is to be driven to total sample depth at the end of each day's drilling effort to prevent potential hole collapse. Split-spoon samplers will be new or decontaminated before reuse. Procedures for decontamination of sampling equipment are contained in WP 2-2, "Field Cleaning and/or Decontamination of Equipment" (ES-WSPM-001).

The depth of the vadose zone borings will be to just below groundwater, unless perched water is encountered. If the U.S. Department of Energy desires to continue the borehole through a perched water zone, then a waiver from the Washington State Department of Ecology (Ecology) would be required. If the U.S. Department of Energy does not seek a waiver or if it is sought but denied by Ecology then, drilling will be terminated and the borehole decommissioned with approved material. In this case, decommissioning will commence immediately following final geophysical logging of the borehole.

The use of field screening instruments will be used for evaluating alpha-, beta-, and gamma-emitting radionuclides. Radiological screening is expected to be effective in determining the initial extent of contamination. Organic vapor monitors, hexavalent chromium test kits, or other appropriate methods, including visual screening, also may be used for field screening.

In addition to the borehole geologic logging, radiation measurements will be made using hand-held instruments on each segment of sample recovered during sampling and on the drill cuttings during cleaning out the borehole. Blow count measurements will be collected during all drive samples collected while advancing the split-spoon sampler. General observation will be noted as to drilling progress and problems. All of this information will be included in each borehole geologic log. Borehole geologic logs and well summary sheets will be prepared in accordance with approved Waste Management Federal Services procedures.

A geologist will prepare a geological log for the vertical boreholes, based on the sediment samples. Borehole geologic logs will be prepared in accordance with approved procedures. The geologic log will include lithologic descriptions, sampling intervals, health physics technician hand-held instrument readings, screening results, evidence of any alteration of sediments, and general information and observations deemed relevant by the geologist to the characterization of subsurface conditions. Sediment samples will be screened with hand-held instruments for radiation, as appropriate, using techniques and procedures defined in the work package. Screening results and general observations as to drilling progress and problems will be included in each borehole log.

Waste containing unknown, low-level mixed radioactive waste and/or hazardous waste will be contained, stored, and disposed of according with Appendix D of DOE/RL-99-36, including waste utilizing the area of contaminant approach, and specified in the quality assurance project plan (Appendix A of DOE/RL-99-36) and will be documented in the field activity reports. Waste will be disposed of at the Mixed Waste Burial Grounds in accordance with Appendix D of DOE/RL-99-36. All important information will be recorded on field activity report forms per approved procedures. The field activity report form includes borehole number, site location drawings, drawing of the downhole tool strings, site personnel, sampling types and intervals, zones noted by the health physics technician as elevated in radiological contaminants, instrument readings will be noted and the depth represented by those readings, and specific information concerning borehole completion.

The new boreholes will be completed as a RCRA-compliant groundwater monitoring wells or decommissioned in accordance with WAC 173-160 following completion of geophysical surveys. All temporary steel casing removed from the boring will be surveyed and either decontaminated and released or transferred to an appropriate disposal facility. If abandoned, the borehole will be pressure-grouted from the bottom up, using a Portland cement/bentonite slurry or other appropriate material in accordance with WAC 173-160. Specific procedures for borehole abandonment will be documented in the field work package. These procedures will comply with U.S. Environmental Protection Agency requirements and WAC 173-160.

If completed as a groundwater monitoring well, a 4-in. stainless steel casing and screen will be permanently installed, and a flush mount surface protection/well seal will be constructed. The well will be completed in accordance with WAC 173-160 requirements to meet groundwater protection goals. Specific work steps for well completion will be documented in the tank farm work package.

Contaminant dragdown during drilling and sampling activities is unavoidable and has been observed in recent sampling activities. Different drilling/sampling techniques will impact dragdown to varying degrees. Because the objective of the characterization activities identified in the DQOs is to safely sample in and below regions of known leakage, the dragdown issue is a secondary concern. However, appropriate drilling procedures will be used to minimize the effect of contaminant dragdown.

A.3.1.2 Geophysical Surveying Activities

Based on sampling and construction methods, downhole spectral-gamma or gross gamma geophysical logging will be conducted to ascertain the gamma-emitting radionuclide concentrations. The spectral-gamma or gross gamma logging frequency will be directed by CH2M HILL Hanford Group, Inc. (CHG).

A full suite of geophysical logs will be run any time the casing size is changed and at the completion of the borehole. This will provide some flexibility with the planning of geophysical logging during the drilling process.

The following logging techniques could be used for the vertical boreholes:

- Gross-gamma logging to support correlation of confining layers and stratigraphy
- Spectral-gamma logging for measuring the distribution of selected radionuclides
- Neutron logging for measuring the relative moisture content
- Neutron-enhanced spectral gamma logging for correlation of high salt tank waste and moisture content with spectral gamma and neutron probes, respectively.

The existing equipment and procedures for gross-gamma and spectral-gamma logging in use at the Hanford Site provide acceptable data (P-GJPO-1783).

A full suite of geophysical logs should be run any time the casing size is changed and at the completion of the borehole.

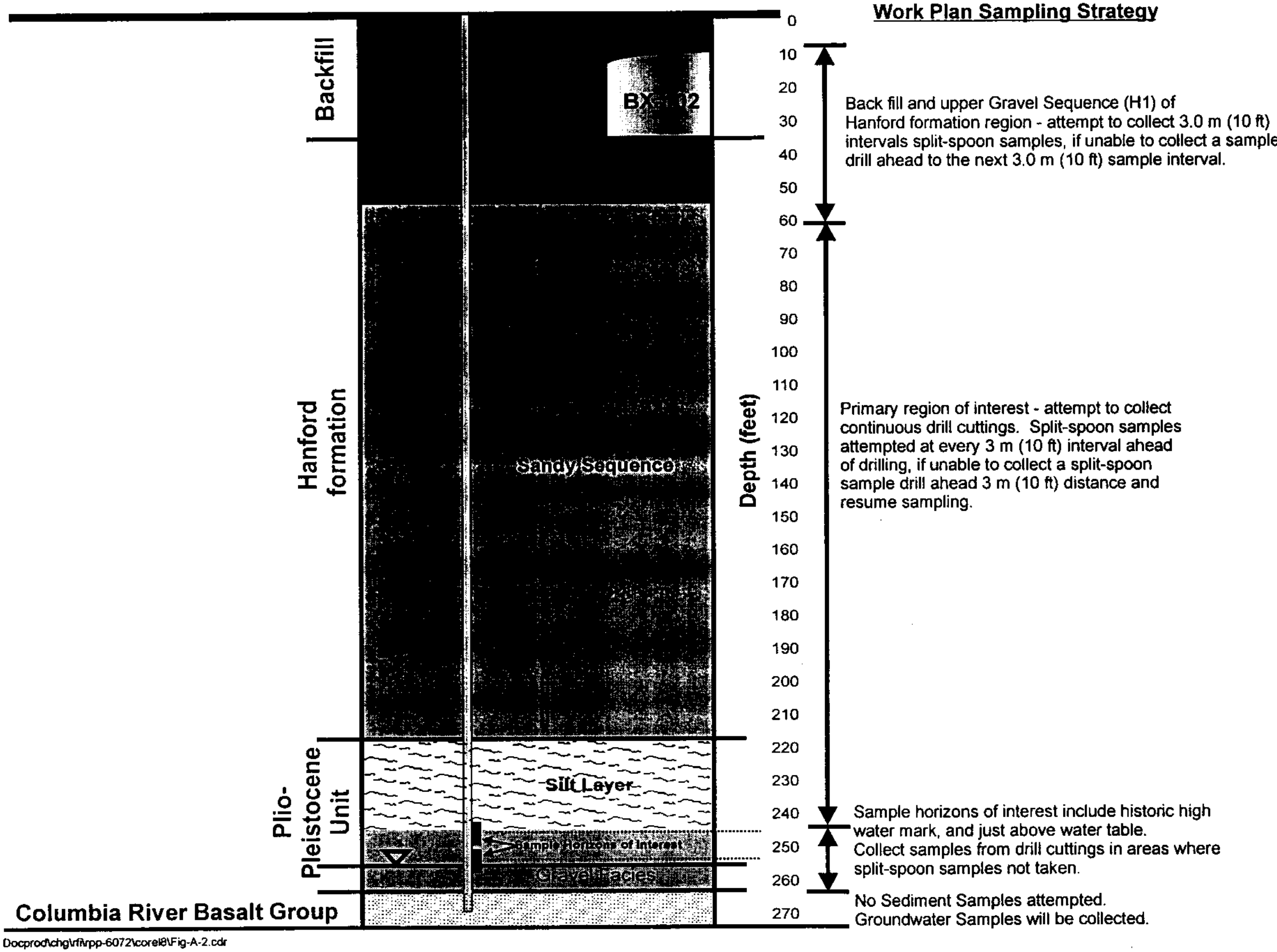
The borehole will be decommissioned following completion of the groundwater sampling described in Section A.3.1.4. All steel casing will be removed and transferred to an appropriate disposal facility or controlled decontamination facility, and each boring will be pressure-grouted from the bottom up, using a Portland cement/bentonite slurry or other approved material. The procedures will comply with EPA requirements and WAC 173-160.

A.3.1.3 Sediment Sampling Activities

Borehole sampling will be performed to define the depth of contamination. The borehole will serve to establish the general lithology of the sediments lying below the site and to give indications of how radionuclides and other contaminants have migrated. It also will provide sediment samples for determination of sediment chemistry and vadose zone properties. This SAP is specific to the borehole sampling event, and is not applicable to future borehole sampling events.

For the new boreholes, sampling will begin at 3 m (10 ft) bgs to allow for a limited open borehole and placement of a sealed surface casing. Drilling and sampling will continue until groundwater is reached. Drill cuttings will be continuously collected. Split-spoon samples will be attempted at every 3 m (10 ft). Figure A.2 shows the proposed sampling strategy for the new boreholes. The borings will extend to just below the water table to provide for groundwater sampling in accordance with guidance from the RCRA Single-Shell Tank Groundwater Monitoring Project.

Figure A.2. New Boreholes Sampling Strategy



After the sediment samples are screened, these samples will be transported to the Pacific Northwest National Laboratory Applied Geology and Geochemistry group for analysis. All material removed from the borehole will be sent to the laboratory for possible future analysis. Samples will be contained in airtight sample containers after their initial screening by the health physics technician and are to be kept under refrigeration. This process is used to retain sediment moisture in as close to field condition as possible. All samples will be transported to the laboratory under refrigeration to further limit alteration of sediment moisture.

Field quality control samples also will be submitted for the full spectrum of chemical and radionuclide analyses. These quality control samples will consist of the following:

- Field duplicate samples: A minimum of 5% of the total collected samples shall be duplicated, or one duplicate for every 20 samples, whichever is greater.

- Equipment rinseate blanks: One equipment rinseate blank per borehole drilling activity or, if multiple types of samplers are used, once per type of sampler.

A.3.1.4 Groundwater Sampling Activities

If the new borehole penetrates the groundwater table, samples of groundwater will be collected and analyzed in accordance with guidance provided in PNNL-13022.

A.3.1.5 Field Reporting Activities

Field logs will be maintained to record all observations and activities conducted. A site representative will record the activities on a field activity report. Items for entry will include the following:

- Borehole number
- Site location drawings
- Drawings of the downhole tool strings
- Site personnel present
- Sampling types and intervals
- Zones noted by the health physics technician as elevated in radiological contaminants
- Instrument readings and the depth represented by those readings
- Specific information concerning borehole progress and completion.

All completed field records will be maintained and processed in accordance with approved CHG procedures.

A.3.2 LABORATORY ANALYSIS (SUBTASK 2B OF CHAPTER 5.0)

The following sections describe the laboratory analyses required for the samples collected from the vertical boreholes. Laboratory analyses will be performed on sediment samples in accordance with this SAP. All analytical work prescribed by this SAP will be performed by qualified laboratories with approved quality assurance plans. If the primary contracting laboratory is unable to complete the analyses, it is the primary contracting laboratory's responsibility to subcontract the laboratory work to a qualified secondary laboratory. Samples for laboratory analysis will be placed in appropriate containers and properly preserved in accordance with SP 4-1, "Soil and Sediment Sampling" (ES-SSPM-001), and in accordance with the quality assurance project plan (Appendix A of DOE/RL-99-36). All samples for laboratory analysis will be transported under chain of custody in accordance with the quality assurance project plan (Appendix A of DOE/RL-99-36).

Sediment cuttings containing low-level and mixed radioactive waste will be contained, stored, and disposed of according to procedures defined in Appendix D of the Phase 1 RFI/CMS work plan (DOE/RL-99-36). Sediment cuttings containing hazardous waste and those containing unknown waste will be contained and disposed of at the mixed waste burial grounds in accordance with Appendix D of the Phase 1 RFI/CMS work plan (DOE-RL-99-36). Storage of archive samples will be done until approval to dispose of the samples is provided by the CHG technical representative.

A.3.2.1 Sediment Sample Analysis

Geologic logging for the vertical boreholes will be conducted as it was for the borehole 41-09-39 extension in WMA S-SX. Specifically, once sample material from the vertical boreholes is received at the laboratory, it will be geologically logged by an assigned geologist in general conformance with standard procedures. The assigned geologist will photograph the samples and describe the geologic structure, texture, and lithology of the recovered samples. Special attention is to be paid to the presence of contaminant alteration. If such a phenomenon is noted, that sample will be noted, preserved for more detailed physical, chemical, and mineralogic analyses, and recorded in the laboratory notebook.

Sediment subsamples for laboratory analysis will be defined by location in the sample after the field screening and geologic logging have been completed and indication of contamination locations have been identified. Approximately 27 sediment subsamples from each of the boreholes will be chosen for screening analysis. The following criteria will be used to identify subsamples for laboratory analysis based on concurrence with Ecology:

- One background subsample will be taken at 6 m (20 ft) bgs.
- One subsample will be taken at 11.6 m (38 ft) bgs, at the level of the tank bottom.
- Two subsamples will be taken at the major lithology changes in the Hanford formation.
- One subsample will be taken at the Hanford formation/Plio-Pleistocene unit (?) silt facies and Hanford formation contact at 66.5 m (218 ft) bgs, and one subsample will be obtained at the Hanford formation/Plio-Pleistocene unit (?) silt facies and Hanford formation/Plio-Pleistocene unit (?) gravel facies contact at 73.7 m (242 ft) bgs.
- One subsample will be taken just above the water table in the capillary fringe zone.
- One subsample will be taken at the historic high water table at approximately 74.4 m (244 ft) bgs.
- Subsamples will be taken of any paleosols seen in the split-spoon drive samples.

- Subsamples will be taken in locations where elevated or altered gamma surveying or moisture content was measured during the geological and geophysical borehole logging process.
- At least one subsample will be taken every 3 m (10 ft) if samples have not already been taken, based on the above criteria to ensure continuous distribution and lithologic completeness.

Figure A.3 shows the subsamples identified for laboratory analyses. Worker safety considerations may limit the collection of samples at certain intervals. A 1:1 water extract of all subsamples shall undergo screening analyses. Screening analyses consist of:

- Nitrate analysis by the colorimetric method
- Electrical conductance
- Total organic carbon/total carbon
- gamma energy analysis
- pH.

These analyses, along with the gamma surveying and moisture content measurements performed during the field geophysical surveys and the laboratory geologic logging, will be used to determine the extent of further subsample analysis. Table A.1 identifies the full complement of analyses and their respective laboratory preparation and analytical methods. This paragraph and the remainder of Appendix A identifies which analysis will be conducted on which sample. If more than one preparation or analytical method is listed, the expertise of the laboratory geochemistry staff will be used to determine which methods will produce the best results and will provide the best understanding of the chemistry involved. For those methods that produce multiple constituents (i.e., inductively coupled plasma), all constituents identified will be reported. Every effort is to be made to meet regulatory holding times where appropriate. The DQO process identified the need for volatile organic analysis and semivolatile organic analysis. An attempt will be made to perform these analysis; however, based on experience from WMA S-SX, it is unlikely that the holding time for volatile organic analysis can be met. If holding times cannot be met, analysis of these compounds will not be performed. Based on previous experience, it is anticipated that holding times for the semi-volatile organic analysis can be met.

Because the purpose of the new borehole analyses is to gain an understanding of the nature and extent of contamination, the fate and transport of the contaminants in the vadose zone and to produce RCRA-compliant data, the analysis of these subsamples comprises two levels. The baseline level involves analysis of organic, inorganic, and radiochemical constituents in full conformance with HASQARD and with no modifications to methods (as defined by HASQARD) without concurrence from the CHG technical representative and from Ecology. Substitutions and deviations to methods as defined by HASQARD will not require concurrence from Ecology. The second level involves a research-type approach to the analyses. In this level, procedures may be modified or developed to gain a more comprehensive understanding of the dynamics involved. Although specific quality control criteria do not apply to this level, compliance with the other quality assurance requirements of HASQARD must still be met and research analysis will be initiated only following review and approval of the activities by the CHG technical representative.

Figure A.3. BX-102 and B-110 Boreholes Subsample Analyses Strategy

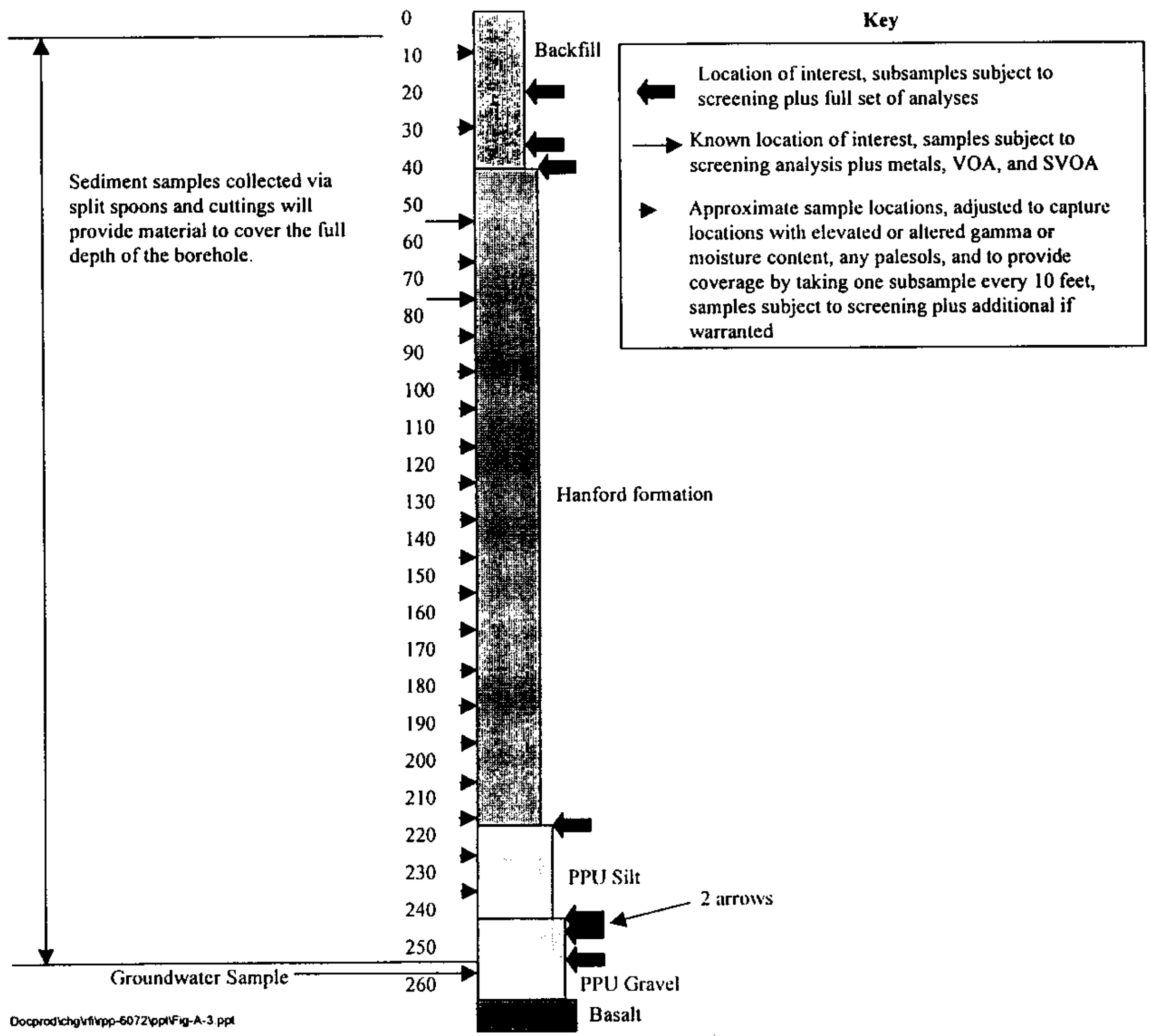


Table A.1. Constituents and Methods for Sediment Sample Analyses and Near-Surface Characterization Samples for WMA B-BX-BY

COPC	CAS #	ACTION LEVELS			NAME/ANALYTICAL TECH.	TARGET REQUIRED QUANTITATION LIMITS				PRECISION WATER	ACCURACY WATER	PRECISION SOIL	ACCURACY SOIL
						WATER[b] low level	WATER[b] high level	SOIL-OTHER low level	SOIL-OTHER high level				
RADIONCULIDE		RR[a] pCi/g	C/I[a] pCi/g	GW[e]		pCi/L	pCi/L	pCi/g	pCi/g				
Americium-241	14596-10-2	31	210	TBD	Americium Isotopic - Alpha Energy Analysis (AEA)	1	400	1	4000	+-20%	70-130%	+-35%	70-130%
Carbon-14	14762-75-5	5.2[f]	33100	TBD	Carbon-14 - Liquid Scintillation	200	NA	50	NA	+-20%	70-130%	+-35%	70-130%
Cesium-137	10045-97-3	6.2	25	TBD	Gamma Energy Analysis	15	200	0.1	2000	+-20%	70-130%	+-35%	70-130%
Cobalt-60	10198-40-0	1.4	5.2	TBD	Gamma Energy Analysis	25	200	0.05	2000	+-20%	70-130%	+-35%	70-130%
Europium-152	14683-23-9	3.3	12	TBD	Gamma Energy Analysis	50	200	0.1	2000	+-20%	70-130%	+-35%	70-130%
Europium-154	15585-10-1	3	11	TBD	Gamma Energy Analysis	50	200	0.1	2000	+-20%	70-130%	+-35%	70-130%
Europium-155	14391-16-3	125	449	TBD	Gamma Energy Analysis	50	200	0.1	2000	+-20%	70-130%	+-35%	70-130%
Hydrogen-3	10028-17-8	359[f]	14,200	TBD	Tritium - Liquid Scintillation	400	400	400	400	+-20%	70-130%	+-35%	70-130%
Neptunium-237	13994-20-2	2.5	62.2	TBD	Neptunium-237 - AEA	1	NA	1	8000	+-20%	70-130%	+-35%	70-130%
Nickel-63	13981-37-8	4026	3008000	TBD	Nickel-63 - Liquid Scintillation	15	NA	30	NA	+-20%	70-130%	+-35%	70-130%
Plutonium-238	13981-16-3	37	483	TBD	Plutonium Isotopic - AEA	1	130	1	1300	+-20%	70-130%	+-35%	70-130%
Plutonium-239/240	PU-239/240	34	243	TBD	Plutonium Isotopic - AEA	1	130	1	1300	+-20%	70-130%	+-35%	70-130%
Total Radioactive Strontium	SR-RAD	4.5	2500	TBD	Total Radioactive Strontium - Gas Proportional Counting (GPC)	2	80	1	800	+-20%	70-130%	+-35%	70-130%
Technetium-99	14133-76-7	5.7[f]	410000	TBD	Technetium-99 - Liquid Scintillation	15	400	15	4000	+-20%	70-130%	+-35%	70-130%
Thorium-232	TH-232	1	5.1	TBD	Thorium Isotopic - AEA (pCi) ICPMS (mg)	1	.002 mg/L	1	0.02 mg/Kg	+-20%	70-130%	+-35%	70-130%
Uranium-234	13966-29-5	160	1200	TBD	Uranium Isotopic - AEA (pCi) ICPMS (mg)	1	.002 mg/L	1	0.02 mg/Kg	+-20%	70-130%	+-35%	70-130%
Uranium-235	15117-96-1	26	100	TBD	Uranium Isotopic - AEA (pCi) ICPMS (mg)	1	.002 mg/L	1	0.02 mg/Kg	+-20%	70-130%	+-35%	70-130%
Uranium-238	U-238	85	420	TBD	Uranium Isotopic - AEA (pCi) ICPMS (mg)	1	.002 mg/L	1	0.02 mg/Kg	+-20%	70-130%	+-35%	70-130%

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Table A.1. Constituents and Methods for Sediment Sample Analyses and Near-Surface Characterization Samples for WMA B-BX-BY (Cont'd)

COPC	CAS #	ACTION LEVELS			NAME/ANALYTICAL TECH.	TARGET REQUIRED QUANTITATION LIMITS				PRECISION WATER	ACCURACY WATER	PRECISION SOIL	ACCURACY SOIL
						WATER[b] low level	WATER[b] high level	SOIL-OTHER low level	SOIL-OTHER high level				
CHEMICAL		Meth B mg/Kg	Meth C mg/Kg	mg/Kg		mg/L	mg/L	mg/Kg	mg/Kg				
Organics													
Ethyl alcohol	64-17-5	none	none	none	Non-Halogenated VOA - 8015[c] - GC	5	NA	5	NA	e	e	e	e
n-Butyl alcohol	71-36-3	8000	350	160	Non-Halogenated VOA - 8015 - GC	5	NA	5	NA	e	e	e	e
Methyl alcohol (methanol)	67-56-1	40000	160000	400	Non-Halogenated VOA - 8015M - GC modified for hydrocarbons	1	NA	1	NA	e	e	e	e
Kerosene (paraffin hydrocarbons)	8008-20-6	200000[h]	200000[h]	200000[h]	Non-Halogenated VOA - 8015M - GC modified for hydrocarbons	0.5	0.5	5	5	e	e	e	e
Carbon tetrachloride	56-23-5	7.69	224	0.0337	Volatile Organics - 8260 - GCMS	0.005	0.005	0.005	0.005	e	e	e	e
2-Propanone (Acetone)	67-64-1	8000	32000	80	Volatile Organics - 8260 - GCMS	0.02	0.02	0.02	0.02	e	e	e	e
Chloroform	67-66-3	164	3200	0.717	Volatile Organics - 8260 - GCMS	0.005	0.005	0.005	0.005	e	e	e	e
Benzene	71-43-2	34.5	1380	0.151	Volatile Organics - 8260 - GCMS	0.005	0.005	0.005	0.005	e	e	e	e
1,1,1-trichlorethane	71-55-6	72000	288000	720	Volatile Organics - 8260 - GCMS	0.005	0.005	0.005	0.005	e	e	e	e
Dichloromethane (methylene chloride)	75-09-2	133	5330	0.583	Volatile Organics - 8260 - GCMS	0.005	0.005	0.005	0.005	e	e	e	e
Carbon Disulfide	75-15-0	8000	32000	80	Volatile Organics - 8260 - GCMS	0.005	0.005	0.005	0.005	e	e	e	e
1,1-dichloroethane	75-34-3	8000	32000	80	Volatile Organics - 8260 - GCMS	0.01	0.01	0.01	0.01	e	e	e	e
1,1-dichloroethene	75-35-4	1.67	66.7	0.00729[f]	Volatile Organics - 8260 - GCMS	0.01	0.01	0.01	0.01	e	e	e	e
1,2-dichloropropane	78-87-5	14.7	588	0.0643	Volatile Organics - 8260 - GCMS	0.005	0.005	0.005	0.005	e	e	e	e
2-butanone	78-93-3	48000	192000	480	Volatile Organics - 8260 - GCMS	0.01	0.01	0.01	0.01	e	e	e	e
1,1,2-trichloroethane	79-00-5	17.5	702	0.0768	Volatile Organics - 8260 - GCMS	0.005	0.005	0.005	0.005	e	e	e	e
1,1,2-trichloroethylene	79-01-6	90.9	3640	0.398	Volatile Organics - 8260 - GCMS	0.005	0.005	0.005	0.005	e	e	e	e
1,1,2,2-tetrachloroethane	79-34-5	5	200	0.0219	Volatile Organics - 8260 - GCMS	0.005	0.005	0.005	0.005	e	e	e	e

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Table A.1. Constituents and Methods for Sediment Sample Analyses and Near-Surface Characterization Samples for WMA B-BX-BY (Cont'd)

COPC	CAS #	ACTION LEVELS			NAME/ANALYTICAL TECH.	TARGET REQUIRED QUANTITATION LIMITS				PRECISION WATER	ACCURACY WATER	PRECISION SOIL	ACCURACY SOIL
		Meth B	Meth C			WATER[b] low level	WATER[b] high level	SOIL-OTHER low level	SOIL-OTHER high level				
CHEMICAL		mg/Kg	mg/Kg	mg/Kg		mg/L	mg/L	mg/Kg	mg/Kg				
Ethyl benzene	100-41-4	8000	32000	80	Volatile Organics - 8260 - GCMS	0.005	0.005	0.005	0.005	e	e	e	e
1,2-dichloroethane	107-06-2	11	440	0.0481	Volatile Organics - 8260 - GCMS	0.005	0.005	0.005	0.005	e	e	e	e
4-methyl-2-pentanone	108-10-1	6400	25600	64	Volatile Organics - 8260 - GCMS	0.01	0.01	0.01	0.01	e	e	e	e
Toluene	108-88-3	16000	64000	160	Volatile Organics - 8260 - GCMS	0.005	0.005	0.005	0.005	e	e	e	e
Chlorobenzene	108-90-7	1600	6400	16	Volatile Organics - 8260 - GCMS	0.005	0.005	0.005	0.005	e	e	e	e
1,1,2,2-tetrachloroethene	127-18-4	19.6	784	0.0858	Volatile Organics - 8260 - GCMS	0.005	0.005	0.005	0.005	e	e	e	e
2-hexanone	591-78-6	none	none	64	Volatile Organics - 8260 - GCMS	0.02	0.02	0.02	0.02	e	e	e	e
cis-1,3-dichloropropene	10061-01-5	5.56	96	0.0243[i]	Volatile Organics - 8260 - GCMS	0.005	0.005	0.005	0.005	e	e	e	e
Trans-1,3-dichloropropene	10061-02-6	5.56	96	0.0243[i]	Volatile Organics - 8260 - GCMS	0.005	0.005	0.005	0.005	e	e	e	e
Xylene (total)	1330-20-7	160000	640000	1600	Volatile Organics - 8260 - GCMS	0.005	0.005	0.005	0.005	e	e	e	e
Dibenz[a,h]anthracene	53-70-3	0.137[f]	5.48	0.0012[e]	Semi-Volatiles - 8270 - GCMS	0.01	0.05	0.33	1	e	e	e	e
Hexachloroethane	67-72-1	71.4	320	0.625	Semi-Volatiles - 8270 - GCMS	0.01	0.05	0.33	1	e	e	e	e
Hexachlorobutadiene	87-68-3	12.8	64	0.0561[i]	Semi-Volatiles - 8270 - GCMS	0.01	0.05	0.33	1	e	e	e	e
Pentachlorophenol	87-86-5	8.33	333	0.0729[f]	Semi-Volatiles - 8270 - GCMS	0.01	0.05	0.33	1	e	e	e	e
2-methylphenol (o-cresol)	95-48-7	4000	16000	80	Semi-Volatiles - 8270 - GCMS	0.01	0.05	0.33	1	e	e	e	e
1,2-dichlorobenzene	95-50-1	7200	28800	72	Semi-Volatiles - 8270 - GCMS	0.01	0.05	0.33	1	e	e	e	e
Nitrobenzene	98-95-3	40	160	0.8	Semi-Volatiles - 8270 - GCMS	0.01	0.05	0.33	1	e	e	e	e
4-methylphenol (p-cresol)	106-44-5	400	1600	8	Semi-Volatiles - 8270 - GCMS	0.01	0.05	0.33	1	e	e	e	e
1,4-dichlorobenzene	106-46-7	41.7	1670	0.0182[f]	Semi-Volatiles - 8270 - GCMS	0.01	0.05	0.33	1	e	e	e	e

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Table A.1. Constituents and Methods for Sediment Sample Analyses and Near-Surface Characterization Samples for WMA B-BX-BY (Cont'd)

COPC	CAS #	ACTION LEVELS			NAME/ANALYTICAL TECH.	TARGET REQUIRED QUANTITATION LIMITS				PRECISION WATER	ACCURACY WATER	PRECISION SOIL	ACCURACY SOIL
		Meth B	Meth C			WATER[b] low level	WATER[b] high level	SOIL-OTHER *low level*	SOIL-OTHER *high level*				
CHEMICAL		mg/Kg	mg/Kg	mg/Kg		mg/L	mg/L	mg/Kg	mg/Kg				
Pyridine	110-86-1	80	320	1.6	Semi-Volatiles - 8270 - GCMS	0.02	0.1	0.66	2	e	e	e	e
Hexachlorobenzene	118-74-1	0.625	25	0.00547[e]	Semi-Volatiles - 8270 - GCMS	0.01	0.05	0.33	1	e	e	e	e
1,2,4-trichlorobenzene	120-82-1	800	3200	8	Semi-Volatiles - 8270 - GCMS	0.01	0.05	0.33	1	e	e	e	e
2,4-Dinitrotoluene	121-14-2	160	640	3.2	Semi-Volatiles - 8270 - GCMS	0.01	0.05	0.33	1	e	e	e	e
Tributyl phosphate	126-73-8	none	none	none	Semi-Volatiles - 8270 - GCMS	0.1	0.5	3.3	5	e	e	e	e
1,3-dichlorobenzene	541-73-1	41.7	1670[j]	0.018[f,j]	Semi-Volatiles - 8270 - GCMS	0.01	0.05	0.33	1	e	e	e	e
Benzo(a)pyrene	50-32-8	0.137[f]	5.48	0.0012[e]	Semi-Volatiles - 8270 - GCMS	0.01	0.05	0.33	1	e	e	e	e
2,4,5-Trichlorophenol	95-95-4	8000	32000	160	Semi-Volatiles - 8270 - GCMS	0.01	0.05	0.33	1	e	e	e	e
gamma-BHC (Lindane)	58-89-9	0.769	30.8	0.00673	Pesticides - 8081 - GC	0.00005	NA	0.00165	NA	e	e	e	e
Dieldrin	60-57-1	0.0625	2.5	0.000547[e]	Pesticides - 8081 - GC	0.0001	NA	0.0033	NA	e	e	e	e
Endrin	72-20-8	24	96	0.48	Pesticides - 8081 - GC	0.0001	NA	0.0033	NA	e	e	e	e
Heptachlor	76-44-8	0.222	8.89	0.00194	Pesticides - 8081 - GC	0.00005	NA	0.00165	NA	e	e	e	e
Aldrin	309-00-2	0.0588	2.35	0.000515[f]	Pesticides - 8081 - GC	0.00005	NA	0.00165	NA	e	e	e	e
Alpha-BHC	319-84-6	0.159	6.35	0.00139[f]	Pesticides - 8081 - GC	0.00005	NA	0.00165	NA	e	e	e	e
Beta-BHC	319-85-7	0.556	2.22	0.00486	Pesticides - 8081 - GC	0.00005	NA	0.00165	NA	e	e	e	e
Toxaphene	8001-35-2	0.909	36.4	0.00795[e]	Pesticides - 8081 - GC	0.005	NA	0.165	NA	e	e	e	e
Total Organic Carbon	TOC	N/A	N/A	none	TOC - 9060- Combustion	1	1	100	100	+-20%	70-130%	+-35%	70-130%
Polychlorinated biphenyls (PCBs)	1336-36-3	0.13	5.19	0.00114[e]	PCBs - 8082 - GC	0.0005	0.005	0.0165	0.1	e	e	e	e
Inorganics													
Ammonia/ammonium	7664-41-7	2720000	10900000	27100	Ammonia - 350.N[d]	0.05	800	0.5	8000	e	e	e	e
Phosphate	14265-44-2	N/A	N/A	none	Anions - 9056 - IC	0.5	15	5	40	e	e	e	e
Nitrate	14797-55-8	128000	512000	2560	Anions - 9056 - IC	0.25	10	2.5	40	e	e	e	e
Nitrite	14797-65-0	8000	32000	160	Anions - 9056 - IC	0.25	15	2.5	20	e	e	e	e
Sulfate	14808-79-8	25000[k]	25000[k]	25000	Anions - 9056 - IC	0.5	15	5	40	e	e	e	e
Chloride	16887-00-6	25000[k]	25000[k]	25000	Anions - 9056 - IC	0.2	5	2	5	e	e	e	e

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Table A.1. Constituents and Methods for Sediment Sample Analyses and Near-Surface Characterization Samples for WMA B-BX-BY (Cont'd)

COPC	CAS #	ACTION LEVELS			NAME/ANALYTICAL TECH.	TARGET REQUIRED QUANTITATION LIMITS				PRECISION WATER	ACCURACY WATER	PRECISION SOIL	ACCURACY SOIL
						WATER[b] low level	WATER[b] high level	SOIL-OTHER low level	SOIL-OTHER high level				
CHEMICAL		Meth B mg/Kg	Meth C mg/Kg	mg/Kg		mg/L	mg/L	mg/Kg	mg/Kg				
Fluoride	16984-48-8	96[k]	200[k]	96	Anions - 9056 - IC	0.5	5	5	5	e	e	e	e
Bromide	24959-67-9	N/A	N/A	none	Anions - 9056 - IC	0.25	NA	2.5	NA	e	e	e	e
Chromium VI	18540-29-9	400	1600	8	Chromium (hex) - 7196 - Colorimetric	0.01	4	0.5	200	e	e	e	e
Mercury	7439-97-6	24	96	0.48	Mercury - 7470 - CVAA	0.0005	0.005	NA	NA	e	e	e	e
Mercury	7439-97-6	24	96	0.48	Mercury - 7471 - CVAA	NA	NA	0.2	0.2	e	e	e	e
Lead	7439-92-1	25000[h]	25000[h]	N/A	Metals - 6010 - ICP	0.1	0.2	10	20	e	e	e	e
Nickel	7440-02-0	1600	6400	32	Metals - 6010 - ICP	0.04	0.04	4	4	e	e	e	e
Silver	7440-22-4	400	1600	8	Metals - 6010 - ICP	0.02	0.02	2	2	e	e	e	e
Antimony	7440-36-0	32[l]	128[l]	6	Metals - 6010 - ICP	0.06	0.12	6	12	e	e	e	e
Arsenic	7440-38-2	6.5[m]	66.7	0.00583[o]	Metals - 6010 - ICP	0.1	0.2	10	20	e	e	e	e
Barium	7440-39-3	5600	22400	112	Metals - 6010 - ICP	0.2	0.2	20	20	e	e	e	e
Beryllium	7440-41-7	0.233	9.3	0.00203[o]	Metals - 6010 - ICP	0.005	0.01	0.5	1	e	e	e	e
Cadmium	7440-43-9	40	160	0.8	Metals - 6010 - ICP	0.005	0.01	0.5	1	e	e	e	e
Chromium (total)	7440-47-3	1600	3500	None	Metals - 6010 - ICP	0.01	0.01	1	2	e	e	e	e
Copper	7440-50-8	2960	11800	59.2	Metals - 6010 - ICP	0.025	0.025	2.5	2.5	e	e	e	e
Selenium	7782-49-2	400	1600	8[f]	Metals - 6010 - ICP	0.1	0.2	10	20	e	e	e	e
Lead	7439-92-1	25000[h]	25000[h]	N/A	Metals - 6010 - ICP(TRACE)	0.01	NA	1	NA	e	e	e	e
Silver	7440-22-4	400	1600	8	Metals - 6010 - ICP(TRACE)	0.005	NA	0.5	NA	e	e	e	e
Antimony	7440-36-0	32[l]	128[l]	6	Metals - 6010 - ICP(TRACE)	0.01	NA	1	NA	e	e	e	e
Arsenic	7440-38-2	6.5[m]	66.7	0.00583[o]	Metals - 6010 - ICP(TRACE)	0.01	NA	1	NA	e	e	e	e
Barium	7440-39-3	5600	22400	112	Metals - 6010 - ICP(TRACE)	0.005	NA	0.5	NA	e	e	e	e
Cadmium	7440-43-9	40	160	0.8	Metals - 6010 - ICP(TRACE)	0.005	NA	0.5	NA	e	e	e	e
Chromium (total)	7440-47-3	1600	3500	None	Metals - 6010 - ICP(TRACE)	0.01	NA	1	NA	e	e	e	e
Selenium	7782-49-2	400	1600	8	Metals - 6010 - ICP(TRACE)	0.01	NA	1	NA	e	e	e	e
pH	pH	N/A	N/A	none	pH - 9045 - Electrode	NA	NA	NA	NA	e	e	e	e
Sulfides	18496-25-8	N/A	N/A	none	Sulfide - 9030 - Colorimetric	0.5	NA	5	NA	e	e	e	e

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Table A.1. Constituents and Methods for Sediment Sample Analyses and Near-Surface Characterization Samples for WMA B-BX-BY (Cont'd)

COPC	CAS #	ACTION LEVELS			NAME/ANALYTICAL TECH.	TARGET REQUIRED QUANTITATION LIMITS				PRECISION WATER	ACCURACY WATER	PRECISION SOIL	ACCURACY SOIL
						WATER[b] low level	WATER[b] high level	SOIL-OTHER low level	SOIL-OTHER high level				
CHEMICAL		Meth B	Meth C			mg/L	mg/L	mg/Kg	mg/Kg				
		mg/Kg	mg/Kg	mg/Kg									
Cyanide	57-12-5	1600	6400	32	Total Cyanide - 9010 - Colorimetric	0.005	0.005	0.5	0.5	e	e	e	e
Uranium (total)	7440-61-1	240[a]	960[a]	4.8	Uranium Total - Kinetic Phosphorescence Analysis	0.0001	0.02	1	0.2	+-20%	70-130%	+-35%	70-130%
Cation exchange capacity	CEC	N/A	N/A	None	Cation exchange capacity/Methods of Soil Analysis Part 2; 9-3.1	N/A	N/A	N/A	N/A	p	p	p	p
Particle size distribution	N/A	N/A	N/A	None	Particle size distribution/ASTM D 422-63, ASTM D 854-83	N/A	N/A	N/A	N/A	p	p	p	p
Mineralogy	N/A	N/A	N/A	None	XRD/SEM/TEM/JEA-3, Rev. 0	N/A	N/A	N/A	N/A	p	p	p	p
Electrical conductance	EC	N/A	N/A	None	Electrometric/PNL-MA-567-FA-2	N/A	N/A	N/A	N/A	p	p	p	p
Moisture content	N/A	N/A	N/A	None	Moisture content/PNL-MA-567-SA-7	N/A	N/A	N/A	N/A	p	p	p	p
Matric potential	N/A	N/A	N/A	None	Matric potential/PNL-MA-567-SA-10	N/A	N/A	N/A	N/A	p	p	p	p
Distribution coefficient	K_d	N/A	N/A	None	Methods for determining radionuclide retardation factors, 1980/PNL-3349 USC-70	N/A	N/A	N/A	N/A	p	p	p	p
Bulk density	N/A	N/A	N/A	None	Bulk density/PNL-MA-567-SA-8	N/A	N/A	N/A	N/A	p	p	p	p
Moisture retention	θr	N/A	N/A	None	Moisture retention/ASTM D 2325-68	N/A	N/A	N/A	N/A	p	p	p	p
Saturated hydraulic conductivity	K_s	N/A	N/A	None	Saturated hydraulic conductivity/ASTM D18.21 (draft in review) Methods of Soil Analysis, Part 2; 13-3.2 and 13-3.3	N/A	N/A	N/A	N/A	p	p	p	p

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Table A.1. Constituents and Methods for Sediment Sample Analyses and Near-Surface Characterization Samples for WMA B-BX-BY (Cont'd)

COPC	CAS #	ACTION LEVELS			NAME/ANALYTICAL TECH.	TARGET REQUIRED QUANTITATION LIMITS				PRECISION WATER	ACCURACY WATER	PRECISION SOIL	ACCURACY SOIL
						WATER[b] low level	WATER[b] high level	SOIL-OTHER low level	SOIL-OTHER high level				
CHEMICAL		Meth B	Meth C										
		mg/Kg	mg/Kg	mg/Kg		mg/L	mg/L	mg/Kg	mg/Kg				

[a]RR - Rural Residential, C/I - Commercial Industrial, GW - Groundwater Protection Radionuclide values from WDOH "Hanford Guidance for Radiological Cleanup", WDOH/320-015.
Radionuclide values are calculated using parameters from WDOH guidance.

[b]Water values for sampling QC (e.g. equipment blanks/rinses) or drainable liquid (if recovered)

[c]All 4 digit numbers refer to "Test Methods for Evaluating Solid Waste" (EPA SW-846)

[d]"Methods of Analysis of Water and Waste" (EPA-600/4-79-020)

[e]Precison and Accuracy Requirements as identified and defined in the referenced EPA procedures.

[f]If quantitation to action level lower than nominal RDL is required, prior notification/concurrence with the laboratory will be required to address special low level detection limits

[g]The 100 times GW rule does not apply to residual radionuclide contaminants. GW protection is demonstrated through technical evaluation using RESRAD (DOE/RL-96-17, Rev. 2).

[h]This value is based upon MTCA Method A values.

[i]TValue based upon most restrictive dichlorpropene 1,3.

[j]Value based upon most restrictive dichlorobenzene compound.

[k]Value based upon soil concentration for groundwater protection RAGs.

[l]Value based upon most restrictive antimony compound.

[m]Default to background.

[n]Value based upon uranium soluble salts value.

[o]Detection limits below ths value not achievable by listed technology. No routine technology likey available to achieve this detection limit.

[p]Precision and accuracy for these measurements are not required because of the nature of the measurement.

AEA - alpha energy analysis
ASTM - American Society for Testing and Materials
CVAA - cold vapor atomic absorption
IC - ion chromatography
ICP - inductively coupled plasma
ICPMS - inductively coupled plasma mass spectrometry
N/A - not applicable NA - not available
NA - not available
SEM - scanning electron microscopy
TEM - transmission electron microscopy
TOC/TC - total organic carbon/total carbon
WDOH - Washington Department of Health
XRD - x-ray diffraction

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The background subsample, backfill – Hanford formation contact subsample, Hanford formation H1 unit and Hanford formation H2 unit contact sample, peak gamma concentration sample, the two subsamples obtained at the Hanford formation/Plio-Pleistocene unit (?) silt facies contact, the Hanford formation/Plio-Pleistocene unit (?) silt facies and Hanford formation/ Plio-Pleistocene unit (?) gravel facies contact, and the subsample obtained just above the water table in the capillary fringe zone will be analyzed for the constituents and properties identified in Table A.1. It is recognized that conditions may occur when all of the analyses identified in Table A.1 are not warranted (e.g., limited potential for data) and these occurrences will be evaluated on a case-by-case basis.

At the request of Ecology, one sample from at or near the base of the tank will be analyzed for volatile and semivolatile organics identified in Tables A.1 and A.2.

Table A.2. Constituents and Methods for Organic Analysis of Borehole Sediment Samples

Analysis/Constituent	Preparation Method	Preparation Procedure Number	Analytical Method	Analytical Procedure Number
VOA	Bulk Sediment	Note 1	GC/MS	SW846-8260
SVOAs with TICs	Bulk Sediment	Note 1	GC/MS	SW846-8270

Note 1: Preparation/extraction procedures for VOA and SVOA analysis will depend on the types of organic compounds present in the sediment.

GC = gas chromatography
MS = mass spectrometry
SVOA = semi-volatile organic analysis
VOA = volatile organic analysis

The remaining samples will be analyzed for specific constituents listed in Table A.1 depending on the results of the nitrate, electrical conductivity, total organic carbon/total carbon, and pH screening analyses. A review of the screening analyses results with technical representatives along with Ecology will be conducted prior to performing additional analyses. Screening analysis may be used to determine whether alternative analytical techniques with lower detection limits should be used for specific radionuclides of concern. The screening criteria and associated analytical requirements are identified as follows.

- Gamma-emitting radioisotopes by gamma energy analysis
- Metals and radioisotopes by inductively coupled plasma-mass spectrometry
- Tritium and strontium 90 by the liquid scintillation method
- Particle size distribution
- Carbon 14.

At the request of Ecology, a minimum of two samples collected within the Hanford formation will be analyzed for metals as identified in Table A.1.

The data obtained from the above analyses will be used to evaluate the location of contamination plumes in the sediment column. The results of the above analyses will also be used to determine if additional analyses are warranted. Additional analyses would be performed based on the judgement and expertise of the responsible Pacific Northwest National Laboratory geochemist, with concurrence from the CHG technical representative and Ecology. The following analyses would be performed as additional analyses:

- Cation exchange capacity
- Mineralogy
- Matric potential
- K_d (distribution coefficient)
- Bulk density
- Moisture retention
- Saturated hydraulic conductivity.

Tables A.1 and A.2 identify the analyses and laboratory methods to be used for the sample analyses. For the chemical and radiological constituents, the preferred methods are those listed in EPA SW-846 or the American Society for Testing Materials standards (ASTM 1998). The requested constituents may be analyzed by laboratory-specific procedures, provided that the procedures are validated and conform to HASQARD. Both the EPA SW-846 methods and the Pacific Northwest National Laboratory methods listed in Tables A.1 and A.2 are based on techniques from "Methods of Soil Analysis." Therefore, these procedures should be comparable. The detection limit, precision, and accuracy guidelines for the parameters of interest are listed in the DQOs workbook for WMA B-BX-BY (HNF-6020).

PART II

NEAR-SURFACE CHARACTERIZATION

The following is a discussion of the field tasks and associated subtasks required for the sampling and sample analysis associated with the near-surface characterization in WMA B-BX-BY. The tasks are generally parallel to those addressed for the vertical boreholes.

A.4.0 PROJECT MANAGEMENT (TASK 1 OF CHAPTER 5.0)

Project management will be followed as described in the Phase 1 RFI/CMS work plan (DOE/RL-99-36).

A.5.0 GEOLOGIC AND VADOSE ZONE INVESTIGATION (TASK 2 OF CHAPTER 5.0)

As with installation of the vertical boreholes, the geologic and vadose zone investigation task for the near-surface characterization has two subtasks: Subtask 2a, field activities, and Subtask 2b, laboratory analysis. The following subsections describe each of the subtasks with a field activity component.

A.5.1 FIELD ACTIVITIES (SUBTASK 2A OF CHAPTER 5.0)

The field activities addressed in this subtask that are required to support the geologic and vadose zone investigation are geophysical surveying, sediment sampling, and reporting.

A.5.1.1 Exploratory Activity

Four areas have been identified for the Phase 1 near-surface vadose zone soil characterization. These areas are within the south end of the B tank farm, east of tank BX-102, and east-southeast of tank BX-110. The B tank farm areas of interest include:

- Unplanned releases near diversion boxes 241-B-151, -152, -153
- Unplanned release north of B-110.

The BX tank farm areas of interest include:

- Unplanned release east and southeast of tank BX-110
- Two transects (east-to-west and north-to-south) in the vicinity east of tank BX-102.

Metal waste leaks have been recorded in the vicinity of the 241-B diversion boxes. The vicinity north of tank B-110 and the vicinity east and southeast of tank BX-110 exhibit separate instances of cesium-137 in vadose zone dry wells that may be indicative of near-surface sources. In addition, a north-south and east-west transect east of tank BX-102 will be conducted if technetium-99 is detected in the upper 18.3 m (60 ft) bgs of the proposed vertical borehole. A total of 31 push sites have been identified.

For the purpose of the DQOs, the shallow investigation of these areas will comprise collecting sediment samples at approximately 31 locations. The general sampling locations are identified on Figure A.1. Sediment samples would be attempted from the tank farm surface to the base of the tanks or refusal using direct-push technology. Although near-surface characterization is focused typically on the upper 4.6 m (15 ft), the sampling methods have the capability to sample deeper and provide additional data for the characterization effort.

Direct-push deployment at the shallow zone characterization locations would include the following.

- Shallow soil characterization will be carried out using a truck-mounted direct-push technology-based system.

- Deployment and interrogation with a gross-gamma/spectral gamma probe. The depth of investigation will be determined by the depth to which the direct-push boring can be advanced using a standard deployment truck. The probe will be deployed using the gross gamma mode with the tool advanced at approximately 2 cm/sec (0.8 in./sec). Based on regulatory requirements, if in the upper 5 m (15 ft) the downhole instrument indicates a potential cesium-137 concentration of 3.7 pCi/g or greater, logging will be shifted to the spectral mode to determine the presence and level of concentration of cesium-137; below 5 m (15 ft) bgs the threshold limit for spectral gamma determinations will be 20 pCi/g. In zones where cesium-137 is present at concentrations greater than 20 pCi/g, spectral gamma readings will be taken at 0.5-m (1.5-ft) intervals.

- The graphical log developed using the gross and spectral gamma measurements will be used to select intervals to be sampled.

- The sampling push is to be made in a location that is no more than 0.7 m (2 ft) from the site of the gamma push.

- A single point sampler will be used to collect the required samples. Sampling intervals will be selected from those horizons with a cesium-137 concentration of 20 pCi/g or greater. In the event that horizons are penetrated that would yield samples having a greater that 50 mrem/hr dose rate at 30 cm (12 in.) (based on calculations using sampler size and cesium-137 concentration) a sample will be collected from the first interval below the high rate zone having a dose rate of less than 50 mrem/hr. No sample will be collected from zones where the gamma instrument exhibits excessive deadtime.

- The samples would be transported to the laboratory and analyzed for the contaminants of concern identified in Table A.1.

The samples selected for analysis would be subject to screening analyses, which consist of nitrate analysis by colorimetric method, pH, electric conductance, and gamma energy analysis. Based on the results of the screening, the samples would be analyzed for the remaining contaminants of concern identified in Table A.1.

A.5.1.1.1 Vicinity North of Tank B-110. Direct-push technology pushes would be required to increase the chance of locating the vertical borehole in an area where contaminants are present and provide indication of continuity or lack of continuity between gamma contamination observed at dry wells 20-10-12 and 20-10-02. The highest recorded levels of cesium-137 contamination associated with this site are in borehole 20-10-12 and 20-10-02 in the northeast quadrant of the tank. Contamination is estimated at about 10^3 pCi/g at about 7.6 to 30.5 m (25 to 100 ft) bgs. A possible strontium-90 plume exists at between 18.3 and 30.5 m (60 and 100 ft) bgs. Up to three sets of gamma probe and sampling pushes may be made to investigate this site for the optimal place to install a vertical borehole. The pushes include the following.

- Adjacent to the 20-10-12 drywell, north of the drywell. This location will be to ascertain if there is a vertical gradient between the push location and the identified elevation of contamination in 20-10-12 and to collect a sample from below the contaminated zone to determine if strontium-90 and mobile contaminants are moving ahead of the cesium-137 hot spot.

- Adjacent to tank B-110 at the one o'clock position. This location is to be as close to the tank as the push-truck can be positioned within dome-load restrictions. The B tank farm tanks are constructed with an outlet port at this point. Experience in other farms has shown that these outlet ports are subject to failure. This push will test the hypothesis that the contamination adjacent to the tank is due to an overfill or transfer event at the outlet port.

- Between the first two pushes for correlation purposes. This location is to be within 3 to 4.5 m (10 to15 ft) of the tank. This location will be used to determine the horizontal and vertical extent of the contamination found in the 20-10-12 borehole.

A.5.1.1.2 Vicinity East-Southeast of Tank BX-110. The direct-push technology pushes would be to determine if contaminants detected at 21-10-03, 21-10-05, and 21-07-06 represent a continuous plume or if they are separate discrete "hot spots." This supports development of source term. The highest recorded levels of cesium-137 contamination associated with this site are in boreholes 21-10-03 and 21-10-05 in the southeast quadrant of the tank. Contamination is estimated at greater than 10^4 pCi/g at a depth of about 2.4 to 11.6 m (8 to 38 ft) bgs for borehole 21-10-03 and about 11.3 to 14.3 m (37 to 47 ft) bgs for borehole 21-10-05. Four sets of gamma probe and sampling pushes are planned to investigate this site. The pushes include the following.

- Adjacent to tank BX-110, east of drywell 21-10-03. Because little contamination is detected in drywell 21-10-01, this push will be used to determine the extent of contamination other than cesium-137 to the north-northeast from borehole 21-10-03. The push will be situated as near the tank as safety considerations allow.

- Along the line projected between 21-10-03 and 21-10-05, adjacent to the spare nozzles at approximately the four o'clock position on tank BX-110 between tanks BX-110 and BX-107. This location will provide information on the extent on contamination known to exist between the two boreholes and assess the depth of movement of that contamination.

- Two sets of pushes along the line projected between 21-10-05 and 21-07-06, southeast of tank BX-110. This location will provide information as to the extent and general direction of movement of contaminants between the two tanks. In addition the information obtained will aid in determining if the contamination is from one leak or multiple leaks and assess whether BX-107 tank or its ancillary equipment is a possible contributor to the contamination.

A.5.1.1.3 241-B Diversion Boxes Site. The direct-technology pushes would be located near the corner of each diversion box (241-B-151, 241-B-152, and 241-B-153). The direct-technology pushes would be to determine the effectiveness of the reported past clean up efforts and provide data needed to determine if additional investigations are required in this area. These data would support development of source term information. The current plan is to conduct gamma logging with goal of collecting limited samples if access limitations and ground conditions permit. A total of 12 sets of direct-push technology pushes would be conducted.

A.5.1.1.4 BX-102 Site. This shallow soil investigation would use 6 direct-push technology pushes each in north-to-south and east-to-west transects of direct pushes to refusal, depending on results of the vertical borehole. The direct-push technology pushes would only be performed if technetium-99 were found in sediments above 18.3 m (60 ft) bgs. Direct-push technology pushes would be for sample collection at intervals determined by split-spoon sample analysis. Direct-push technology pushes, if required, would be to refine the constituent concentration model and source term. A total of 12 sets of direct pushes would be conducted.

A.5.1.2 Field Quality Control

After the samples are screened, these samples will be transported to the Pacific Northwest National Laboratory Applied Geology and Geochemistry group for analysis. All material removed from the push holes will be sent to the laboratory for possible future analysis. Samples will be contained in airtight sample containers after their initial screening by the health physics technician and are to be kept under refrigeration. This process is used to retain sediment moisture in as close to field condition as possible and prevent chemical and physical changes from occurring. All samples will be transported to the laboratory under refrigeration to further limit alteration of sediment moisture.

Field quality control samples also will be submitted for the full spectrum of chemical and radionuclide analyses. These quality control samples will consist of the following:

- Equipment rinseate blanks: One equipment rinseate blank per each type of sampler or, if multiple types of samplers are used, once per type of sampler.

A.5.1.3 Geophysical Surveying Activities

Prior to sediment sampling using the direct push, downhole gross gamma and spectral gamma geophysical surveying will be conducted to ascertain the gamma-emitting radionuclide concentration in the surrounding sediments. After each push with the direct push or each borehole with the hollow-stem auger, decommissioning will occur.

A.5.1.4 Field Reporting Activities

Field logs will be maintained to record all observations and activities conducted. A site representative will record the activities on a field activity report. Items for entry will include the following:

- Direct push or borehole number
- Site location drawings, including distances from known locations
- Drawings of the downhole tool strings for direct push
- Site personnel present
- Sampling types and intervals
- Zones noted by the health physics technician as elevated in radiological contaminants
- Instrument readings and the depth represented by those readings
- Specific information concerning borehole completion.

All completed field records will be maintained and processed in accordance with approved CHG procedures.

A.5.2 LABORATORY ANALYSIS (SUBTASK 2B OF CHAPTER 5.0)

The following sections describe the laboratory analyses required for the samples collected from the near-surface characterization.

A.5.2.1 Near-Surface Characterization Sediment Sample Analysis Requirements

A total of approximately 31 site locations have been identified for the near-surface characterization effort. Once received at the laboratory, these samples shall undergo analysis using the analytical methods listed in Table A.1. This analysis may be sample-limited. Therefore, hold points have been inserted into the process to allow the laboratory and CHG technical staff to collaborate and review data before each new round of analyses. Analyses may be reprioritized based on the results of other measurements.

Based on the results of the screening analyses that were identified in the vertical boreholes, and spectral gamma surveys performed during the field geophysical surveys, and the geologic logging and field notes, geological technical experts, CHG technical staff, the laboratory technical staff, and decision-makers (Ecology and the U.S. Department of Energy) will convene to determine what, if any, additional analyses should be conducted. Some of the determining criteria will be the amount and integrity of the remaining sample, screening analytical results, and regulatory requirements. Based on these decisions, additional analyses will be performed.

PART III

SAMPLING PERFORMED IN CONJUNCTION WITH THE INSTALLATION OF RCRA GROUNDWATER MONITORING WELLS

A.6.0 PROPOSED RCRA GROUNDWATER MONITORING WELL SEDIMENT SAMPLE ANALYSIS (SUBTASK 2B OF CHAPTER 5.0)

Drill cutting samples will be collected in conjunction with the installation of two RCRA groundwater monitoring wells. The two proposed RCRA groundwater monitoring wells will be located southeast of the BX tank farm (Figure A.1). Drill cuttings will be collected from these two wells. Selected portions of the cuttings will be analyzed for their chemical and physical characteristics. A detailed description of the work associated with the installation of these monitoring wells has been developed (Narbutovskih 1999). Only details associated with analysis of sediment drill cuttings are addressed in this SAP.

Samples for analysis will be from each stratigraphic unit, stratigraphic contacts, weathered bedding structures and lithologic facies changes.

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