0053611

DOE/RL-99-66
Rev. 0

200-CW-5 U-Pond/ Z-Ditches Cooling Water Group Operable Unit RI/FS Work Plan

United States
Department of Energy

DOE/RL-99-66
Rev. 0

200-CW-5 U-Pond/Z-Ditches Cooling Water Group Operable Unit RI/FS Work Plan

August 2000

United States Department of Energy

P.O. Box 550, Richland, Washington 99352

ACRONYMS

AAMSR	aggregate area management study report
ARAR	applicable or relevant and appropriate requirement
bdb	below ditch bottom
bgs	below ground surface
CERCLA	*Comprehensive Environmental Response, Compensation, and Liability Act of 1980*
COC	contaminant of concern
COPC	contaminant of potential concern
DQA	data quality assessment
DQO	data quality objectives
Ecology	Washington State Department of Ecology
EMI	electromagnetic induction
EPA	U.S. Environmental Protection Agency
EQH	environmental hazard quotient
ERC	Environmental Restoration Contractor
FS	feasibility study
FFS	focused feasibility study
GPR	ground penetrating radar
GRA	general response action
HASP	health and safety plan
HPGe	high-purity germanium
IDW	investigation-derived waste
K_d	distribution coefficient
LFI	limited field investigation
msl	mean sea level
MTCA	*Model Toxics Control Act*
NEPA	*National Environmental Policy Act of 1969*
OU	operable unit
PCB	polychlorinated biphenyl
PFP	Plutonium Finishing Plant
ppb	parts per billion
PRG	preliminary remediation goal
PUREX	Plutonium/Uranium Extraction
QRA	qualitative risk assessment
RAO	remedial action objective
RCP	reinforced concrete pipe
RCRA	*Resource Conservation and Recovery Act of 1976*
RESRAD	Residual Radioactivity
RI	remedial investigation
ROD	Record of Decision
SAP	sampling and analysis plan
SGL	spectral gamma logging
Tri-Party Agreement	*Hanford Federal Facility Agreement and Consent Order*
TSD	treatment, storage, and/or disposal

ACRONYMS (cont.)

UNH	uranyl nitrate hexahydrate
UPR	unplanned release
VCP	vitrified clay pipeline
WAC	*Washington Administrative Code*
WCP	waste control plan
WIDS	Waste Information Data System

CONTENTS

CONTENTS (cont.)

APPENDICES

FIGURES

FIGURES (cont.)

TABLES

THIS PAGE INTENTIONALLY
LEFT BLANK

1.0 INTRODUCTION

This work plan supports the *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA) remedial investigation/feasibility study (RI/FS) activities for the 200-CW-5 Operable Unit (OU). The general RI/FS process is described in the *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA* (EPA 1988). The application of the process in the 200 Areas is described in the *200 Areas Remedial Investigation/Feasibility Study Implementation Plan - Environmental Restoration Program* (Implementation Plan) (DOE-RL 1999); the Implementation Plan is summarized in Section 1.1 of this work plan. The 200 Area is one of four areas on the Hanford Site that is on the U.S. Environmental Protection Agency's (EPA) National Priorities List under CERCLA.

The 200-CW-5 OU is located near the center of the Hanford Site in south-central Washington State. This OU consists of nine waste sites and three associated unplanned releases (UPRs) as defined in the Implementation Plan (DOE-RL 1999). This OU was initially assigned eight UPRs; however, six of them were found to be duplicate designations of other sites within the OU. The duplicate UPR sites were subsequently rejected from the Waste Information Data System (WIDS), following the *Hanford Federal Facility Agreement and Consent Order* (Tri-Party Agreement) procedure (TPA-MP-14, "Maintenance of the Waste Information Data System [WIDS]") for waste site reclassification (DOE-RL 1998).

One new UPR (UPR-200-W-110) is identified in this work plan. UPR-200-W-110 is a one-time waste disposal trench that received contaminated backfill material from the original 216-Z-1 Ditch and is located adjacent to the Z-Ditches. This UPR has been reassigned to the 200-CW-5 OU following the Tri-Party Agreement procedure for waste site reclassification (DOE-RL 1998).

The waste sites received cooling water, steam condensate, and chemical sewer waste from facilities in the 200 West Area. Effluents were discharged to the 200-CW-5 OU waste sites from the UO_3 Plant, U Plant, the 284-W Powerhouse, the 2723-W and 2724-W Laundries, the 242-S Evaporator, and Z Plant (including the Plutonium Finishing Plant [PFP]), as well as other smaller facilities. These effluent streams carried chemicals and radionuclides, which contaminated the waste sites.

The characterization and remediation of waste sites at the Hanford Site are addressed in the Tri-Party Agreement (Ecology et al. 1998). The schedule of work at the Hanford Site is governed by Tri-Party Agreement milestones. The milestone controlling the schedule for the 200-CW-1 OU is M-13-22, "Submit U Pond/Z-Ditches Cooling Water Group Work Plan," December 31, 1999. All characterization work for nontank farm OUs in the 200 Areas is scheduled to be completed by December 31, 2008 (Milestone M-15-00C).

1.1 200 AREAS IMPLEMENTATION PLAN

The Implementation Plan outlines a strategy that is intended to streamline the characterization and remediation of waste sites in the 200 Areas, including CERCLA sites; *Resource Conservation and Recovery Act of 1976* (RCRA) past-practice sites; and RCRA treatment, storage, and/or disposal (TSD) units. The plan outlines the framework for implementing assessment activities and evaluationing remedial alternatives in the 200 Areas to ensure consistency in documentation, level of characterization, and decision making. A regulatory framework is established in the Implementation Plan to integrate the requirements of RCRA and CERCLA into one standard approach for cleanup activities in the 200 Areas. Because the 200-CW-5 OU consists entirely of CERCLA past-practice sites, integration with RCRA requirements is not necessary. The CERCLA approach is used as illustrated in Figure 1-1.

The Implementation Plan consolidates much of the information normally found in an OU-specific work plan to avoid duplication of this information in each of the 22 OUs in the 200 Areas. The Implementation Plan also lists potential applicable or relevant and appropriate requirements (ARARs) and preliminary remedial action objectives (RAOs), and contains a discussion of potentially feasible remedial technologies that may be employed in the 200 Areas. This work plan references the Implementation Plan for further details on several topics, such as general information on the physical setting and operational history of 200 Area facilities, ARARs, RAOs, and post-work plan activities.

1.2 SCOPE AND OBJECTIVES

This work plan documents OU-specific background information, defines OU-specific characterization and assessment activities and schedule based on the framework established in the Implementation Plan, and identifies the steps required to complete the RI/FS process for the OU. The general approach to characterization and evaluation of 200 Area OUs is outlined in the Implementation Plan; OU-specific detail is presented in this work plan, including background information on the waste sites in this OU, existing data regarding contamination at the representative waste sites, and the approach that will be used to investigate, characterize, and evaluate the sites. A discussion of the RI planning and execution process is included, along with a schedule for the characterization work. Preliminary RAOs that are likely to be considered for the OU are identified in the work plan. These preliminary remedial alternatives will be further developed and agreed to in the FS, the proposed plan, and the eventual Record of Decision (ROD).

A data quality objectives (DQO) process was conducted for this OU to define the chemical and radiological constituents to be characterized and to specify the number, type, and location of samples to be collected at representative sites within the OU. The results of the DQO process form the basis for the work plan and the associated sampling and analysis plan (SAP) included in Appendix A. The SAP includes an OU-specific quality assurance project plan and a field sampling plan for implementing the characterization activities in the field. A waste control plan (WCP) is included in Appendix B, which details the management and ultimate disposal of wastes generated by the characterization activities.

After characterization data have been collected, results will be presented in a group-specific RI report. The RI report will include an evaluation of the characterization data for the representative sites, including an assessment of the accuracy of the conceptual model and development of a contaminant distribution model. The RI report will support the evaluation of remedial alternatives that will be included in the group-specific FS. The FS will use the existing and newly collected data to evaluate a range of remedial actions for the representative sites and for the remaining sites within the OU that fall within the contaminant distribution model. Remedial alternatives may be applied at any or all of the waste sites in an OU, and different alternatives may be applied to different waste sites depending on site characteristics. The FS will ultimately support a group-specific proposed plan leading to a ROD for all of the waste sites in the OU. The schedule for assessment activities at the 200-CW-5 OU is presented in Section 6.0.

THIS PAGE INTENTIONALLY
LEFT BLANK

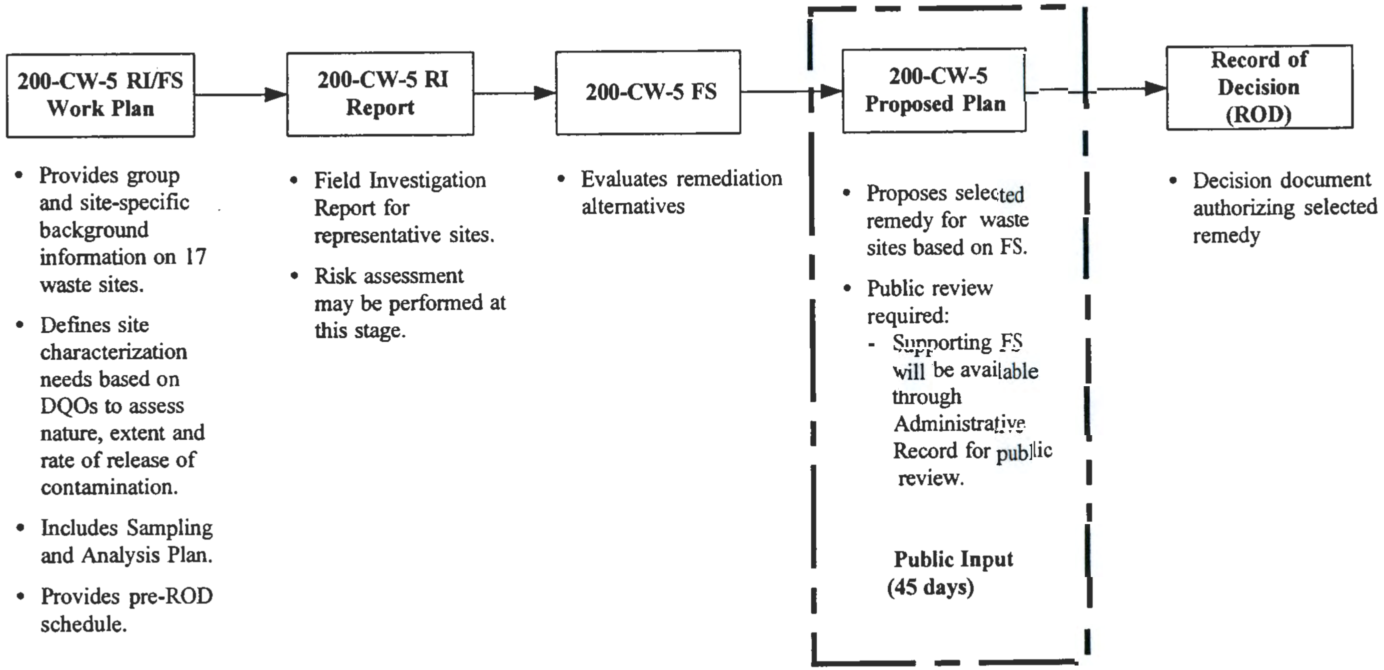


Figure 1-1. Regulatory Process for 200-CW-5 Operable Unit (modified from DOE-RL 1999).

2.0 BACKGROUND AND SETTING

This section describes the 200-CW-5 U-Pond/Z-Ditches Cooling Water OU, its associated waste sites, and the physical setting of the 200 West Area and vicinity. Information in this section is summarized mainly from the following resources:

- *200 Areas Remedial Investigation/Feasibility Study Implementation Plan – Environmental Restoration Program* (DOE-RL 1999)
- *U Plant Source Aggregate Area Management Study Report* (DOE-RL 1992b)
- *Z Plant Source Aggregate Area Management Study Report* (DOE-RL 1992c)
- *Waste Site Grouping for 200 Areas Soil Investigation* (DOE-RL 1997)
- *Limited Field Investigation for the 200-UP-2 Operable Unit* (DOE-RL 1995)
- *Focused Feasibility Study for the 200-UP-2 Operable Unit* (DOE-RL 1996)
- WIDS (WIDS data sheets and historical files).

The waste sites in the 200-CW-5 U-Pond/Z-Ditches Cooling Water Group are located on the Hanford Site in southeastern Washington State, in and around the southeast portion of the 200 West Area (Figure 2-1). This OU consists of 12 waste sites that received mostly cooling water from a variety of 200 Area operations.

The type of future land use within the 200 Areas is not certain at this time, but industrial land use is favored by the Tri-Parties. Outside the 200 Area boundary, the preferred land use is preservation and conservation (DOE 1999). Figure 2-2 shows the locations of the 200-CW-5 OU waste sites relative to the 200 Area waste management boundary. As this figure illustrates, only one of the 200-CW-5 waste sites (216-U-9 Ditch) extends beyond the 200 Area boundary and may be subject to the preservation and conservation land use.

2.1 PHYSICAL SETTING

The following sections contain a synopsis of the geology and hydrology of the area in the 200-CW-5 OU. More detail on the physical setting of the 200 Areas is provided in Appendix F of the Implementation Plan (DOE-RL 1999).

2.1.1 Topography

Most of the 200 Area is situated on a plateau that rises approximately 75 m (250 ft) above the Columbia River. The topography of the 200 West Area is generally flat. The elevation ranges from approximately 221 m (725 ft) above mean sea level (msl) along the northern half of the eastern perimeter, to approximately 197 m (647 ft) above msl in the southwestern corner

(DOE-RL 1993a). The surface elevation at the 216-U-10 Pond is approximately 202.5 m (665 ft) above msl (BHI 1998).

2.1.2 Geology

The following paragraphs provide an overview of the geology of the 200-CW-5 OU. More detail can be found in Appendix F of the Implementation Plan (DOE-RL 1999) and from borehole data collected from the 200-UP-2 OU limited field investigation (LFI) (DOE-RL 1995).

The 200-CW-5 OU is located in the Pasco Basin on the Columbia Plateau. It is underlain by basalt of the Columbia River Basalt Group and a sequence of suprabasalt sediments. From oldest to youngest, major geologic units of interest are the Elephant Mountain Basalt Member, the Ringold Formation, the Plio-Pleistocene/early Palouse unit, and the Hanford formation. The Ringold Formation is informally divided into several units. These are, from oldest to youngest, Unit A, Lower Mud, Unit E, and Upper Unit. The Plio-Pleistocene unit locally is a subunit that is interpreted to be a weathering surface developed on the top of the Ringold Formation (WHC 1994, Bjornstad 1990). The Hanford formation has two major facies (i.e., gravel-dominated and sand-dominated).

The Elephant Mountain Basalt Member is overlain by the Ringold Formation in all of the 200 West Area. The Ringold Formation consists of an interstratified sequence of unconsolidated clay, silt, sand, and granule to cobbley gravel deposited by the ancestral Columbia River. These alluvial sediments consist of four major units. From oldest to youngest, these are the fluvial gravel and sand of Unit A, the buried soil horizons and lake deposits of the Lower Mud sequence, the fluvial sand and gravel of Unit E, and the lacustrine mud of the Upper Unit.

Overlying the Ringold Formation in the 200 West Area is the locally derived subunit of the Plio-Pleistocene unit. The locally derived subunit consists of poorly sorted, locally derived, interbedded reworked loess, silt, sand, and basaltic gravel (WHC 1994). The subunit consists of a lower carbonate-rich part and an upper silty part. The carbonate-rich part consists of interbedded carbonate-poor and carbonate-rich strata. Its high degree of cementation and white color characterize this unit. The high degree of cementation is an impediment to the vertical migration of water and vapor; however, there may be more permeable pathways through the unit, such as clastic dikes.

The upper silty part of the Plio-Pleistocene unit is interpreted to be early Pleistocene loess and is sometimes referred to as the early Palouse soil (Bjornstad 1990). Generally, it is well-sorted, quartz-rich/basalt-poor, silty sand to sandy silt (BHI 1996). The early Palouse soils are differentiated from the overlying Hanford slackwater deposits by greater calcium content, cohesive structure in core samples, uniform fine-grained texture, and high natural gamma response. This soil is fine-grained and acts as an impediment to downward migration of water and contaminants.

The Hanford formation consists of unconsolidated gravel, sand, and silt deposited by Pleistocene cataclysmic floodwaters. These deposits consist of gravel-dominated and sand-dominated facies. The gravel-dominated facies consists of cross-stratified, coarse-grained sands and granule to bouldery gravel. The gravel is uncemented and matrix poor. The sand facies consists of wellstratified fine- to coarse-grained sand and granuley gravel. Silt in this facies is variable and may be interbedded with the sand. Where the silt content is low, an open-framework texture is common.

The cataclysmic floodwaters that deposited sediments of the Hanford formation also locally reshaped the topography of the Pasco Basin. The floodwaters deposited a thick sand and gravel bar that constitutes the higher southern portion of the 200 Areas, informally known as the 200 Area Plateau.

Holocene-aged deposits overlie the Hanford formation and are dominated by eolian sand that forms a thin veneer across the site, except in localized areas where they are absent. Surficial deposits consist of very fine- to medium-grained sand to occasionally silty sand. Silty deposits less than 1 m (approximately 3 ft) thick have also been documented at waste sites where fine-grained, windblown material has settled out through standing water over many years. A generalized stratigraphic column for the 200-CW-5 OU is shown in Figure 2-3.

2.1.3 Vadose Zone

Information from this section is summarized from the *Borehole Summary Report for the 200-UP-2 Operable Unit, 200 West Area* (Kelty et al. 1995) and the *Waste Site Groupings for 200 Areas Soil Investigations* (DOE-RL 1997).

The vadose zone thickness ranges from 58 to 79 m (196 to 259 ft) thick. Sediments in the vadose zone are the Ringold Formation, the Plio-Pleistocene unit, and the Hanford formation. Erosion during cataclysmic flooding removed some of the Ringold Formation and Plio-Pleistocene unit. The Plio-Pleistocene unit/early Palouse soil is the most significant aquitard in the 200 West Area above the water table. This soil has been a major component controlling the accumulation of perched water where effluent was discharged because of the formation of abundant calcium carbonate (caliche) in this horizon. Perched water has been documented in wells drilled at the 216-U-14 Ditch (Kelty et al. 1995).

Recharge to the unconfined aquifer within the 200 Areas historically was from artificial sources but is currently from natural sources. If natural recharge occurs, it originates from precipitation. Estimates of recharge from precipitation range from 0 to 10 cm/yr (0 to 4 in./yr), largely dependent on soil texture and the type and density of vegetation. Artificial recharge occurred when effluent such as cooling water was discharged to the ground. Zimmerman et al. (1986) reported that between 1943 and 1980, 6.33×10^{11} L (1.67×10^{11} gal) of liquid wastes were discharged to the soil column in the 200 Areas. The volume of effluent received by each waste site is presented in Section 3.0. Only permitted effluent sources continue to discharge in the 200 Areas.

2.1.4 Groundwater

The groundwater table in the 200-CW-5 OU occurs primarily in the Ringold Formation. The depth to the water table from the ground surface varies from about 62 m (203 ft) to greater than 73 m (240 ft). A large groundwater mound created by the 216-U-10 Pond raised the water table by about 20 m (66 ft) above pre-operational conditions (PNNL 1998). Since 1984, when the 216-U-10 Pond was decommissioned, water levels have declined more than 6 m (20 ft).

Groundwater flow in the 200-CW-5 OU is to the east at a gradient of about 0.00173. The elevation of the water table in the 216-U-10 Pond area was approximately 139 m (456 ft) NAVD88 in June 1998 (PNNL 1999). Agricultural irrigation in the upper Cold Creek Valley may recharge the groundwater and influence water table elevations in the 200 West Area.

2.2 WASTE SITE DESCRIPTION AND HISTORY

The 200-CW-5 OU is located near the center of the Hanford Site in south-central Washington State. This OU consists of nine waste sites and three associated UPRs as defined in the Implementation Plan (DOE-RL 1999). This OU was initially assigned eight UPRs. However, six of the UPRs were found to be duplicate designations of other sites within the OU. The duplicate UPR sites were subsequently rejected from WIDS, following the Tri-Party Agreement procedure for waste site reclassification (DOE-RL 1998).

One new UPR (UPR-200-W-110) is identified in this work plan. UPR-200-W-110 is a one-time waste disposal trench that received contaminated backfill material from the original 216-Z-1 Ditch and is located adjacent to the Z-Ditches. This UPR has been reassigned to the 200-CW-5 OU following the Tri-Party Agreement procedure for waste site reclassification (DOE-RL 1998).

In general, the sites received large volumes of low-level radioactive wastewater and UPRs of higher level radioactive wastewater discharges. The sites in this group received wastes from several sources, including noncontact heating and cooling water, steam condensates, chemical sewer waste, and laundry wastewater. Over the decades of use, these discharges have resulted in accumulations of transuranic, fission, and activation product inventories. The noncontact wastewater was mainly contaminated by minor pinholes and cracks in the piping, allowing contact with process waste and, on rare occasions, from operator error.

Most of the effluent discharged to waste sites in this OU was from the 242-S Evaporator, the UO_3 Plant, 221-U (U Plant), the 284-W Powerhouse, the 2723-W and 2724-W Laundries, and Z-Plant (including the 234-5Z PFP), along with other smaller facilities. Effluent from these sources was all ultimately distributed to a large evaporation/percolation pond (i.e., the U Pond system) by means of ditches and/or a retention basin. Unplanned releases in this OU included sludge trenches created to bury sludge scraped from the 207-U Retention Basin during maintenance activities and a narrow trench east of and adjacent to the 216-Z-11 Ditch that received contaminated backfill during the creation of the 216-Z-19 Ditch.

2.2.1 Process Information

The waste sites in the 200-CW-5 OU received predominantly cooling water and steam condensate but also received effluent containing very low concentrations of radionuclides and/or chemicals. The cooling water remained entirely separate from contaminated process liquids by physical barriers, which typically were the walls of a heating or cooling pipe coil.

Steam and cooling water were used to make temperature adjustments in process vessels by circulating through coils inside the vessels. The temperature was increased by regulating the rate of steam entering the coils; the spent steam was condensed with cooling water after exiting the process vessel. The condensed steam and cooling water were released to plant sewers or piping systems that discharged to ditches and ponds. The use of very large volumes of cooling water for steam condensation and process vessel cooling resulted in the generation of very large volumes of effluent; more than 90% of all liquids discharged to the soil column in the 200 Areas were from cooling water (DOE-RL 1999).

The coils that circulated steam and cooling water inside chemical process tanks often developed pinholes and hairline cracks due to the corrosive chemicals and high thermal gradients in these tanks. These minor defects usually did not lead to contamination of the steam and cooling water because the pressure in the pipe coils was greater than the pressure in the process or condenser vessels. However, there were instances when the pressure in the coils was reduced or suspended and minor leakage through the flaws contaminated the waste stream. Other accidental releases due to other causes such as operator error have led to the contamination of the effluent discharged to the waste facilities in this OU.

The discussions that follow summarize the buildings and processes involved in discharging effluent to the 200-CW-5 OU waste sites. Discharges from Z-Plant were made to the 216-Z-Ditch system. The remainder of the waste streams discharged to the 216-U-14 Ditch.

The 284-W Powerhouse generated steam for 200 West Area heating purposes. Three operating configurations at the powerhouse produced wastewater: routine operations for steam generation, batch runs for water softener regeneration, and equipment blowdown. Routine operations used pretreated water from the Columbia River to cool various components in the plant. The water softener columns in the plant were regenerated with a brine solution. This process was performed in batch mode only and generated a waste solution composed of sodium chloride in water. The blowdown of scale from inside the boilers generated waste solutions consisting of boiler scale and low concentrations of residual oxygen-scavenging chemicals (WHC 1990c). Discharges from the 284-W Powerhouse to the 216-U-14 Ditch occurred from 1944 until 1984. Other facilities associated with the 284-W Powerhouse that discharged to the 216-U-14 Ditch were as follows:

- 282-W Reservoir: Cooling water, pump strainer backflush water, heater condensate, and reservoir overflow.
- 283-W Waste Treatment Facility: Filter backwash, floor drains, heater condensate, cooling water, basin washdown water, clearwell overflow, basin overflow, water testing and sampling station, and continuous turbidity meter wastewater.
- 277-W Complex: Floor drains, cooling water, steam condensate, fire water blowdown, and hydrotesting.

The 2723-W Laundry and Mask Cleaning Station began operating in 1944 to wash personal protective equipment that was both radioactive and nonradioactive. After the construction of the new laundry building (2724-W) in 1952, the 2723-W Building was used only as a mask cleaning station to wash respiratory protective equipment. Effluent from this facility consisted of washwater and rinse water from batch laundry operations and steam condensate from steam-heated dryers. Detergents, phosphate, and radioactive contaminants were expected in the wastewater (Singleton and Lindsey 1994). The 2723-W Building released effluent to the 216-U-14 Ditch from 1944 to 1981.

The 2724-W Laundry Building was constructed as a replacement for the 2723-W Laundry Building in 1952. It served the same purpose as the 2723-W Laundry Building in that it washed personal protective clothing. Effluents discharged from this facility were the same as those described above for the 2723-W Laundry and Mask Cleaning Station (Singleton and Lindsey 1994). The 216-U-14 Ditch received these liquid discharges until 1981.

The 221-U Building (U Plant) was constructed in 1944 as one of three original chemical separations plants (221-B, 221-T, and 221-U Buildings). However, the 221-U Building was never used to extract plutonium from irradiated fuel rods as the 221-B and 221-T Buildings (B and T Plant, respectively) did, because production needs were met by these other facilities. The 221-U Building was used to train B and T Plant operators until 1952 when it was converted to recover uranium from the waste sludge generated by B and T Plant operations (DOE-RL 1992b). Effluents discharged to the 200-CW-5 OU included cooling water, steam condensate, and chemical sewer wastes (DOE-RL 1993a). Most of the U Plant releases to the 216-U-14 Ditch were from 1952 to 1984. It is difficult to identify constituents of chemical sewer wastes because nonradioactive contaminants were not monitored or documented to the extent that radioactive discharges were monitored. Typically, chemical sewer wastes consisted of makeup tank rinses with lesser quantities of off-specification batches of chemicals and overflow chemicals from tanks during aqueous makeup runs. These chemical solutions and dry chemicals commonly consisted of nitric, phosphoric, and formic acids, and sodium and aluminum nitrate.

The 271-U Building is included as part of the U Plant; its effluent streams are also included with those of the U Plant.

The UO_3 Plant was a complex of several buildings, tank farms, storage areas, and loading facilities, which includes the 224-U Building. The UO_3 Plant was constructed in 1944 for plutonium processing but was never used for that purpose. It operated from 1944 to 1950 as a training facility and from 1952 to 1954 as a uranium-reduction facility. In 1955 it was reconfigured to support Plutonium/Uranium Extraction (PUREX) Plant operations. The PUREX-generated liquid uranyl nitrate hexahydrate was converted to powdered uranium trioxide in the 224-U Building. Cooling water from 224-U processes was discharged as effluent to the 216-U-14 Ditch and the 216-U-10 Pond.

The 241-U-110 tank was used to store large quantities of mixed waste. Condenser water effluents were discharged from this unit to the 216-U-14 Ditch from 1954 until 1955.

The 242-S Evaporator operated from 1973 to 1980 to concentrate low-level radioactive waste in the double-shell tanks. Steam condensate waste streams included condensate from the evaporator reboiler, steam heating coils, purging system steam traps, and seal water from an air sampling pump that were discharged to the 216-U-14 Ditch from 1973 until 1980. Key constituents may include cesium-137, strontium-90, ruthenium-106, cerium-144, and uranium isotopes (WHC 1990a).

The 231-Z Building was the site of the Plutonium Isolation Facility and was used to condense plutonium nitrate solution from the separations facilities into plutonium paste from 1945 to 1949. The building housed various laboratories and office space after 1949. Effluents from this building that were discharged to the Z-Ditches were process cooling water, steam condensate, and laboratory wastes (DOE-RL 1992c).

The 234-5Z Building was first constructed in 1949 and was the site of the PFP. The PFP used the RECUPLEX process to convert plutonium nitrate solutions to other usable forms of plutonium. Discharges for the purpose of this study consisted of cooling water and steam condensate released to the Z-Ditches from 1949 to 1988. Liquid wastes from operation of this facility historically have contained traces of plutonium and other transuranic elements (DOE-RL 1992c).

The 291-Z Building was an air flow emission stack. Effluents from this facility that were discharged to the Z-Ditches included cooling and seal water.

2.2.2 Representative Sites

The concept of using analogous sites to reduce the amount of site characterization and evaluation required to support remedial action decision making is discussed in the Implementation Plan (DOE-RL 1999). The use of this approach relies on first grouping sites with similar location, geology, waste site history, and contaminants. One or more representative sites are then chosen for comprehensive field investigations, which includes sampling. Findings from site investigations at representative sites are extended to apply to other sites in the waste group that were not characterized. Sites for which field data have not been collected are assumed to have chemical characteristics similar to the characterized sites. Confirmatory investigations of limited scope can be performed at the sites not selected as representative sites, rather than full characterization efforts.

Data from representative sites are used to evaluate remedial alternatives and to select one or more alternatives to apply for the entire waste group. Confirmatory sampling of the analogous sites after remedy selection will be performed to the extent necessary to demonstrate that analogous conditions exist.

Several features common to waste sites in the 200-CW-5 OU make this characterization effort amenable to the analogous site concept. Of these attributes, the most significant are geography, waste characteristics (i.e., effluent volume and waste stream chemistry), physical setting, and expected distribution of contaminants. Waste sites in this group are in close proximity, all of the ditches lead to a common pond system, and all received primarily cooling water, steam condensate, and/or chemical waste streams. The proximity of sites within the same geochemical setting suggests that conditions affecting contaminant fate and transport should be very similar.

High volumes, low contaminant concentrations, low salt, low organic contents, alkaline nature, and a pH between 4 and 10 are general characteristics of the majority of the waste streams. Radioactive contaminants common to these waste streams include uranium, plutonium, cesium, and strontium (DOE-RL 1997).

Sites within the 200-CW-5 OU that represent typical and worst-case conditions were initially identified as representative sites in the *Waste Site Grouping for 200 Areas Soil Investigation* (DOE-RL 1997) and were later confirmed in the DQO process performed for this project (BHI 1999). The representative sites chosen are the 216-U-10 Pond, the 216-U-14 Ditch, and the

216-Z-11 Ditch. The 216-U-10 Pond was chosen as a "worst-case" representative site because of its reported high contaminant inventory, the large quantities of liquid discharged to the site, the level of characterization conducted under the 200-UP-2 OU LFI activities, and because it is a common end point for the Z-Ditches and 216-U-14 Ditch effluent. The 216-U-14 Ditch was selected as a representative site for its suspected high contaminant inventory, presence of laundry detergent waste discharges, long history of operations, and level of past characterization. The 216-Z-11 Ditch was chosen to document known contamination distribution because of its suspected high contamination inventory (DOE-RL 1997).

The following subsections describe the representative sites in detail. Information was obtained from the WIDS database and WIDS historical files, unless otherwise noted.

2.2.2.1 216-U-10 Pond. The 216-U-10 Pond (U Pond) was first created from a natural topographic depression to act as a seepage area for the infiltration of wastewater from the 216-U-14 and 216-Z-1 Ditches. There is some discrepancy in the literature as to when the U Pond first began operations; some documents list the start date as 1943, while others list it as 1944. (For the purposes of this document, the U Pond started operations in 1944.) The pond was located in the southwestern corner of the 200 West Area. The pond was later diked on the south and west edges, and three overflow trenches were added on the east side in approximately 1952-1953 to increase volume capacity. At its maximum extent, including the overflow trenches, the pond covered an area roughly 12 ha (30 ac). A representative stratigraphic column for the 216-U-10 Pond based on data from nearby wells is shown in Figure 2-4.

The pond was active from 1944 to 1985. The U Pond was deactivated and interim stabilized in 1985. Stabilization activities included scraping contaminated pond sediments from peripheral areas to a depth of 0.3 m (1 ft) or greater and placing the sediments in the center of the pond. The peripheral areas were covered with a minimum of 0.6 m (2 ft) of clean soil, and the central pond area was covered with a minimum of 1.2 m (4 ft) of clean soil and seeded (DOE-RL 1996). In 1990, 0.6 ha (1.5 ac) of contaminated soil on the south side of the pond were covered with an additional 0.6 m (2 ft) of clean fill to stabilize surface contamination that had been detected (DOE-RL 1992b). In November 1994, contamination was detected at a strip along the south and west perimeters of the pond (about 1 ha [2.5 ac]) and was stabilized with soil from the U-11 Borrow Pit (Hayward 1995).

It is estimated that the U Pond received a total of 1.65×10^{11} L (4.3×10^{10} gal) of low-level liquid waste (DOE-RL 1992b). The following waste streams were directed into the 216-U-10 Pond at various times via the 216-U-14 Ditch and Z-Ditches:

- 284-W Powerhouse cooling water, steam condensate, and wastewater from batch operations
- 282-W Reservoir cooling water, steam condensate, and wastewater from batch operations (Alexander et al. 1993)
- 283-W filter steam condensate, cooling water, and wastewater from batch operations (Alexander et al. 1993)

- 277-W Complex cooling water, steam condensate, and wastewater from batch operations (Alexander et al. 1993)
- 231-Z Building steam condensate and laboratory waste
- 234-5Z Building cooling water and steam condensate
- 2723-W Mask Cleaning Station solution
- 2724-W Laundry wastewater
- 221-U and 271-U Building cooling water, steam condensate, and chemical sewer waste
- 224-U Building cooling water
- 291-Z Building cooling water and vacuum pump seal water
- 241-U-110 Tank condenser water
- 242-S Evaporator steam condensate and vacuum pump seal water.

More detail on these building processes and wastewater streams is provided in Section 3.0, in addition to a summary of previous characterization work.

2.2.2.2 216-U-14 Ditch. The 216-U-14 Ditch began operations in 1944 as one of the original effluent ditches to the 216-U-10 Pond. The ditch was an unlined, open excavation with a total length of 1,731 m (5,680 ft) and ran from northeast to southwest across about 1.6 km (1 mi) of the 200 West Area. The ditch originated 500 m (1,600 ft) north of U Plant and terminated at the 216-U-10 Pond. It was excavated with a minimum bottom width of 2.4 m (8 ft) and side slopes of 2.5:1. The ditch includes a 1.2-m (4-ft)-diameter by 46-m (150-ft)-long culvert that passes under 16th Street and a 0.6-m (2-ft)-diameter culvert that passes under 19th Street (DOE-RL 1992b). Figure 2-5 shows the representative stratigraphy beneath the 216-U-14 Ditch.

The 216-U-14 Ditch operated until 1995. During its operation, the ditch received effluent from a number of sources that entered the ditch at several locations (Last et al. 1994). The head end of the ditch received wastewater from the 284-W Powerhouse and associated buildings, the 2723-W Mask Cleaning Station, and the 2724-W Laundry Building via a common pipeline (U.S. Atomic Energy Commission, Hanford Atomic Products Operation, General Electric, Drawing M-2904-W, sheet 14). The second waste discharge point into the ditch was located 1,050 m (3,444 ft) south of the ditch head, near where the ditch passed under 16th Street. Chemical sewer wastewater, steam condensate, and cooling water from the 221-U and 271-U were discharged through a 46-cm (18-in.) vitrified clay pipe (VCP) (U.S. Atomic Energy Commission, Hanford Atomic Products Operation, General Electric, Drawing M-2904-W, sheet 19).

Cooling water from the 224-U Building was discharged through a 61-cm (24-in.) VCP (U.S. Atomic Energy Commission, Hanford Atomic Products Operation, General Electric, Drawing M-2904-W, sheet 19) and into the 207-U Retention Basin. Effluent exited the 207-U Retention Basin through another 61-cm (24-in.) VCP and was discharged to the ditch via a culvert under 16th Street. Condenser water from the 241-U-110 Tank was discharged to the ditch through a pipeline south of 16th Street (U.S. Atomic Energy Commission, Richland Operations Office, Vitro Engineering Company, Drawing H-2-31374). No information was found on the type or size of pipe. The last waste discharge point into the ditch was located 370 m (1,213 ft) downstream from the second waste discharge point where the ditch turned westward. At this point, evaporator condensate and cooling water from the 242-S Evaporator Building entered and traveled the last length of the ditch to the 216-U-10 Pond (Last et al. 1994). Construction drawings showing pipelines from the 242-S Evaporator Building to the 216-U-14 Ditch are not available.

In 1986, an accident led to the discharge of approximately 2,365 L (625 gal) of reprocessed nitric acid to the ditch through the 207-U Retention Basin in less than 1 day. This release occurred during the transfer of the acid from a storage tank to a railroad car for transport to the PUREX Facility. This release was diluted with cooling water originating from the 224-U Facility that also flowed through the ditch. The residual effluent stream was measured at a pH <2.0 and was estimated to contain approximately 39 kg (86 lb) of uranium (Whiting 1988).

During the useful life of the ditch, the growth of live plants and the accumulation of dead plant material would cause localized damming. Buildup of fly ash, scale, and lint from the powerhouse and laundry discharges reduced the infiltration capacity of the ditch. To prevent discharge backups, the ditch was periodically dredged. Sediments removed from dredging activities were piled on a berm on the west bank. This berm was removed and buried in a low-level waste burial ground in 1979 to reduce the risk of contamination spread (Last et al. 1994).

In 1981, the 2723-W and 2724-W Laundry Facilities' effluent was rerouted to the newly constructed 216-W-LWC Crib. In 1984, wastes from the 221-U, 224-U, and 271-U Facilities were rerouted to the 216-U-16 Crib and were no longer discharged to the 216-U-14 Ditch. However, after it was discovered that the 216-U-16 Crib failed in 1986, the effluent was diverted back to the 216-U-14 Ditch and the 216-U-12 Crib. Although the 216-U-17 Crib (completed in 1988) replaced the 216-U-16 Crib, the 216-U-14 Ditch continued to receive effluent from 224-U and 221-U until 1994. Discharge from the 284-W Powerhouse was rerouted to the 284-WB Powerhouse ponds in 1984 (Singleton and Lindsey 1994). The outlet pipe from the 207-U Retention Basin was plugged in 1994 to prevent effluent from entering the ditch. In 1995, the end of the effluent pipe into the 216-U-14 Ditch was capped to eliminate the discharge of steam condensate from the 242-S Evaporator.

The entire length of the ditch has been surface stabilized (DOE-RL 1996). In 1985, the northern section of the ditch (from the head to the 207-U Basin) was stabilized in conjunction with the 216-U-10 Pond. The southern or westernmost section of the ditch between Cooper Avenue and the 216-U-10 Pond was surface stabilized in 1992 with gravel and cobbles; however, this section of the ditch was still in use and received seal water effluent from an air sampling pump at the 242-S Evaporator until 1995. The central or easternmost section was stabilized in 1995 by chemically killing all vegetation, consolidating the contaminated soil into the center of the ditch, and backfilling with clean backfill. The westernmost section that was stabilized with gravel and cobbles in 1992 was backfilled with clean soil and restabilized in 1997.

2.2.2.3 216-Z-11 Ditch. The 216-Z-11 Ditch began operations in 1959 to dispose wastewater from the Z Plant operations to the 216-U-10 Pond (DOE-RL 1992b). It served as a replacement ditch for the 216-Z-1D Ditch. The 216-Z-11 Ditch was 798 m (2,615 ft) long and 0.6 m (2 ft) deep. It was 1.2 m (4 ft) wide at the bottom and had side slopes of 2.5:1 with a 0.05% grade. The first 37 m (120 ft) of the ditch was in common with the 216-Z-1D Ditch and began at a point immediately east of the 231-Z Building. The middle section of the ditch ran parallel to the 216-Z-1D Ditch, then rejoined it for the last 203 m (665 ft) to the 216-U-10 Pond. The representative stratigraphy beneath the 216-Z-11 Ditch is presented in Figure 2-6.

The 216-Z-11 Ditch operated from 1959 until 1971. The ditch received laboratory waste and steam condensate from the 231-Z Building via a 46-cm (18-in.)-diameter VCP (Hanford Engineer Works Drawing H-2-10011, 1947). Process cooling water and steam condensate from the 234-5Z Building and vacuum pump seal water and cooling water from the 291-Z Building entered the ditch via a 38-cm (15-in.) VCP process sewer (Atlantic Richfield Hanford Company Drawing H-2-32528, 1959). A 30-cm (12-in.) storm sewer was connected to the ditch from an elevated water tank immediately south of the 234-5Z Building (Atlantic Richfield Hanford Company Drawing H-2-32528, 1959). Total volumes of effluent discharged are not known for this site. The chemical inventory is reported as part of the 216-U-10 Pond inventory (WIDS). The 216-Z-11 Ditch was deactivated and replaced by the 216-Z-19 Ditch. The site was backfilled to grade when it was retired, and additional backfill material was added when the 216-Z-19 Ditch was deactivated in 1981. The 216-Z-11 Ditch has a reported contamination burden of 137 Ci of plutonium-239 and 37 Ci of plutonium-240 and is reported as a transuranic-contaminated soil site (DOE-RL 1992b).

Figure 2-7 shows a graphical representation of the waste streams that discharged to the 216-Z-11 Ditch, the 216-U-14 Ditch and, ultimately, the 216-U-10 Pond.

2.3 CONCEPTUAL MODEL CONSIDERATIONS

The effluent discharged to the ponds and ditches of the 200-CW-5 OU was mainly cooling water, with some steam condensate, laundry wastewater, and other lesser sources. Large quantities of effluent were released, and the effluent contained small quantities of contaminants that accumulated over time.

The following general observations were considered during construction of the conceptual models:

- Most of the contaminants were retained in the organic sediments at the bottom of the ponds or ditches, or in the upper few meters of the soil column.
- The most significant contaminants based on historical characterization data for the 216-U-10 Pond and 216-U-14 Ditch were uranium and cesium-137. For the Z-Ditches, plutonium and americium were the most significant contaminants. The 216-U-10 Pond and 216-U-14 Ditch have been extensively studied; however, the 216-Z-11 Ditch has not been as well characterized.

- The contaminated pond/ditch bottom sediments have been surface stabilized with nominally 2 m (6.6 ft) of soil overburden and remain in place.

- Contaminant concentrations rapidly decrease with depth below the waste sites.

- Downward migration of effluent contributed trace amounts of mobile contaminants through the vadose zone to groundwater.

- The contaminants retained in the upper zone of the soil column have high distribution coefficients (K_d). Contaminants with lower K_d values (e.g., nitrate and uranium) are not as readily adsorbed onto soil particles and are carried downward through the soil column with large quantities of effluent.

- Perched water zones under percolation areas developed during discharge periods but dissipated after effluent flows ceased. Contaminants were detected in these perched water zones.

- Lateral spreading may have occurred in the vadose zone, mainly in association with the perched water zones or fine-grained sediment layers.

- Effluent percolated through the vadose zone beneath the 216-U-10 Pond and reached the groundwater. The most significant effect of the large quantities of effluent to the groundwater was on the groundwater flow regime, moving contaminants in the aquifer resulting from other facilities.

The conceptual model for the 200-CW-5 OU during the active periods of discharge is shown in Figure 2-8. The conceptual model postulates that the highest concentration of contaminants resides in the pond/ditch sediment layers.

Waste sites in the 200-CW-5 OU no longer receive effluent. Most of the sites in this group have been stabilized and covered with clean soil. With the cessation of artificial recharge, the downward flux of moisture through the vadose zone has declined. The moisture flux was significant beneath the sites during their operational history, locally raising the water table and contaminating the groundwater. When operations ceased at the sites, the moisture flux began to decrease, as expressed in the locally declining water table. Residual effluent from operations is expected to remain in the vadose zone and continue to drain, decreasing over time as moisture levels decrease and equilibrate with natural recharge from precipitation.

Figure 2-1. Location of the Hanford Site and Waste Sites in the 200-CW-5 Operable Unit.

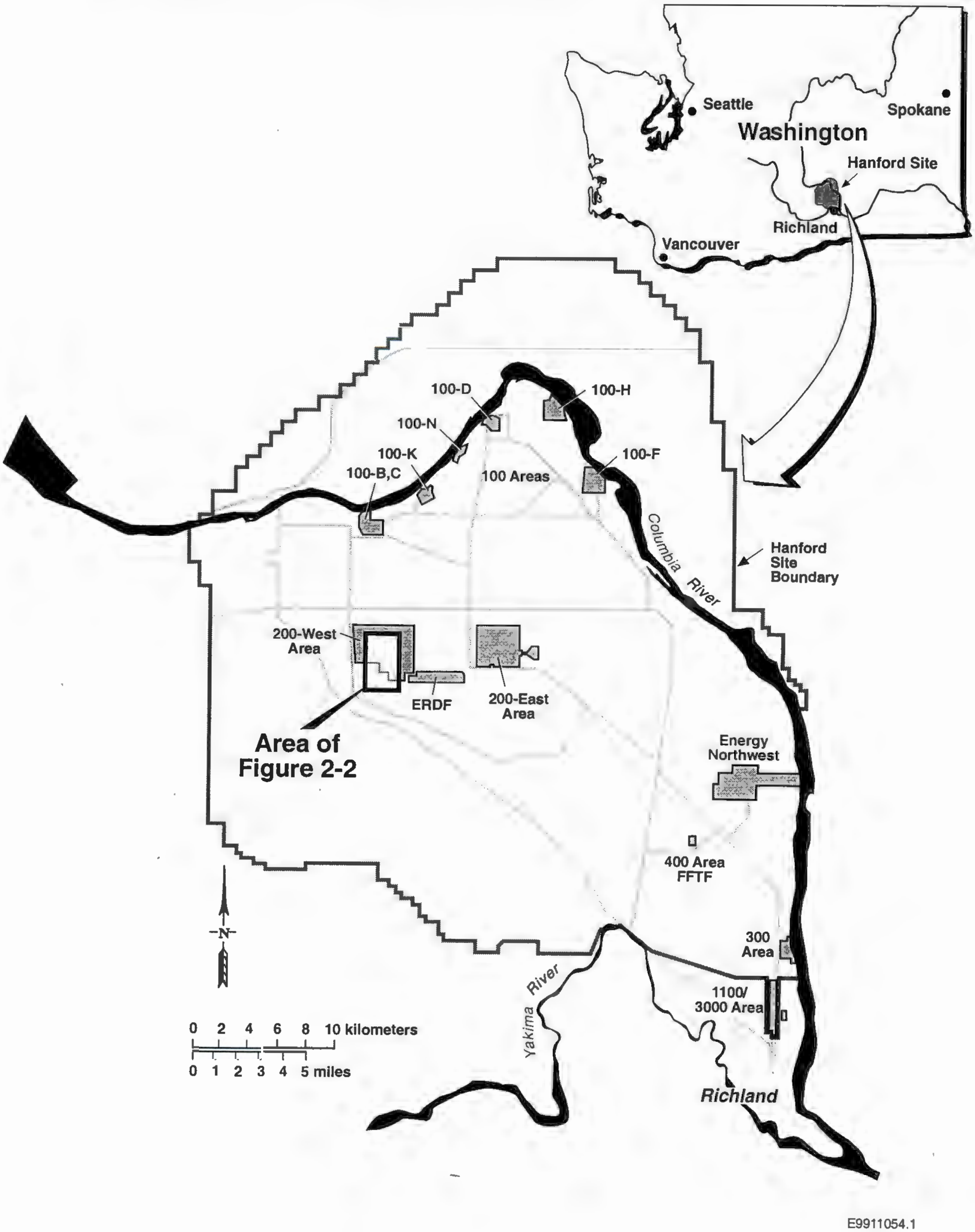


Figure 2-2. 200-CW-5 Operable Unit Waste Sites Relative to the Final Hanford Comprehensive Land-Use Plan Environmental Impact Statement (DOE 1999) 200 Area Waste Management Boundary.

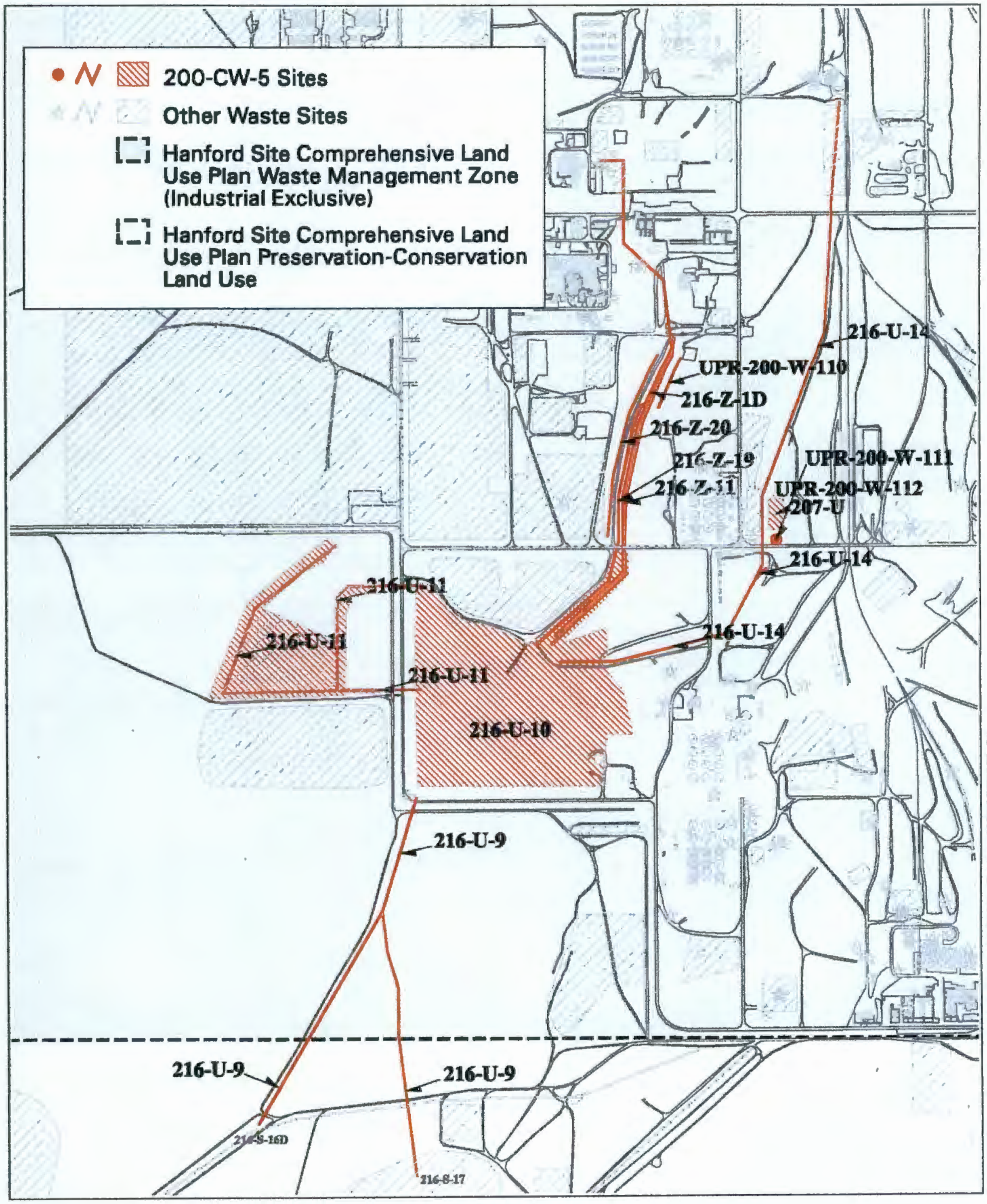
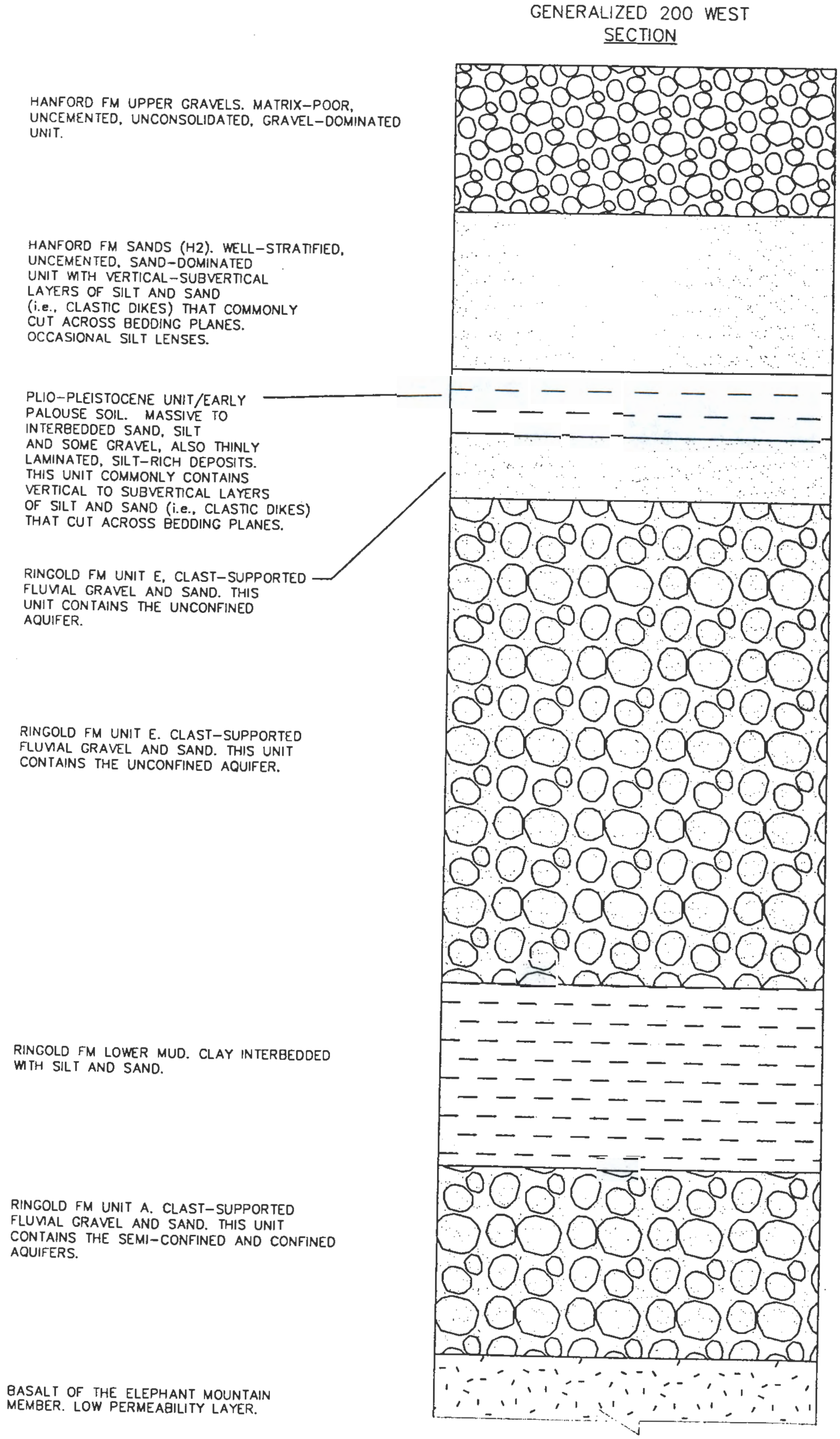


Figure 2-3. Generalized Stratigraphic Column for the 200 West Area.



2W:062999A

Figure 2-4. Representative Stratigraphy Beneath the 216-U-10 Pond.

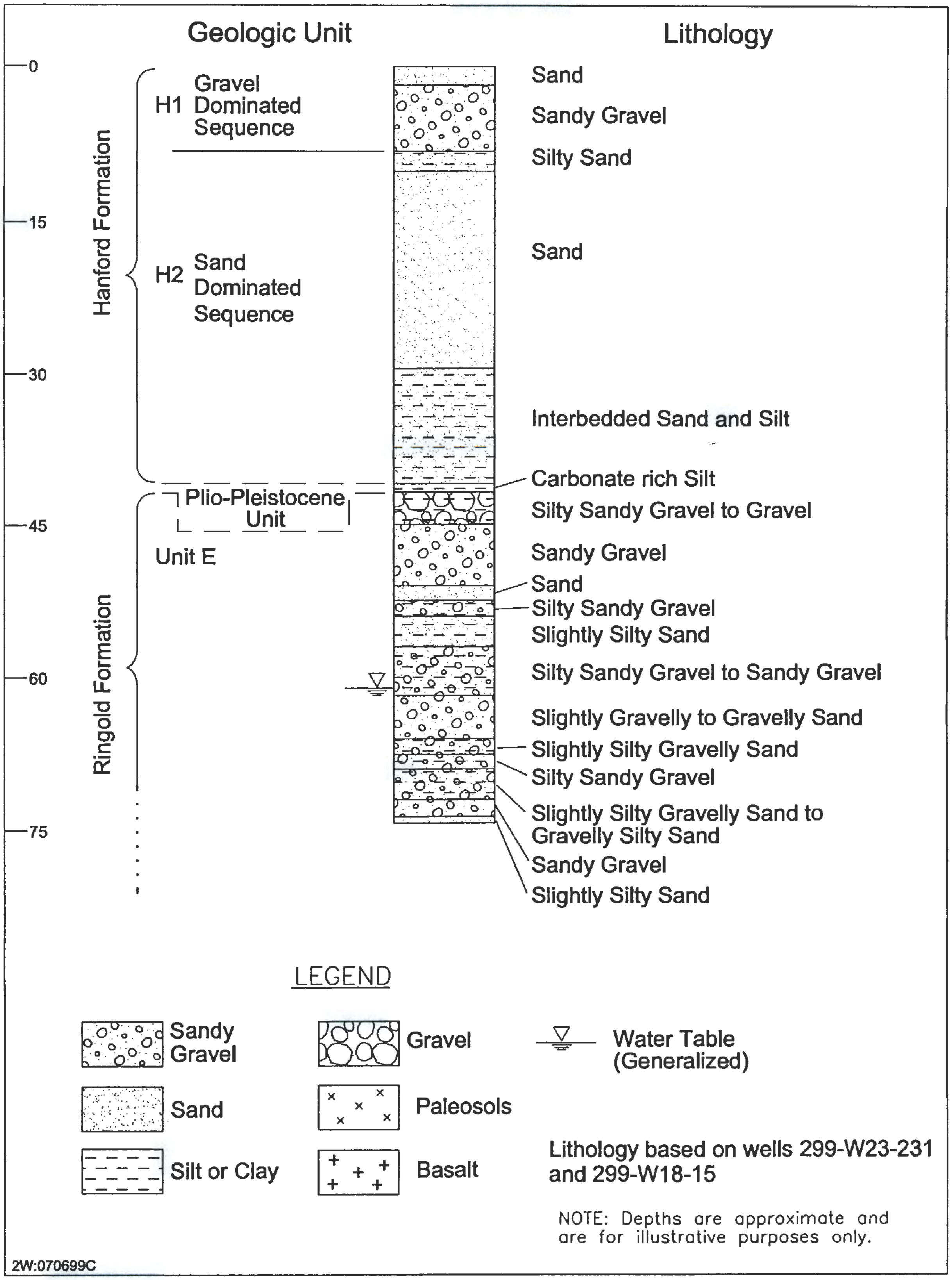


Figure 2-5. Representative Stratigraphy Beneath the 216-U-14 Ditch.

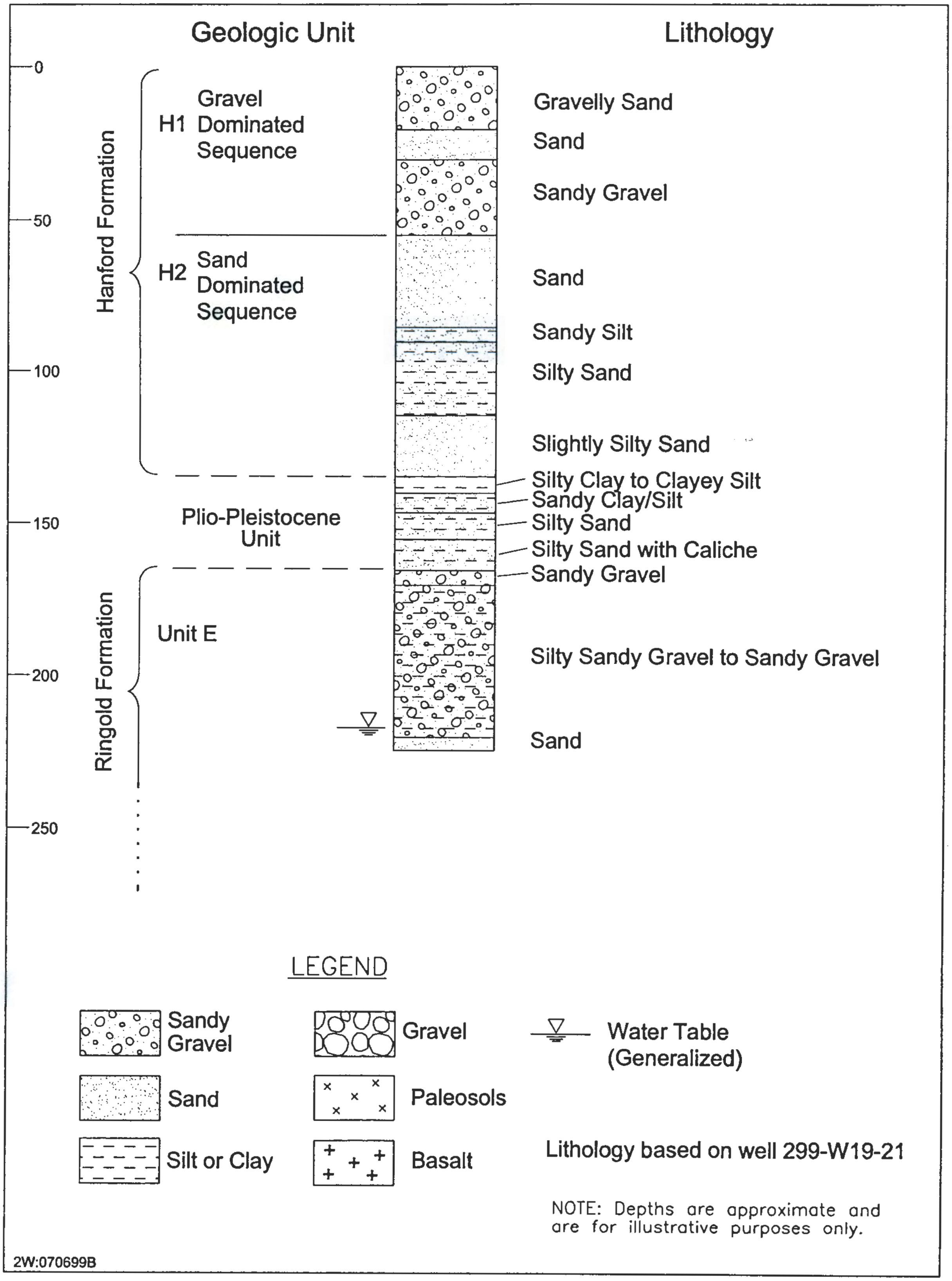
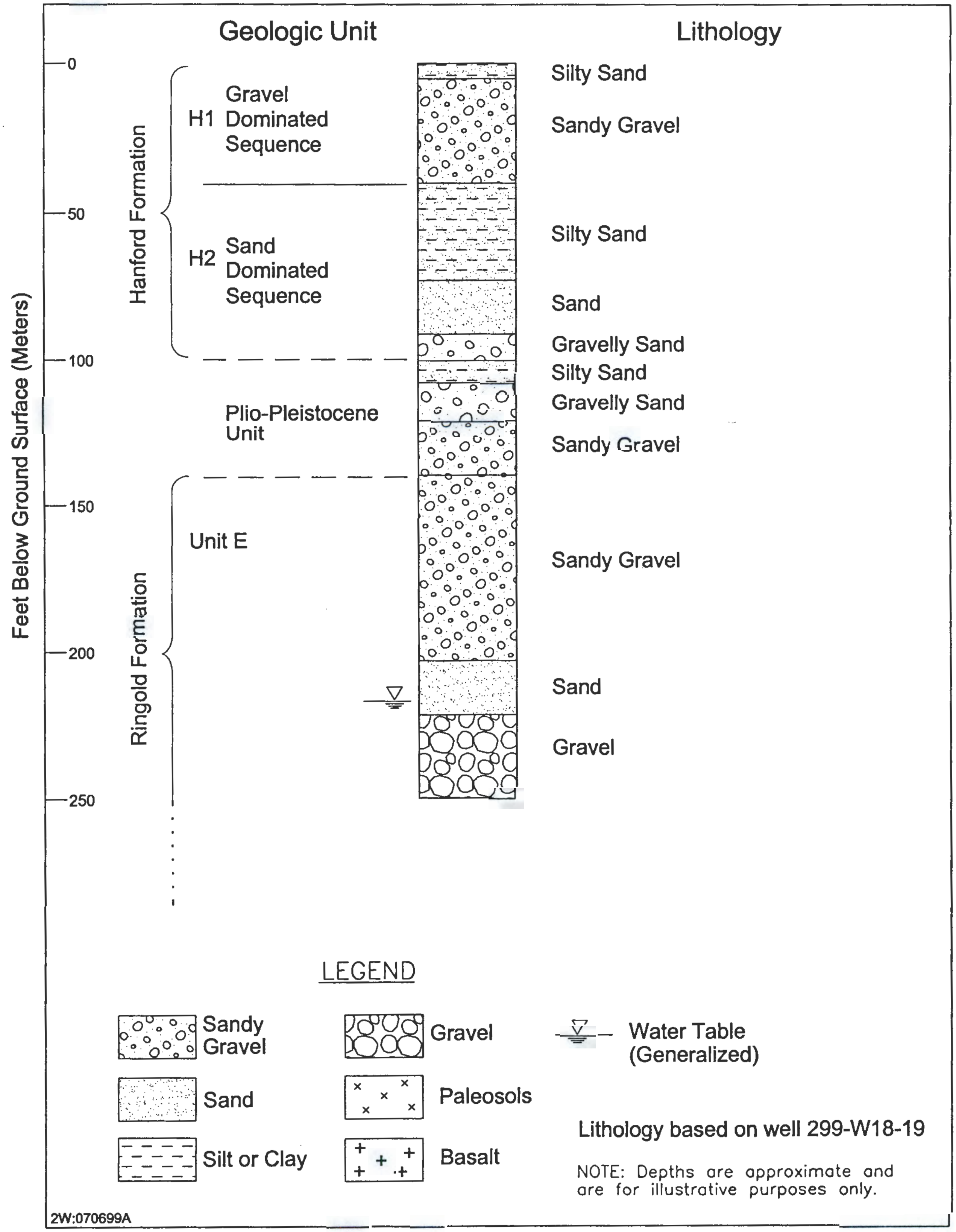


Figure 2-6. Representative Stratigraphy Beneath the 216-Z-11 Ditch.



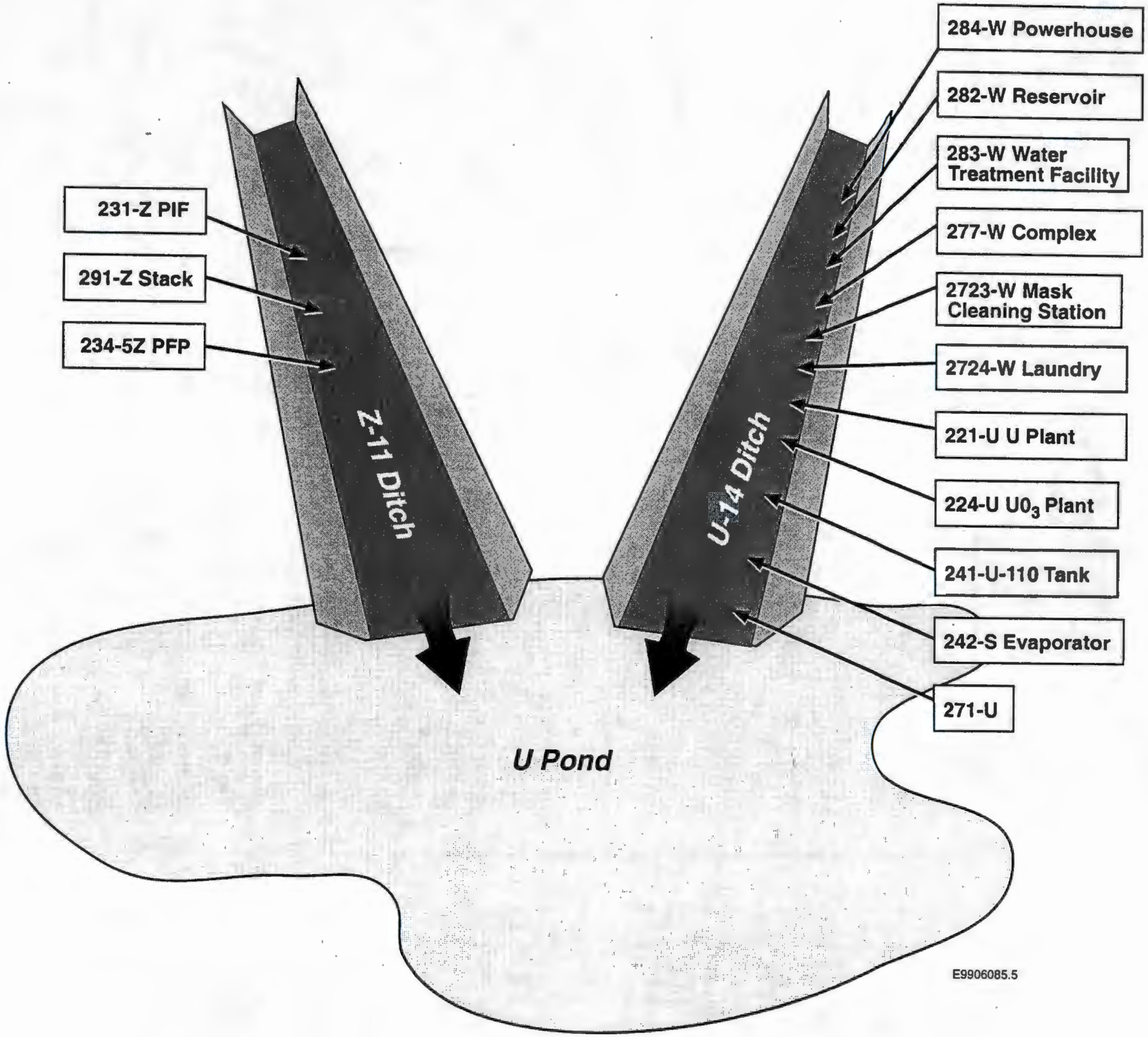
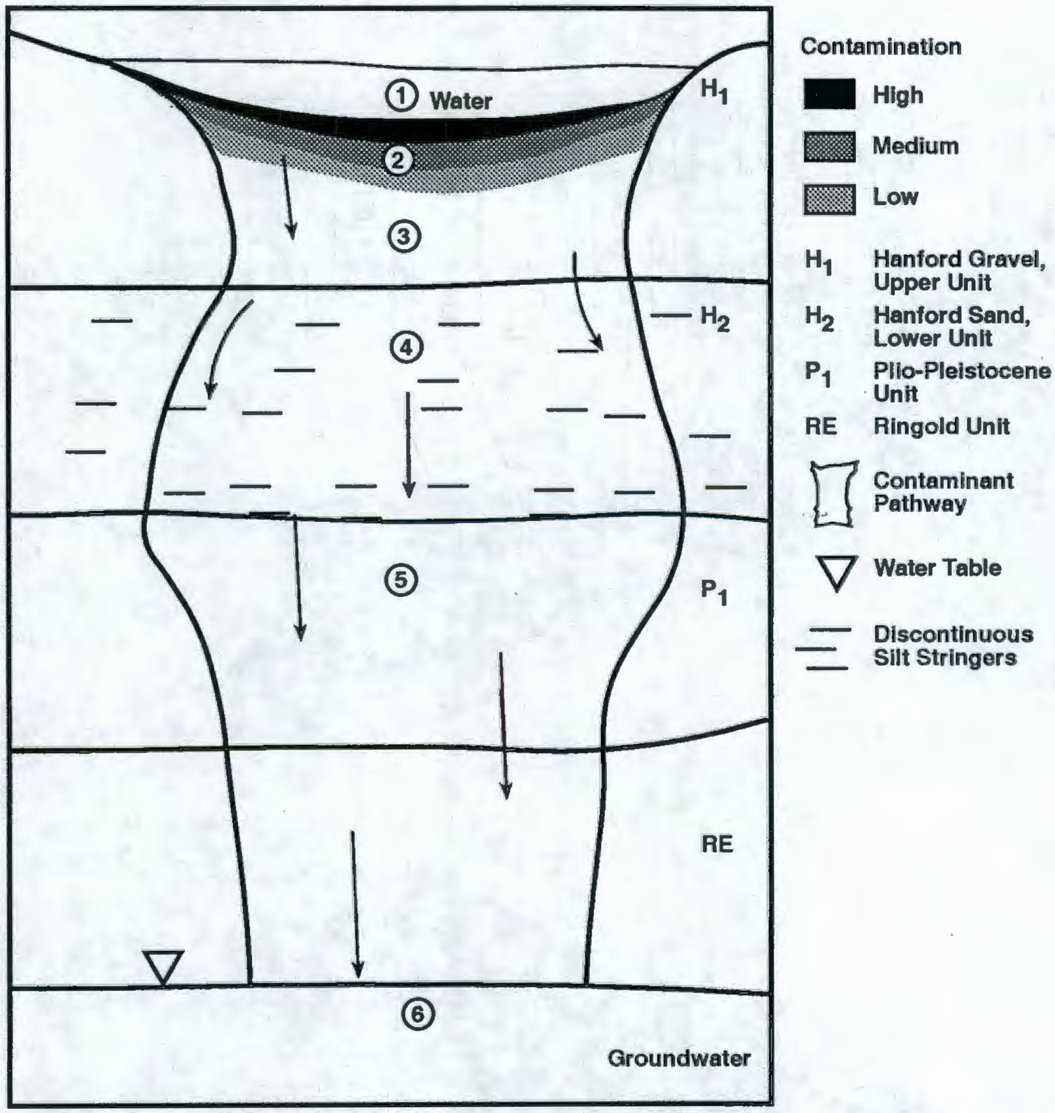


Figure 2-7. Graphical Representation of the 200-CW-5 Operable Unit Waste Streams and Discharge Paths.

Figure 2-8. Conceptual Model of Contaminant Distribution at the 200-CW-5 Operable Unit Waste Sites During Period of Active Discharge.



① High volume of alkaline, low salt, low organic solutions discharged to the ditches/ponds.

② Some particulates in solution (e.g., Pu-239/240, Am-241, Cs-137) settled out in the bottom of units. Most of the dissolved contaminants in solution sorbed to sediments within 2 m of the bottom of the units; concentrations decrease rapidly with depth.

③ Contaminant concentrations are very low compared to the bottom of the ditch.

④ Lateral spreading within the lower unit of the Hanford formation and at the top of the Plio-Pleistocene unit; areas of perched water that formed under some of the units.

⑤ Wetting front moves vertically down into Ringold Unit E.

⑥ High volumes of liquid exceeded vadose zone soil pore volumes and reach groundwater table.

E9910047.2

Table 2-1. Waste Sites in the 200-CW-5 Operable Unit. (2 Pages)

Site Name	Dates of Operation	Approx. Depth	Analogous Representative Site	Dimensions	General Description	Source Facility
207-U Retention Basin	1952 – 1994	2 m (6.5 ft)	216-U-14	75 x 37 m (246 x 123 ft)	Plastic-lined concrete basin divided into two equal halves.	221-U, 224-U
216-U-9 Ditch	1952 – 1975		216-U-10	1,067 x 1.8 m (3,500 x 6 ft)	Unlined ditch. Backfilled in 1954; portion was reopened in 1973 and used until 1975.	Overflow from 216-U-10 Pond
216-U-10 Pond	1944 – 1985		216-U-10	12 ha (30 ac)	Unlined topographic depression. Backfilled and surface stabilized in 1985.	284-W, 231-Z, 234-5Z, 2723-W, 2724-W, 221-U, 224-U, 241-U-110, 242-S, 271-U, 291-Z
216-U-11 Ditch	1944 – 1957	1.8 m (6 ft)	216-U-10	1,375 x 1.5 m (4,510 x 5 ft)	Unlined ditch. Backfilled and surface stabilized in 1985 in conjunction with 216-U-10 Pond.	Overflow from 216-U-10 Pond
216-U-14 Ditch	1944 – 1995	1.2 m (4 ft)	216-U-14	1,731 x 2.4 m (5,680 x 8 ft) (minimum bottom width)	Unlined ditch. Backfilled and surface stabilized in sections, with last section completed in 1997.	284-W, 2723-W, 2724-W, 221-U, 224-U, 241-U-110, 242-S, 271-U
216-Z-1D Ditch	1944 – 1959	0.6 m (2 ft)	216-Z-11	1,295 x 1.22 m (4,250 x 4 ft)	Unlined ditch. Backfilled and surface stabilized in 1959.	231-Z, 234-5Z, 291-Z
216-Z-11 Ditch	1959 – 1971	0.6 m (2 ft)	216-Z-11	797 x 1.2 m (2,615 x 4 ft)	Unlined ditch. Backfilled and surface stabilized in 1971.	231-Z, 234-5Z, 291-Z
216-Z-19 Ditch	1971 – 1981	0.6 m (2 ft)	216-Z-11	843 x 1.2 m (2,765 x 4 ft)	Unlined ditch. Backfilled and surface stabilized in 1981.	231-Z, 234-5Z, 291-Z
216-Z-20 Ditch Replacement Tile Field	1981 – 1995	2.7 – 8.8 m (9 – 29 ft) bgs, variable	216-Z-11	463 x 3 m (1,519 x 10 ft)	Unlined underground gravel tile field covered with soil.	234-5Z, 231-Z, 291-Z, 232-Z, 236-Z, 2736-Z
UPR-200-W-110	One-time use in 1971	4.6 m (15 ft)	216-Z-11	130 m (425 ft)	Narrow trench east of, and adjacent to, the 216-Z-11 Ditch. It received contaminated backfill material generated during the construction of the 216-Z-19 Ditch. The contaminated backfill was from the 216-Z-1 Ditch. This trench is within the same underground radioactive material zone.	216-Z-1 Ditch

Table 2-1. Waste Sites in the 200-CW-5 Operable Unit. (2 Pages)

Site Name	Dates of Operation	Approx. Depth	Analogous Representative Site	Dimensions	General Description	Source Facility
UPR-200-W-111	One-time use in 1960s	3.1 m (10 ft)	216-U-14	12.2 x 4.6 m (40 x 15 ft)	Narrow trench adjacent to 207-U that was dug to bury approximately 21 m^3 (27 yd^3) of sludge scraped from bottom of south side of 207-U Retention Basin. Sludge covered with 1.2 m (4 ft) of clean soil. Surface stabilized in 1997.	207-U Retention Basin
UPR-200-W-112	One-time use in 1960s	3.1 m (10 ft)	216-U-14	12.2 x 4.6 m (40 x 15 ft)	Narrow trench adjacent to 207-U that was dug to bury approximately 21 m^3 (27 yd^3) of sludge scraped from bottom of north side of 207-U Retention Basin. Sludge covered with 1.2 m (4 ft) of clean soil. Surface stabilized in 1997.	207-U Retention Basin

NOTE: Waste site dimensions in this table were taken from WIDS and differ from those listed in Figure 3-1 (Section 3.0).
bgs = below ground surface

3.0 INITIAL EVALUATION OF REPRESENTATIVE SITES

The purpose of this section is to present results of previous characterization efforts at representative sites in the 200-CW-5 OU and provide a background for understanding the waste sites. The contaminant inventory, effluent volume, available soil and groundwater data, and current understanding of the distribution of contamination are also discussed for the representative sites. This information is used to develop site-specific contaminant distribution models for the representative sites.

The DQO process for the 200-CW-5 OU recognized that the 216-U-10 Pond and 216-U-14 Ditch were characterized as part of the 200-UP-2 OU and by Singleton and Lindsey (1994). The 200-UP-2 OU characterization activities were conducted under an approved work plan (DOE-RL 1993b), and the results were compiled in a LFI report (DOE-RL 1995). A focused FS (DOE-RL 1996) that evaluated immediate action requirements was submitted for regulatory review. The FS was never finalized because the near-term risks were low for the evaluated waste sites and no interim actions beyond institutional controls were required. Therefore, these sites have been characterized but not fully evaluated for appropriate final remedial actions. When the OUs were reorganized in accordance with the Implementation Plan (DOE-RL 1999), these two sites were assigned to the 200-CW-5 OU for completion of their RI/FS process. The characterization data previously obtained for these sites are sufficient to support the 200-CW-5 RI/FS process; therefore, characterization aspects of this work plan focus solely on the 216-Z-11 Ditch. The process history information pertaining to the 216-U-10 Pond and the 216-U-14 Ditch are provided in the following subsections to support completion of the remedial decision-making process for those sites.

3.1 KNOWN AND SUSPECTED CONTAMINATION

As discussed in Section 2.0, waste sites in this OU received dilute concentrations of a number of radionuclides in cooling water and infrequent influxes of unusually high concentrations of wastes associated with UPRs. This and the following sections detail the known and suspected discharges of contamination to the waste sites.

The estimated inventory of the primary radionuclides and chemicals that were discharged to waste sites in the 200-CW-5 OU was obtained from WIDS, aggregate area management study reports (AAMSRs) for the 200 Areas (e.g., DOE-RL 1992a, 1992b, 1992c), and Appendix A of the *Waste Site Grouping for 200 Areas Soil Investigations* (DOE-RL 1997), as well as other documents referenced in Section 3.0. Where available, the estimated contaminant inventory for the waste sites in this OU is presented in Table 3-1. Only nitrate, carbon tetrachloride, uranium, plutonium, americium-241, cesium-137, and strontium-90 are tabulated, along with the effluent volumes.

The volumes and types of contaminants from the waste sites are difficult to quantify because they were not routinely monitored. However, lists of contaminants of potential concern (COPCs) for the 216-Z-11 Ditch, developed from process information, are presented in the

200-CW-5 U-Pond and Z Ditches Cooling Water Operable Unit Remedial Investigation DQO Summary Report (BHI 1999).

3.2 ENVIRONMENTAL MONITORING

Currently, environmental monitoring at the Hanford Site consists of effluent monitoring, environmental surveillance, and groundwater and select characterization within the vadose zone. Environmental surveillance is performed for the following:

- Air
- Surface water and sediment
- Drinking water
- Farm and farm product
- Soil and vegetation
- External radiation.

Air, external radiation, soil, and vegetation are routinely evaluated in the 200 Areas as part of the Hanford Site near-facility and environmental monitoring programs. The most recent of these annual reports are the *Hanford Site Near-Facility Environmental Monitoring Data Report for Calendar Year 1998* (Perkins et al. 1999) and the *Hanford Site Environmental Report for Calendar Year 1998* (Dirkes et al. 1999). The near-facility document focuses on monitoring activities near facilities that have, or that have the potential to discharge, store, or dispose radioactive or hazardous materials, including the 200 East and 200 West Areas. The Hanford Site environmental report covers the entire Hanford Site, including those areas not associated with operations (such as the 600 Area). The environmental reports examine the resources associated with the Hanford Site, including those media listed above, as well as groundwater. Results of these monitoring efforts for the 200-CW-5 OU waste sites are presented in Section 3.3. The potential impacts of contamination in these waste sites on human health and the environment are discussed in Section 3.4.

Groundwater is also routinely monitored Site-wide. Over 600 monitoring wells are sampled annually to characterize groundwater flow; groundwater contamination by metals, radionuclides, and chemical constituents; and the area of contamination. Groundwater remediation, ingestion risk, and dose are also assessed. Results of groundwater monitoring and remediation are presented annually in the *Hanford Site Groundwater Monitoring for Fiscal Year 1999*, (PNNL 2000). This document also summarizes vadose zone characterization activities conducted on the Site through other projects.

3.3 NATURE AND EXTENT OF CONTAMINATION

This section uses previously published data to describe the contamination associated with the representative sites. The facilities that contributed to the waste stream did not generally keep facility-specific records of discharges. However, later records exist for these facilities. For example, since 1984, the powerhouse effluent was sampled and sent to the powerhouse pond (constructed over part of the 216-U-14 Ditch). Records were documented in the 216-U-10 Pond inventory according to the U Plant AAMSR (DOE-RL 1992b).

Even though substantial quantities of water were disposed to the waste sites in 200-CW-5 OU, the OU is not a major source of groundwater contamination (note, however, as discussed later in this section, contaminants are present in the groundwater below the 216-U-10 Pond and the 216-U-14 Ditch). The largest impact of 216-U-10 Pond on the hydrology has been on the flow system through the formation of a groundwater mound that provided a driving force to move contamination in the aquifer resulting from other disposal facilities (Last et al. 1994).

A summary of ecological resources for the 200 Areas is provided in Appendix F, Sections 8.0 and 9.0 of the 200 Area Implementation Plan (DOE-RL 1999). Site-specific ecological data are presented in the following subsections for the representative sites. Several other sources of information, while not pertinent to a specific representative site, provide useful data in the vicinity of the sites. These data sources include the following:

- *Historical Records of Radioactive Contamination in Biota at the 200 Areas of the Hanford Site* (Johnson et al. 1994)

- *Ecological Sampling at Four Waste Sites in the 200 Areas* (Mitchell 1995).

Eighty-five environmental monitoring records of wildlife and vegetation at the 200 East and 200 West Areas since 1965 were reviewed and summarized by Johnson et al. (1994). The report indicates that several areas in the vicinity of the 200-CW-5 OU waste sites have been sampled from 1965 to 1993. About 4,500 individual cases of monitoring for radionuclide uptake or transport in biota in the 200 Area environs were included in the documents reviewed by Johnson et al. (1994). Approximately 1,900 (42%) of these biota had radionuclide concentrations in excess of 10 pCi/g. These radionuclide transport or uptake cases were distributed among 45 species of animals (found mostly in small mammals and feces) and 30 species of vegetation.

Wildlife species most commonly associated with uptake of radioactive contamination in the 200 Areas have historically been house mice and deer mice, but other animals such as birds (including waterfowl), coyotes, cottontail rabbits, mule deer, and elk have been sampled (Johnson et al. 1994, Perkins et al. 1999).

Plant species may be potentially exposed to contaminated soils and/or groundwater present in the vadose zone soil. Johnson et al. (1994) demonstrated radionuclide uptake by plants within the 200 Area. Plants live in direct contact with the soil and can take up contaminants through physical and biological processes. Exposure is a function of the plant species, root depth, physical nature of the contamination, and the contaminant concentrations and distributions in the soil. Plants are generally tolerant of ionizing radiation (IAEA 1982) but potentially present a contaminant pathway to wildlife through the consumption of contaminated seeds, leaves, roots, or stalks. The vegetative species most commonly associated with the contamination was the Russian thistle. The largest numbers and levels of radionuclide uptake or transport occurred at the Z-Ditches and at several sites unrelated to the 200-CW-5 OU, including the 216-B-3 Ditches, the 216-BC Cribs, the 241-B Tank Farm, and the 241-BX/BY Tank Farms. Much of this information was collected prior to stabilization activities at the individual waste sites. Noticeable improvements in reducing the uptake and transport of radionuclide contaminants by biota were observed in areas where interim stabilization activities have taken place (Johnson et al. 1994).

Mitchell (1995) summarized a sampling effort to collect ecological samples at four sites within the 200 Areas, including the 216-U-11 Ditch, which is located near the U Pond and is part of the 200-CW-5 OU. Control samples were collected from a site on the Saddle Mountain Wildlife Refuge. Soil, vegetation, small mammal, and insect samples were collected and analyzed for EPA's target analyte list constituents, strontium-90, total uranium, and gamma-emitting radionuclides using gamma spectroscopy. Soil and vegetation samples were also analyzed for technetium-99. The basis of the sampling strategy was to select some worst-case sites to focus future biota sampling activities.

Vegetation analysis included two cheatgrass and two Russian thistle samples at the 216-U-11 Ditch. Strontium-90 was detected in one cheatgrass sample and both Russian thistle samples, and copper and zinc were detected in one cheatgrass sample and both Russian thistle samples; however, copper was also present in the associated sample blank. The only analytes detected in small mammal (pocket mouse) samples were strontium-90 (one out of four samples) and selenium (three out of four samples, but also detected in the associate sample blank). Strontium-90 was the only analyte detected in the composite insect sample. The following constituents were undetected in all samples: technetium-99, cobalt-60, cesium-137, cadmium, mercury, selenium, silver, and cyanide.

Mitchell (1995) concluded that Russian thistle is the preferred vegetative indicator for radionuclide and metal uptake, and pocket mice are preferred mammalian indicators of contaminant uptake at terrestrial sites. They also recommended deleting the 216-U-11 Trench site from further study of surface contamination sites based on the effectiveness of stabilization and isolation of the contaminants from the surrounding environment.

Ecological samples were also collected from the 216-U-11 Trench as part of the *Limited Field Investigation for the 200-UP-2 Operable Unit* (DOE 1995). Plants were found to contain above background concentrations of copper, cesium-137, strontium-90, plutonium-239, and total uranium. Concentrations of copper, cyanide, cesium-137, strontium-90, plutonium-239, and total uranium were detected in small mammals that exceeded the 200 Area reference locations.

Soil and vegetation samples are collected from Stations 104 and 110 in the vicinity of the 216-U-11 Ditch as part of the near-facility environmental monitoring. The 1998 analytical results for these stations are presented in Table 3-2.

No thermoluminescent dosimeter locations have been placed at any of the representative waste sites in the 200-CW-5 OU. However, a TLD sample collected in 1998 at the 216-Z-20 Ditch (located just west of the 216-Z-11 Ditch) showed an annual dose rate of 85 mrem/yr at this site (Perkins et al. 1999).

3.3.1 216-U-14 Ditch

Several facilities discharged waste streams to the 216-U-14 Ditch (and from there to the 216-U-10 Pond), as described in Section 2.0. The volume of liquids discharged to the 216-U-14

Ditch varies as reported by different authors. Diediker (1999) reported a cumulative volume of 1.22×10^9 L (3.2×10^8 gal). However, Singleton and Lindsey (1994) reported that approximately this quantity is released almost every year of operation. The stream-specific report for the 242-S Evaporator (WHC 1990a) reported that 6.4×10^7 L/yr (1.7×10^7 gal/yr) were discharged from that facility to the 216-U-14 Ditch. Alexander et al. (1993) reported that 1.56×10^8 L/yr (4.2×10^7 gal/yr) of effluent was discharged to the 216-U-14 Ditch from the 284-W Powerhouse in 1990.

3.3.1.1 Facilities Disposing Wastes to the 216-U-14 Ditch.

242-S Evaporator. The 242-S Evaporator operated from 1973 to 1980. The evaporator was designed to reduce the volume of radioactive waste from the 241-S Tank Farm through evaporation and concentration, thereby reducing the number of double-shell tanks required to store these wastes. The steam condensate from the evaporation process was diverted to the 216-U-14 Ditch and from there to the 216-U-10 Pond. Approximately 6.44×10^7 L/yr (1.7×10^7 gal/yr) were discharged to the 216-U-14 Ditch during the evaporator's operation (WHC 1990a). A thorough review of construction drawings reveals no evidence of pipelines from the 242-S Evaporator to the 216-U-14 Ditch.

Four contributors in the 242-S Evaporator comprised the waste stream: reboiler steam condensate, steam condensate and raw water from the heating and cooling jackets, purging system steam trap condensate, and vacuum pump seal water. The process did not involve the intentional addition of constituents to the waste stream or its contributors. However, because the water was used to cool or heat process vessels that served to reduce the amount of radioactive material stored in the tanks, it is feasible that leaks in the system allowed these single-shell tank contents to contaminate the condensate disposed to the 216-U-14 Ditch. No sampling data are available from the period of operation 1973 to 1980.

284-W Powerhouse. The wastewater streams from the powerhouse included cooling water, backflush water, condensate, floor drains, and overflow (WHC 1990c). Samples from the powerhouse streams indicate high total salt concentrations and neutral to moderately basic pH, with some metals (e.g., aluminum, nonradioactive strontium, barium, and cerium) and ions present (Alexander et al. 1993). In 1990 (WHC 1990c, Alexander et al. 1993) the estimated average flow rate for the 284-W Powerplant wastewater effluent was 1.56×10^8 L/yr (4.2×10^7 gal/yr).

2723-W Mask Cleaning Station and 2724-W Laundry. The AAMSR states that 570,000 L (150,000 gal) of laundry wastewater per day were discharged to the 216-U-14 Ditch. The sources from the laundries include the washing machines, dryers (condensate), floor drains, cleanouts, sinks, and the heating, ventilation, and air conditioning system. Nonradioactive and potentially radioactive clothes were washed in addition to respiratory protective equipment (WHC 1990b). Detergents may have been important in reducing the retardation factor of contaminants in soil, thereby decreasing travel times to groundwater.

U Plant Sites. The U Plant buildings contributed wastewater to the 216-U-14 Ditch from cooling water, steam condensate, facility water drains, and rainwater drains (Toebe et al. 1990).

Low levels of contamination in large volumes of water are expected from these sources, but for many years the effluent was not sampled or evaluated.

The UO_3 Plant was a complex of several buildings, tank farms, storage areas, and loading facilities, which includes the 224-U Building. PUREX-generated liquid uranyl nitrate hexahydrate was converted to powdered uranium trioxide in the 224-U Building. Cooling water from 224-U processes was discharged as effluent to the 216-U-14 Ditch.

The chemical sewer stream from 221-U (U Plant) was also discharged to the 216-U-14 Ditch (DOE-RL 1992b). Sewer streams in general contain a variety of hazardous constituents, including hydrazine; sulfuric, nitric, phosphoric, and formic acids; sodium hydroxide; sodium and aluminum nitrate; cadmium; and chromium. As with other waste sites, the quantity and types of nonradiological contaminants released to the chemical sewer are difficult to quantify because they were not routinely monitored.

Tank 241-U-110 discharged condenser water to the 216-U-14 Ditch.

Additional Releases. In 1986, approximately 3,000 L (800 gal) of 50% reprocessed nitric acid (pH <2.0) was released to the 207-U Retention Basin and 216-U-14 Ditch during the transfer of acid from a 211-U storage tank to a railroad car. The total release, including dilution water, was reported at 100,000 kg (225,000 lb) and 39 to 45 kg (86 to 100 lb) of uranium (DOE-RL 1992b, Whiting 1988).

Two other smaller releases of uranyl nitrate hexahydrate (UNH) occurred in 1992. On May 30, 1992, approximately 42.8 L (11.3 gal) of UNH were released to the 207-U Retention Basin and the 216-U-14 Ditch. It is estimated that between 9 and 12 kg (21.6 and 26.4 lb) of uranium and 16.3 and 19.6 kg (36 and 43 lb) of uranyl nitrate were discharged. An incident on October 19, 1992, led to the discharge of approximately 11,171 L (2,952 gal) containing 7.3 kg (16.1 lb) of uranium to the 207-U Retention Basin. The mass of uranium actually discharged to the 216-U-14 Ditch at the outlet from the 207-U Retention Basin was reported as 3.5 kg (7.7 lb).

Pipelines Connected to the 216-U-14 Ditch. As stated in Section 2.0, several pipelines carried effluent from the discharge sources to the 216-U-14 Ditch. Wastewater from the 284-W Powerhouse and associated buildings, the 2723-W Mask Cleaning Station, and the 2724-W Laundry entered the ditch via a common pipeline (General Electric Drawing M-2904-W, sheet 14). This pipeline increased in diameter as it progressed to the ditch: at the exit point from the 2723-W Mask Cleaning Station, the pipeline is a VCP, 20 cm (8 in.) in diameter; it becomes a 25.4-cm (10-in.) VCP as it passes the 2724-W Laundry; it increases to a 81.2-cm- (13-in.) reinforced-concrete pipe (RCP) near the 282-W Reservoir; and finally, the pipeline becomes a 107-cm (42-in.) RCP after passing the 282-W Reservoir. There is a manhole where the 107-cm (42-in.) RCP pipeline connects to the ditch at a wing headwall.

Cooling water from 224-U was discharged through a 61-cm (24-in.) VCP (General Electric Drawing M-2904-W, sheet 19) and into the 207-U Retention Basin. Effluent exited the 207-U Retention Basin through another 61-cm (42-in.) VCP and was discharged to the ditch via a culvert than ran under 16th Street. A manhole is located immediately west of the 207-U Retention Basin.

Chemical sewer wastewater, steam condensate, and cooling water from 221-U and 271-U were discharged through a 46-cm (18-in.) VCP that was south of and parallel to 16th Street (General Electric Drawing M-2904-W, sheet 19). A manhole is located 114.3 m (375 ft) from the timber headwall where the pipeline discharged to the ditch.

Condenser water from tank 241-U-110 was discharged through a pipeline that connected to the 216-U-14 Ditch immediately south of 16th Street (Vitro Engineering Company Drawing H-2-31374, 1965). No information is available regarding pipeline type or size.

3.3.1.2 Summary of Previous 216-U-14 Ditch Characterization. In 1986, uranium concentrations in the groundwater below the ditch were slightly elevated, indicating that some uranium had migrated through the vadose zone (DOE-RL 1992b). Uranium concentrations in the groundwater below the ditch were still slightly elevated in 1995 (Figure 3-3, in Schmidt et al. 1996) but, by 1993, had declined below the drinking water standard (20 parts per billion [ppb]). The U Plant AAMSR (DOE-RL 1992b) reports that gamma logs acquired in 1986 and 1987 from six wells near the 216-U-14 Ditch showed that radionuclide contamination may be present in the upper 12 m (40 ft) of the wells, with a series of distinct peaks at depths of 4.3 and 11.9 m (14 and 39 ft) in well W19-93.

Sampling of the ditch bottom was performed in 1987 to determine the effects of the accidental release of reprocessed nitric acid that occurred in 1986. Samples taken from three vadose zone wells showed uranium at levels only slightly above background. Data from core samples taken from the center of the ditch suggest that the uranium sorbed to sediments in the ditch bottom (Singleton 1993, from Internal Memo #65631-87-054 from R. C. Routson to V. W. Hall on July 8, 1987). A maximum of 185 pCi/g of uranium was measured in a core taken at 15- to 30-cm (6- to 12-in.) depth.

Three test pits were excavated to 3 m (10 ft) in March 1992 to support the development of the *Groundwater Impact Assessment Plan for the 216-U-14 Ditch* (Singleton 1993). These pits were located in the section of the ditch between Cooper Avenue and the 216-U-10 Pond. This portion of the ditch was still active and received cooling water from the 224-U Plant; thus, the test pits were excavated through approximately 0.6 m (2 ft) of standing water. Data collected from the excavations indicated that radiological contamination was concentrated within a few feet of the bottom of the ditch. A summary of maximum levels detected is provided in Table 3-3. Test pit samples were not analyzed for metals or organic constituents.

Singleton and Lindsey (1994) continued to characterize the 216-U-14 Ditch using historical information and construction of three groundwater monitoring wells, two perched water monitoring wells, and three additional test pits. Table 3-4 lists the results of their historical data and characterization sampling for selected contaminants in test pits, well sediments, the perched water zone, and groundwater. For some contaminants, the upgradient concentrations in groundwater are also presented. Overall, Singleton and Lindsey's (1994) conclusions include the following:

- Arsenic is slightly elevated in groundwater to maximum levels of 23 ppb (unfiltered water from the perched water zone) and 14 ppb in filtered groundwater.

- Aroclor-1254 was detected in only one sample, at 7 ppb from a depth of 1.8 m (6 ft) in a test pit.

- Carbon tetrachloride was not detected in sediments or perched water but was detected at a maximum level of 140 ppb in groundwater below the U Pond and a maximum of 17 ppb below the 216-U-14 Ditch.

- Cesium-137 was found almost entirely within 0.3 m (1 ft) of the ditch bottom; the highest level (2,740 pCi/g) was in the eastern end of the ditch. This is in contrast to Last and Duncan (1980), who found the highest cesium-137 levels near the 216-U-10 Pond.

- Plutonium-239/240 contamination was detected at a maximum concentration of 10 pCi/g in ditch sediments but was not detected in the perched water zone.

- Strontium-90 was observed in the perched water zone at the eastern end of the ditch at concentrations up to 24.6 pCi/g but was not detected in the groundwater; sediment samples showed up to 6.6 pCi/g at depths up to 17 m (57 ft).

- Uranium-238 concentrations were highest within 1.2 m (4 ft) of the ditch bottom at levels up to 178 pCi/g. Below 1.2 m (4 ft), the maximum concentration was 7 pCi/g. Uranium-238 was found in the perched water zone up to 42.6 pCi/L and up to 13.5 pCi/L in groundwater under the 216-U-14 Ditch.

- The maximum thickness of the perched water zone was 17 m (56 ft) below the eastern end of the ditch; the perched water zone is limited to the vicinity of the ditch.

- Subsurface contaminants that are attributed to the 216-U-14 Ditch are americium-241, arsenic, aroclor-1254, bis-(2-ethylhexyl) phthalate, cesium-137, cobalt-60, gross alpha, gross beta, manganese, plutonium, stronium-90, technetium-99, and uranium-238.

- Arsenic, cobalt-60, gross alpha and gross beta, manganese, stronium-90, and uranium-238 extended to the perched water zone. Arsenic, cobalt-60, gross alpha and gross beta, and manganese were detected in water samples from this zone; strontium-90 and uranium-238 were detected in soil samples.

- Only arsenic, carbon tetrachloride, manganese, and uranium-238 were detected in the groundwater.

Below a portion of the 216-U-14 Ditch, south of the 207-U Retention Basin, is an area of perched water above impermeable layers in the Plio-Pleistocene unit (DOE-RL 1992b). Schmidt et al. (1996) reported that water in the perched monitoring wells had drained away after input to the ditch was terminated. Anomalous occurrences of arsenic and stronium-90 were detected in these wells, suggesting that some contaminants had migrated through the soil column (Schmidt et al. 1996). Perched water was also detected in boreholes at the 216-U-14 Ditch in the section between U Pond and Cooper Avenue. Seven contaminants were identified in soil samples collected from this perched water zone: arsenic, cobalt-60, gross alpha, gross beta, manganese, strontium-90, and uranium-238 (Singleton and Lindsey 1994).

Last and Duncan (1980) and Last et al. (1994) sampled soil from the ditch and reported levels of cesium-137, cobalt-60, stronium-90, and plutonium-239/240 from upgradient and downgradient of the 207-U Retention Basin outfall. For cesium, the contamination levels in samples from the ditch immediately upstream of the 216-U-10 Pond were higher than those levels found upgradient of the 207-U Retention Basin, which had a maximum value of 5,430 pCi/g (decayed to 3,509 pCi/g in 1999). Unlike cesium, europium-154 levels were higher in the upper part of the ditch (36.9 pCi/g, decayed to 8.3 pCi/g in 1999). Strontium-90 was not as widespread nor as well sampled for as cesium-137. Strontium-90 observed concentrations were consistently lower than those of cesium-137.

Landeen and Leitz (1982) sampled the sediment in the bottom of the ditch (21 samples), at a depth of 5 to 30 cm (2 to 12 in.) from the head end to the outflow into U Pond. Conclusions include the following:

- Cesium-137 contamination levels averaged 371 pCi/g (decayed to 245 pCi/g in 1999). Cesium levels tended to be higher in the western half of the ditch (west of Cooper Avenue) than in the eastern half.
- Cobalt-60 contamination levels averaged 33.5 pCi/g (decayed to 3 pCi/g in 1999).
- Total uranium contamination levels averaged 9.9 pCi/g.

Surface radiation surveys (DOE-RL 1996) indicate that the greatest degree of surface contamination is in the vicinity of the 207-U Retention Basin.

Diediker (1999) compiled and calculated the decayed inventory of many 200 Area waste sites, including the 216-U-14 Ditch. Diediker reported a volume of 1.22×10^9 L (3.22×10^8 gal) released to the site. The associated radionuclide inventory is shown in Table 3-5. However, as noted earlier, this total volume conflicts with information reported in Singleton and Lindsey (1994), who report comparable volumes disposed to the 216-U-14 Ditch every year, from initial use to 1993. Thus, the radionuclide inventory shown in Table 3-5 may underestimate the quantities present.

The *Focused Feasibility Study for the 200-UP-2 Operable Unit* (DOE-RL 1996) reports a contaminated soil volume for the 216-U-14 Ditch of 26,600 m^3 (34,800 yd^3) and an excavated soil volume of 85,540 m^3 (65,400 yd^3). The contaminated soil volume is based on a contamination area 2.4 m (8 ft) deep, 8.5 m (28 ft) wide, and 1,700 m (5,600 ft) long. The depth of 2.4 m is based on a vertical extent of contamination 1.2 m (4 ft) below the bottom of the ditch. Figure 3-1 (from DOE-RL 1996) shows an estimated lateral extent of contamination for the waste sites in the 216-U-10 Pond system (including 216-U-14), based on a preliminary remediation goal (PRG) of 100 mrem/yr. Figure 3-1 is provided for information only and does not assume a PRG for these sites. It should be noted that waste site dimensions (as given in Figure 3-1) differ from those used in Table 2-1, which were obtained from WIDS.

No ecological data were collected for this site as part of the 200-UP-2 LFI (DOE-RL 1995). However, soil and vegetation samples have been collected in the vicinity of the 216-U-11 Ditch as part of the near-facility environmental monitoring at Stations 004 and 031. The 1998 analytical results are presented in Table 3-2.

3.3.2 216-Z-11 Ditch

The 216-Z-11 Ditch is not as thoroughly characterized as the other representative sites. The 216-Z-11 Ditch parallels the 216-Z-1D and 216-Z-19 Ditches and may be difficult to clearly distinguish from these other ditches in the field because they overlap in sections and all have been backfilled by a uniform soil cover. The total volume discharged to the site is not known, but Last et al. (1994) report that from 1969 to 1971, 6.7×10^8 L (1.77×10^8 gal) of water were released to the ditch. It is reported as a transuranic-contaminated soil site in WIDS and in the Hanford Defense Waste Environmental Impact Statement (DOE 1987).

3.3.2.1 Facilities Disposing to the 216-Z-11 Ditch. The 231-Z Building was the site of the Plutonium Isolation Facility and was used to condense plutonium nitrate solution from the separations facilities into plutonium paste from 1945 to 1949. The building housed various laboratories and office space after 1949. Effluents from this building were cooling water, steam condensate, and laboratory wastes (DOE-RL 1992c).

The 234-5Z Building (PFP) converted plutonium nitrate solutions to other usable forms of plutonium. Discharges consisted of cooling water and steam condensate, assumed to contain plutonium and other transuranic elements (DOE-RL 1992c).

The 291-Z Building was an air-flow emission stack. Effluents from this facility that were discharged included cooling and seal water (DOE-RL 1992c).

Pipelines Connected to the 216-Z-11 Ditch. As stated in Section 2.0, several pipelines connected discharge sources to the 216-Z-11 Ditch. Steam condensate and laboratory wastes from 231-Z entered the ditch via a 46-cm- (18-in.) diameter VCP (Hanford Engineer Works Drawing H-2-10011, 1947). A manhole to the pipeline is located approximately 61 m (200 ft) south of 19th Street. Process cooling water and steam condensate from the 234-5Z Building and vacuum pump seal water and cooling water from the 291-Z Building entered the ditch via a 38-cm (15-in.) VCP process sewer (Atlantic Richfield Hanford Company Drawing H-2-32528, 1959). Three manholes are in the pipeline (General Electric Company, Hanford Works Drawing H-2-14035, 1948). A 30-cm (12-in.) storm sewer also connected to the ditch from an elevated water tank immediately south of the 234-5Z Building (Atlantic Richfield Hanford Company Drawing H-2-32528, 1959).

3.3.2.2 Summary of Previous 216-Z-11 and Related Ditches Characterization. Last et al. (1994) conducted a characterization study of the 216-U-10 Pond and 216-Z-19 Ditch in 1980 that was published in 1994. During this characterization work, the 216-Z-19 Ditch was active. Two deep monitoring wells and 17 shallow exploration boreholes were drilled along the 216-Z-19 Ditch and its two predecessors (216-Z-1D and 216-Z-11). The shallow exploration boreholes were drilled to locate the backfilled 216-Z-1D and 216-Z-11 Ditches and to sample for radioactive contamination present in the sediment. Limited analytical data exist for these boreholes; contamination estimated from the data and ditch locations was considered by the authors to be only rough approximations. However, in the absence of any other data sources, the data are provided for use in locating contamination "hot spots" and assessing vertical contaminant distribution and approximate concentrations.

This paragraph provides an overview of the data collected from these shallow exploration boreholes dug in the Z-Ditches (Last et al. 1994). Four shallow exploration boreholes were dug in the area believed to be the 216-Z-11 Ditch. Approximately 60 m (197 ft) from the outfall of the 234-5Z Building, samples taken at a depth of 0.9 m (3 ft) indicate a contamination level of 40,000 pCi/g of plutonium-239/240. An additional six exploration boreholes were believed to have been located the 216-Z-1 Ditch. Data from a borehole located approximately 160 m (525 ft) from the 234-5Z outfall in the 216-Z-1 Ditch showed plutonium-239/240 contamination concentrations of 380,000 pCi/g at a depth of 2.1 m (6.9 ft) below ground surface. This depth was the previous bottom of the ditch (sediment and vegetation layer); the material above the former ditch bottom consisted of backfill added when the 216-Z-11 and 216-Z-19 Ditches were constructed. Another borehole 380 m (1,247 ft) from the 234-5Z outfall indicated 270,000 pCi/g of plutonium-239/240 at a depth of 2.4 m (7.9 ft). The geology of these boreholes is documented as "slightly silty, slightly pebbly, medium to very fine sand, and decayed vegetation." Because plutonium has a very high distribution coefficient (K_d value), it is probable that the plutonium adsorbed to the fine-grained soil and the decayed organic matter in the ditch bottom. Contaminant concentrations decrease rapidly with depth. Near-surface (<1-m [3.2-ft] depth) contamination data show one area of very high contamination near the U Pond delta area of 13,000,000 pCi/g of plutonium-239/240. This sample was taken while the U Pond delta area was in operation.

Last et al. (1994) reported an estimated total plutonium inventory of 8,075 g for the 216-Z-11 Ditch (with an additional 138.5 g in 216-Z-1 and 143.0 g in 216-Z-19). However, Last et al. indicated that these inventory values may be erroneous for four reasons. First, calculations of plutonium-239/240 could have been made excessively high because of unknown amounts of plutonium-239/240 in the waste streams. Second, assays of the waste streams from the Z Plant facilities were performed mostly by alpha count. Conversions of plutonium activity to weight from alpha counts could cause the contaminant concentrations to be overestimated. Third, periodic sampling of the waste streams could have missed some intermittent plutonium discharges, leading to a low estimate of plutonium concentration in the waste streams. Finally, during the early 1960s, while the Space Nuclear Auxiliary Power program was in operation, no plutonium releases to the 216-Z-11 Ditch were documented. In 1967, a simple estimated total of 7.86 kg for the previous years (1961 to 1967) was reported. The Space Nuclear Auxiliary Power program isolated plutonium-238 and released plutonium-239/240 to the 216-Z-11 Ditch as a waste product.

Last et al. (1994) reported that previous studies had not been able to determine if the plutonium discharged to the Z-Ditches was bound up in the sediments or eventually made its way to the 216-U-10 Pond. Most of the plutonium documented in their study was concentrated in the first 50 cm (20 in.) of soil in the ditch bottom, but contamination extended to depths of at least 6 m (19.7 ft) at very low concentrations. Americium-241 is reported to be the second dominant radionuclide in the ditch, with low concentrations (<1 pCi/g) at a depth of least 11 m (36 ft) below the neighboring 216-Z-19 Ditch.

Last et al. (1994, Appendix A) included an analytical report from 1959 of total alpha and plutonium contamination in soils from the 216-Z-1 Ditch (known at that time as the 234-5 Ditch). The samples were collected at the inlet to the ditch and at 30-m (100-ft) intervals along the ditch (three samples at each 30-m [100-ft] interval; one sample at 0.3 m [1 ft] from the ditch edge, one at 0.9 m [3 ft] from the edge, and one at 1.5 m [5 ft] from the edge). Samples were also collected at 30-m (100-ft) intervals around the shore of the 216-U-10 Pond. The contaminant distribution generally decreased with increasing distance from the inlet, but the maximum reported concentration was 240 m (800 ft) from the inlet to the ditch. The three reported concentrations at any one 30-m (100-ft) sampling interval varied up to three orders of magnitude, showing the heterogeneous nature of contaminant distribution.

The *Disposal of Hanford Defense High-Level, Transuranic and Tank Wastes, Final Environmental Impact Statement* (DOE 1987) reported total plutonium inventories for the 216-Z-11 and 216-Z-19 Ditches as follows: 8.1 kg over an area of 3,300 m^2 with an average transuranic concentration of 790 nCi/g for 216-Z-11, and 140 g over an area of 1,400 m^2 with an average transuranic concentration of 100 nCi/g for 216-Z-19. A transuranic-contaminated site was defined as one at which the average concentration of transuranics in the soil exceeds 100 nCi/g based on a soil density of 1.9 g/cm^3 or a site that received more than 80 g of plutonium per 100 m^2.

Last et al. (1994) report that one groundwater monitoring well for the U Pond system was sampled in 1979; this well reached the groundwater below the Z-Ditches. Water from the well showed average concentrations of less than 17 pCi/L total alpha contamination, less than 75 pCi/L total beta contamination, 22.5 pCi/L tritium, and 12 ppm NO_3.

DOE-RL (1996) reported a contaminated soil volume for the 216-Z-11 Ditch of 6,200 m^3 (8,100 yd^3) with an excavated soil volume of 7,000 m^3 (9,100 yd^3). The contaminated volume does not include the sections shared with the 216-Z-1D Ditch and is based on a length of 560 m (1,830 ft), a depth of 0.6 m (2 ft), and a width of 4.3 m (14 ft). However, because the 216-Z-1D, 216-Z-11, and 216-Z-19 Ditches are located so closely together, a total soil volume for all three may be more useful; the estimated contaminated soil volume for all three Z-Ditches is 31,500 m^3 (41,200 yd^3) contaminated and 41,057 m^3 (53,700 yd^3) excavated (DOE-RL 1996).

The only ecological data available from the Z-Ditches are radionuclide concentrations in mice from the 216-Z-19 Ditch. The maximum strontium-90 concentration in the mice from this site was greater than the concentrations at 200 Area reference location. Plutonium-239 was also detected in the mice; however, reference data were not available for comparison. One soil and vegetation sampling station is located in the vicinity of the 216-Z-11 Ditch. Samples from station 008 are collected every other year as part of the near-facility environmental monitoring program (Perkins et al. 1999). The 1998 analytical results from this station are presented in Table 3-2.

3.3.3 216-U-10 Pond

Several facilities discharged waste streams to the 216-U-14 Ditch and the 216-Z-11 Ditch (and from these ditches to the 216-U-10 Pond), as described in Section 2.0. The total effluent volume discharged to U Pond is difficult to quantify, because total volumes discharged to the 216-U-14 Ditch as reported in the literature are inconsistent, and the total volume discharged to the 216-Z-11 Ditch is not known. Yearly volumes of wastewater released to the 216-U-10 Pond as reported by Hanson et al. (1973) ranged from 1.62×10^8 L in 1944 up to 1.19×10^{10} L in 1956, with a total volume through 1971 of 1.17×10^{11} L (3.0×10^{10} gal).

3.3.3.1 Facilities Disposing Wastes to the 216-U-10 Pond. The 216-U-10 Pond was the final destination for wastes that were discharged via the 216-U-14 Ditch and the 216-Z-11 Ditch. The individual facilities that discharged to each of these two ditches were discussed previously in Sections 3.3.1.1 and 3.3.2.1.

3.3.3.2 Summary of Previous 216-U-10 Characterization. The 216-U-10 Pond system has been extensively monitored and characterized. Hanson et al. (1973) summed discharges to the 216-U-10 Pond and reported that 1,430 kg (3,146 lb) of uranium, 8.1 kg (17.6 lb) of plutonium, <16.8 Ci of stronium-90, and <12 Ci of cesium-137 were disposed there from 1944 to 1971.

In 1980, a comprehensive study was conducted on the pond and its associated trenches to prepare for their eventual closure (Last and Duncan 1980). Last and Duncan incorporated pre-existing data into their study and took additional samples to fill in data gaps. Last et al. (1994) published a 1981 report summarizing the results of Last and Duncan (1980) and additional data. In addition, a LFI study (DOE-RL 1995) completed additional characterization activities, including 1 borehole, 1 test pit, 10 cone penetrometer holes, a surface radiological survey, and surface soil and vegetation samples.

Last et al. (1994) did extensive sampling of cores from the bottom of the pond and surface samples from the perimeter of the pond (sampling performed in 1979). Cesium-137 concentrations for surface soil samples from the perimeter of the pond ranged from 1.86 to 26,200 pCi/g (1.17 to 16,548 pCi/g decayed to 1999), with an average of 4,544 pCi/g (2,870 pCi/g decayed to 1999). The highest results were near the inlet of the Z-Ditches and 216-U-14 Ditch. Last et al. (1994) considered cesium-137 the "index" radionuclide to determine the lateral extent of contamination. An "index" radionuclide is the isotope whose distribution best estimates the maximum extent of contamination. The study also concluded that plutonium, americium-241, uranium, and strontium-90 were important nuclides to note for decommissioning but used contamination limits in the tens-of-picocuries range to determine significance.

For well sediment data, Last et al. (1994) concluded that stronium-90 was a better index radionuclide to determine depth of contamination, because it was found at higher concentrations at depth than cesium-137. In well 299-W23-228 (at the confluence of the 216-U-14 Ditch and the 216-U-10 Pond), strontium-90 was 13 pCi/g in the first 10 cm of the sediment and 0.77 pCi/g at a depth of 7 m. In the same well, cesium-137 was 2,000 pCi/g at the top of the sediment layer and 0.25 pCi/g at 7-m depth.

The LFI for the 200-UP-2 OU (DOE-RL 1995) summarized the most significant results of its investigations from historic and LFI studies as follows:

- Historical data: Pond sediments showed maximum concentrations of cesium-137 and americium-241 in the northern area of the pond. Both contaminants showed measurable levels in the 0- to 10-cm depth of the pond bottom (while the pond was operating) and concentrations generally less than detection limits below this depth.

- Test pit: The pond bottom was found at a depth of 1.8 m (6 ft). A 15-cm (6-in.)-thick organic-rich silt layer indicated the old pond bottom. The contaminant inventory was highest in this layer: cesium-137 = 4,800 pCi/g; plutonium-238 = 23 pCi/g;

plutonium-239/240 = 36 pCi/g; stronium-90 = 190 pCi/g; uranium-233/234 = 85 pCi/g; and uranium-238 = 88 pCi/g (Figure 3-2). No additional layers of contaminants from previous stabilization activities were noted in the test pit.

- Borehole 299-W23-231: Americium-241 and cesium-137 were elevated at the depth of the former pond bottom, and plutonium-239/240 and uranium-233/234 were at slightly above background levels at the caliche layer in the Plio-Pleistocene unit (41.2 to 41.8 m [135 to 137 ft]). Figure 3-2 shows the sampling results from the LFI borehole and test pit.

- Cone penetrometer test: Results included elevated readings at the pond bottom (1.8 to 2 m [6 to 6.5 ft]) deep, with some deeper contamination. Elevated levels were also seen above the former pond bottom in some places, possibly as a result of previous stabilization activities that scrapped contamination from the perimeter to the center of the pond.

- Surface radiation survey: The pond's perimeter showed the highest amount of radioactivity.

- Surface soil and vegetation sampling: Generally low concentrations of contamination were found, but peaks of stronium-90 (415 pCi/g) were detected in a vegetation sample in the southwestern corner of the pond. Peaks of plutonium-239/240 (74.9 pCi/g) were also detected in the Z-Ditch delta region.

Prior to the LFI for the 200-UP-2 OU, the 200 Area U Plant AAMSR examined historical data regarding contamination at the 216-U-10 Pond. Conclusions from the U Plant AAMSR (DOE-RL 1992b) include the following:

- High plutonium values were localized in the delta region of the pond and in the lowermost reaches of the 216-Z-19 Ditch (adjacent to the 216-Z-11 Ditch). The maximum plutonium-239/240 concentration in the U Pond sediments was 12,500,000 pCi/g in a sample from 1980. Total plutonium concentrations may be higher because plutonium-238 was not included in the value. In 1974, the highest value reported for plutonium-238 was 1,144 pCi/g, with an average of 390 pCi/g for 60 samples. These contaminants were concentrated in the organic-rich former pond bottom.

- The distribution of americium-241 mimicked the plutonium distribution, but at levels an order of magnitude lower. The highest americium-241 concentration was 28,000 pCi/g in the delta region, with an average concentration of 54 pCi/g for 32 samples from the entire basin area.

- The highest concentration of total uranium in the pond sediments was 1,238 ppm, with most of the pond area bottom containing between 100 and 1,000 ppm uranium.

- The highest stronium-90 concentration in the sediments was 724 pCi/g (450 pCi/g decayed to 1999); the highest concentration of cesium-137 in the pond sediments was 19,600 pCi/g (12,400 pCi/g decayed to 1999).

Carbon tetrachloride was not detected in sediments or the perched water, but was detected at a maximum level of 140 ppb in groundwater below the 216-U-10 Pond.

Riley at al. (1986) examined the levels of polychlorinated biphenyls (PCBs) in the 216-U-10 Pond. The highest concentration from 21 samples of the pond sediments was 1.5 ppm from the delta region, with samples from other areas in the range of hundreds of parts per billion.

Groundwater monitoring at the 216-U-10 Pond indicates uranium at approximately 20 µg/L beneath the 216-U-10 Pond (Figure 3-3), indicating movement of uranium from the pond through the vadose zone (Schmidt et al. 1996). Last et al. (1994) reported 1980 groundwater sampling results and found uranium at 41 pCi/L in well 299-W18-15 below U Pond, and provided no results for uranium in perched water from well 299-W23-228. Other 1980 radionuclide sampling results for well 299-W18-15 from Last et al. (1994) were 32 pCi/L total alpha contamination, 2.4 pCi/L total beta contamination, <4.3 pCi/L cesium-137, <30 pCi/L cobalt-60, and 540 pCi/L tritium. Figures 3-4, 3-5, and 3-6 (from PNNL 1999) show contaminant plume maps for carbon tetrachloride, chloroform, and uranium under the 200 West Area, including the U Pond system. The chloroform plume in the 200 West Area is associated with the carbon tetrachloride plume; chloroform is a degradation product of carbon tetrachloride (PNNL 1999) and is believed to be the source of this plume.

The 200-UP-2 focused feasibility study (FFS) (DOE-RL 1996) reports an estimated contaminated volume of soil for the 216-U-10 Pond at 259,108 m^3 (338,900 yd^3), with an excavated soil volume of 265,300 m^3 (347,000 yd^3). The contaminated soil volume is based on a lateral area of 12 ha (30 acres) and depth of 2 m (7 ft) and assumes 1.2 m (4 ft) of backfill. Figure 3-1 shows an estimated lateral extent of contamination based on a RAO of 100 mrem/yr (from the FFS); this is provided for information only and is not provided to determine an appropriate RAO for these sites.

Ecological samples were collected from the 216-U-10 Pond as part of the *Limited Field Investigation for the 200-UP-2 Operable Unit* (DOE-RL 1995). Plants were found to contain concentrations of copper, lead, zinc, cesium-137, strontium-90, and plutonium-239 at concentrations greater than those detected from 200 Area reference locations. Barium and vanadium concentrations were greater than 100 Area reference locations. Concentrations of cesium-137 and strontium-90 were detected in small mammals that exceeded the 200 Area reference locations.

Additional ecological samples are routinely collected in the vicinity of the 216-U-10 Pond as part of the near-facility environmental monitoring. Soil and vegetation data samples are collected every two years from stations 001 through 004. The 1998 analytical results from these stations are presented in Table 3-2; station locations are presented in Perkins et al. (1999).

3.4 POTENTIAL IMPACTS TO HUMAN HEALTH AND THE ENVIRONMENT

This section describes the conceptual model developed to identify potential impacts on human health and the environment from waste sites in this group. Information pertaining to contaminant sources, release mechanisms, transport media, exposure route, and receptors is discussed to develop a conceptual understanding of potential risks and exposure pathways. This information will be used to support an evaluation of potential human health and environmental risk.

The largest sources of contamination at the waste sites in this group were major facilities (e.g., U Plant, Z Plant, and 242-S Evaporator) in the 200 West Area; lesser sources include the laundry facilities and the powerhouse in the 200 West Area. These facilities routinely discharged low-level contaminated wastewater to unlined ponds and ditches. Releases to the environment have resulted in secondary contaminant sources, which are the contaminated soils beneath the waste sites and the UPR sites. Secondary releases can occur through infiltration, resuspension of contaminated soil, volatilization, biotic uptake, leaching, and external radiation (gamma). The dominant mechanism of contaminant transport is related to infiltration. Residual moisture from effluent discharge has the potential to impact groundwater, as it may be currently migrating through the soil column by gravity drainage in some areas.

Potential receptors (human and ecological) may be exposed to the affected media through several exposure pathways, including inhalation, ingestion, and direct exposure to external gamma radiation. Potential human receptors include current and future site workers and visitors (occasional users). Potential ecological receptors include terrestrial plants and animals. The conceptual exposure model for the 200-CW-5 OU is shown in Figure 3-7. Aquatic biota and surface water (Columbia River) are not included in the conceptual exposure model because there is no surface water in the OU, and groundwater contamination from this OU is low enough such that aquatic biota along the Columbia River are unlikely receptors. Future impacts to humans are largely dependent on the land use. The type of future land use has been identified in the *Revised Draft Hanford Remedial Action Environmental Impact Statement and Comprehensive Land Use Plan* (DOE 1999).

Identification of ecological receptors and potential impacts to those receptors have been evaluated at waste sites within the 200 Areas (Perkins et al. 1999, Rogers and Rickard 1977, Stegen 1993). The vegetation cover within the 200 Area Plateau is dominantly a rabbitbrush/cheatgrass and sagebrush/cheatgrass association with incidence of herbaceous and annual species. Many areas are disturbed and non-vegetated, or sparsely vegetated with annuals and weedy species such as Russian thistle. The contamination pathway to ecological exposures for the waste sites are minimized due to stabilization activities that have been conducted.

Ecological risks associated with exposure of the Great Basin pocket mouse to chemical and radiological contaminants were evaluated as part of the *Limited Field Investigation for the 200-UP-2 Operable Unit* (DOE 1995). The evaluation was conducted based on biological monitoring data (Johnson, et al., 1994) and modeling results using relative risks to evaluate the sites. Risks were assigned to each of the waste sites based on environmental hazard quotient (EHQ) results, and are presented below:

- High (EHQ $\geq$ 100)
- Medium (EHQ >10 and <100)
- Low (EHQ $\leq$ 10).

216-U-10 Pond. Chemicals and radionuclides were modeled from soil to the ecological receptors to estimate potential impacts on 216-U-10 biota. No chemicals at a soil depth of 0 to 1.9 m (0 to 6 ft) were predicted to be potentially hazardous to the mouse. Barium, copper, and zinc were found to have EHQs greater than 1 for soil depths from 1.9 to 4.5 m (6 to 15 ft). No radionuclides were found to result in a dose of greater than 1 rad/day to the mouse.

Modeling maximum concentrations measured in plants resulted in an HQ greater than 1 for barium, copper and vanadium. A total internal dose rate of less than 1 rad/day to the mouse was estimated from ingestion of the maximum activity measured in plant matter.

Data collected from mice living adjacent to the 216-U-10 Pond and 216-Z-19 Ditch from 1975 to 1977 (during operation) showed the highest exposure rate of 1.47 roentgens (R)/week or 0.21 R/day to the pocket mouse (Gano 1979). Soil data was also collected along the same sampling transects for the mice. Results showed the highest gamma exposure of 37 mrad/yr or 0.1 mrad/day and neutron exposure of 75 R/yr or 0.2 R/day from soils 0 to 1 decimeter below the surface.

216-U-11 Trench. Chemicals from the soil to the ecological receptors for the 216-U-11 biota were inferred from the modeling results from 216-U-10 Pond, which incorporated the 216-U-10 and 216-U-11 data. Radionuclides from the soil to the ecological receptor were modeled; no radionuclides were found to result in a dose greater than 1 rad/day to the mouse using soil concentrations from the 0- to 1.9-m (0- to 6-ft) interval.

Modeling maximum concentrations measured in plants resulted in an HQ greater than 1 for copper. A total internal dose rate of less than 1 rad/day to the mouse was estimated from ingestion of the maximum activity measured in plant matter.

216-U-14 Ditch. Radionuclides were modeled from soil to the ecological receptors to estimate potential impacts on 216-U-14 biota. No radionuclides were found to result in a dose of greater than 1 rad/day to the mouse for the sample interval 0 to 1.9 m (0 to 6 ft).

216-Z-11 Ditch. The only ecological data from the Z-Ditches are radionuclides concentrations in mice from the 216-Z-19 Ditch; therefore, no modeling was conducted.

The risk modeling conducted for the 200-UP-2 LFI, concluded that the ecological risk associated with the 216-U-10 Pond and 216-U-11 ditch were considered medium, the 216-Z-11 Ditch was considered low to medium, and the 216-U-14 Ditch was considered low. Based on the ecological sampling and associated evaluations conducted at the sites in the 200-CW-5 OU, no additional site-specific ecological data are considered necessary to support the RI/FS process.

3.5 DEVELOPMENT OF CONTAMINANTS OF POTENTIAL CONCERN

The development of the COPC list for the 216-Z-11 Ditch and refinement to the contaminant of concern (COC) list was one of the main objectives of the DQO process for the 200-CW-5 DQO. The DQO process is more fully described in Section 4.1. The preliminary list of COPCs included the complete set of contaminants that were potentially discharged to the ditch from the

Z Plant, as discussed in Section 2.2. The master list of COPCs was developed during the DQO process from the Z Plant AAMSR (DOE-RL 1992c) and the *Plutonium Finishing Plant Wastewater Stream-Specific Report* (Jensen 1990). This list was subsequently evaluated against a set of exclusion criteria to enable the development of a final COC list. Chemical characteristics such as toxicity, persistence, and chemical behavior in the environment were considered. The criteria for exclusion, as detailed in the DQO summary report (BHI 1999), are as follows:

- Short-lived radionuclides (half-lives of less than 3 years)
- Radionuclides that constitute less than 1% of the fission product inventory. Historical sampling also indicates that these radionuclides have not been detected in the environment
- Naturally occurring isotopes that were not created during Hanford Site operations
- Constituents with atomic mass greater than 242 that represent less than 1% of the actinide activities
- Progeny radionuclides that build insignificant activities within 50 years, and/or for which parent/progeny relationships exist that permit progeny estimation
- Constituents that have been diluted, neutralized, and/or decomposed by the facility processes (e.g., mixture with very large water volumes or the mixture of acids and bases)
- Solid materials that could not have leaked past process tubes for release to the environment
- Chemicals in the gaseous state that cannot accumulate in soil media
- Chemicals used in minor quantities relative to the bulk-production chemicals consumed in the normal processes; these chemicals are not likely to be present in toxic or high concentrations due to the significant dilution during cooling water discharges
- Chemicals that are not persistent in the environment due to biological degradation or a natural mitigating feature.

The exclusion process resulted in a final list of COCs for the 216-Z-11 Ditch, which is presented in Table 3-6. The preliminary lists of COPCs and the excluded analytes and rationale for exclusion are presented in Tables 1-5 and 1-6 of the DQO summary report (BHI 1999). Additional information regarding the COPCs is presented in the DQO summary report and Section 4.0 of this document.

3.6 SITE-SPECIFIC CONCEPTUAL MODELS

Site-specific conceptual models have been developed from the previous information presented in Section 3.0 for each of the representative waste sites. These models, presented in Figures 3-8 through 3-10, share certain of the waste deposition and transport properties with the generic conceptual model in Section 2.3, but there are differences in the COCs, their concentrations, and their effect on the vertical contaminant distribution in the vadose zone. These site-specific differences are noted for each waste site in the figures provided.

Waste Site Dimensions	
216-U-10 Pond	**- 12.2 hectares (30 acres)/1.8 m (6 ft.) deep**
216-U-14 Ditch	**- 1,700 m (5,600 ft.) long/1.2 m (4 ft.) deep**
216-Z-1D Ditch	- 1,311.5 m (4,300 ft.) long/.6 m (2 ft.) deep
216-Z-11 Ditch	**- 797.0 m (2,615 ft.) long/.6 m (2 ft.) deep**
216-Z-19 Ditch	- 843.3 m (2,765 ft.) long/1.2 m (4 ft.) deep
216-Z-20 Crib	- 463.3 m (1,519 ft.) long/5.5 m (18 ft.) deep
216-U-11 Trench	- 1,375.5 m (4,510 ft.) long/1.2 m (4 ft.) deep
216-U-9 Ditch	- 2,135 m (7,000 ft.) long/1.5 m (5 ft.) deep
207-U Basins	- 75 m (246 ft.) x 37.5 m (123 ft.)/2 m (6.5 ft.) deep

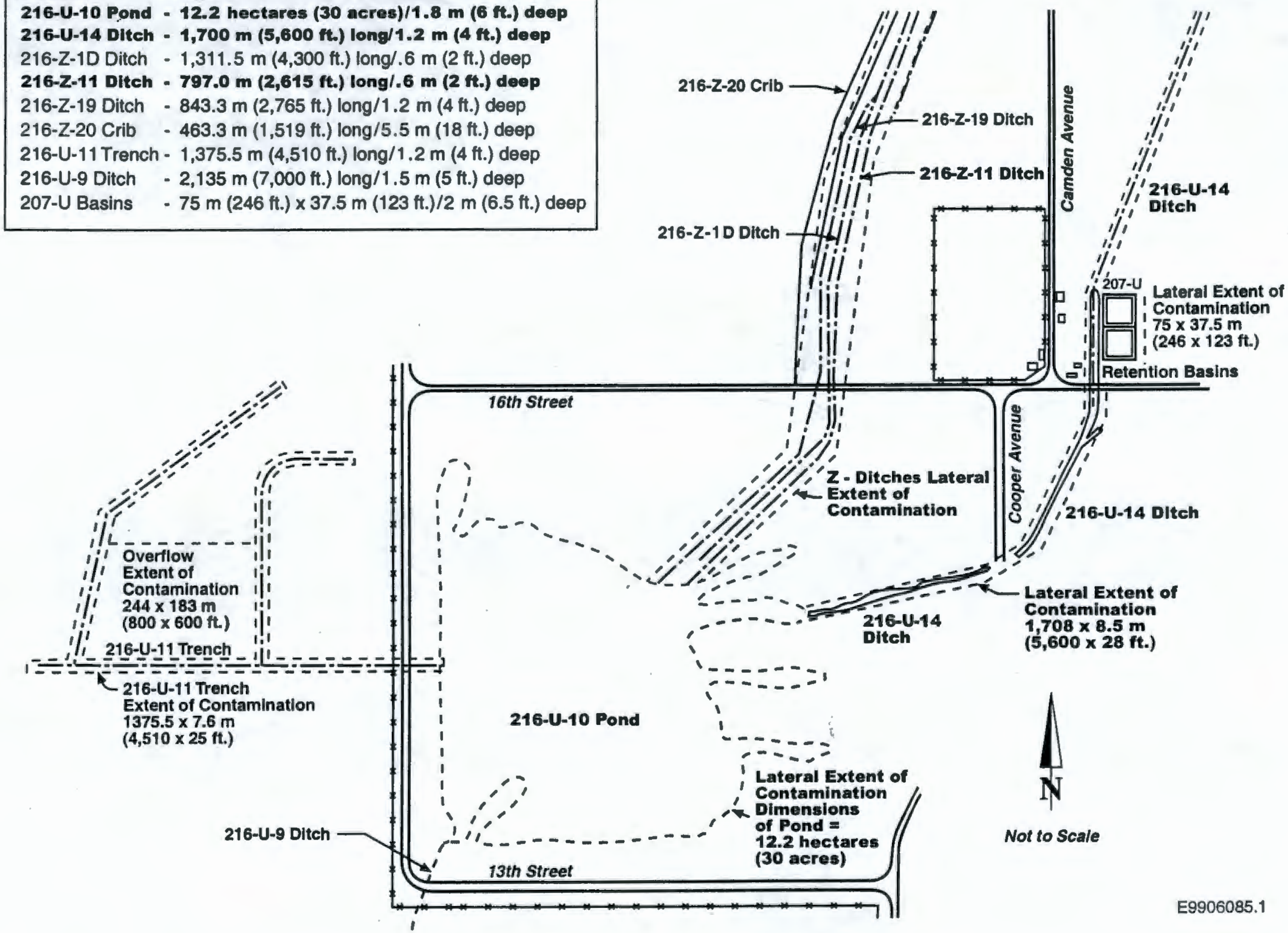


Figure 3-1. 216-U-10 Pond System Lateral Contamination (from DOE-RL 1996).

THIS PAGE INTENTIONALLY
LEFT BLANK

Figure 3-2. 216-U-10 Pond Borehole Data (from DOE-RL 1996)

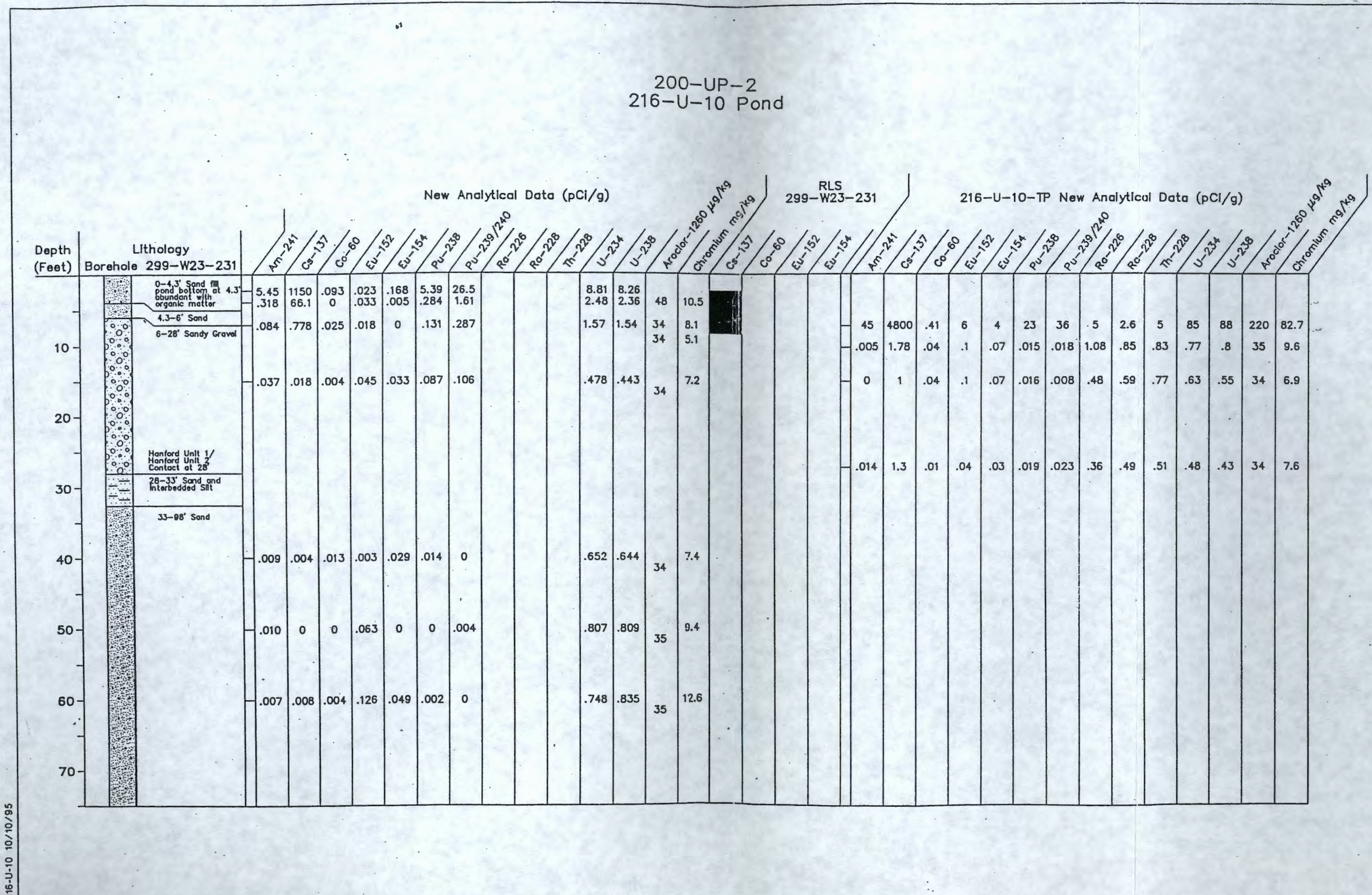


Figure 3-3. 216-U-10 Pond Borehole Data (from DOE-RL 1996).

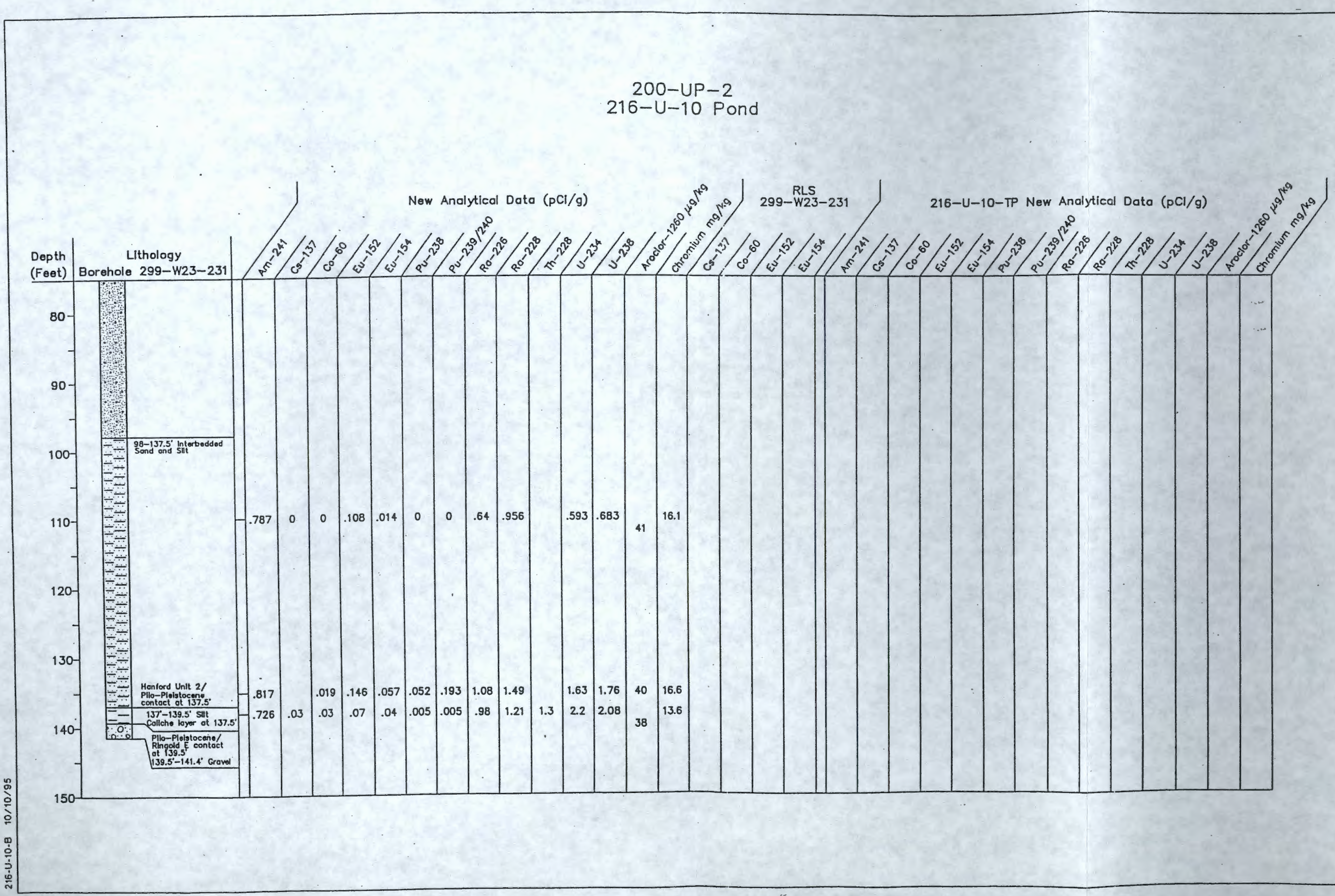


Figure 3-4. Uranium Concentration Versus Time Near the 216-U-14 Ditch.

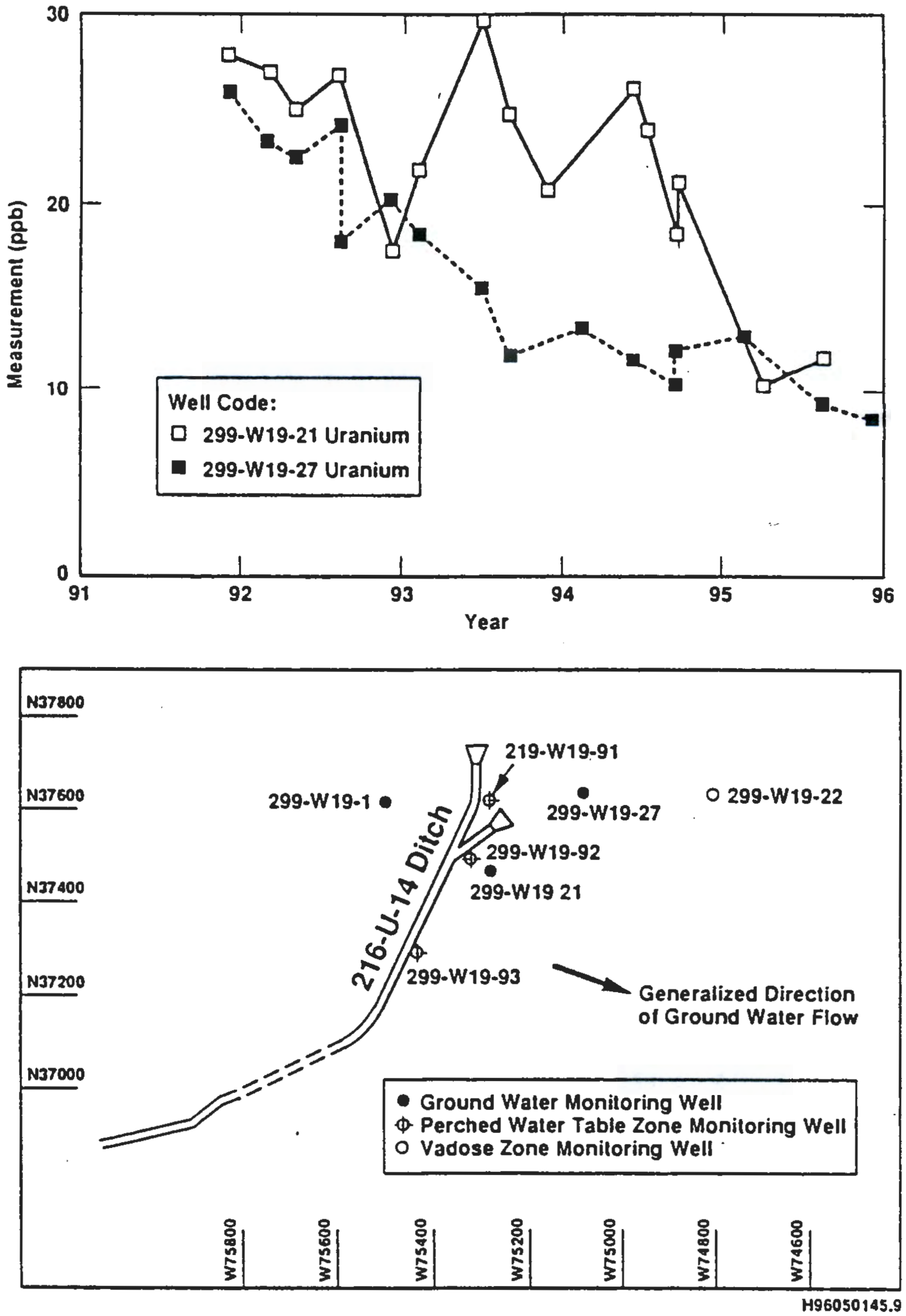
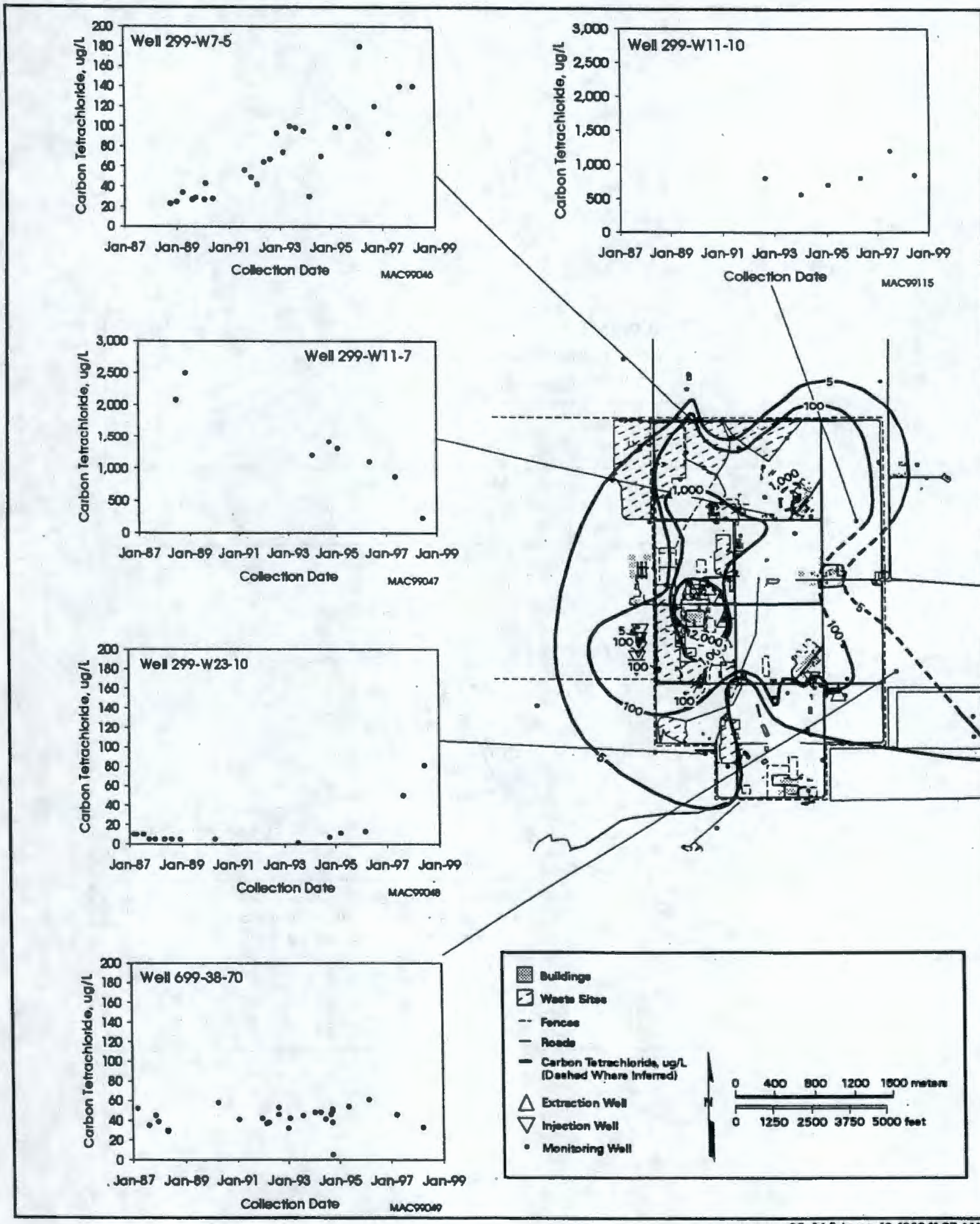


Figure 3-5. Carbon Tetrachloride Concentrations in Wells Monitoring the 200 West Area, Top of Unconfined Aquifer.



can_gwrep98_24 February 12, 1999 11:37 AM

Figure 3-6. Average Chloroform Concentrations in the 200 West Area, Top of Unconfined Aquifer.

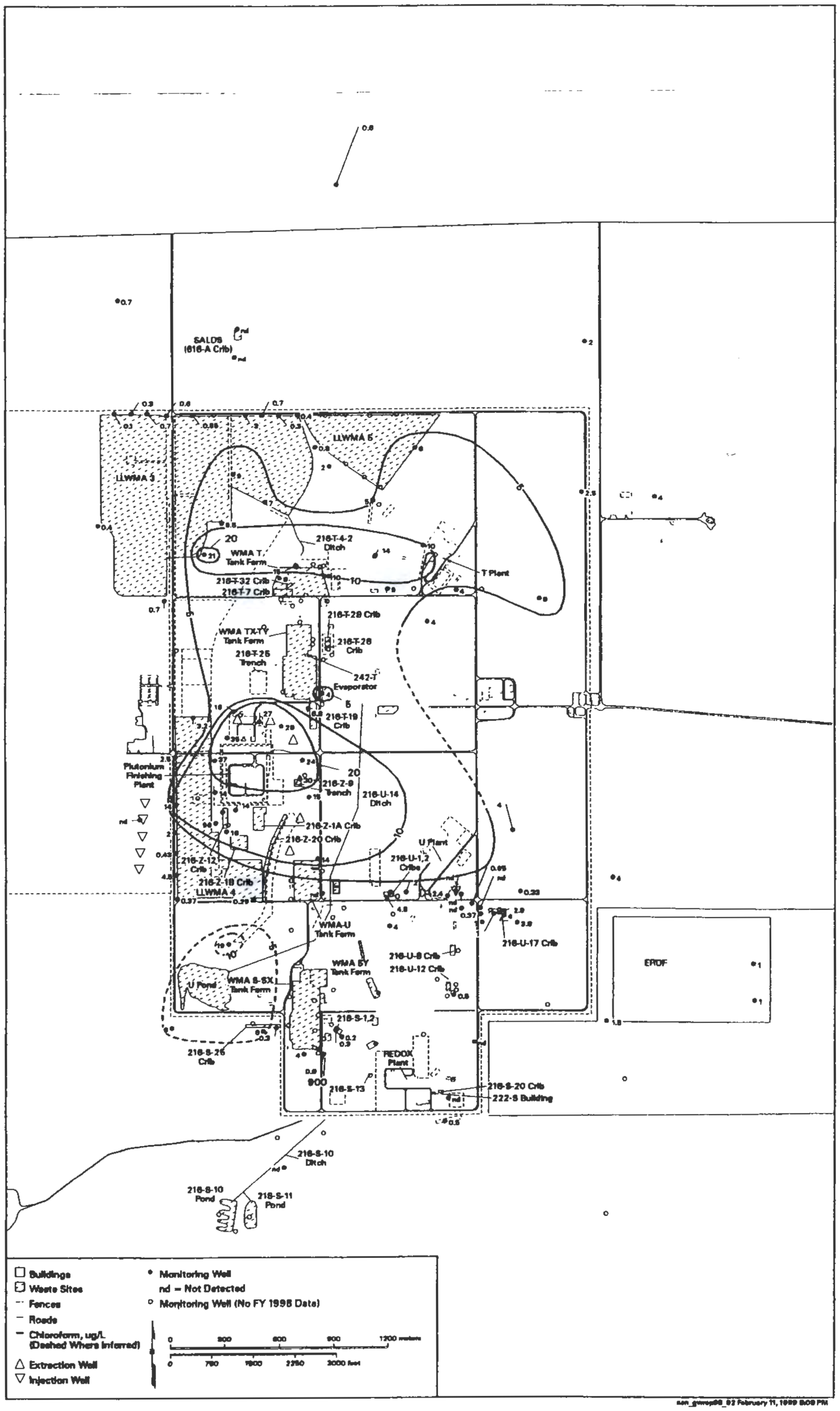
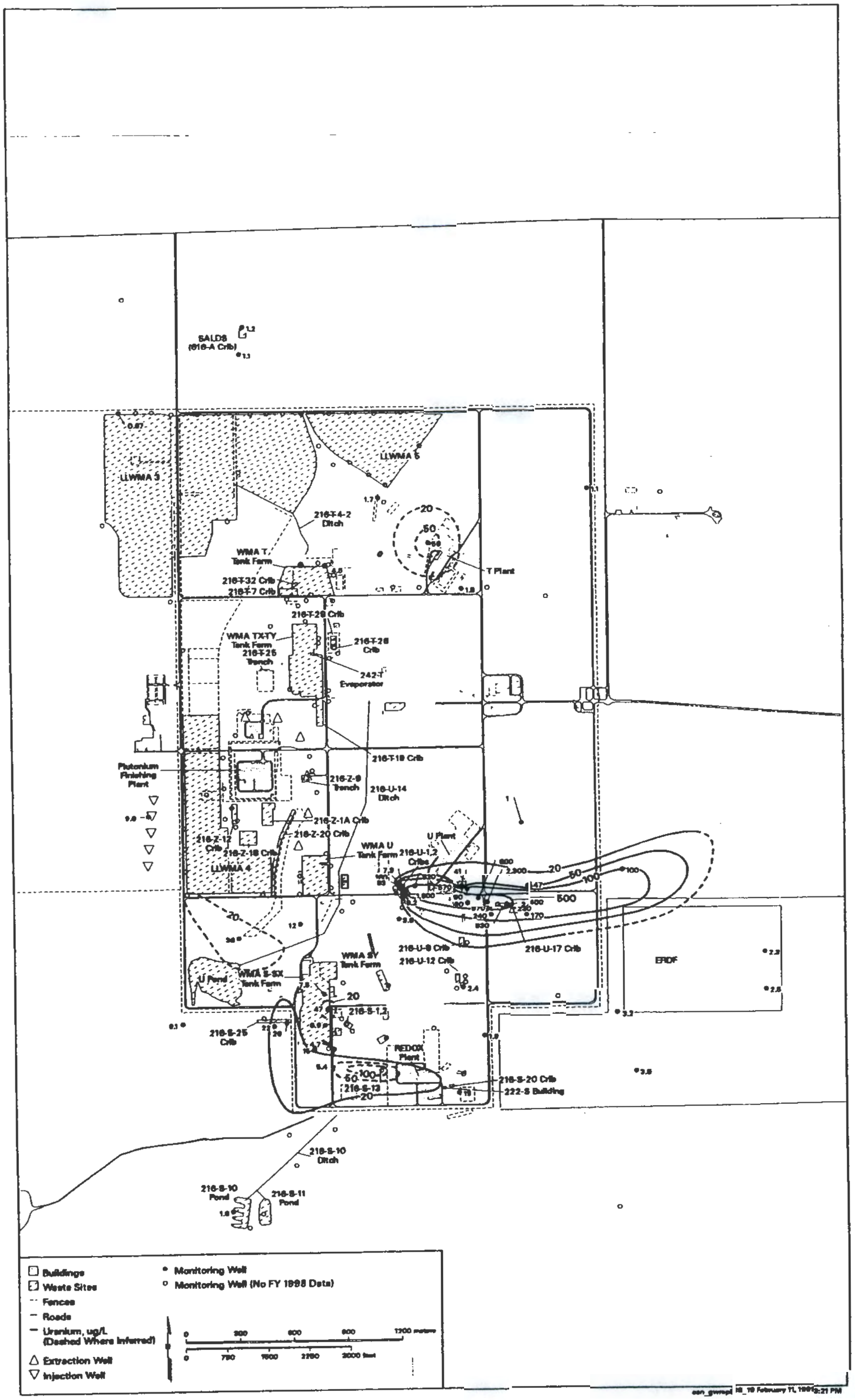


Figure 3-7. Average Uranium Concentrations in the 200 West Area, Top of Unconfined Aquifer.



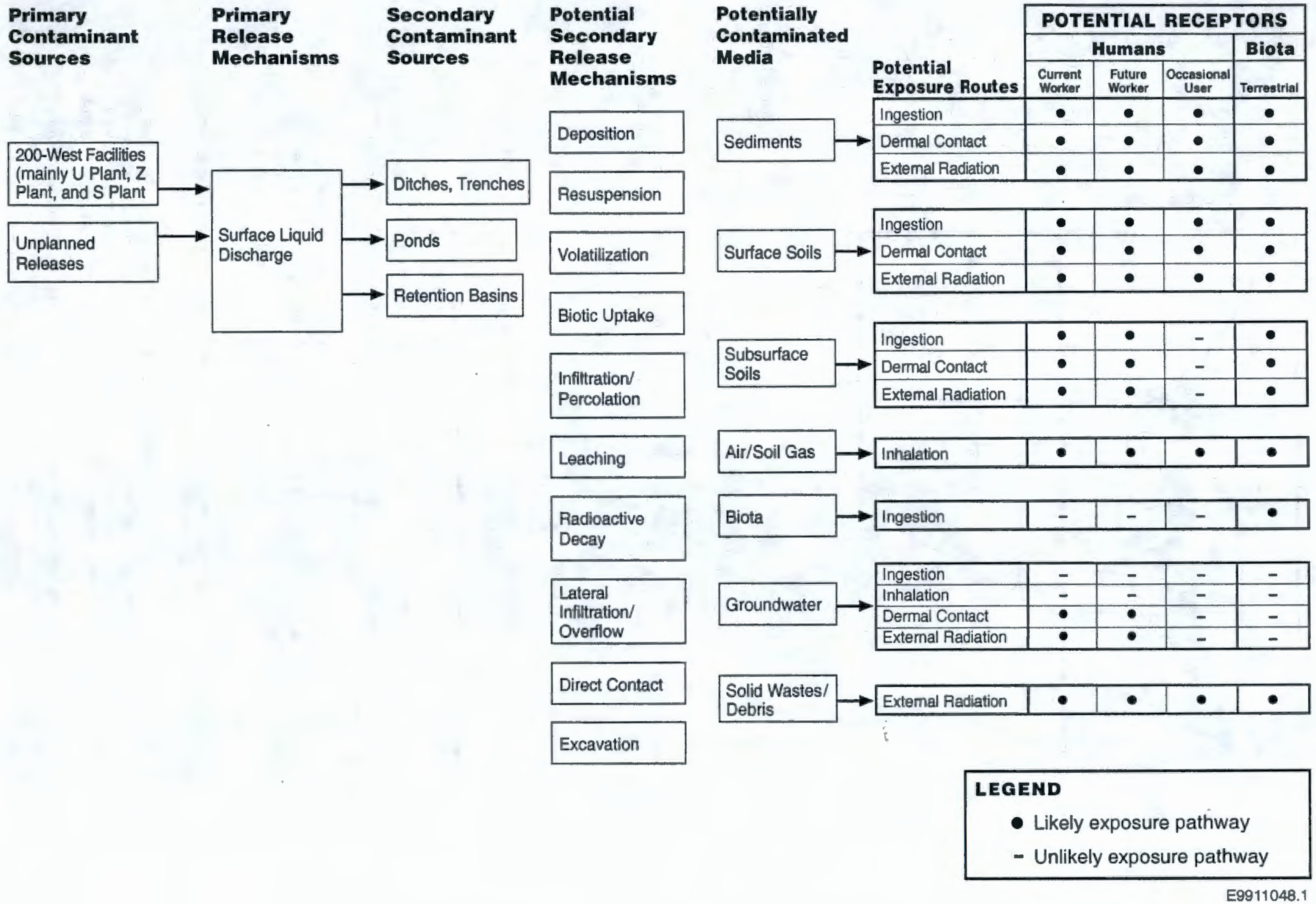
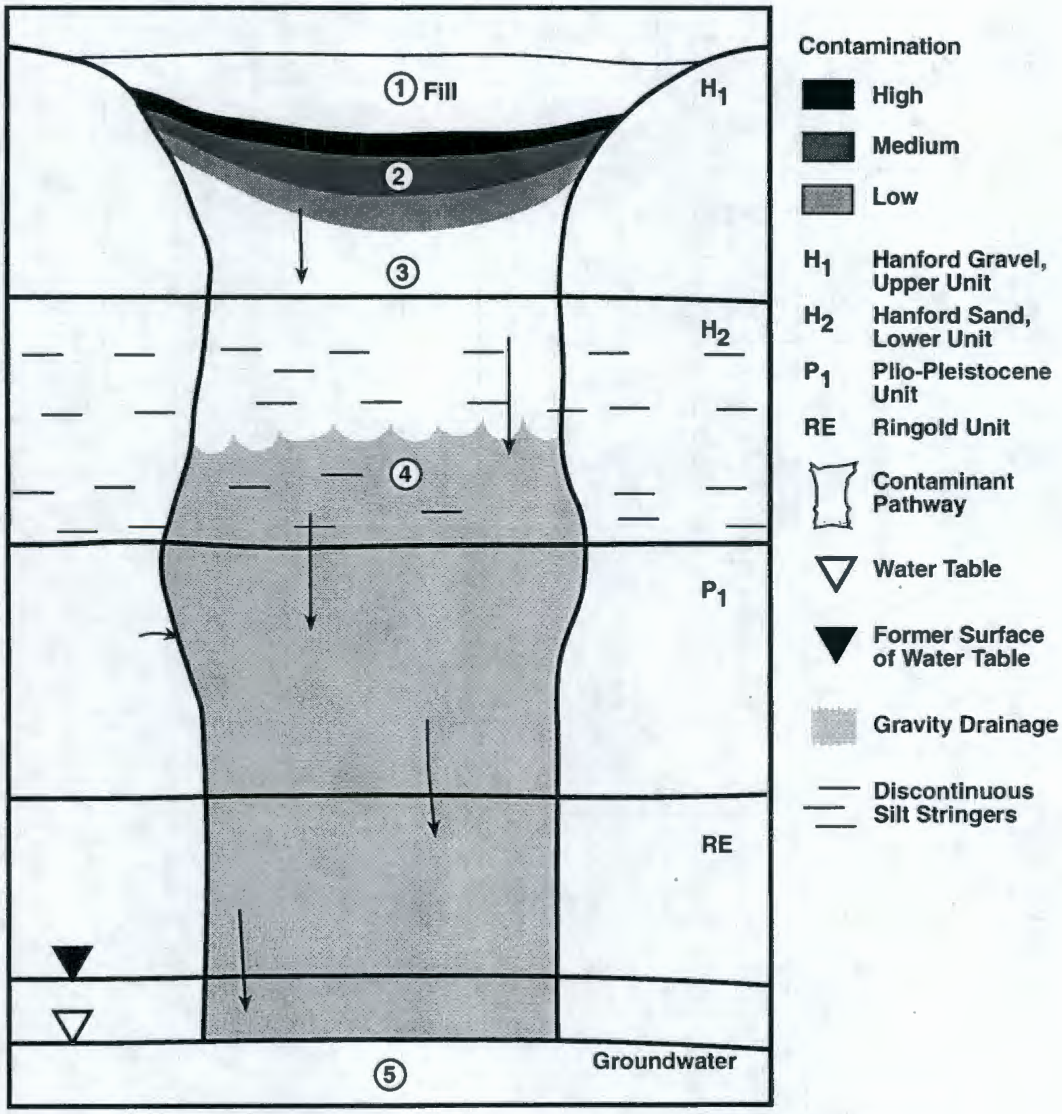


Figure 3-8. Conceptual Exposure Model for the 200-CW-5 Operable Unit Waste Sites.

Figure 3-9. Conceptual Model of Contaminant Distribution at the 216-U-10 Pond After Cessation of Discharge.



① Site has been backfilled/stabilized with clean soil. Upward migration of contaminants has been noted in the clean fill on the Hanford site.

② Some particulates in solution (e.g.,Cs-137, Pu-239/240, uranium, Sr-90, metals, and PCB's) settled out in the bottom of the pond and sorbed to sediments. The highest concentrations are within 2 m of the pond bottom and decrease rapidly with depth. Some uranium complexed with carbonates in the soil and moved with the wetting front.

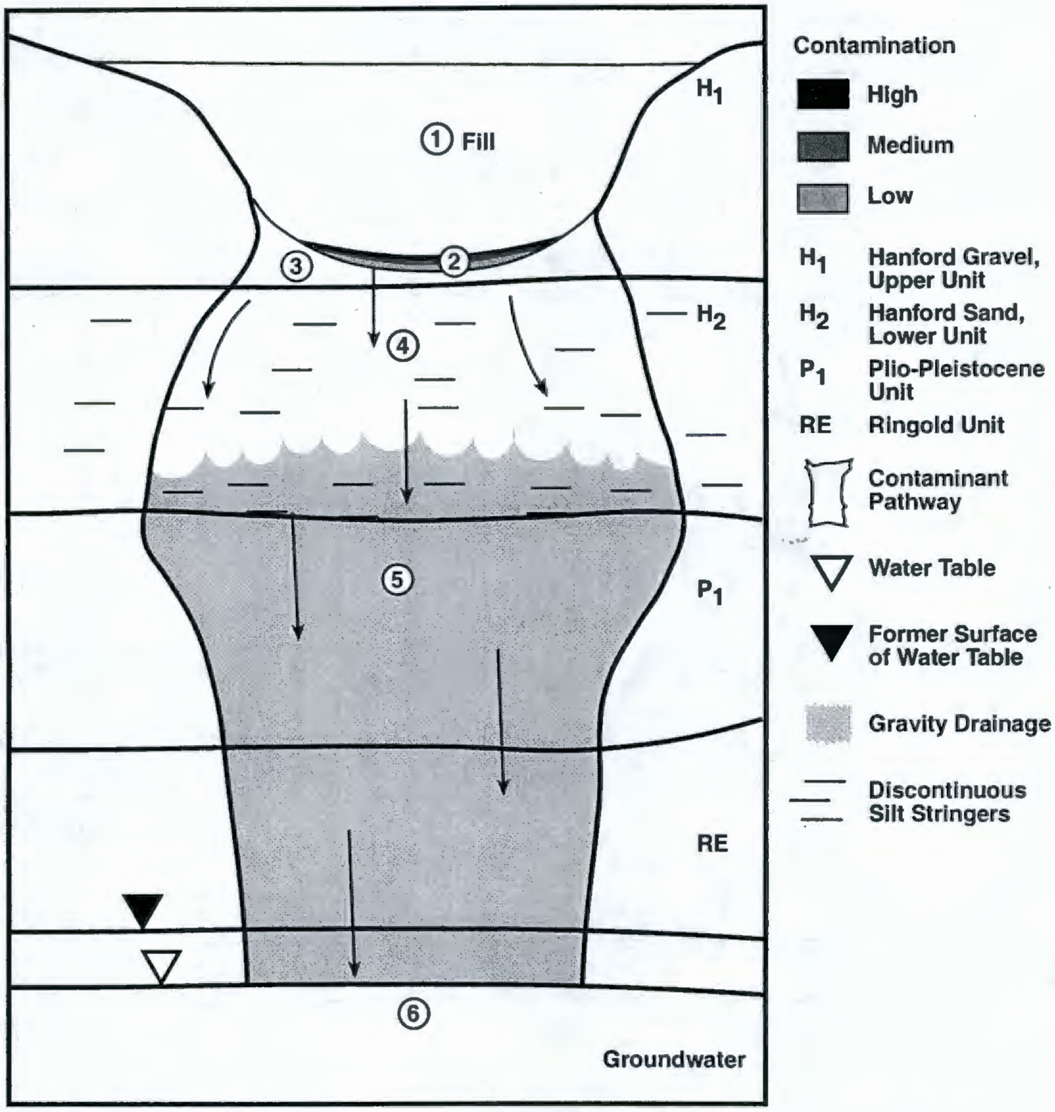
③ Contaminant concentrations are very low compared to the bottom of the pond. Uranium and Sr-90 may be detected in this zone.

④ High moisture zone. Lateral spreading within the lower unit of the Hanford formation and at the top of the Plio-Pleistocene unit. Moisture flux in this zone is decreasing over time. Wetting front moves vertically down into Ringold Unit E with gravity drainage. Residual contamination may remain in vadose zone after gravity drainage.

⑤ High volumes of liquid exceeded soil pore volumes and clastic dikes may have been mechanisms to allow low levels of contaminants to reach groundwater. Evidence suggests that uranium from the pond has impacted the groundwater.

E9906085.4

Figure 3-10. Conceptual Model of Contaminant Distribution at the 216-U-14 Ditch After Cessation of Discharge.



① Site has been backfilled/stabilized with clean soil. Upward migration of contaminants has been noted in the clean fill on the Hanford site.

② Some particulates in solution (e.g., Cs-137) settled out in the bottom of ditch. Most of the dissolved contaminants in solution sorbed to sediments within 2 m of the ditch bottom; concentrations decrease rapidly with depth. Some uranium complexed with carbonates in the soil and moved with the wetting front.

③ Contaminant concentrations are very low compared to the bottom of the ditch.

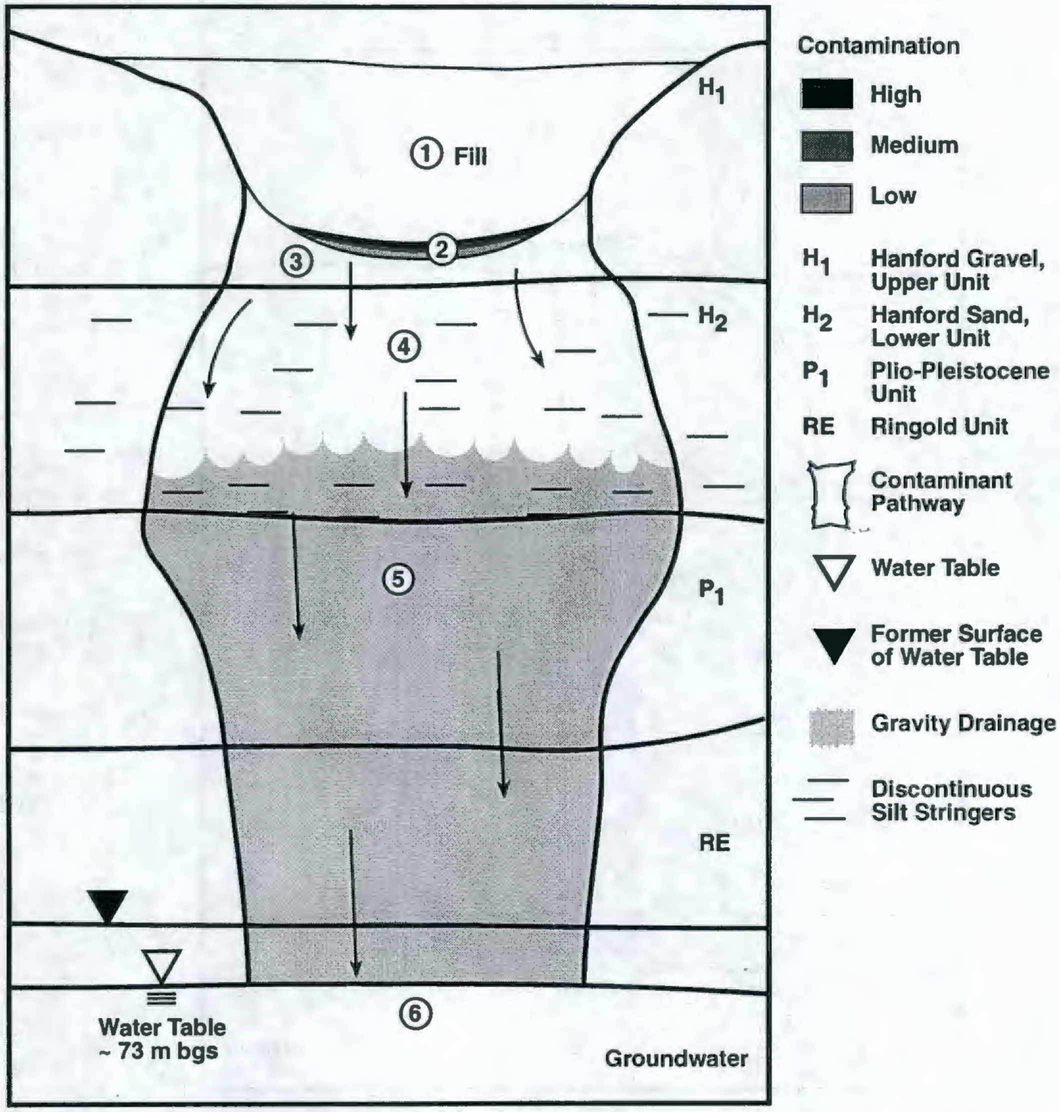
④ Lateral spreading within the lower unit of the Hanford formation and at the top of the Plio-Pleistocene unit; perched water zones formed under much of the ditch during period of active discharge. Contaminants that were detected in the perched water are: arsenic, manganese, Sr-90, Co-60, U-238, and gross alpha and beta.

⑤ High moisture zone. Moisture flux in this zone is decreasing over time as effluent is no longer discharged to the soil column. Wetting front moves vertically down into Ringold Unit E with gravity drainage. Residual contamination may remain in the vadose zone after gravity drainage.

⑥ High volumes of liquid exceeded soil pore volumes and clastic dikes may have been mechanisms to allow low levels of contaminants (e.g., manganese, U-238) to reach groundwater.

E9906085.3

Figure 3-11. Conceptual Model of Contaminant Distribution at the 216-Z-11 Ditch After Cessation of Discharge.



① Site has been backfilled/stabilized with approximately 2 m of clean soil. Upward migration of contaminants has been noted in the clean fill on the Hanford site.

② Some particulates in the effluent (e.g., Pu-239/240, Am-241) settled out in the bottom of ditch. Most of the dissolved contaminants in solution sorbed to sediments within 2 m of the ditch bottom; concentrations decrease rapidly with depth.

③ Contaminant concentrations are very low compared to the bottom of the ditch.

④ Lateral spreading within the lower unit of the Hanford formation and at the top of the Plio-Pleistocene unit.

⑤ High moisture zone. Moisture flux in this zone is decreasing over time. Wetting front moves vertically down into Ringold Unit E with gravity drainage. Residual concentrations of the more mobile contaminants may remain in the vadose zone after gravity drainage.

⑥ No contaminants have been attributed to the groundwater from the 216-Z-11 ditch.

E9910047.1

Table 3-1. Estimated Inventory for 200-CW-5 Operable Unit Waste Sites.

Waste Site	Total U (kg)	Total Pu (g)	Am-241 (Ci)	Cs-137 (Ci)	Sr-90 (Ci)	CCl_4 (kg)	Nitrate (kg)	Effluent Volume (m^3)
216-U-10	1.4E+03	-- [a]	--	1.2E+01	1.7E+01	--	--	>1.17E+11
216-U-14	4.5E+01	--	--	--	--	--	--	>1.22E+09
216-Z-1D	--	--	--	--	--	--	--	1.0E+03
216-Z-11	--	8.1E+03 [b]	4.92E-01 [b]	--	--		--	>6.7E+08
216-Z-19	--	--	--	--	--	1.0E+00	--	--
216-Z-20	--	1.48E-01	1.01E+00	8.64E-02	6.30E-02	--	3.4E+03	3.8E+06

[a] Not reported.
[b] Plutonium inventory for the Z-Ditches in most documents is included with the inventory for the 216-U-10 Pond but, because most of the plutonium is expected to be remaining in the ditches, it is shown here as part of the 216-Z-11 Ditch.
CCl_4 = carbon tetrachloride

Table 3-2. 1998 Surface Soil and Vegetation Data (in pCi/g).[a]

Isotope	216-U-10 Pond		216-U-11 Trench		216-U-14 Ditch	216-Z-11 Ditch
	Soil (D002)	Soil (D004)	Soil (D104)	Soil (D110)	Soil (D004)	Soil (D008)
Co-60	3.8E-03	2.4E-04	3.2E-03	1.3E-04	2.4E-04	-2.0E-03
Zn-65	-5.5E-03	4.6E-03	-7.3E-03	-3.0E-03	4.6E-03	-3.7E-03
Sr-90	5.5E-03	3.2E-02	2.5E-01	3.4E-01	3.2E-02	-1.0E-01
Ru-103	-1.8E-03	3.6E-03	3.9E-04	-1.6E-03	3.6E-03	-4.6E-03
Ru-106	-2.5E-02	-3.2E-02	-3.0E-02	7.4E-02	-3.2E-02	-7.8E-04
Sn-113	-2.8E-03	-7.0E-03	-8.8E-03	1.1E-03	-7.0E-03	2.5E-03
Sb-125	3.6E-03	1.3E-02	-1.0E-02	3.5E-03	1.3E-02	9.7E-03
Cs-134	3.4E-02	3.0E-02	2.4E-02	4.4E-02	3.0E-02	3.9E-02
Cs-137	1.4E-01	6.2E-01	3.4E+00	6.0E-03	6.2E-01	5.0E-02
Ce-144	-4.4E-02	3.2E-02	-1.6E-02	4.4E-02	3.2E-02	-1.6E-02
Eu-152	-1.6E-02	-1.5E-02	-9.3E-03	5.9E-02	-1.5E-02	-5.2E-03
Eu-154	-9.5E-03	-3.1E-03	-7.5E-03	-6.9E-03	-3.1E-03	4.5E-03
Eu-155	5.1E-02	2.1E-02	5.4E-02	3.8E-02	2.1E-02	4.0E-02
U-234	2.0E-01	1.9E-01	2.1E-01	1.6E-01	1.9E-01	1.3E-01
U-235	2.0E-02	1.3E-02	1.4E-02	2.7E-02	1.3E-02	1.3E-02
U-238	2.1E-01	2.4E-01	2.4E-01	1.4E-01	2.4E-01	1.5E-01
Pu-238	4.0E-03	9.7E-04	-5.9E-03	2.3E-03	9.7E-04	2.0E-02
Pu-239/240	1.0E-02	2.2E-02	4.9E-03	2.3E-03	2.2E-02	1.4E+00

Isotope	216-U-10 Pond		216-U-11 Trench		216-U-14 Ditch	216-Z-11 Ditch
	Vegetation (D002)	Vegetation (D004)	Vegetation (D104)	Vegetation (D110)	Vegetation (D004)	Vegetation (D008)
Co-60	-1.5E-02	-1.7E-02	8.2E-03	-9.1E-03	-1.7E-02	-1.4E-02
Zn-65	1.1E-01	1.1E-01	-5.9E-02	1.3E-01	1.1E-01	-3.1E-02
Sr-90	4.8E-01	-3.5E-02	4.4E-04	1.3E-02	-3.5E-02	-3.3E-02
Ru-103	-3.4E-02	-2.2E-02	9.5E-03	-1.1E-02	-2.2E-02	-2.1E-02
Ru-106	-2.5E-02	-1.5E-01	-1.5E-01	-7.6E-02	-1.5E-01	2.1E-01
Sn-113	-2.9E-02	-4.2E-02	3.8E-03	-1.8E-02	-4.2E-02	-3.4E-02
Sb-125	2.3E-02	-1.2E-01	-3.0E-02	5.7E-02	-1.2E-01	2.6E-02
Cs-134	1.8E-02	5.2E-02	2.9E-03	-1.7E-02	5.2E-02	1.5E-02
Cs-137	2.5E-01	5.8E-02	-7.7E-03	-2.0E-02	5.8E-02	-1.4E-03
Ce-144	4.7E-02	-1.7E-01	-6.7E-02	3.5E-02	-1.7E-01	-2.4E-01
Eu-152	1.1E-01	5.3E-02	1.5E-02	-9.1E-03	5.3E-02	4.3E-02
Eu-154	-3.3E-02	-1.4E-01	-9.4E-03	-3.7E-02	-1.4E-01	3.5E-02
Eu-155	6.2E-02	-3.6E-02	2.4E-02	8.2E-02	-3.6E-02	1.1E-01
U-234	4.2E-02	1.1E-02	3.5E-02	3.0E-02	1.1E-02	9.4E-03
U-235	1.3E-02	6.0E-03	2.1E-02	1.5E-02	6.0E-03	5.7E-03
U-238	1.1E-02	8.7E-03	8.9E-03	7.3E-03	8.7E-03	7.3E-03
Pu-238	-5.7E-04	6.2E-03	3.7E-03	3.0E-03	6.2E-03	5.5E-03
Pu-239/240	1.1E-03	3.4E-03	-2.5E-03	1.0E-02	3.4E-03	6.1E-02

[a]Data from the *Hanford Site Near-Facility Environmental Monitoring Data Report for Calendar Year 1998* (PNNL 1999b).

Table 3-3. Summary of Maximum Levels Detected from Three 1992 Test Pits in the West End of the 216-U-14 Ditch (from Singleton 1993).

Constituent	Maximum Level Detected (pCi/g)	Depth (ft)
Am-241	1.6	0-0.05
Co-60	2.3	0-0.5
Cs-137	1600	0-0.5
Pu-238/239	2.1	0.5-1
Sr-90	6.6	5-6
Pb-214	0.1	3-4
Total U	350	0.05-1

Table 3-4. Summary of Contaminants Reported by Singleton and Lindsey (1994) at the 216-U-14 Ditch and 216-U-10 Pond. (4 Pages)

Contaminant	Location	Well 299-W18-15 (216-U-10 Pond) (min-max)	216-U-14 Ditch (1980-1992 max)	216-U-14 Ditch (1993 max)
Aroclor-1254 (ppb)	Test Pits	ND	ND	7
	Well Sediments	ND	ND	UD
	Perched Water Zone	ND	ND	UD
	Groundwater	UD	ND	UD
Arsenic (ppb)	Test Pits	ND	ND	2,200
	Well Sediments	ND	ND	3,700
	Perched Water Zone	ND	ND	22
	Groundwater	10-12	14	14
Acetone (ppb)	Test Pits	ND	ND	12
	Well Sediments	ND	ND	16
	Perched Water Zone	ND	ND	UD
	Groundwater	UD	UD	UD
Bis-(2-ethyl hexyl) phthalate (ppb)	Test Pits	ND	ND	97
	Well Sediments	ND	ND	UD
	Perched Water Zone	ND	UD	UD
	Groundwater	UD	UD	UD
Carbon Tetrachloride (ppb)	Test Pits	ND	ND	UD
	Well Sediments	ND	UD	UD
	Perched Water Zone	ND	UD	UD
	Groundwater	89-140	17/8.2[a]	9.2/14
Manganese (ppb)	Test Pits	ND	ND	330,000
	Well Sediments	ND	ND	470,000
	Perched Water Zone	ND	ND	44
	Groundwater	UD/10	UD/53[a]	51/210[a]

Table 3-4. Summary of Contaminants Reported by Singleton and Lindsey (1994) at the 216-U-14 Ditch and 216-U-10 Pond. (4 Pages)

Contaminant	Location	Well 299-W18-15 (216-U-10 Pond) (min-max)	216-U-14 Ditch (1980-1992 max)	216-U-14 Ditch (1993 max)
Silver (ppb)	Test Pits	ND	ND	3,300
	Well Sediments	ND	ND	UD
	Perched Water Zone	ND	ND	UD
	Groundwater	UD	3	UD
Nitrate (ppb)	Test Pits	ND	ND	ND
	Well Sediments	ND	ND	7,000
	Perched Water Zone	ND	1,400	1,900
	Groundwater	UD-27,600	3,440/7,000[a]	600/18,000[a]
Nickel (ppb)	Test Pits	ND	ND	11,000
	Well Sediments	ND	ND	69,000
	Perched Water Zone	ND	ND	UD
	Groundwater	UD	UD	UD
Vanadium (ppb)	Test Pits	ND	ND	68,000
	Well Sediments	ND	ND	69,000
	Perched Water Zone	ND	ND	37
	Groundwater	21	40	35
Methyl ethyl ketone (ppb)	Test Pits	ND	ND	UD
	Well Sediments	ND	ND	47
	Perched Water Zone	ND	UD	UD
	Groundwater	UD	UD	UD
Pyridine (ppb)	Test Pits	ND	ND	ND
	Well Sediments	ND	ND	210
	Perched Water Zone	ND	ND	ND
	Groundwater	ND	ND	ND
Tetrahydrofuran (ppb)	Test Pits	ND	ND	UD
	Well Sediments	ND	ND	25
	Perched Water Zone	ND	UD	UD
	Groundwater	UD	UD	UD
Americium-241 (pCi/g)	Test Pits	ND	100/1.6[b]	1
	Well Sediments	ND	ND	UD
	Perched Water Zone	ND	UD	0.05
	Groundwater	UD	UD/0.77[a]	UD
Cobalt-60 (pCi/g)	Test Pits	ND	290/2.3[a]	1
	Well Sediments	ND	ND	ND
	Perched Water Zone	ND	UD	5.28
	Groundwater	UN-9.2	UD/5.93[d]	UD

Table 3-4. Summary of Contaminants Reported by Singleton and Lindsey (1994) at the 216-U-14 Ditch and 216-U-10 Pond. (4 Pages)

Contaminant	Location	Well 299-W18-15 (216-U-10 Pond) (min-max)	216-U-14 Ditch (1980-1992 max)	216-U-14 Ditch (1993 max)
Cesium-137 (pCi/g)	Test Pits	ND	1,500/1,600[d]	2,740
	Well Sediments	ND	ND	UD
	Perched Water Zone	UD	UD	UD
	Groundwater	UD-34	UD	UD
Gross Alpha (pCi/g)	Test Pits	ND	ND	ND
	Well Sediments	ND	ND	ND
	Perched Water Zone	ND	182[c]	70.2
	Groundwater	23-334	26.3/6.26[a]	18.1/4.6[a]
Gross Beta (pCi/g)	Test Pits	ND	ND	ND
	Well Sediments	ND	ND	ND
	Perched Water Zone	ND	413	67.8
	Groundwater	6.5-68.2	81.8/127[a]	17.7/430[a]
Plutonium-238,239,240 (pCi/g)	Test Pits	ND	2.1	10
	Well Sediments	ND	ND	UD
	Perched Water Zone	UD	UD	UD
	Groundwater	UD	UD	UD
Ruthenium-106 (pCi/g)	Test Pits	ND	ND	ND
	Well Sediments	ND	ND	ND
	Perched Water Zone	ND	49.1	68.8
	Groundwater	UD-68.3	72.8/47.1[a]	UD
Strontium-90 (pCi/g)	Test Pits	ND	6.6	1
	Well Sediments	ND	ND	0.97
	Perched Water Zone	ND	14.3	24.6[a]
	Groundwater	0.10-0.60	UD	UD
Technetium-99 (pCi/g)	Test Pits	ND	ND	12
	Well Sediments	ND	ND	ND
	Perched Water Zone	ND	UD	UD
	Groundwater	UD	3.73/521[a]	UD/1,970[a]
Tritium (pCi/g)	Test Pits	NA	NA	NA
	Well Sediments	NA	NA	NA
	Perched Water Zone	ND	537	UD
	Groundwater	42-3,200	219/1,550[a,c]	UD/582[a]
Uranium-234 (pCi/g)	Test Pits	ND	ND	ND
	Well Sediments	ND	ND	ND
	Perched Water Zone	ND	ND	14.2
	Groundwater	15.5/23.5	8.65	10.5

Table 3-4. Summary of Contaminants Reported by Singleton and Lindsey (1994) at the 216-U-14 Ditch and 216-U-10 Pond. (4 Pages)

Contaminant	Location	Well 299-W18-15 (216-U-10 Pond) (min-max)	216-U-14 Ditch (1980-1992 max)	216-U-14 Ditch (1993 max)
Uranium-238 (pCi/g)	Test Pits	ND	178194	
	Well Sediments	ND	ND	<1
	Perched Water Zone	ND	ND	42.2
	Groundwater	15.8-24.5	13.5	11/3.6[b]

[a]Upgradient concentration.
[b]Greater concentrations of the contaminant were reported before 1980; much of the contaminant burden was removed by dredging before 1980. The two values reported are 1982 and 1992 data, respectively.
[c]A data point from 1966 indicates that tritium was as high as 6,800 pCi/L.
[d]Outliers removed.
NA = not applicable
ND = no data available
UD = undetected

Table 3-5. Radionuclide Inventory in the 216-U-14 Ditch, in Curies Decayed to December 31, 1998.

Tritium	Sr-90	Ru-106	Cs-137	Total U	Pu-239/240	Am-241	Total Alpha	Total Beta
2.08	5.34×10^{-2}	2.84×10^{-13}	5.74×10^{-2}	6.38×10^{-2}	1.60×10^{-4}	2.86×10^{-4}	3.11×10^{-2}	2.45×10^{-1}

Table 3-6. List of Contaminants of Concern for the 216-Z-11 Ditch. (2 Pages)

Final COCs	Rationale for Inclusion
Radioactive Constituents	
Americium-241	Process knowledge indicates potential presence. No basis for exclusion.
Cesium-137	
Cobalt-60	
Curium-243	
Europium-152	
Europium-154	
Europium-155	
Neptunium-237	Detected in Z Crib downwell logging results.
Nickel-63[a]	Present in 100 Area D&D and remediation sites. Evaluated in 200-CW-5 OU as a precautionary measure.
Niobium-94	Process knowledge indicates potential presence. No basis for exclusion.
Plutonium-238	
Plutonium-239/240	
Radium-226	
Radium-228	
Strontium-90	
Technetium-99[a]	
Thorium-232	
Tritium[a]	
Uranium-234	
Uranium-235	
Uranium-236	
Uranium-238	
Chemical Constituents - Metals	
Arsenic	Process knowledge indicates potential presence. No basis for exclusion.
Barium	
Beryllium	
Cadmium	
Chromium	
Copper	
Hexavalent chromium	Present in sodium dichromate and potassium dichromate, which are potentially present, based on process knowledge.
Lead	Process knowledge indicates potential presence. No basis for exclusion.
Mercury	
Nickel	
Selenium	
Silver	
Zinc	

Table 3-6. List of Contaminants of Concern for the 216-Z-11 Ditch. (2 Pages)

Final COCs	Rationale for Inclusion
Chemical Constituents – Other Inorganics	
Chloride	Constituent present in several compounds that were identified by process knowledge.
Fluoride	
Nitrate	
Sulfate	
Sulfide	
Chemical Constituents - Volatile Organics	
Acetone	Process knowledge indicates potential presence. No basis for exclusion.
Acetonitrile	
2-Butanone (MEK)	
Carbon tetrachloride	
Chlorobenzene	
Chloroform (Trichloromethane)	
Cyclohexane	
Decane	
Dichloromethane	
Hexane	
Perchloroethylene	
Pseudo cumene (1,2,4 Trimethyl benzene)	
Tetrahydrofuran	
Toluene	
Trichloroethene	
Vinyl chloride	
Xylenes	
Semi-Volatile Organics	
Creosote	Process knowledge indicates potential presence. No basis for exclusion.
Cyclohexanone	
Kerosene[b]	
Naphthylamine	
Normal paraffins[b]	
Paint thinner[b]	
Polychlorinated biphenyls	
Tar	
Tributyl phosphate	

[a]These COCs are deep zone sensitive only. No analyses are required for these in the shallow zone soils, as they are soft beta emitters in low abundance that have insignificant dose impact in the shallow zone.
[b]Analyzed as kerosene total petroleum hydrocarbons.
D&D = decontamination and decommissioning

4.0 WORK PLAN APPROACH AND RATIONALE

4.1 SUMMARY OF DATA QUALITY OBJECTIVE PROCESS

The RI needs for the 200-CW-5 OU were developed in accordance with the DQO process (EPA 1993; BHI-EE-01, *Environmental Investigations Procedures*, Procedure 1.2). The DQO process is a seven-step planning approach that is used to develop a data collection strategy consistent with data uses and needs. The goals of the process are to provide the data needed to refine the preliminary site conceptual model and support remedial decisions.

The DQO process was implemented by a team of subject matter experts and key decision makers. Subject matter experts provided input on regulatory issues, the physical condition of the sites, and sampling and analysis methods. Key decision makers from the U.S. Department of Energy and the EPA participated in the process to develop the characterization approach outlined in the DQO summary report. The DQO process and involvement of the team of experts and decision makers provides a high degree of confidence that the right type and quality of data are collected to fulfill informational needs of the 200-CW-5 RI. Results of the DQO process for characterization of the representative sites in the 200-CW-5 OU are presented in the *200-CW-5 U-Pond and Z Ditches Cooling Water Operable Unit Remedial Investigation DQO Summary Report* (BHI 1999). During the DQO process, it was determined that the characterization data previously obtained for the 216-U-10 Pond and 216-U-14 Ditch are sufficient to support the 200-CW-5 RI/FS process. Therefore, characterization activities outlined in this work plan focus only on the 216-Z-11 Ditch.

4.1.1 Data Uses

Data generated during characterization of the 216-Z-11 representative site will consist mainly of soil contaminant data. This contaminant data will be used along with existing data from the 216-U-10 and 216-U-14 representative sites to define the nature and extent of radiological and chemical contamination; support an evaluation of risks; and assist in the evaluation and selection of a remedial alternative. By defining the type and distribution of contamination, the conceptual model for contaminant distribution can be verified or refined. Verification of the current model will direct the application of the analogous site concept at the remaining 200-CW-5 OU waste sites. A limited amount of data will be collected to characterize the physical properties of soils that will be used to support an assessment of risk (e.g., RESidual RADioactivity [RESRAD] dose model or other risk modeling, as required). Contaminant and soil property data will be obtained by sampling and analyzing soils.

4.1.2 Data Needs

A considerable amount of information has been presented in Sections 2.0 and 3.0 regarding 200-CW-5 OU waste sites. Existing data were sufficient to develop an understanding of contaminant distribution for the 216-U-10 Pond and 216-U-14 Ditch; however, the data are insufficient to develop a distribution model for the 216-Z-11 Ditch. The most pertinent existing information was used to develop a site-specific conceptual model for the 216-Z-11 waste site, and additional information is provided by reference. For the representative waste sites (and the other waste sites in the OU in general), information is available regarding location, construction design, major types of waste disposed, and radiological contaminants associated with the bottom of the waste sites. However, the data needed to verify and/or refine the site conceptual model at 216-Z-11 and to develop a contaminant distribution model are limited. These data are needed to support remedial decision making at the 216-Z-11 Ditch and any analogous sites. As defined by the DQO process, the focus of the 200-CW-5 RI is to determine the nature and extent of contamination in the vadose zone within the boundary of the waste site. Specifically, determinations of the type, concentration (particularly the highest concentration), and vertical distribution of radiological and chemical contamination in the vadose zone at the 216-Z-11 Ditch are the major data needs. Data are also required to determine the physical properties of soils; these data will provide additional input to support an evaluation of risk through the use of models for fate and transport of contaminants through the vadose zone to groundwater, exposure to radionuclides, and exposure to chemicals.

4.1.3 Data Quality

Data quality was addressed during the DQO session. The data quantity and quality for 216-U-10 and 216-U-14 were determined to be sufficient; COCs were identified for these sites based on data previously collected under an approved work plan. During the DQO process, data quality for 216-Z-11 Ditch was addressed by identifying potential COCs and establishing associated analytical performance criteria. The process of identifying potential COCs is summarized in Section 3.5. Analytical performance criteria were established by evaluating potential ARARs and PRGs, which are regulatory thresholds and/or standards or derived risk-based thresholds. These potential ARARs and PRGs represent chemical-, location-, and action-specific requirements that are protective of human health and the environment. Regulatory thresholds and/or standards or preliminary action levels provide the basis for establishing cleanup levels and dictate analytical performance levels (i.e., laboratory detection limit requirements). Detection limit requirements and standards for precision and accuracy are used to define data quality.

To provide the necessary data quality, detection limits should be lower than preliminary action levels. Additional data quality is gained by establishing specific policies and procedures for the generation of analytical data and field quality assurance/quality control requirements. These requirements are discussed in detail in the SAP (Appendix A). Analytical performance requirements are specified in Table 3-7 of the DQO summary report (BHI 1999). The potential ARARs and PRGs for 200 Area waste sites are discussed in Sections 4.0 and 5.0 of the Implementation Plan (DOE-RL 1999).

4.1.4 Data Quantity

Data quantity refers to the number of samples collected. The number of samples needed to refine the site conceptual model and make remedial decisions is based on a biased sampling approach. Biased sampling is the intentional location of a sampling point within a waste site based on process knowledge of the waste stream and expected behavior of the potential COCs. It is the preferred sampling approach as defined in Section 6.2.2 of the Implementation Plan (DOE-RL 1999) for the RI phase. Using this approach, sampling locations can be selected that increase the chance of encountering the highest contamination in the local soil column.

Sample locations at the 216-Z-11 representative site were selected based on the preliminary conceptual model presented in the DQO summary report. Sampling locations in the ditch will be identified through a four-step characterization approach designed to locate areas that contain the highest contamination. Sampling points will be located with the goal of intersecting the highest areas of contamination and to determine the vertical and lateral extent (i.e., along the ditch) of contamination within the historical boundary of the ditches. Soil samples will be taken from deep and shallow boreholes and will be collected from different depths at the waste site to evaluate the vertical extent of contamination. Extra soil samples may be collected as warranted by observations such as changes in lithology and visual indications of contamination. This biased sampling approach was designed to provide the data needed to meet DQOs for this phase of the RI/FS process.

4.2 CHARACTERIZATION APPROACH

This section provides an overview of characterization activities that are planned to collect the required data identified in the DQO process. Characterization will be performed through four separate activities, including the following:

- Surface geophysical surveys
- Spectral gamma logging (SGL) of shallow casings
- Borehole drilling, soil sampling, and geophysical logging
- Pipeline sludge characterization.

This sampling strategy is designed to minimize worker exposure by first using nonintrusive methods to locate contamination "hot spots." Sample collection will be guided by field screening efforts and a sampling scheme that identifies critical sampling depths.

4.2.1 Surface Geophysical Surveys

Ground penetrating radar (GPR) and electromagnetic induction (EMI) surveys will be performed along transects at up to seven locations (Figure 4-1). Because of the close proximity of the 216-Z-1D, 216-Z-11, and 216-Z-19 Ditches and the difficulty in distinguishing the ditches from each other under the uniform stabilization cover materials, the surface geophysical surveys will be conducted across the entire width of the Z-Ditches. The geophysical information gained from this phase will be used to determine the ditch bottom profiles and to determine if the three parallel ditch locations can be discriminated in plan view.

4.2.2 Spectral Gamma Logging of Shallow Casings

SGL will be used to determine areas of high americium-241 and plutonium-239/240 concentrations in a series of shallowly installed casings. Casing will be installed to a depth of approximately 7.6 m (25 ft) below ditch bottom (bdb) at up to five locations along the ditch. The SGL data will be used to construct logs of radiological activity in the boreholes. Results of the SGL will be evaluated to identify the preferred borehole sampling locations and depths in the borehole drilling, soil sampling, and geophysical logging characterization step.

After the results of the SGL logging have been evaluated, the borehole casing with the highest and/or deepest concentrations of transuranic materials will be chosen for additional SGL assay. The casing at that location will be driven to a depth of at least 15 m (50 ft) bdb for additional gamma logging to determine if the mobility of neptunium-237 (via measurement of protactinium-233) results in detectable concentrations at depth below the ditch.

The SGL system uses standard laboratory high-purity germanium (HPGe) detector instrumentation to identify and quantify gamma-emitting radionuclides in wells as a function of depth. The HPGe detector is calibrated to National Institute of Standards and Technology testing requirements and includes corrections for environmental conditions that deviate from the standard calibration condition.

4.2.3 Borehole Drilling, Soil Sampling, and Geophysical Logging

Areas of high contamination identified during the SGL of the shallow casings will be chosen as locations for the drilling of up to three shallow boreholes and one deep borehole for soil sampling and geophysical borehole logging. Boreholes are necessary to determine the contaminant concentrations in the ditch sediment layer and in the soils immediately beneath the ditch sediments. The sample collection strategy has been designed to characterize the ditch sediments and the vadose zone materials beneath them to the top of the groundwater table. Sampling will begin at the ditch sediment layer, but if contamination is detected in backfill materials, additional samples may be taken in the backfill.

Shallow boreholes will extend to a depth of approximately 7.6 m (25 ft) below ground surface (bgs) to document contaminant concentrations to a depth that is significant for remedial action decision making and to confirm the preliminary conceptual model for vertical contaminant distribution. Samples will be collected at 15-cm (6-in.) intervals at the ditch bottom/sediment layer elevation, then at 0.6-m (2-ft) intervals from depths of 0.8, 1.5, and 2.2 m (2.5, 5.0, and 7.5 ft) below the ditch sediment layer. Sampling will continue at 0.6-m (2-ft) intervals at depths of 4 to 4.6 and 7.0 to 8 m (13 to 15 and 23 to 25 ft) bgs. Critical sample intervals are at the ditch sediment layer, 4 to 4.6 m (13 to 15 ft) bgs, and 7.0 to 8 m (23 to 25 ft) bgs.

A deep borehole is planned for the area of highest and/or deepest contamination as determined by the shallow-casing SGL. This borehole is required to determine transuranic and other contaminant concentrations through the vadose zone extending to groundwater. This characterization step is designed to confirm the preliminary site conceptual model for vertical contaminant distribution. The sampling design for the deep borehole is the same as for the shallow borehole described in the previous paragraph, with the addition of samples to be taken every 15 m (50 ft) from depths of 8 m (25 ft) bgs to groundwater. Critical sample intervals are the same as the shallow boreholes (at the ditch sediment layer, 4 to 4.6 m [13 to15 ft] and 7.0 to 8 m [23 to 25 ft] bgs). In addition, a soil sample will be collected just above the water table. The maximum total depth of the investigation at the Z-Ditches will be approximately 73 m (238 ft) based on the depth to water in nearby wells. The presence of water-saturated soils will indicate the end of the borehole and will be determined by the site geologist.

Additional samples from any borehole may be collected at the discretion of the geologist/sampler based on field screening and geologic information. Actual conditions during drilling may warrant changes in sampling design, borehole location, or drilling depth; the changes may be implemented after approval of the task lead and site technical representative.

The sampling design is presented in the SAP (Appendix A). Key features of the sampling design are presented in Table A3-1. Field screening methods are provided in Table A3-2, and sampling details are provided in Table A3-3.

After borehole sampling is complete, the SGL system and a neutron moisture logging system will be used to geophysically log the deep borehole. This logging will provide continuous vertical logs of gamma-emitting radionuclides and moisture. The geophysical logging system that measures moisture employs a weak radioactive neutron source and neutron detector to provide a direct reading of hydrogen atom distribution in the soil surrounding the borehole.

The geophysical logs will be used to supplement the laboratory radionuclide and moisture content data to determine the vertical distribution of radionuclides in the vadose zone beneath the Z-Ditches, aid in geological interpretation of subsurface stratigraphy, and assess moisture conditions.

Existing wells in the vicinity of the Z-Ditches may be logged with the SGL system to expand the Z-Ditches SGL database. Logging can only be performed in existing wells that have one casing string and lack annular seals (i.e., casing in contact with the formation). A list of potential wells to be logged is identified in the SAP (Appendix A, Table A3-1).

The drilling method used must allow the use of a 13-cm (5-in.) outside-diameter split-spoon sampler. The drilling method must not use any system that circulates air or water into the formation to be sampled.

4.2.4 Pipeline Sludge Characterization

This step involves in situ radiological measurement within the Z-Ditch discharge piping via the manholes. Figure 4-2 identifies the Z-Ditch discharge pipelines and manhole locations being considered for field assay. Figure 4-3 shows typical section views of manholes in the Z-Ditch pipelines.

4.2.5 Field Screening

All samples and/or cuttings from the boreholes will be field screened for evidence of radionuclides. Radioactivity screening of the soils will assist in the selection of sampling intervals (other than those already identified as critical sampling depths).

4.2.6 Analysis of Soil

Soil samples will be collected for chemical and radionuclide analysis and the determination of select soil properties. A fairly broad and comprehensive list of analytes has been selected for this investigation; this list was developed based on an evaluation of all potential contamination that was discharged to the Z-Ditches. Development of this list of COCs is presented in Section 3.5 and Table 3-6. Tables A2-1 and A2-2 of the SAP list detailed descriptions of analytical methods, holding times, and quality assurance and quality control procedures for each contaminant. A limited number of samples will also be analyzed to determine soil physical properties such as moisture content and particle size.

Figure 4-1. Location of Planned Surface Geophysical Surveys at the 216-Z-Ditches (216-Z-19 Ditch Shown as Open).

Figure 4-2. Z-Ditch Discharge Pipelines and Manhole Locations.

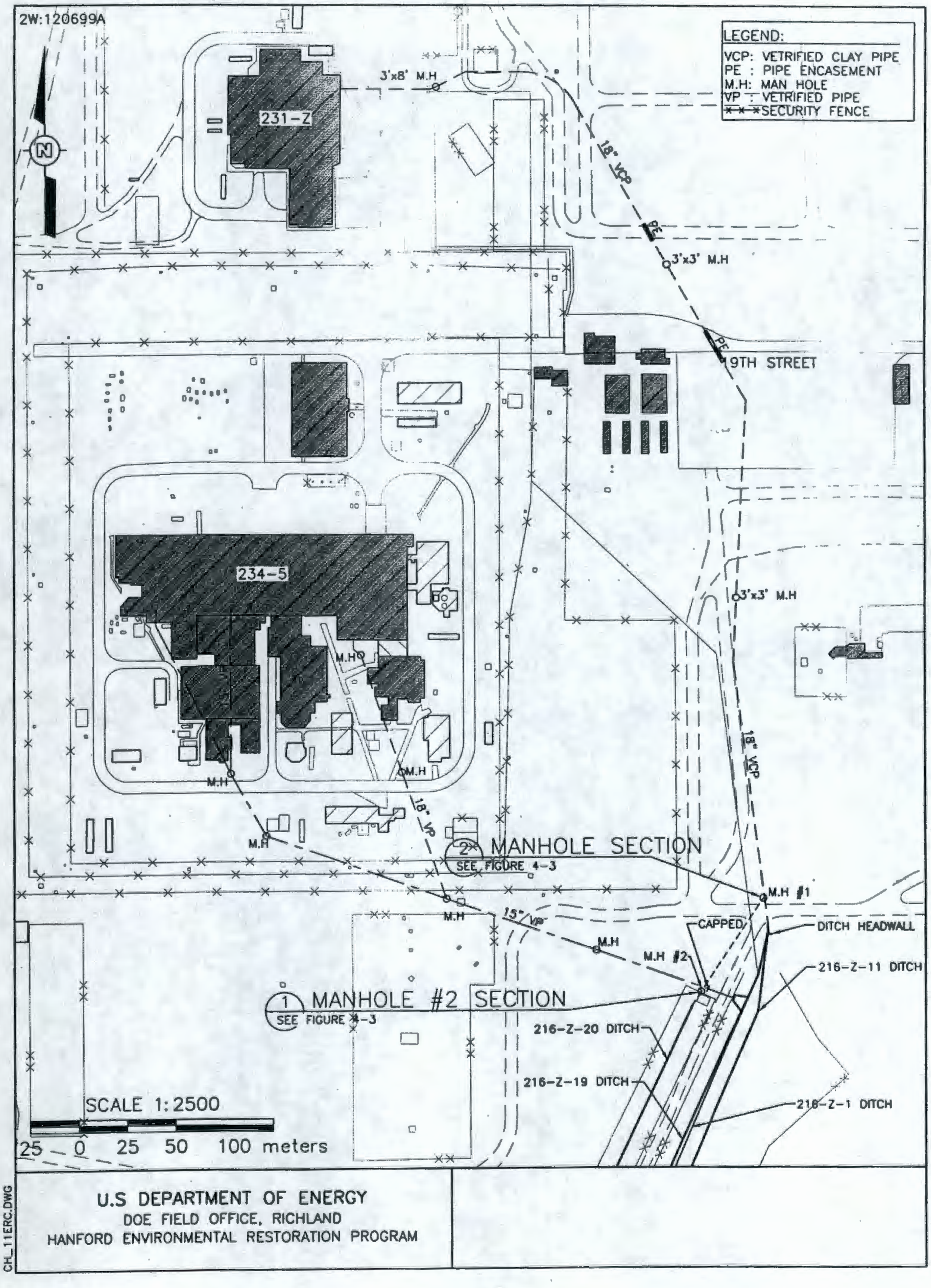
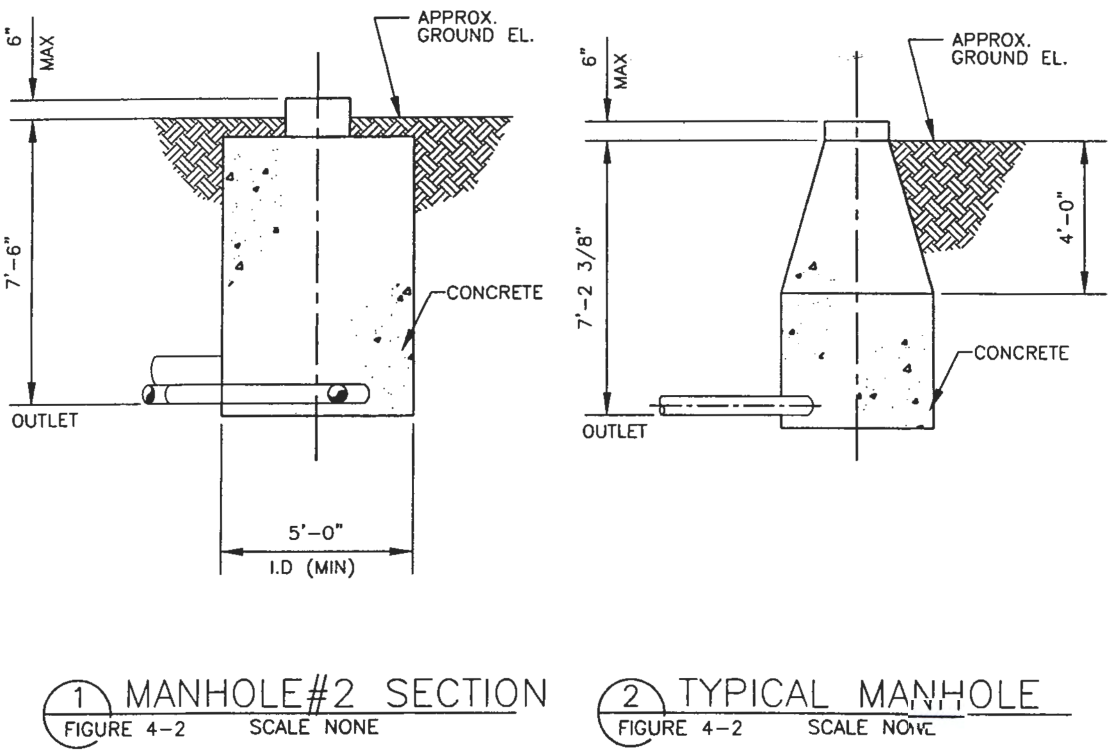


Figure 4-3. Typical Section Views of Manholes in Z-Ditch Pipelines.

2W:120699B



NOTES.

1. ALL DIMENSION SHOWN ARE REFERENCED IN FEET AND INCHES

U.S DEPARTMENT OF ENERGY
DOE FIELD OFFICE, RICHLAND
HANFORD ENVIRONMENTAL RESTORATION PROGRAM

CH_11ERC.DWG

5.0 REMEDIAL INVESTIGATION/FEASIBILITY STUDY PROCESS

This section describes the RI/FS process for the 200-CW-5 OU. The development of and rationale for this process is provided in the Implementation Plan (DOE-RL 1999) and is summarized in Figure 1-1. The process follows the CERCLA format. A summary of the regulatory process is provided in Section 5.1.

Section 5.2 outlines the tasks to be completed during the RI phase, including planning and conducting field sampling activities and preparation of the RI report. These tasks are designed to effectively manage the work, satisfy DQOs identified in Section 4.0, document the results of the RI, and manage waste generated during field activities. The general purpose of the RI is to characterize the nature, extent, concentration, and potential transport of contaminants and provide data to determine the need for and type of remediation. The detailed information that will be collected to carry out these tasks is presented in the SAP (Appendix A) and the WCP (Appendix B).

Tasks to be completed following the RI include a FS (Section 5.3) and a proposed plan, followed by a ROD (Section 5.4).

Project management occurs throughout the RI/FS process. Project management is used to direct and document project activities so that objectives of the work plan are met and to ensure that the project is kept within budget and schedule. The initial project management activity will be to assign individuals to roles established in Section 7.2 of the Implementation Plan (DOE-RL 1999). Other project management activities include day-to-day supervision of and communication with project staff and support personnel; meetings; control of cost, schedule, and work; records management; progress and final reports; quality assurance; health and safety; and community relations.

Appendix A of the Implementation Plan (DOE-RL 1999) provides the overall quality assurance framework that was used to prepare an OU-specific quality assurance project plan for the 200-CW-5 RI (Appendix A, Section A2.0). Appendix C of the Implementation Plan reviews data management activities that are applicable to the 200-CW-5 OU RI/FS and describes the process for the collection/control of data, records, documents, correspondence, and other information associated with OU activities.

5.1 REGULATORY PROCESS

The process for characterization of the 200-CW-5 OU uses this work plan in combination with the Implementation Plan (DOE-RL 1999) to satisfy the requirements for an RI/FS work plan. General facility background information, potential ARARs, preliminary RAOs, and preliminary remedial technologies developed in the Implementation Plan are incorporated by reference into this work plan. Following the completion of the work plan, an RI will be performed that will be limited to the investigation of representative waste sites. A report summarizing the results of the RI will then be prepared.

After the RI is complete, remedial alternatives will be refined and evaluated against performance standards and evaluation criteria. The process for the evaluation of remedial alternatives includes the preparation of an FS.

The decision-making process for the 200-CW-5 OU will be based on the use of a proposed plan and a ROD. Based on the FS, a proposed plan will be prepared that identifies the preferred remedial alternative for waste sites within the OU. The proposed plan will be issued for a 45-day public review and comment period. Supporting documents, including the FS, will also be made available to the public at this time. A combined public meeting/public hearing may be held during the comment period to provide information on the proposed action and to solicit public comment. After the public review, the EPA will respond to comments and make a final decision on the proposed action that will be documented in a ROD.

Additional guidance is provided in Section 2.4 of the Implementation Plan (DOE-RL 1999).

5.2 REMEDIAL INVESTIGATION ACTIVITIES

This section summarizes the planned tasks that will be performed during the RI phase for the 200-CW-5 OU, including the following:

- Planning
- Field investigation
- Management of investigation-derived waste (IDW)
- Laboratory analysis and data verification
- Data evaluation and reporting.

These tasks and subtasks reflect the work breakdown structure that will be used to manage the work and to develop the project schedule provided in Section 6.0.

5.2.1 Planning

The planning subtask includes activities and documentation that must be completed before field activities can begin. These include the preparation of a hazard classification analysis, activity hazards analysis, and site-specific health and safety plan (HASP), radiation work permits, WCP, excavation permits and supporting surveys (e.g., cultural, radiological, wildlife, and utilities), work instructions, personnel training, and the procurement of materials and services (e.g., drilling and geophysical logging services).

Appendix B of the Implementation Plan (DOE-RL 1999) provides a general HASP that outlines health and safety requirements for RI activities. Site-specific HASPs will be prepared for drilling following the requirements of the general HASP. Initial surface radiological surveys will be performed to document any radiological surface contamination and background levels in and around the sampling locations. This information will be used to document initial site conditions and prepare HASPs and radiation work permits.

5.2.2 Field Investigation

The field investigation task involves data-gathering activities performed in the field that are required to satisfy DQOs. The field characterization approach is summarized in Section 4.2 and detailed in the SAP provided in Appendix A of this work plan. The scope includes geophysical surveys and logging, followed by soil sampling and analyses to characterize the vadose zone at one representative waste site (216-Z-11 Ditch) and effluent pipeline sampling and analyses. Major subtasks associated with the field investigation include the following:

- Surface geophysical surveys
- SGL of shallow casing
- Borehole drilling, soil sampling, and geophysical logging
- Pipeline sludge characterization
- Preparation of field report.

5.2.2.1 Surface Geophysical Surveys. This task involves surveys of the combined stabilized Z-Ditches (216-Z-1D, 216-Z-11, and 216-Z-19) using GPR and EMI methods. The intent of this initial activity is to distinguish the ditch bottom profiles for the three parallel ditches in the subsurface.

5.2.2.2 Spectral Gamma Logging of Shallow Casings. Drill casing will be installed along the ditch to a depth of at least 7.6 m (25 ft) and logged with an SGL system to determine areas of high americium-241 and plutonium-239/240 activity. Results of the SGL readings will be evaluated to identify the preferred locations for borehole soil sampling.

After SGL operations have been completed, the boreholes will be abandoned in accordance with *Washington Administrative Code* (WAC) 173-160, "Minimum Standards for Construction and Maintenance of Wells," and initial site conditions will be re-established.

5.2.2.3 Borehole Drilling, Soil Sampling, and Geophysical Logging. This characterization activity involves the drilling of up to three shallow boreholes and one deep borehole for the purpose of collecting soil samples for chemical, radionuclide, and physical property analyses. Geologic and geophysical (SGL and neutron logging) logs will also be prepared. These data are significant for determining the contaminant concentrations through the vadose zone down to groundwater, as well as for confirmation of the conceptual contaminant distribution model.

Samples will be collected with split-spoon samplers and packaged for shipment to an offsite laboratory, provided that the activities do not exceed laboratory radiological limits. Samples taken from radiological hot spots may have sufficiently high radioactivity that they will require analysis at an onsite laboratory. At the completion of sampling, the boreholes will be abandoned in accordance with WAC 173-160, and initial site conditions will be re-established. Alternatively, the deep borehole may be completed as a groundwater monitoring well, if needed by the Hanford Site groundwater monitoring program. Other drilling-related activities include work zone setup, mobilization/demobilization of equipment, equipment decontamination, and field analyses. Planned field analyses include radiological field screening and geologic characterization. A geologic log will be prepared for each borehole.

Borehole geophysical logging will be used to gather in situ radiological and physical data from the boreholes and from several existing wells (specified in Section A3.3.3.3 of the SAP). Spectral gamma-ray logging will be performed to assess the distribution of gamma-emitting radionuclides, and neutron logging will be performed for moisture content distribution over the borehole or well interval. A geologic log will also be prepared for each borehole.

5.2.2.4 Pipeline Sludge Characterization. The Z-Ditches discharge piping sludge will be characterized through manhole access ports. Visual inspection will be performed by remote video camera, followed by in situ spectral gamma measurements. Sodium iodide and/or HPGe detectors will be employed for this purpose.

5.2.2.5 Preparation of Field Reports. At the completion of the field investigation, a field report will be prepared to summarize activities performed and information collected in the field. Information to be collected will include, but not be limited to, surface geophysical survey data; borehole geophysical logging data; the number, location, and types of soil/sludge samples collected and associated Hanford Environmental Information System numbers; inventory of IDW containers; geological logs; and field screening results. Laboratory analytical results will also be summarized, if available. Otherwise, laboratory analytical results will be included in the RI report.

5.2.3 Management of Investigation-Derived Waste

Waste generated during the RI will be managed in accordance with a WCP. Appendix E of the Implementation Plan (DOE-RL 1999) provides general waste management processes and requirements for this IDW and forms the basis for activity-specific WCPs. A WCP is provided in Appendix B that addresses the handling, storage, and disposal of IDW generated during the RI phase. Furthermore, the plan identifies governing Environmental Restoration Contractor (ERC) procedures and discusses types of waste expected to be generated, the waste designation process, and the final disposal location. The IDW management task begins at the start of the field investigation, when IDW is first generated, through waste designation and disposal.

5.2.4 Laboratory Analysis and Data Validation

Soil samples collected from boreholes will be analyzed for a comprehensive suite of radionuclides and chemicals and for select physical properties based on established DQOs and as defined in the SAP. This task includes the laboratory analysis of samples, the compilation of laboratory results in data packages, and the validation of a representative number of laboratory data packages.

5.2.5 Remedial Investigation Report

This section summarizes data evaluation and interpretation subtasks leading to the production of an RI report. The primary activities include performing a data quality assessment (DQA); evaluating the nature, extent, and concentration of contaminants based on sampling results; assessing contaminant fate and transport; refining the site conceptual models; and evaluating risks through a qualitative risk assessment (QRA). These activities will be performed as part of the RI report preparation task.

5.2.5.1 Data Quality Assessment. A DQA will be performed on the analytical data to determine if they are the right type, quality, and quantity to support their intended use. The DQA completes the data life cycle of planning, implementation, and assessment that began with the DQO process. In this task, the data will be examined to see if they meet the analytical quality criteria outlined in the DQO summary report (BHI 1999) and are adequate to resolve the decisions in the DQO process.

5.2.5.2 Data Evaluation and Conceptual Model Refinement. This task will include evaluating the information collected during the investigation. The chemical and radiological data obtained from sampling activities will be compiled, tabulated, and statistically evaluated to gain as much information to satisfy the data needs as possible. Data evaluation tasks may include the following:

- Graphically evaluating the data for vertical distribution of contamination within each borehole.
- Stratifying the data and computing basic statistical parameters such as mean and standard deviation for individual depths.
- Constructing contour diagrams and variograms to evaluate spatial correlations within each stratum, which will indicate if contamination is concentrated in a particular area.
- Performing analyses on the data to evaluate the presence or absence of contamination. There are many facets to this step, including determining the distribution of the data and selecting the appropriate statistical tests. The initial screening for contamination should evaluate the data with respect to background by using simple comparisons of an upper bound of the data to background concentrations (e.g., *Model Toxics Control Act* [MTCA] tests), or more complex comparisons, such as nonparametric hypothesis tests (e.g., Wilcoxon Rank Sum test). These tests may also compare the data to appropriate cleanup levels.

All of these statistical evaluations will aid in refining the conceptual model for this OU and selecting the remedial alternative.

The analytical, physical properties, and geophysical data will be used to refine the conceptual model and as inputs to a QRA. Data on the soil physical properties will be used to develop input parameters for contaminant fate and transport modeling, if needed (see Section 5.2.5.3). For example, lithology, moisture conditions, and grain-size distribution will assist in selecting representative unsaturated hydraulic conductivity values/moisture retention curves.

5.2.5.3 Qualitative Risk Assessment. Varying degrees of a QRA may be used to evaluate risk to human receptors from exposure to contaminants in accessible surface sediments and shallow subsurface soils. The first degree of risk analysis will be the evaluation of the data against the PRGs for the OU. If no chemicals exceed the PRGs (i.e., MTCA or other standards as specified in the work plan), no additional chemical risk assessment is warranted. However, if chemical concentrations exceed PRGs, some additional analysis may be warranted. For example, if concentrations greatly exceed PRGs and a remedial action is inevitable, the analysis may not be cost effective. If concentrations are near or only slightly above PRGs, a more extensive degree of risk assessment may be warranted to evaluate other exposure scenarios more in line with the site-specific characteristics and to evaluate potential impacts to groundwater. The degree of risk assessment is highly dependent on the data from the investigation. More sophisticated risk modeling or fate and transport modeling may be needed to evaluate potential impacts to groundwater.

The computer program RESRAD will be used to model radionuclide dose. Other contaminant fate and transport models may be used to assess impacts to groundwater from chemicals and radionuclides in the vadose zone. The radiological and/or physical characterization data obtained in this study will be used in RESRAD or other models along with input parameters appropriate to the land use. The input parameters recommended by the Washington State Department of Health (WDOH 1997) will be considered for this effort.

5.3 FEASIBILITY STUDY

After the RI is complete, remedial alternatives will be developed and evaluated against performance standards and evaluation criteria in an FS report. The FS process consists of the following steps:

1. Defining RAOs.

2. Identifying general response actions (GRAs) to satisfy RAOs.

3. Identifying potential technologies and process options associated with each GRA.

4. Screening process options to select a representative process for each type of technology based on their effectiveness, implementability, and cost.

5. Assembling viable technologies or process options into alternatives representing a range of treatment and containment in addition to the no action alternative.

6. Evaluating alternatives and presenting information needed to support remedy selection.

Although some refinement is expected during the final FS, Appendix D of the Implementation Plan (DOE-RL 1999) satisfies the requirements for the screening phase (steps 1 through 6) of the FS process. The preliminary RAOs, PRGs, GRAs, and the screening-level analysis of alternatives are incorporated by reference into this work plan. As a result of the work completed in the Implementation Plan, the FS report will focus on the final phase of the FS consisting of refining and analyzing in detail a limited number of alternatives identified in the screening phase. Remedial action alternatives considered to be applicable the 200-CW-5 OU include the following:

- No action
- Engineered surface barriers with or without vertical barriers

- Excavation and disposal with or without ex situ treatment

- In situ vitrification with or without removal of the vitrified material and with or without engineered surface barriers

- In situ grouting and stabilization

- Monitored natural attenuation (with institutional controls).

During the detailed analysis, each alternative will be evaluated against the following criteria:

- Overall protection of human health and the environment
- Compliance with ARARs
- Long-term effectiveness and permanence
- Reduction of toxicity, mobility, or volume
- Short-term effectiveness
- Implementability
- Cost
- State acceptance.

One additional modifying criterion, community acceptance, will be applied following the FS, at the proposed plan and ROD phase.

National Environmental Policy Act of 1969 (NEPA) values will also be evaluated as part of the U.S. Department of Energy's responsibility under this authority. The NEPA values include impacts to natural, cultural, and historical resources; socioeconomic aspects; and irreversible and irretrievable commitments of resources.

The FS will also include supporting information needed to complete the detailed analysis, including the following:

- Summarize the RI, including the nature and extent of contamination, the contaminant distribution models, and an assessment of the risks to help establish the need for remediation and to estimate the volume of contaminated media

- Refine the conceptual exposure pathway model to identify pathways that may need to be addressed by remedial action

- Provide a detailed evaluation of ARARs, starting with potential ARARs identified in the Implementation Plan (Section 4.0, DOE-RL 1999)

- Refine RAOs and PRGs based on the results of the RI, ARAR evaluation, and current land-use considerations

- Refine the list of remedial alternatives identified in the Implementation Plan (Appendix D, DOE-RL 1999), based on the RI.

5.4 PROPOSED PLAN AND ROD

The decision-making process for the 200-CW-5 OU will be based on the use of a proposed plan and a ROD. Following the completion of the FS, a proposed plan will be prepared that identifies the preferred remedial alternative for the OU. In addition to identifying the preferred alternative, the proposed plan will:

- Provide a summary of the completed RI/FS.
- Provide criteria by which analogous waste sites within the OU not previously characterized will be evaluated after the ROD to confirm that the contaminant distribution model for the site is consistent with the preferred alternative. Contingencies to move a waste site to a more appropriate waste group will also be developed.
- Identify performance standards and ARARs applicable to the OU.

After the public review process is complete, EPA as the lead regulatory agency will make a decision on the remedial action to be taken that is documented in a ROD.

5.5 POST-ROD ACTIVITIES

After the ROD has been issued, a remedial design report and remedial action work plan will be prepared to detail the scope of the remedial action. As part of this activity, DQOs will be established and SAPs will be prepared to direct confirmatory and verification sampling and analysis efforts. Prior to the start of remediation, confirmation sampling will be performed to ensure that sufficient characterization data are available to confirm that the selected remedy is appropriate for all waste sites within the OU, to collect data necessary for the remedial design, and to support future risk assessments, if needed. Verification sampling will be performed after the remedial action is complete to determine if ROD requirements have been met and if the remedy was effective. Additional guidance for confirmatory and verification sampling is provided in Section 6.2 of the Implementation Plan (DOE-RL 1999).

The remedial design report/remedial action work plan will include an integrated schedule of remediation activities for the OU. Following the completion of the remediation effort, closeout activities will be performed as discussed in Section 2.4 of the Implementation Plan (DOE-RL 1999).

6.0 PROJECT SCHEDULE

The project schedule for activities discussed in this work plan is shown in Figure 6-1. This schedule is the baseline for the work planning process and will be used to measure the implementation of this work plan. The schedule for preparation, review, and issuance of the RI report, FS, and proposed plan is also shown in Figure 6-1. The schedule concludes with the preparation of a ROD.

One Tri-Party Agreement milestone is associated with this project: Complete Draft A of the Work Plan by December 31, 1999, for transmittal to the regulators (M-13-22).

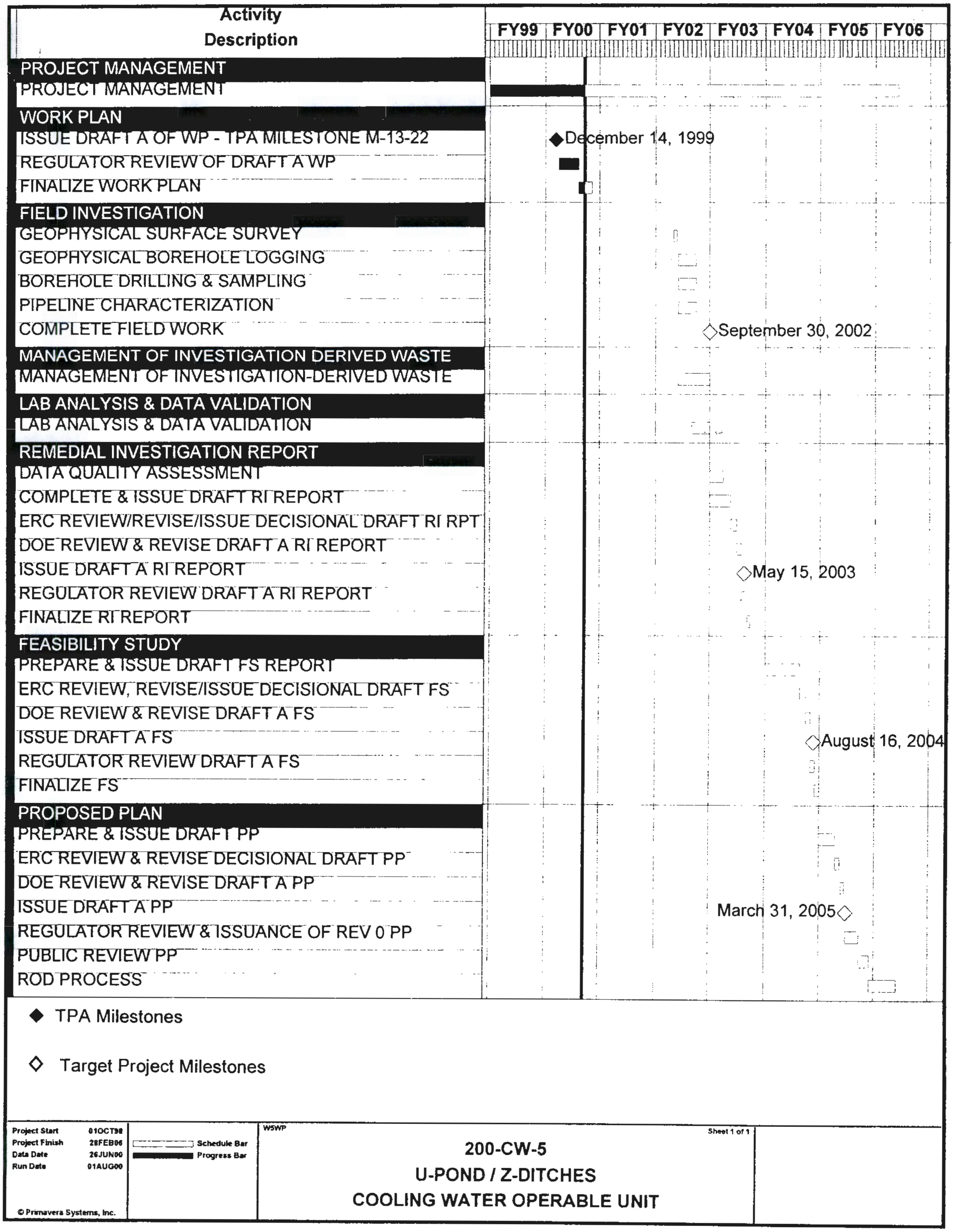
The following are proposed project milestone completion dates for key activities:

- Complete field activities – *September 30, 2002**
- Submit Draft A RI report for regulator review – *May 15, 2003**
- Submit Draft A FS for regulator review – *August 16, 2004**
- Submit Draft A proposed plan for regulator review – *March 31, 2005**.

Interim milestones to be designated under the Tri-Party Agreement will be established through negotiations between the Tri-Parties. A Class II change form will be submitted to EPA and the Washington State Department of Ecology (Ecology) to request the addition of any interim milestones. Any updates to the project schedule or associated milestones will be reflected in the annual work planning process.

* Target project milestones.

Figure 6-1. Project Schedule for the 200-CW-5 Operable Unit.



7.0 REFERENCES

Alexander, D. J., V. G. Johnson, and K. A. Lindsey, 1993, *Groundwater Impact Assessment Report for the 284-WB Powerplant Ponds*, WHC-EP-0679, Westinghouse Hanford Company, Richland, Washington.

BHI, 1996, *Preoperational Baseline and Site Characterization Report for the Environmental Restoration Disposal Facility,* BHI-00270, Vols. 1 and 2, Rev. 1, Bechtel Hanford, Inc., Richland, Washington.

BHI, 1998, *Hanford Site Atlas*, BHI-01119, Rev. 0, Bechtel Hanford, Inc., Richland, Washington.

BHI, 1999, *200-CW-5 U-Pond and Z Ditches Cooling Water Operable Unit Remedial Investigation DQO Summary Report*, BHI-01294, Rev. 0, Bechtel Hanford, Inc., Richland, Washington.

BHI-EE-01, *Environmental Investigations Procedures*, Bechtel Hanford, Inc., Richland, Washington.

Bjornstad, B. N., 1990, *Geohydrology of the 218-W-5 Burial Ground, 200 West Area, Hanford Site*, PNL-7336, Pacific Northwest Laboratory, Richland, Washington.

Comprehensive Environmental Response, Compensation, and Liability Act of 1980, 42 U.S.C. 9601, et seq.

Diediker, L. P., 1999, *Radionuclide Inventories of Liquid Waste Sites at Hanford*, HNF-1744 (In press), Fluor Daniel Hanford, Richland, Washington.

Dirkes, R. L., R. W. Hanf, and T. M. Poston, 1999, *Hanford Site Environmental Report for Calendar Year 1998*, PNNL-12088, Pacific Northwest National Laboratory, Richland, Washington.

DOE, 1987, *Disposal of Hanford Defense High-Level, Transuranic and Tank Wastes, Final Environmental Impact Statement*, DOE/EIS-0113 (Vol. 2 of 5), U.S. Department of Energy, Washington, D.C.

DOE, 1999, *Final Hanford Comprehensive Land-Use Plan Environmental Impact Statement*, DOE/EIS-0222F, U.S. Department of Energy, Washington, D.C.

DOE-RL, 1992a, *S Plant Source Aggregate Area Management Study Report*, DOE/RL-91-60, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE-RL, 1992b, *U Plant Aggregate Area Management Study Report*, DOE/RL-91-52, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE-RL, 1992c, *Z Plant Source Aggregate Area Management Study Report*, DOE/RL-91-58, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE-RL, 1993a, *200 West Groundwater Aggregate Area Management Study Report*, DOE/RL 92-16, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE-RL, 1993b, *RCRA Facility Investigation/Corrective Measures Study Work Plan for the 200-UP-2 Operable Unit, Hanford Site, Richland, Washington*, DOE/RL-91-19, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE-RL, 1995, *Limited Field Investigation for the 200-UP-2 Operable Unit*, DOE/RL-95-13, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE-RL, 1996, *Focused Feasibility Study for the 200-UP-2 Operable Unit*, DOE/RL-95-106, Draft A, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE-RL, 1997, *Waste Site Grouping for 200 Areas Soil Investigations*, DOE/RL-96-81, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE-RL, 1998, *Tri-Party Agreement Handbook Management Procedures*, Guideline Number TPA-MP-14, "Maintenance of the Waste Information Data System (WIDS)," RL-TPA-90-0001, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE-RL, 1999, *200 Areas Remedial Investigation/Feasibility Study Implementation Plan – Environmental Restoration Program*, DOE/RL-98-28, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

Ecology, EPA, and DOE, 1998, *Hanford Federal Facility Agreement and Consent Order*, 2 vols., as amended, Washington State Department of Ecology, U.S. Environmental Protection Agency, and U.S. Department of Energy, Richland Operations Office, Olympia, Washington.

EPA, 1988, *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA*, EPA/540/G-89/004, U.S. Environmental Protection Agency, Washington, D.C.

EPA, 1993, *Data Quality Objectives Process for Superfund Workbook*, 9355.9-01A, EPA 540-R-93-078, PB94-963204, U.S. Environmental Protection Agency, Washington, D.C.

Gano, K. A., 1979, *Analysis of Small Mammal Populations Inhabiting the Enviros of a Low-Level Radioactive Waste Pond*, PNL-2479/UC-11, Pacific Northwest Laboratory, Richland, Washington.

Hanson, G. L., J. D. Anderson, G. R. Kiel, B. J. McMurray, and N. P. Nisick, 1973, *Input and Decayed Values of Radioactive Liquid Wastes Discharged to the Ground in the 200 Areas through 1971*, ARH-2761, Atlantic Richfield Hanford Company, Richland, Washington.

Hayward, W. M., 1995, *RARA FY 1995 Summary Report*, BHI-00621, Rev. 0, Bechtel Hanford, Inc., Richland, Washington.

International Atomic Energy Agency (IAEA), 1982, *Effects of Ionizing Radiation on Plants and Animals at Levels Implied by Current Radiation Protection Standards*, IAEA-TECDOC-332, IAEA, Vienna, Austria.

Jensen, D. B., 1990, *Plutonium Finishing Plant Wastewater Stream-Specific Report*, WHC-EP-0342, Addendum 8, Westinghouse Hanford Company, Richland, Washington.

Johnson, et .al, 1994, *Historical Records of Radioactive Contamination in Biota at the 200 Areas of the Hanford Site*, WHC-MR-0418, Rev. 0., Westinghouse Hanford Company, Richland, Washington.

Kelty, G. G., K. A. Lindsey, S. E. Kos, and R. E. Price, 1995, *Borehole Summary Report for the 200-UP-2 Operable Unit, 200 West Area*, BHI-00034, Rev. 01, Bechtel Hanford, Inc., Richland, Washington.

Landeen, D. S. and J. G. Leitz, 1982, *Environmental Characterization of 216-U-14 Ditch*, RH0-HS-EV-4, Rockwell International, Rockwell Hanford Operations, Richland, Washington.

Last, G. V. and D. W. Duncan, 1980, *Radionuclide Distributions in Soils of the U-Pond Disposal System*, RHO-CD-1119, Rockwell Hanford Operations, Richland, Washington.

Last, G. V., D. W. Duncan, M. J. Graham, M. D. Hall, V. W. Hall, D. S. Landeen, J. G. Leitz, and R. M. Mitchell, 1994, *216-U-10 Pond and 216-Z-19 Ditch Characterization Studies*, WHC-EP-0707, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

Mitchell, R. M., 1995, *Ecological Sampling at Four Waste Sites in the 200 Areas*, BHI-00032, Rev. 1, Bechtel Hanford, Inc., Richland, Washington.

National Environmental Policy Act of 1969, 42 U.S.C. 4321, et seq.

Perkins, C. J., B. M. Markes, S. M. McKinney, R. M. Mitchell, and R. C. Roos, 1999, *Hanford Site Near-Facility Environmental Monitoring Data Report for Calendar Year 1998*, PNNL-12088, App. 2, Pacific Northwest National Laboratory, Richland, Washington.

PNNL, 1998, *Hanford Site Groundwater Monitoring for Fiscal Year 1997*, PNNL-11793, Pacific Northwest National Laboratory, Richland, Washington.

PNNL, 1999, *Hanford Site Groundwater Monitoring for Fiscal Year 1998*, PNNL-12086, Pacific Northwest National Laboratory, Richland, Washington.

PNNL, 2000, *Hanford Site Groundwater Monitoring for Fiscal Year 1999*, PNNL-13116, Pacific Northwest National Laboratory, Richland, Washington.

Resource Conservation and Recovery Act of 1976, 42 U.S.C. 6901, et seq.

Riley, R. G., L. A. Prohammer, D. A. Neitzel, R. M. Bean, and J. M. Thomas, 1986, *A Research Report for Rockwell Hanford Operations, Inventory and Chemical Analysis of Sediments From U Pond and S-19 Pond*, Pacific Northwest Laboratory, Richland, Washington.

Rogers, L. E., and W. H. Rickard, 1977, *Ecology of the 200 Area Plateau Waste Management Environs: A Status Report*, PNL-2253, Pacific Northwest Laboratory, Richland, Washington.

Schmidt, J. W., J. W. Fassett, V. G. Johnson, R. M. Mitchell, B. M. Markes, S. M. McKinney, K. J. Moss, and C. J. Perkins, 1996, *Westinghouse Hanford Company Operational Environmental Monitoring Annual Report, Calendar Year 1995*, WHC-EP-0573-4, Westinghouse Hanford Company, Richland, Washington.

Singleton, K. M., 1993, *Groundwater Impact Assessment Plan for the 216-U-14 Ditch*, WHC-SD-EN-AP-111, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

Singleton, K. M. and K. A. Lindsey, 1994, *Groundwater Impact Assessment Report for the 216-U-14 Ditch*, WHC-EP-0698, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

Stegen, J. A., 1993, *Vegetation Communities Associated with the 100 Area and the 200 Area Facilities on the Hanford Site*, WHC-SD-EN-TI-216, Westinghouse Hanford Company, Richland, Washington.

Toebe, W. E., L. L. Adams, and D. C. Hedengren, 1990, *UO3/U Plant Wastewater Stream-Specific Report*, WHC-EP-0342, Addendum 7, Westinghouse Hanford Company, Richland, Washington.

WAC 173-160, "Minimum Standards for Construction and Maintenance of Wells," *Washington Administrative Code*, as amended.

WAC 173-340, "Model Toxics Control Act - Cleanup," *Washington Administrative Code*, as amended.

WDOH, 1997, *Hanford Guidance for Radiological Cleanup*, WDOH/320-015, Washington State Department of Health, Division of Radiation Protection, Olympia, Washington.

WHC, 1990a, *242-S Evaporator Steam Condensate Stream-Specific Report*, WHC-EP-0342, Addendum 29, Westinghouse Hanford Company, Richland, Washington.

WHC, 1990b, *2724-W Laundry Wastewater Stream-Specific Report*, WHC-EP-0342, Addendum 11, Westinghouse Hanford Company, Richland, Washington.

WHC, 1990c, *284-W Powerplant Wastewater Stream-Specific Report*, WHC-EP-0342, Addendum 27, Westinghouse Hanford Company, Richland, Washington.

WHC, 1994, *Geologic Setting of the Low-Level Burial Grounds*, WHC-SD-EN-TI-290, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

Whiting, W. P., 1988, *Unusual Occurrence Report, Public Information Release* (Westinghouse Hanford Company Correspondence No. 8856882) Westinghouse Hanford Company, Richland, Washington.

Zimmerman, D. A, A. E. Reisenauer, G. D. Black, and M. A. Young, 1986, *Hanford Site Water Changes 1950 through 1980, Data Observation and Evaluation,* PNL-5506, Pacific Northwest Laboratory, Richland, Washington.

APPENDIX A

SAMPLING AND ANALYSIS PLAN

THIS PAGE INTENTIONALLY
LEFT BLANK

CONTENTS

FIGURES

TABLES

ACRONYMNS

ASTM	American Society for Testing and Materials
bdb	below ditch bottom
bgs	below ground surface
CFR	*Code of Federal Regulations*
COC	contaminant of concern
DOE	U.S. Department of Energy
DQO	data quality objective
EMI	electromagnetic induction
EPA	U.S. Environmental Protection Agency
ERC	Environmental Restoration Contractor
FSP	field sampling plan
GPR	ground penetrating radar
HEIS	Hanford Environmental Information System
HEPA	high-efficiency particulate air
OU	operable unit
QAPjP	quality assurance project plan
QC	quality control
RCT	radiological control technician
SAP	sampling and analysis plan
SGL	spectral gamma logging
TRU (waste)	waste media contaminated with 100 nCi/g concentrations of transuranic materials having half-lives above 20 years
VCP	vitrified clay pipe
WAC	*Washington Administrative Code*

A1.0 INTRODUCTION

This sampling and analysis plan (SAP) directs sampling and analysis activities that will be performed to characterize the 216-Z-11 Ditch in the 200-CW-5 U Pond/Z Ditches Cooling Water Group Operable Unit (OU). The sampling and analysis described in this document will be performed to provide soil/sediment/sludge data that may be used to refine and/or validate the site conceptual model, support an assessment of risk, and evaluate remedial alternatives for the 216-Z-11 Ditch and analogous waste sites. Characterization activities described in this plan are based on the implementation of the data quality objectives (DQO) process, as documented in the *200-CW-5 U Pond/Z Ditches Cooling Water Waste Group Remedial Investigation DQO Summary Report* (BHI 1999).

The scope of activities described in this SAP involves a four-step characterization approach that includes surface geophysical surveys (ground penetrating radar [GPR] and electromagnetic induction [EMI]), borehole geophysical logging by use of spectral gamma logging (SGL) and neutron monitoring methods, the drilling of up to three shallow boreholes and one deep borehole for soil sampling, and sampling of sludge/silt from accessible Z Plant discharge piping. Soil samples will be collected and analyzed for radiological and chemical contaminants of concern (COCs) and select physical properties. Boreholes will be geophysically logged with the spectral gamma and neutron moisture detectors to obtain additional information on the distribution of contamination and soil moisture.

A1.1 BACKGROUND

The 200-CW-5 OU waste sites primarily received steam condensate and cooling water from several facilities in the 200 West Area. This effluent typically contained low concentrations of contaminants, but occasional failure in the process systems resulted in significant amounts of radionuclides being released to the ponds and ditches in the OU. Some contamination may have penetrated the vadose zone and reached the aquifer beneath the waste sites. Pipelines carrying wastewater to the ditches and the 216-U-10 Pond may also have impacted the subsurface through leaks.

Three waste sites were chosen as representative sites in the *200 Areas Remedial Investigation/Feasibility Study Implementation Plan – Environmental Restoration Program* (Implementation Plan) (DOE-RL 1999) to represent typical and worst-case conditions of contamination in the OU. These waste sites are the 216-U-10 Pond, the 216-U-14 Ditch, and the 216-Z-11 Ditch. During the DQO process, it was determined that sufficient vadose characterization data exist for the 216-U-10 Pond and the 216-U-14 Ditch. Because the characterization performed to date on the 216-Z-11 Ditch was considered insufficient, it is the focus of the characterization activities in this SAP. Knowledge gained from characterizing this site and existing data for the 216-U-10 and 216-U-14 sites will be used to refine the conceptual models and support remedial action decision making for the OU.

A1.2 200-CW-5 GROUP/WASTE SITE LOCATIONS

The 200-CW-5 waste sites are located in southeastern Washington State on the Hanford Site in the 200 West Area. Figure A1-1 shows the specific locations of waste sites in the 200-CW-5 OU.

A1.3 SITE DESCRIPTION AND HISTORY

The following sections describe the waste site that will be investigated. More detail is provided in Section 2.2 of the work plan. Section 3.3 of the work plan contains information on the nature and extent of contamination and previous investigations.

A1.3.1 216-Z-11 Ditch

The 216-Z-11 Ditch began operations in 1959 to dispose of wastewater from the Z Plant to the 216-U-10 Pond (DOE-RL 1992). It served as a replacement ditch for the 216-Z-1D Ditch. The 216-Z-11 Ditch was 797 m (2,615 ft) long and 0.6 m (2 ft) deep. The ditch was 1.2 m (4 ft) wide at the bottom and had side slopes of 2.5:1 with a 0.05% grade. The first 36.6 m (120 ft) of the ditch was in common with the 216-Z-1D Ditch and began at a point immediately east of the 241-Z Building. The middle section of the ditch ran parallel to the 216-Z-1D Ditch, then rejoined it for the last 203 m (665 ft) to the 216-U-10 Pond.

The 216-Z-11 Ditch operated from 1959 until 1971. The ditch received process cooling water and steam condensate from the 234-5Z Building, vacuum pump seal water and cooling water from the 291-Z Building, and laboratory waste and steam condensate from the 231-Z Building. The 216-Z-11 Ditch was deactivated and replaced by the 216-Z-19 Ditch. The site was backfilled to grade when it was retired, and additional backfill material was added when the 216-Z-19 Ditch was deactivated in 1981. The 216-Z-11 Ditch has a contamination burden of 137 Ci plutonium-239 and 37 Ci plutonium-240 and is reported as a transuranic-contaminated soil site (DOE-RL 1992).

A1.4 CONTAMINANTS OF CONCERN

Step 1 of the DQO process identifies the need to develop a list of COCs for 200-CW-5 waste sites. Development of the COCs is an essential step toward refining the site conceptual model. From an initial list of more than 340 contaminants that potentially could have been discharged to 200-CW-5 waste sites, 66 COCs were retained as a result of the DQO process. Development of this list is described in the DQO summary report (BHI 1999), which is summarized in Section 3.5 of this work plan. The COCs are identified in Table A1-1.

If contaminants not identified as COCs are detected during laboratory analysis, the data will be evaluated against regulatory standards, or risk-based levels if exposure data are available, and existing process knowledge in support of remedial action decision making.

A1.5 DATA QUALITY OBJECTIVES

The U.S. Environmental Protection Agency (EPA) document, *Guidance for the Data Quality Objectives Process* (EPA 1994a), was used to support the development of this SAP. The DQO process is a strategic planning approach that provides a systematic process for defining the criteria that a data collection design should satisfy. Using the DQO process ensures that the type, quantity, and quality of environmental data used in decision making will be appropriate for the intended application.

This section summarizes the key outputs resulting from the implementation of the seven-step DQO process. For additional details, the reader should refer to the DQO summary report (BHI 1999).

A1.5.1 Statement of the Problem

The primary objectives of the DQO process for the 200-CW-5 OU are to determine the environmental measurements necessary to refine the preliminary site conceptual model, support an evaluation of risk, and evaluate remedial alternatives. As identified in Section 5.3 of the work plan, possible remedial alternatives considered in the development of the DQO included the following:

- No-action alternative (no institutional controls)
- Capping
- Excavate and dispose of waste
- In situ vitrification
- In situ grouting and stabilization
- Monitored natural attenuation (with institutional controls).

A1.5.2 Decision Rules

Decision rules are developed from the combined results of DQO Steps 2, 3, and 4. These results include the principal study questions, decision statements, remedial action alternatives, data needs, COC action levels, analytical requirements, and the scale of the decision(s). Decision rules are generally structured as "IF…THEN" statements that indicate what action will be taken when a prescribed condition is met. Decision rules incorporate the parameters of interest (e.g., COCs), the scale of the decision (e.g., location), the action level (e.g., COC concentration), and the action(s) that would result. The 200-CW-5 decision rules are summarized in Table A1-2.

A1.5.3 Error Tolerance and Decision Consequences

The consequence of selecting an inadequate nonstatistical sampling design is not considered severe. According to the guidance in Table 4-5a in the DQO summary report (BHI 1999), the sampling design rigor requirements are not significant because of the combination of low severity and continued accessibility on the 216-Z-11 Ditch for further sampling after remedial investigation sampling. If the sampling design is determined to be inadequate, additional sampling may be performed. Section 5.2 of the work plan summarizes the sampling activities that are planned as described in this SAP.

A1.5.4 Sample Design Summary

A nonstatistical sampling design (i.e., professional judgement; biased) was used to determine sampling requirements for the 216-Z-11 Ditch. A biased sampling approached was developed from process knowledge, expected behavior of COCs, the observed distribution of contamination in the other Z Ditches, and the preliminary conceptual site model developed for this waste group. To overcome the lack of historical data on the 216-Z-11 Ditch and the presence of a 1.8-m- (6-ft) thick blanket of stabilizing soil, a four-step characterization approach was developed to cost-effectively locate and sample transuranic material "hot spots" and assess the nature and extent of other contaminants. Using this approach, sample locations are selected that increase the likelihood of encountering the worst-case conditions/maximum contaminant concentrations.

The preliminary site conceptual model suggests that highest contaminant concentrations should be detected near the bottom of the ditch and decrease with depth below the ditch bottom. Therefore, the sampling design focuses on sampling in the ditch sediment layer at the bottom of the 216-Z-11 Ditch. Sample frequency will decrease with depth below the ditch sediment layer based on the expected distribution of contamination. Additional samples may be collected at the discretion of the site geologist based on the field screening data. The sample design for this characterization is presented in Section A3.0.

The sample design developed for this SAP has several potential limitations that may affect the sampling results. Some of the factors that could affect the outcome of this sampling effort and an assessment of the possible contingencies are discussed in Section A3.3.6.

Figure A1-1. Location of Waste Sites in the 200-CW-5 Operable Unit.

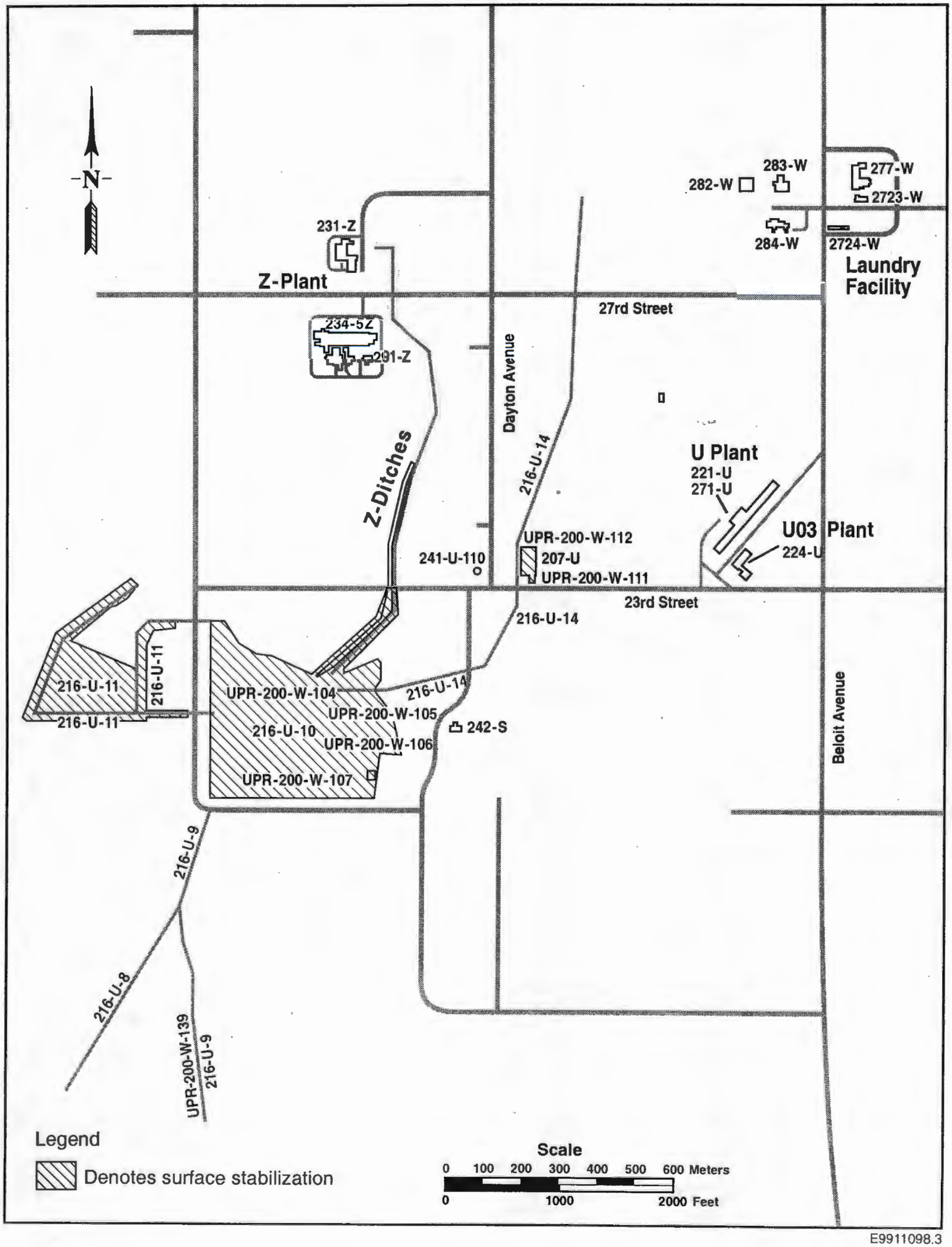


Table A1-1. Contaminants of Concern for 200-CW-5 Operable Unit (from BHI 1999, Table 1-7). (2 Pages)

Radioactive Constituents	
Americium-241	Plutonium-239/240
Cesium-137	Radium-226
Cobalt-60	Radium-228
Curium-243	Strontium-90
Europium-152	Technetium-99[a]
Europium-154	Thorium-232
Europium-155	Tritium[a]
Neptunium-237	Uranium-234[b]
Nickel-63[a]	Uranium-235[b]
Niobium-94	Uranium-236[b]
Plutonium-238	Uranium-238[b]
Chemical Constituents – Metals	
Arsenic	Lead
Barium	Mercury
Beryllium	Nickel
Cadmium	Selenium
Chromium	Silver
Copper	Zinc
Hexavalent chromium	
Chemical Constituents - Other Inorganics	
Chloride	Sulfate
Fluoride	Sulfide
Nitrate	
Chemical Constituents - Volatile Organics	
Acetone	Hexane
Acetonitrile	Perchloroethylene
2-Butanone (MEK)	Pseudo cumene (1,2,4 trimethyl benzene)
Carbon tetrachloride	Tetrahydro furan
Chlorobenzene	Toluene
Chloroform (trichloromethane)	Trichloroethene
Cyclohexane	Vinyl chloride
Decane	Xylenes
Dichloromethane	

Table A1-1. Contaminants of Concern for 200-CW-5 Operable Unit (from BHI 1999, Table 1-7). (2 Pages)

Semi-Volatile Organics	
Creosote	Paint thinner
Cyclohexanone	Polychlorinated biphenyls
Kerosene[c]	Tar
Naphthylamine	Tributyl phosphate
Normal paraffins	

[a] These COCs are deep-zone sensitive only. Analyses are not required for these COCs in the shallow zone (<7.6 m [25 ft] below ground surface) soils, as they are soft beta emitters in low abundance that have insignificant dose impact in the shallow zone.
[b] Uranium will be analyzed for total abundance in all samples; any samples with values significantly above background levels will be analyzed for these individual species.
[c] Analyzed as kerosene total petroleum hydrocarbons.

Table A1-2. Data Quality Objectives Decision Rules (from BHI 1999, Table 5-5). (2 Pages)

DR #	Decision Rule
1	If the 95% UCL of the mean or average (as applicable) detected spectral gamma logging results and/or the maximum detected soil sampling results for the transuranic COCs in the 216-Z-11 Ditch sediment layer exceed the TRU definition of 100 nCi/g, then the chemical COCs will be evaluated in accordance with DR#4, and the need for special remedial alternatives will be evaluated in a FS. If the 95% UCL of the mean or average (as applicable) detected spectral gamma logging results and/or the maximum detected soil sampling results for the transuranic COCs in the 216-Z-11 Ditch sediment layer do not exceed the TRU definition of 100 nCi/g, then the results will be evaluated by the RESRAD analytical model to determine if sediment layer exceeds the annual exposure limits for human health protection under the appropriate exposure scenario, the chemical COCs will be evaluated in accordance with DR#4, and the need for conventional remedial alternatives will be evaluated for the sediment layer in a feasibility study.
2	If the RESRAD analysis of the 95% UCL of the mean or average (as applicable) detected spectral gamma logging results and/or the maximum detected soil sampling results for the radiological COCs in the 216-Z-11 Ditch from the bottom of the sediment layer (about 3.6 m [12 ft] below ground surface) to 4.5 m (15 ft) bgs exceed or do not exceed the annual exposure limits for human health protection (under the appropriate scenario), then the chemical COCs will be evaluated in accordance with DR#5, and a FS will be performed to evaluate the need for remedial action alternatives, or a streamlined approach to site closure will be applied administratively, via an existing ROD.
3	If the RESRAD analysis of the 95% UCL of the mean or average (as applicable) detected spectral gamma logging results and/or the maximum detected soil sampling results for the radiological COCs in the 216-Z-11 Ditch from 4.5 m (15 ft) bgs to 7.6 m (25 ft) bgs exceed or do not exceed the annual exposure limits for human health protection (under the appropriate scenario), then the chemical COCs will be evaluated in accordance with DR#6, and a FS will be performed to evaluate the need for remedial action alternatives, or a streamlined approach to site closure will be applied administratively, via an existing ROD.
4	If the analytical results of the 216-Z-11 Ditch sediment layer samples indicate that the three-part MTCA criteria or average detected values (as applicable) have or have not been met for the respective chemical COCs preliminary action levels, then a FS will be performed to evaluate the need for remedial action alternatives, or a streamlined approach to site closure will be applied administratively, via an existing ROD.

Table A1-2. Data Quality Objectives Decision Rules (from BHI 1999, Table 5-5). (2 Pages)

DR #	Decision Rule
5	If the analytical results of the 216-Z-11 Ditch from the bottom of the sediment layer (about 4 m [12 ft] bgs) to 4.6 m (15 ft) indicate that the three-part MTCA criteria or average detected values (as applicable) have or have not been met for the respective chemical COCs preliminary action levels, then a FS will be performed to evaluate the need for remedial action alternatives, or a streamlined approach to site closure will be applied administratively, via an existing ROD.
6	If the analytical results of the 216-Z-11 Ditch from 4.6 m (15 ft) bgs to 8 m (25 ft) indicate that the 95% UCL of the mean or average detected values (as applicable) have or have not been met for the respective chemical COCs preliminary action levels, then a FS will be performed to evaluate the need for remedial action alternatives, or a streamlined approach to site closure will be applied administratively, via an existing ROD.
7	If the detected values indicate that the contamination distribution in the 0- to 8-m (0- to 25-ft) elevation and from 8 m (25 ft) to groundwater for the 216-Z-11 Ditch does not differ significantly from the preliminary contaminant distribution model, then the preliminary model will not be revised prior to use for remedial decision making or remedial action planning. If the detected values indicate that the contamination distribution in the 0- to 8-m (0- to 25-ft) elevation and from –8 m (-25 ft) to groundwater for the 216-Z-11 Ditch differs significantly from the preliminary contaminant distribution model, then the preliminary model will be revised prior to use for remedial decision making or remedial action planning.

[a] The use of the term "remedial action" is used collectively to refer to one of the alternatives described in the project objectives discussion.

bgs = below ground surface
COC = contaminant of concern
MTCA = *Model Toxics Control Act*
UCL = upper confidence limit

A2.0 QUALITY ASSURANCE PROJECT PLAN

The quality assurance project plan (QAPjP) establishes the quality requirements for environmental data collection, including sampling, field measurements, and laboratory analysis. The overall QAPjP for Environmental Restoration (ER) waste sites in the 200 Areas is included in Appendix A of the Implementation Plan (DOE-RL 1999). The QAPjP complies with the requirements of the following:

- U.S. Department of Energy (DOE) Order 5700.6c, *Quality Assurance*
- *Code of Federal Regulations* (CFR), 40 CFR 830.120, "Quality Assurance Requirements"
- *EPA Requirements for Quality Assurance Project Plans for Environmental Data Operations* (EPA 1994b)
- *Hanford Analytical Services Quality Assurance Requirements Documents* (HASQARD) (DOE-RL 1996a).

The Implementation Plan provides the general framework of technical and administrative requirements that apply to 200-CW-5 and other OUs in the 200 Areas.

The following sections describe the supplemental waste group quality requirements and the procedural controls applicable to this investigation. The 200 Areas QAPjP (Appendix A of the Implementation Plan [DOE-RL 1999]) and this section of the SAP will serve as the QAPjP for the 200-CW-5 RI.

A2.1 FIELD QUALITY CONTROL

Field QC samples shall be collected to evaluate the potential for cross-contamination and laboratory performance. Field QC for sampling in the 200-CW-5 OU will require the collection of co-located duplicates, field splits, equipment rinsate blanks, and trip blank samples. The QC samples are described in this section with the required frequency of collection.

QC samples will not be collected from the ditch sediment layer, which is expected to contain transuranic-contaminated soils, because of the extreme cost and handling requirements associated with transuranic materials.

A2.1.1 Co-Located Duplicates

Co-located duplicates are independent samples collected as close as possible to the same point in space and time, taken from the same source, stored in separate containers, and analyzed independently. These samples are useful in documenting homogeneity in the soil. It is important that these samples are not homogenized together.

A minimum of 5% of the total collected soil samples shall be duplicated, or one field duplicate shall be collected for every 20 samples, whichever is greater. At least one co-located duplicate shall be collected from each borehole. The duplicates should generally be collected from an area that is expected to have some contamination, so that valid comparisons between the samples can be made (i.e., at least some of the COCs will be above detection limit). When sampling with a split spoon, the duplicate sample will probably be from a separate split spoon either above or below the main sample because of volume constraints. The split-spoon duplicate should be collected somewhere below the interval of continuous coring and above 7.6 m (25 ft) below ground surface (bgs) (see Section A3.2.3 for a discussion of borehole sampling, which applies to split-spoon sampling from boreholes).

A2.1.2 Field Splits

One soil split sample shall be collected during soil sampling in the 216-Z-11 Ditch. The split sample shall be retrieved from the same sample interval using the same equipment (collected from one split spoon) and sampling technique; sampling limitations involving split spoons as discussed in Section A2.1.1 also apply to field splits. Samples shall be homogenized, split into two separate aliquots in the field, and sent to two independent laboratories. The split will be used to verify the performance of the primary laboratory.

The split sample will be obtained from sample media suitable for analysis in an offsite laboratory and shall be analyzed for all of the COCs listed in Table A2-1.

A2.1.3 Equipment Rinsate Blanks

Equipment blanks shall be collected at the same frequency as co-located duplicate samples, where applicable, and are used to verify the adequacy of sampling equipment decontamination procedures. The field geologist may request that additional equipment blanks be taken. Equipment blanks shall consist of pure deionized water washed through decontaminated sampling equipment and placed in containers identical to those used for actual field samples.

Equipment rinsate blanks shall be analyzed for the following:

- Gross alpha
- Gross beta
- Metals (excluding hexavalent chromium and mercury)
- Anions (except cyanide)
- Semivolatile organic analyte
- Volatile organic analytes.

These analytes are considered to be the best indicators of decontamination effectiveness.

A2.1.4 Trip Blanks

The volatile organic trip blanks will constitute approximately 5% of all samples, which equates to approximately every sixth batch (cooler) of sample containers shipped. The trip blank shall consist of pure deionized water added to one clean sample container in the field and will be returned unopened to the laboratory. Trip blanks are prepared as a check for possible contamination originating from container preparation methods, shipment, handling, storage, or site conditions. The trip blank shall be analyzed only for volatile organic compounds.

A2.1.5 Prevention of Cross-Contamination

Special care should be taken to prevent cross-contamination of soil samples. Particular care will be exercised to avoid the following common ways in which cross-contamination or background contamination may compromise the samples:

- Improperly storing or transporting sampling equipment and sample containers
- Contaminating the equipment or sample bottles by setting them on or near potential contamination sources, such as uncovered ground
- Handling bottles or equipment with dirty hands
- Improperly decontaminating equipment before sampling or between sampling events.

A2.2 QUALITY OBJECTIVES AND CRITERIA FOR MEASUREMENT DATA

Quality objectives and criteria for soil measurement data are presented in Table A2-1 for chemical and radiological analytes, as well as physical properties of interest. Table A2-1a provides the analytical performance requirements for SGL. Analysis of soil physical properties will be performed according to American Society for Testing and Materials (ASTM) procedures, if applicable.

A2.3 SAMPLE PRESERVATION, CONTAINERS, AND HOLDING TIMES

Soil sample preservation, containers, and holding times for chemical and radiological analytes of interest and physical property test are presented in Table A2-2. Final sample collection requirements will be identified on the Sampling Authorization Form.

A2.4 ONSITE MEASUREMENTS QUALITY CONTROL

The collection of QC samples for onsite measurements QC is not applicable to field-screening techniques described in this plan. Field-screening instrumentation will be calibrated and controlled according to the procedures identified in Section A2.7.

A2.5 DATA MANAGEMENT

Data resulting from the implementation of this QAPjP shall be managed and stored by the Environmental Restoration Contractor (ERC) organization responsible for sampling and characterization, in accordance with BHI-EE-01, Section 2.0, "Sample Management." At the direction of the task lead, all analytical data packages shall be subject to final technical review by qualified personnel before their submittal to regulatory agencies or inclusion in reports. Electronic data access, when appropriate, shall be via a database (e.g., Hanford Environmental Information System [HEIS] or a project-specific database). Where electronic data are not available, hard copies shall be provided in accordance with Section 9.6 of the *Hanford Federal Facility Agreement and Consent Order* (Ecology et al. 1998).

A2.6 VALIDATION AND VERIFICATION REQUIREMENT

Validation shall be performed on completed data packages by qualified Bechtel Hanford, Inc. Sample Management personnel or by a qualified independent contractor. Validation shall consist of verifying required deliverables, requested versus reported analyses, and transcription errors. Validation shall also include the evaluation and qualification of results based on holding time, method blanks, matrix spikes, laboratory control samples, laboratory duplicates, and chemical and tracer recoveries, as appropriate to the methods used. No other validation or calculation checks will be performed. At least 5% of all data shall be validated.

Assuming that about 18 samples will be collected during the 200-CW-5 investigations (including full QC sets, but exclusive of discretionary samples; see Table A3-4), at least 1 data package/(sample delivery group containing up to 18 sample sets) will be generated. Validation requirements identified in this section are consistent with Level C validation, as defined in data validation procedures (WHC 1993a, 1993b). No validation for physical data will be performed.

A2.7 TECHNICAL PROCEDURES AND SPECIFICATIONS

Soil sampling and onsite environmental measurements shall be performed according to approved procedures. Sampling and field measurements will be conducted according to BHI-EE-01, *Environmental Investigations Procedures*; and BHI-EE-05, *Field Screening Procedures*; and other approved procedures listed below. Individual procedures that may be used during performance of this SAP include the following:

- BHI-EE-01, *Environmental Investigations Procedures*

  Section 1.0, General Information

  - Procedure 1.5, "Field Logbooks"
  - Procedure 1.6, "Survey Requirements and Techniques"

  Section 2.0, Sample Management

  - Procedure 2.0, "Sample Event Coordination"
  - Procedure 2.1, "Sampling Documentation Processing"

Section 3.0, General Sampling

- Procedure 3.0, "Chain of Custody"
- Procedure 3.1, "Sample Packaging and Shipping"
- Procedure 3.2, "Field Decontamination of Sampling Equipment"

Section 4.0, Soil, Groundwater, and Biotic Sampling

- Procedure 4.0, "Soil and Sediment Sampling"
- Procedure 4.2, "Sample Storage and Shipping Facility"

Section 6.0, Drilling

- Procedure 6.0, "Documentation of Well Drilling, Abandonment, Remediation, and Completion Operations"
- Procedure 6.1, "Drilling and Sampling in Radiological Contaminated Areas"
- Procedure 6.2, "Field Cleaning and/or Decontamination of Drilling Equipment"

Section 7.0, Geologic and Hydrologic Data Collection

- Procedure 7.0, "Geologic Logging"
- Procedure 7.2, "Geophysical Survey Work"

- BHI-EE-05, *Field Screening Procedures*

  - Procedure 1.0, "Routine Field Screening"
  - Procedure 2.4, "Operation of the Man-Carried Radiological Detection System (MRDS)"
  - Procedure 2.5, "Operation of Mobile Surface Contaminant Monitor II"
  - Procedure 2.12, "Eberline E-600 Usage for Environmental Surveys"

- BHI-FS-03, *Field Support Waste Management Instructions*

  - Instruction W-011, "Control of CERCLA and Other Past-Practice Investigation Derived Waste"

Work shall also be performed in accordance with the following manuals:

- BHI-EE-02, *Environmental Requirements*, Section 11.0, "Solid Waste System Operations"

- BHI-QA-01, *ERC Quality Program*

- BHI-QA-03, *ERC Quality Assurance Program Plans*

  - Plan 5.1, "Field Sampling Quality Assurance Program Plan"
  - Plan 5.2, "Onsite Measurements Quality Assurance Program Plan"
  - Plan 5.3, "Radiological Measurements and Environmental Support Quality Assurance Program Plan"

- BHI-MA-02, *ERC Project Procedures*
- BHI-SH-01, *Hanford ERC Environmental, Safety, and Health Program*
- BHI-SH-05, *Industrial Hygiene Work Instructions*
- BHI-SH-02, *Safety and Health Procedures,* Volumes 1 through 4
- BHI-EE-10, *Waste Management Plan*
- BHI-SH-04, *Radiological Control Work Instructions*
- *Hanford Site Radiatiological Control Manual* (DOE-RL 1996b)
- Specification for environmental drilling services specific to 200-CW-5
- *Sampling Services Procedures Manual*, ES-SSPM-001, Rev. 0, Procedure 2-5, "Laboratory Cleaning of Sampling Equipment," Waste Management Northwest (WMNW 1998).

A2.7.1 Sample Location

Sample locations (e.g., geophysical surveys and boreholes) shall be staked and labeled before starting the activity. Locations shall be staked by the technical lead or field team leader assigned by the project manager. After the locations have been staked, minor adjustments to the location may be made to mitigate unsafe conditions, avoid structural interferences, or bypass utilities. Locations shall be identified during or after sampling following BHI-EE-01, Procedure 1.6, "Survey Requirements and Techniques." Changes in sample locations that do not impact the DQOs will require approval of the project manager. However, changes to sample locations that result in impacts to the DQOs will require EPA concurrence.

A2.7.2 Sample Identification

The ERC Sample and Data Tracking database will be used to track the samples through the collection and laboratory analysis process. The HEIS database is the repository for the laboratory analytical results. The HEIS sample numbers will be issued to the sampling organization for this project in accordance with BHI-EE-01, Procedure 2.0, "Sample Event Coordination." Each chemical/radiological and physical properties sample will be identified and labeled with a unique HEIS sample number. The sample location, depth, and corresponding HEIS numbers will be documented in the sampler's field logbook.

Each sample container will be labeled with the following information using a waterproof marker on firmly affixed, water-resistant labels:

- HEIS number
- Sample collection date/time
- Name/initials of person collecting the sample

- Analysis required
- Preservation method, if applicable.

A2.7.3 Field Sampling Log

All information pertinent to field sampling and analysis will be recorded in bound logbooks in accordance with BHI-EE-01, Procedure 1.5, "Field Logbooks." The sampling team will be responsible for recording all relevant sampling information including, but not limited to, the information listed in Appendix A of Procedure 1.5. Entries made in the logbook will be dated and signed by the individual who made the entry.

A2.7.4 Sample Custody

A chain-of-custody record will be initiated in the field at the time of sampling and will accompany each set of samples (cooler) shipped to any laboratory in accordance with BHI-EE-01, Procedure 3.0, "Chain of Custody." The analyses requested for each sample will be indicated on the accompanying chain-of-custody form. Chain-of-custody procedures will be followed throughout sample collection, transfer, analysis, and disposal to ensure that sample integrity is maintained. Each time responsibility for custody of the sample changes, the new and previous custodians will sign the record and note the date and time. The sampler will make a copy of the signed record before sample shipment and transmit it to ERC Sample Management within 24 hours of shipping, as detailed in BHI-EE-01, Procedure 2.1, "Sampling Documentation Processing."

A custody seal (i.e., evidence tape) shall be affixed to the lid of each sample jar. The container seal will be inscribed with the sampler's initials and the date sealed. For any sample jars collected inside the glovebag or glovebox and "bagged out," the evidence tape may be affixed to the seal of the bag to demonstrate that tampering has not occurred. This will eliminate problems associated with contaminated soils adhering to the custody tape while inside the glovebox.

A2.7.5 Sample Containers and Preservatives

Level I EPA pre-cleaned sample containers will be used for soil samples collected for chemical and radiological analysis. Container sizes may vary depending on laboratory-specific volumes needed to meet analytical detection limits. If, however, the dose rate on the outside of a sample jar or the curie content exceeds levels acceptable by an offsite laboratory, the sampling lead and task lead can send smaller volumes to the laboratory after consultation with ERC Sample Management to determine acceptable volumes. Preliminary container types and volumes are identified in Table A2-2. Final types and volumes will be provided in the Sample Authorization Form.

A2.7.6 Sample Shipping

The outside of each sample jar will be surveyed by the radiological control technician (RCT) to verify that the container is free of smearable surface contamination. The RCT shall also measure the radiological activity on the outside of the sample container (through the container) and will mark the container with the highest contact radiological reading in either disintegrations per minute (dpm) or mrem/hr, as applicable. Unless pre-qualified, all samples will have total activity analysis performed by the Radiological Counting Facility (RCF), 222-S Laboratory, or other suitable onsite laboratory, before shipment. This information, along with other data that may pre-qualify the samples, will be used to select proper packaging, marking, labeling, and shipping paperwork in accordance with U.S. Department of Transportation regulations (49 CFR) and to verify that the sample can be received by the offsite analytical laboratory in accordance with the laboratory's acceptance criteria. The sampler will send copies of the shipping documentation to ERC Sample Management within 24 hours of shipping, as detailed in BHI-EE-01, Procedure 2.1, "Sampling Documentation Processing."

As a general rule, samples with activities <1 mR/hr will be shipped to an offsite laboratory. Samples with activities between 1 mR/hr and 10 mR/hr may be shipped to an offsite laboratory; samples with activities in this range will be evaluated on a case-by-case basis by ERC Sample Management. Samples with activities >10 mR/hr will be sent to an onsite laboratory arranged by Sample Management. Potential impacts of onsite laboratory measurements are discussed in footnote "a" of Table A2-1.

Table A2-1. Analytical Performance Requirements. (3 Pages)

Data Type	Analytical Method	Analyte	Preliminary Action Level	Detection Limit Requirements[a]		Accuracy Required	Precision Required
				MDL	PQL		
Radiological Constituents, in pCi/g							
Rad, α	AmAEA[b]	Americium-241	c	0.1	1	70-130	±30
Rad, γ	HPGe	Cesium-137	c	0.05	0.1	80-120	±30
Rad, γ	HPGe	Cobalt-60	c	0.05	0.1	80-120	±30
Rad, α	AmAEA[b]	Curium-243	c	0.1	1	70-130	±30
Rad, γ	HPGe	Europium-152	c	0.1	0.2	80-120	±30
Rad, γ	HPGe	Europium-154	c	0.1	0.2	80-120	±30
Rad, γ	HPGe	Europium-155	c	0.1	0.2	80-120	±30
Rad, α	NpAEA[b]	Neptunium-237	c	0.1	1	70-130	±30
Rad, β	Liq Scintillation	Nickel-63	c	5	30	70-130	±30
Rad, γ	HPGe	Niobium-94	c	0.1	1	80-120	±30
Rad, α	PuAEA[b]	Plutonium-238	c	0.1	1	70-130	±30
Rad, α	PuAEA[b]	Plutonium-239/240	c	0.1	1	70-130	±30
Rad, γ	HPGe	Radium-226	c	0.1	0.2	80-120	±30
Rad, γ	HPGe	Radium-228	c	0.1	0.2	80-120	±30
Rad, β	RADSr	Radiogenic strontium	c	0.2	1	70-130	±30
Rad, β	Liq Scintillation	Technetium-99	c	5	15	70-130	±30
Rad, α	ThAEA[b]	Thorium-232	c	0.1	1	70-130	±30
Rad, β	Liq Separation	Tritium	c	5	400	70-130	±30
Rad	KPA[d]	Total uranium	N/A	0.2 mg/kg	1.0 mg/kg	70-130	±30
Rad, α	UAEA[b]	Uranium-234	c	0.1	1	70-130	±30
Rad, α		Uranium-235/236	c	0.1	1	70-130	±30
Rad, α		Uranium-238	c	0.1	1	70-130	±30
Data Type	**Analytical Method**	**Analyte**	**Preliminary Action Level**	**Detection Limit Requirements[a]**		**Accuracy Required**	**Precision Required**
			Method C	**MDL**	**PQL**		
Inorganic Chemical Constituents[e], in mg/kg							
Chem	EPA 6010	Arsenic	6.5[f]	2.5/0.2[g]	10/1[g]	70-130	±30
Chem	EPA 6010	Barium	245	0.1	1	70-130	±30
Chem	EPA 6010	Beryllium	1.51[f]	0.03	0.2	70-130	±30
Chem	EPA 6010	Cadmium	0.5[h]	0.3	0.8	70-130	±30
Chem	EPA 6010	Chromium (III)	3,500[h]	0.4	1	70-130	±30
Chem	EPA 6010	Copper	130[h]	0.5	2	70-130	±30
Chem	EPA 7196	Hexavalent chromium	8[i]	0.1	0.7	70-130	±30

Table A2-1. Analytical Performance Requirements. (3 Pages)

Data Type	Analytical Method	Analyte	Preliminary Action Level	Detection Limit Requirements[a]		Accuracy Required	Precision Required
			Method C	MDL	PQL		
Inorganic Chemical Constituents[c], in mg/kg							
Chem	EPA 6010	Lead	1000[h,j]	5	20	70-130	±30
Chem	EPA 7471	Mercury	0.33[f,h]	0.005	0.05	70-130	±30
Chem	EPA 6010	Nickel	70[h]	1	4	70-130	±30
Chem	EPA 6010	Selenium	5[h]	5/.05	20/0.5	70-130	±30
Chem	EPA 6010	Silver	10[h]	0.7	2	70-130	±30
Chem	EPA 6010	Zinc	500[h]	0.5	2	70-130	±30
Chem	EPA 300.0	Chloride	25,000	0.2	2	70-130	±30
Chem	EPA 300.0	Fluoride	200	0.2	1	70-130	±30
Chem	IC 300 modified and 353.1[k]	Nitrate/nitrite	4,400	0.2	1	70-130	±30
Chem	EPA 300.0	Sulfate	25,000	2	10	70-130	±30
Chem	EPA 9030	Sulfide	N/A	4	20	70-130	±30
Organic Chemical Constituents, in mg/kg							
Chem	EPA 8260	Acetone	175	0.01	0.05	70-130	±30
Chem	EPA 8260	Acetonitrile	10.5	0.02	0.1	l	l
Chem	EPA 8260	2-Butanone (MEK)	1050	0.01	0.05	l	l
Chem	EPA 8260	Carbon tetrachloride	0.337	0.001	0.005	l	l
Chem	EPA 8260	Chlorobenzene	10.0	0.002	0.010	l	l
Chem	EPA 8260	Chloroform (trichloromethane)	7.17	0.001	0.005	l	l
Chem	EPA 8270	Creosote/Tar	N/A	Var[m]	Var[m]	l	l
Chem	EPA 8260 as TIC	Cyclohexane	N/A	N/A	N/A	l	l
Chem	EPA 8270 as TIC	Cyclohexanone	17,500	N/A	N/A	l	l
Chem	EPA 8260 as TIC	Decane	N/A	N/A	N/A	l	l
Chem	EPA 8260	Dichloromethane	5.83	0.001	0.005	l	l
Chem	EPA 8260 as TIC	Hexane	105	N/A	N/A	l	l
Chem	EPA 8270	Naphthylamine	N/A	0.3	0.85	l	l
Chem	EPA 8260	Perchloroethylene	100	0.001	0.005	l	l
Chem	EPA 8080/ 8082	Polychlorinated biphenyls	0.5	0.01	0.1	l	l
Chem	EPA 8260 as TIC	Pseudo cumene (1,2,4 trimethyl benzene)	N/A	N/A	N/A	l	l
Chem	EPA 8260	Tetrahydro furan	N/A	0.01	0.05	l	l
Chem	EPA 8260	Toluene	100	0.001	0.005	l	l
Chem	EPA 8270	Tributyl phosphate	N/A	0.4	4	l	l
Chem	EPA 8260	Trichloroethene	100	0.001	0.005	l	l
Chem	EPA 8260	Vinyl chloride	0.023	0.001	0.005	l	l
Chem	EPA 8260	Xylenes	1,000	0.001	0.005	l	l

Table A2-1. Analytical Performance Requirements. (3 Pages)

Data Type	Analytical Method	Analyte	Preliminary Action Level	Detection Limit Requirements[a]		Accuracy Required	Precision Required
			Method C	MDL	PQL		
Organic Chemical Constituents, in mg/kg							
Chem	NWTPH-Dx modified for kerosene range	Kerosene, normal paraffins, paint thinner	N/A	0.5	5	1	1
Soil Physical Properties							
D2216		Moisture content	N/A	wt%		N/A	N/A
D422		Particle size distribution	N/A	wt%		N/A	N/A
BHI-EE-01, Procedure 7.0		Lithology	N/A	Descriptive		N/A	N/A

[a] Detection limits are based on optimal conditions in a standard fixed laboratory. Interferences and matrix effects may degrade the values shown. If soil samples are determined to contain radiological contaminants in high concentrations, they will need to be analyzed in an onsite laboratory because of offsite laboratory acceptance criteria limits. In this case, expected impacts include high analytical costs, degradation of detection limits (four order of magnitude impact for the gamma isotopes), reduced analyte lists, and long turnaround times.
[b] AmAEA, PuAEA, UAEA, NpAEA, ThAEA – chemical separation, electro/microprecipitation deposition, alpha energy analysis via Si barrier detector.
[c] There are no preliminary action levels for radionuclides at this time. They will be developed in the remedial investigation and feasibility study process.
[d] Uranium will be analyzed for total abundance in all samples; any samples with values significantly above background levels will be analyzed for the individual species.
[e] Waste disposition for this project will comply with the Phase IV RCRA implementation requirements per 40 CFR 261.24 and 40 CFR 268.40. This applies to the toxicity characteristic metals, and require performance of toxicity characteristic leaching procedure (TCLP) analyses for sample results that exceed the LDR threshold values (determined by applying the 20 times totals values). If TCLP analyses are performed, the analyte list will be expanded to include antimony and thallium as potential underlying hazardous constituents.
[f] This value represents Hanford Site background.
[g] First value shown is via routine inductively coupled plasma (ICP); second value via "trace" ICP or graphite furnace atomic absorption.
[h] If reported value is given by the laboratory, the approximate detection limit will be identified.
[i] Based on Federal ambient water quality control criteria and assumed dilution-attenuation factor of 2.
[j] MTCA Method A, Table 3 (WAC 173-340-740).
[k] Nitrate/nitrite analysis yields total nitrogen.
[l] As reported by SW-846 procedure.
[m] Creosote is a mixture of, primarily, aromatic (e.g., benzene) and polynuclear aromatic (e.g., pyrene) constituents. Analysis by EPA 8260 and 8270 will report primary constituents at detection limits comparable to benzene and pyrene.
α = alpha analysis
γ = gamma analysis
HPGe = high-purity germanium
KPA = kinetic phosphorescence analysis
N/A = not applicable

Table A2-1a. Analytical Performance Requirements for Spectral Gamma Logging.

Data Type	Analytical Method	Analyte	Preliminary Action Level	Detection Limit Requirements[a]		Accuracy Required	Precision Required
				MDL	PQL		
Rad, γ	HPGe	Americium-241	100 nCi/g	~25 nCi/g	-	70-130	±30
Rad, γ	HPGe	Cesium-137	a	0.3 pCi/g	-	70-130	±30
Rad, γ	HPGe	Cobalt-60	a	0.2 pCi/g	-	70-130	±30
Rad, γ	HPGe	Europium-152	a	2 pCi/g	-	70-130	±30
Rad, γ	HPGe	Europium-154	a	2 pCi/g	-	70-130	±30
Rad, γ	HPGe	Europium-155	a	5 pCi/g	-	70-130	±30
Rad, γ	HPGe	Neptunium-237	100 nCi/g	~100 pCi/g	-	70-130	±30
Rad, γ	HPGe	Plutonium-239/240	100 nCi/g	~ 50 nCi/g	-	70-130	±30

[a]There are no preliminary action levels for these radionuclides at this time. They will be developed in the remedial investigation and feasibility study process.

γ = gamma analysis

HPGe = high purity germanium

Table A2-2. Sample Preservation, Container, and Holding Time Guidelines. (2 Pages)

Analytes	Analytical Priority	Matrix	Bottle		Volume[a]	Preservation	Packing Requirements	Holding Time
			Number	Type				
			Radionuclides					
Americium AEA	2	Soil	1	G/P	10 g	None	None	6 months
Gamma spectroscopy	4	Soil	1	G/P	1,500 g	None	None	6 months
Isotopic plutonium	1	Soil	1	G/P	10 g	None	None	6 months
Isotopic thorium	8	Soil	1	G/P	6 g	None	None	6 months
Isotopic uranium	[b]	Soil	1	G/P	10 g	None	None	6 months
Neptunium-237	4	Soil	1	G/P	10 g	None	None	6 months
Nickel-63	4[c]	Soil	1	G/P	6 g	None	None	6 months
Radiogenic strontium	6	Soil	1	G/P	10 g	None	None	6 months
Technetium-99	4[c]	Soil	1	G/P	6 g	None	None	6 months
Total uranium	7	Soil	1	G/P	6 g	None	None	6 months
Tritium – H3	15	Soil	1	G	100 g	None	None	6 months
			Chemicals					
Alcohols, glycols, and ketones – 8015	11	Soil	3	G	40 mL	None	Cool 4°C	14 days
IC anions – 300.0	17	Soil	1	G/P	250 g	None	Cool 4°C	28 days/ 48 hours
ICP metals – 6010A (Add-on)	3	Soil	1	G/P	250 g	None	None	6 months
ICP metals – 6010A (TAL)	3	Soil	1	G/P	15 g	None	None	6 months
Chromium hex – 7196	13	Soil	1	G/P	500 mL	None	Cool 4°C	30 days
Mercury – 7471 – (CV)	12	Soil	1	G	125 g	None	None	28 days
PCBs – 8082	5	Soil	1	aG	250 g	None	Cool 4°C	14/40 days
SVOA – 8270A (TCL)	10	Soil	1	aG	250 g	None	Cool 4°C	14/40 days
Sulfides – 9030	14	Soil	1	G	40 g	None	Cool 4°C	7 days
Total petroleum hydrocarbons – kerosene range	9	Soil	1	G	200 g	None	Cool 4°C	14 days
VOA – 8260A (TCL)	16	Soil	1	G	50 g	None	Cool 4°C	14 days

Table A2-2. Sample Preservation, Container, and Holding Time Guidelines. (2 Pages)

Analytes	Analytical Priority	Matrix	Bottle		Volume[a]	Preservation	Packing Requirements	Holding Time
			Number	Type				
Physical Properties								
Moisture content – ASTM D2216	18	Soil	1	G/P	1,000 g	None	None	None
Particle size distribution – ASTM D422	18	Soil	1	G/P	TBD	None	None	None
Lithology - BHI-EE-01 Procedure 7.0	18	Soil	Descriptive					

[a] Optimal volumes, which may be adjusted downward to accommodate the possibility of small sample recoveries. Minimum sample size will be defined in the Sampling Authorization Form.
[b] Uranium will be analyzed for total abundance in all samples; any samples with values significantly above background levels will be analyzed for individual species.
[c] These radionuclides are constituents of concern in the deep zone only and will only be analyzed for in the deeper borehole samples (4.5 m [>25 ft]). Their analytical priority will be the same as ICP metals (4).
aG = amber glass
ASAP = as soon as possible
G = glass
P = plastic
TBD = to be determined

A3.0 FIELD SAMPLING PLAN

A3.1 SAMPLING OBJECTIVES

The DQO summary report for 200-CW-5 (BHI 1999) concluded that the historical characterization data available for the 216-U-10 Pond and 216-U-14 Ditch met the needs of the DQO for remedial action decision making, but the lack of data available for the 216-Z-11 Ditch imposes the need for additional characterization. The following characterization goals exist for this project:

1. Determine the probable locations of transuranic material "hot spots" based on ditch hydraulics and physical features

2. Determine the maximum concentrations of transuranic materials present in the identified "hot spots"

3. Obtain characterization data for the chemical constituents in the 216-Z-11 Ditch.

Based on the preliminary conceptual site model, the majority of the contamination is expected in the ditch sediment layer. Because the Z Ditches were stabilized with approximately 1.8 m (6 ft) of cover soils, intrusive techniques must be employed to obtain samples for laboratory analysis. The presence of the stabilizing fill material and the lack of ditch location coordinates indicated that a multi-step sampling approach would be needed to minimize cost and to focus the sampling in the most highly contaminated locations. Therefore, a characterization approach was developed that includes surface geophysical surveys, spectral gamma logging (SGL) of shallow casings, soil sample collection via borehole, and discharge pipeline sludge characterization. These four steps are discussed in the following text and are summarized in Table A3-1.

Additional sampling that is not included in this SAP may be performed to support other, related projects. The deep borehole planned for soil sampling to groundwater may also be completed as a groundwater well, and not abandoned in place. The decision to perform additional sampling and/or convert the deep borehole for groundwater monitoring will be made by the ERC Project Manager.

A3.2 SURFACE RADIATION SURVEYS

Surface radiation surveys are a project baseline activity that will be performed over the 216-Z-11 Ditch. The surveys will identify existing surface contamination and support preparation of supporting health and safety documents. Surface radiation surveys shall be conducted by qualified RCTs in accordance with BHI-EE-05, Procedures 2.4, "Operation of the Man-Carried Radiological Detection System," and Procedure 2.5, "Operation of the Mobile Surface Contamination Monitoring System," or other applicable approved procedures, as necessary. A post-sampling survey will also be performed to document changes to the surface contamination levels as a result of sampling activities.

A3.3 216-Z-11 DITCH CHARACTERIZATION

The logic used to develop the characterization approach for the 216-Z-11 Ditch is based on the physical constraints present at the site. The use of the characterization techniques identified in this SAP is expected to yield meaningful radiological and chemical characterization data. The sampling design includes three vadose zone characterization steps and one discharge pipe characterization activity:

- Surface geophysical surveys over the 216-Z-11 Ditch

- SGL of shallow casings in selected locations over the 216-Z-11 Ditch

- Borehole soil sampling of the 216-Z-11 Ditch

- Characterization of the sludge through manhole access ports in the Z Ditch discharge piping between the Z Plant and the 216-Z-11 Ditch.

The first three vadose zone characterization steps listed above will be performed in sequence to effectively locate and sample the soils within the ditch. The pipeline characterization activity may be performed at any time, because it is remote from the ditch and is not dependent on ditch characterization activities.

The individual characterization techniques are described further in the following text.

A3.3.1 Surface Geophysical Surveys

One of the primary objectives of the soil sampling in the 216-Z-11 Ditch is to locate and sample the radiological hot spot areas for laboratory analysis. However, stabilizing fill placed on the site for contamination control purposes rendered it unrecognizable from the surrounding features. This, combined with a lack of accurate photographs or site coordinates, helped to define the first characterization challenge: locate the site. Historical records indicate that the stabilizing fill is shallow (nominally 1.8 m [6 ft] thick) and the ditch bottom is covered with a fine-grained layer of sediment, a configuration that is expected to work well with surface geophysical survey techniques. This is because the depth of stabilizing fill material is within the range of the current surface scanning technologies, and the fine-grained sediment layer should act as a reflecting media for survey signals. Therefore, surface geophysical survey techniques were chosen as the first vadose zone characterization activity.

Two geophysical survey techniques will be used to locate the 216-Z-11 Ditch, including GPR and EMI. Historical sampling data from the other Z Ditches indicate that fluid velocity changes likely caused sediments to deposit, creating radiological hot spots. Historical aerial photographs and site maps were studied in an effort to select locations where fluid velocity changes were likely. As a result, seven locations were identified over the presumed location of the 216-Z-11 Ditch for surface geophysical surveys: between the head-end of the discharge pipe and the 216-U-10 Pond. Figure A3-1 shows the planned locations for performance of surface geophysical surveys.

A3.3.1.1 Ground Penetrating Radar. GPR uses a transducer to transmit FM frequency electromagnetic energy into the ground. Interfaces in the ground, defined by contrasts in dielectric constants, magnetic susceptibility, and to some extent, electrical conductivity, reflect the transmitted energy. The GPR system then measures the travel time between transmitted pulses and arrival of reflected energy. Geologic features (i.e., crossbedding, lateral and vertical changes in soil properties, and rock interfaces) can cause reflections of a portion of the electromagnetic energy.

The reflected energy provides the means for mapping the subsurface features of interest, whether synthetic or geologic. Display and interpretation of GPR data are similar to that of seismic reflection data. When numerous adjacent profiles are collected, often in two orthogonal directions, a plan view map showing the location and depth of features can be generated.

A3.3.1.2 Electromagnetic Induction. EMI is a noninvasive method of detecting, locating, and/or mapping shallow subsurface features. It is a good complementary tool for use with GPR because of the way it responds to subsurface anomalies and its ability to quickly obtain reconnaissance-level information over large areas to help focus GPR efforts. EMI techniques are used to determine the electrical conductivity of the subsurface soil, rock, and groundwater. They are generally used for shallow investigations. The method is based on a transmitting coil radiating an electromagnetic (EM) field that induces eddy currents in the earth. A resulting secondary EM field is measured at a receiving coil as a voltage that is linearly related to the subsurface conductivity.

A3.3.2 Spectral Gamma Logging of Shallow Casings

Characterization data provided by Last et al. (1994) indicate that contamination concentrations varied significantly across the ditch bottom. This led to the conclusion that a screening technique was needed to optimize the selection of borehole locations based on indications of radiological activity. Because the ditch sediment layer is buried, the screening technique would need to be intrusive. Therefore, a SGL technique for use in shallow drill casings was identified as the second characterization activity for the 216-Z-11 Ditch.

The 216-Z-11 Ditch will be logged with a high-resolution SGL system to determine the distribution and relative concentrations of amercium-241, plutonium-239, and neptunium-237 (via its gamma-emitting daughter product, protactinium-233) along the length of the ditch, and vertically. The results will be used to locate the transuranic material “hot spots” for subsequent borehole soil sampling and laboratory analysis. These methods are described in Section 4.3 of the work plan.

Drill casing will be installed vertically at least 7.6 m (25 ft) below the bottom of the 216-Z-11 Ditch in a series of transects perpendicular to the ditch axis. At least three casings are expected to be installed and logged per transect. Up to five transects are expected to be logged along the ditch at locations indicated by the surface geophysical surveys. A spectral gamma detector (high purity germanium) will be lowered the full depth of the casings, retrieved, and moved to the next core barrel, until all of the casings have been surveyed. The starting point for logging will be recorded, usually ground surface or the top of the casing. Multiple installation steps and logging may be required to assess the potential for “drag-down” as the casing is driven into the soil.

The site geologist will witness logging runs and verify before and after field calibrations and repeat log intervals. Additional geophysical logging associated with the soil sampling boreholes is discussed in Section A3.3.3.

A3.3.2.1 Logging at Depth. All casings will be initially installed to a depth of at least 7.6 m (25 ft) below the ditch bottom. After the results of the SGL logging have been evaluated, the casing with the highest and/or deepest concentrations of transuranic materials will be chosen for deeper SGL assays. The casing at that location will be installed to a depth of at least 15 m (50 ft) below the ditch bottom for additional gamma logging to determine if the mobility of neptunium-237 results in detectable concentrations at depth below the ditch. Geologic constraints such as the presence of boulders may limit the depth to which casing can be installed.

A3.3.3 Borehole Sampling and Analysis

The third characterization step involves the interpretation of the spectral logging data, selection of the most highly contaminated locations, and installation of boreholes for soil sampling. Soil samples will be collected via the use of a split-spoon-type sampler.

Boreholes will be installed in the 216-Z-11 Ditch to collect soil samples for chemical, radiological, and physical properties analyses. They will be drilled at the locations that correspond to the transuranic material "hot spots," based on interpretation of the SGL data. Up to three shallow boreholes and one deep borehole will be used for soil sampling in accordance with the sampling schedule presented in Table A3-3. The final sampling intervals may vary somewhat depending on the thickness of the strata observed in the split-spoon samples and field-screening results. The intent of the sampling design is to begin sample collection at the ditch sediment layer. As the split spoon samples are removed, the ditch sediment layer will be identified by use of field-screening methods and geologic observations in the drill cuttings. Figure A3-2 illustrates the planned borehole sampling intervals.

Sampling will be initiated at the ditch sediment layer. It is a critical sample point because the highest transuranic material concentrations are expected at this horizon. Samples from 4.6 m (15 ft) bgs and 7.6 m (25 ft) bgs are also considered critical sampling points for remedial alternative decision making. Sampling from depths greater than 7.6 m (25 ft) bgs will be used to verify the site conceptual model and to evaluate potential groundwater impacts. Drilling and sampling will stop when the water table is encountered.

Sampling will be performed in accordance with *Washington Administrative Code* (WAC) 173-160, as well as BHI-EE-01, Procedure 4.0, "Soil and Sediment Sampling," and Procedure 6.1, "Drilling and Sampling in Radiological Contaminated Areas," using a split-spoon sampler. The split-spoon samplers will be equipped with four separate stainless steel or lexan liners. Site personnel will not overdrive the sampling device. With the exception of samples for volatile organic analysis, soil shall be transferred to a pre-cleaned, stainless steel mixing bowl; homogenized; and then containerized in accordance with the sampling procedure. Samples collected for volatile organic analysis shall be transferred directly from the liners to an appropriate container without mixing the sample. The analytes associated with the various sampling intervals are summarized in Table A3-3. If sample volume requirements cannot be met due to poor split spoon recovery, samples will be collected according to the priority presented in

Table A2-2. Analytical priorities are based on expected contaminant inventories and associated potential level of risk. Contaminants with the largest inventory that are expected to be the greatest risk drivers have the highest priority. Radiological and chemical samples will always take precedence over physical property samples.

Physical soil properties of interest are moisture content, grain-size distribution, and lithology. Samples will be analyzed in accordance with ASTM methods, listed in Table A2-1 (ASTM 1993), if applicable. A minimum of three soil samples will be collected for analysis of physical properties. The samples will be collected coincident with chemical and radiological split-spoon sample intervals. Additional samples may be obtained as determined by the field geologist. Requirements for the collection of physical property samples are also listed in Table A3-2.

Geologic materials removed from the borehole will be logged by the site geologist on a borehole log, as specified in BHI-EE-01, Procedure 7.0, "Geologic Logging." The log includes, but is not limited to, the lithologic description, including potential caliche and silt horizons, sample depths, HEIS database sample numbers for each sample interval, field screening results, relevant and/or pertinent events, and general information about the borehole. Recording and reporting of drilling activities and the abandonment plan will conform to BHI-EE-01, Procedure 6.0, "Documentation of Well Drilling, Abandonment, Remediation, and Completion Operations," as well as all applicable WAC regulations.

Investigation-derived waste generated during this activity will be handled according to applicable procedures in Section A2.0 and the Waste Control Plan (Appendix B of the work plan).

A3.3.3.1 Soil Screening. All samples and cuttings from boreholes will be field screened for evidence of radioactive contamination by the RCT. Surveys of these materials will be conducted with field instruments. Potential screening instruments are listed in Table A3-2 with their respective detection limits. The RCT will record all field measurements, noting the depth of the sample and the instrument reading.

Before excavation, a local area background reading will be taken with the field-screening instruments at a background site to be selected in the field. Field screening of drill cuttings and visual observations of the soil (i.e., sediment/clay layer, organic debris) will be used to optimize sample selection, assist in determining sample shipping requirements, and support worker health and safety monitoring. The field geologist will use professional judgment, screening data, and the information provided in this field sampling plan (FSP) to finalize sampling decisions.

Samples exceeding 0.5 mrem/hr will be stored at a temporary onsite radioactive material storage area until shipment to the laboratory. If soil samples contain significant concentrations of radiological COCs, they will be analyzed in an onsite laboratory. Because the analytical costs for highly contaminated soils are extreme, Table A3-1 identifies a reduced analyte list for samples analyzed in onsite laboratories.

Field-screening instruments will be used, maintained, and calibrated in accordance with the manufacturer's specifications and other approved procedures. The field geologist will record field-screening results in the borehole log.

A3.3.3.2 Borehole Spectral Logging. As the four soil sampling boreholes are installed, they will be geophysically logged via the high-resolution SGL detector. The deep borehole will also be logged with the neutron moisture detector. The spectral gamma data will be used to expand the Z Ditches SGL database and may be evaluated for possible correlation with the soil analytical data. Multiple drilling and logging steps may be required to assess the potential for "drag-down" as the casing is driven into the soil.

The data obtained during from the borehole SGL monitoring may not be directly comparable with the shallow SGL assays, because of potential differences in the casing diameter and thickness.

A3.3.3.3 Logging in Existing Wells. Existing boreholes and groundwater wells sufficiently near the Z Ditches that are properly configured for SGL (i.e., single casing in contact with the formation) will also be logged with the spectral gamma detector to expand the Z Ditches SGL database. Table A3-1 identifies the existing wells that may be suitable for SGL.

A3.3.4 Z Ditches Discharge Pipe Characterization

Particulates that may have settled in the bottom of the manhole access vaults could represent the "worst-case" contaminated media associated with the Z Ditches. Therefore, the manhole ports will be characterized to assess impacts on remedial decision making and for health and safety purposes.

The 216-Z-11 and 216-Z-19 Ditches received liquid effluents from the 231-Z Building via a vitrified clay pipe (VCP) discharge pipe. As shown in Figure A3-3, four manholes are upstream of the 216-Z-11 Ditch along the length of this 45-cm- (18-in.) diameter discharge pipe. The 234-5Z and 291-Z Buildings' effluents were discharged to the 216-Z-11 Ditch via a 38-cm- (15-in.) diameter VCP pipe. This pipeline has six manholes that are being considered for characterization. Figure A3-4 shows typical section views of the manholes in the Z Ditch pipelines.

The Z Ditches discharge piping will be visually inspection through the manhole access ports by remote video camera, followed by in situ spectral gamma measurements. Sodium iodide and/or high purity germanium detectors will be employed for this purpose.

A3.3.5 Summary of Sampling Activities

A summary of the number and types of samples to be collected is presented in Table A3-4.

A3.3.6 Potential Sample Design Limitations

The sample design developed for this SAP has several potential limitations that may affect the sampling results. Some of the factors that have the potential to affect the outcome of this sampling effort include the following:

1. The geophysical survey locations were based on the assumption that the transuranic COCs would preferentially be deposited where the wastewater velocities decreased. It is possible that transuranic deposition was influenced by other factors. The historical data

for the 216-Z Ditches show significant spatial variability in both axial and longitudinal orientations in the ditch bottoms, with measured concentrations varying by several orders of magnitude over minor distances. Last et al. (1994) reported that the transuranics may have preferentially collected on mats of decayed organic plant matter, which would be impossible to locate under a blanket of stabilizing fill.

2. The effectiveness of the geophysical survey techniques in identifying the 216-Z-11 Ditch bottom under the stabilizing fill soil has not been determined. Certain factors could degrade the survey results sufficiently to preclude positive identification of the subsurface ditch profile.

3. The use of the shallow drill casings for logging with spectral gamma detectors is a proven technology, but the weak gamma emissions from the target isotopes could yield disappointing results if the drill casings are not placed in close proximity to the contaminated ditch sediment layer.

4. The sampling design is based on the use of multiple interdependent technologies to locate and characterize the 216-Z-11 Ditch. The overall success of this sampling effort depends on the effective utilization of the individual technologies.

5. Drilling impediments (e.g., boulders) may be encountered, and/or insufficient sample volumes may be retrieved from the split-spoon samplers.

6. The sample design is based on a limited number of samples that could limit the ability to identify TRU hot spot locations.

7. The discharge pipeline manholes may not be accessible for in situ measurements, or safety/radiological concerns may prohibit access.

8. Because the soil samples retrieved from the ditch sediment layer are expected to contain significant concentrations of radiological COCs, it is likely that they will be analyzed in an onsite laboratory. In this case, expected impacts include high analytical costs, degradation of detection limits, reduced analyte lists, and long turnaround times.

A3.3.6.1 Sampling Contingencies. This SAP includes an assessment of the possible contingency considerations to offset the possible limitations encountered during sampling in the 216-Z-11 Ditch. The ERC project engineer will evaluate the need to implement these contingencies on a case-by-case basis.

Surface Geophysical Surveys – If the results of the surface geophysical surveys do not clearly indicate the presence of a ditch, or if the results are difficult to interpret, it is possible to employ three-dimensional interpretation techniques to enhance the results.

It may be necessary to select locations for installation of the shallow SGL casings and perform geophysical logging with little or no surface geophysical survey data. In this case, ditch coordinates would be based on best judgment, using historical data, maps, photographs, and/or global positioning instruments. Under this circumstance, it may be advantageous to install more shallow casings than originally planned to increase the likelihood of locating the highly contaminated ditch sediment layer.

Spectral Gamma Logging of Shallow Casings – If the borehole spectral geophysical logging of shallow casings does not locate the ditch sediment layer, or if only low concentration areas within the sediment layer are encountered, the SGL measurements may not meet sampling objectives. This may be overcome by placing additional casings and by repeating the gamma logging for extended count times. If the SGL is not successful in identifying appropriate borehole locations, sampling activities in the 216-Z-11 Ditch will cease, and existing analytical data from the 216-Z-1 Ditch may be used as the "worst-case analogous information" for the 216-Z-11 Ditch.

Borehole Soil Sampling – If sample volume recoveries from the split-spoon samplers are not sufficient to meet analytical needs, then analyses will be performed in accordance with the priorities established in Table A2-2. Higher detection limits and reduced analyte lists associated with onsite laboratories are considered acceptable because only soil with high contaminant concentrations will be sent to the onsite laboratories, and the primary risk drivers will be analyzed.

Pipeline Characterization – If manholes are not accessible for in situ measurements or safety/radiological concerns prohibit access, pipeline characterization will be eliminated, and the sampling effort will focus on ditch soil sampling.

A3.4 RADIOLOGICAL CONTROLS DURING CHARACTERIZATION ACTIVITIES

The high levels of alpha contamination associated with 216-Z-11 Ditch soils represent significant radiological control challenges because previous Z-Ditch sample data indicates significant plutonium and americium activity levels. The RI relies heavily on nonintrusive measurement techniques. However, soil sampling will be required. Borehole drilling and associated split-spoon soil sampling could potentially result in airborne exposure and contamination spread if not properly planned and controlled. Detailed pre-job planning and preparation may require the use of mockup staging. Typical precautions when drilling through the highly contaminated vadose zone will include the following:

- Drilling equipment will likely use windscreens to prevent contamination spread. Operators will likely require respiratory protection.
- Opening split spoons, sample preparation, sample packaging, and equipment decontamination will likely need to be performed inside glovebags with high-efficiency particulate air (HEPA) ventilation exhaust. Drill casings will likely be sleeved with HEPA evacuation during removal.

Special precautions expected during characterization of the discharge pipelines include the following:

- The alpha contamination in the discharge pipeline is likely to be present in fine-grained particulates that may be more transferable and more likely to become airborne than that found in the soil. Consequently, opening manway covers and installing and removing equipment will likely require glovebags or tents for containment with HEPA exhaust ventilation.

- Special handling and disposal considerations are required for transuranic-contaminated IDW wastes.

- Additional RCT support will likely be needed when performing borehole and pipeline work.

A3.5 BOREHOLE ABANDONMENT SURVEYING

All boreholes will be surveyed after the sampling and abandonment activities are completed. Surveys shall be performed according to BHI-EE-01, Procedure 1.6. Data will be recorded in the North American Vertical Datum of 1988 (NAVD 1988) and the Washington State Plane (South Zone) North American Datum of 1983 (NAD 1983), with the 1991 adjustment for horizontal coordinates. All survey data will be recorded in meters and feet.

Table A3-1. Key Features of the Sampling Design for the 216-Z-11 Ditch (modified from BHI 1999, Table 7-4). (3 Pages)

Sample Collection Methodology	Key Features of Design	Basis for Sampling Design
	Step 1 Vadose Zone Characterization	
Surface Geophysical Surveys (GPR and EMI)	Perform GPR/EMI over the width of the Z Ditches in series of transects at up to seven locations shown in Figure A3-1. GPR/EMI surveys will begin over the ditch headwall and the first few feet of the ditches to provide a baseline definition of the ditch profile that supports interpretation of results from later transect surveys. Each of the survey transects will be closely spaced parallel lines to maximize the coverage over the survey areas.	GPR/EMI are expected to distinctly identify the 216-Z-11 Ditch relative to the other Z Ditches. It is the first step in a three-step vadose zone characterization sequence. It will identify the parallel Z Ditches in the "x-y" plane and depth bgs. The results of the GPR will be evaluated to locate the shallow SGL casings.
	Step 2 Vadose Zone Characterization	
Spectral Gamma Logging (SGL) of Shallow Casings	Install shallow drill casings to a depth of 8 m (25 ft) bdb for SGL assays. Nominally, three casings will be installed at each of up to five transects across the 216-Z-11 Ditch. Locations will be based on interpretation of the geophysical surveys. The casings will initially be installed to a depth of 7.6 m (25 ft) bdb. At the location of the highest and/or deepest indicated contamination level, the casing will be advanced to a depth of at least 15 m (50 ft) bdb to determine if Np-237 (via Pa-233) is present (it is more mobile than americium or plutonium). Drill casing material will be 1.27-cm (5-in.) diameter, 0.0635-cm- (0.25-in.) thick steel.	SGL is expected to effectively locate the areas of high Am-241, Pu-239/240, and Np-237 (Pa-233) activity. Americium and plutonium are expected to coincide in the vertical strata due to similar chemical behavior. These are the target isotopes for gamma detection because of characteristic gamma emissions and the absence of interfering gamma isotopes. The results of the SGL readings will be evaluated to identify the preferred locations and depths for borehole soil sampling.

Table A3-1. Key Features of the Sampling Design for the 216-Z-11 Ditch (modified from BHI 1999, Table 7-4). (3 Pages)

Sample Collection Methodology	Key Features of Design	Basis for Sampling Design
	Step 3 Vadose Zone Characterization	
Borehole drilling and soil sampling	***Sampling from Surface to 8 m (25 ft) bgs***	
	Up to three shallow boreholes to 8 m (25 ft) depth bgs and one deep borehole (to groundwater) will be installed based on the highest and/or deepest readings from the SGL data. The borehole casing size will be reduced (at approximately 2.2 m [7 ft] bgs) to prevent "drag-down" of contaminants from the high contaminant concentration (sediment) layer into the moderate contaminant concentration zone. Collect samples at 15-cm (6-in.) intervals within the first 0.6 m (2 ft) of the ditch sediment layer. Collect samples at 0.6-m (2-ft) intervals at 0.8-, 1.5-, and 2.3-m (2.5-, 5-, and 7.5-ft) depths below the ditch bottom, then at 4 to 4.6 m (13 to 15 ft) and 7 to 8 m (23 to 25 ft) bgs. Critical sampling depths are the top 0.6 m (2 ft) of the ditch sediment layer, 4 to 4.6 m (13-15 ft) bgs and 7 to 8 m (23 to 25 ft) bgs.	Soil samples are required to determine the TRU concentrations in the ditch sediment layer and in the underlying soils. Sampling to 8 m (25 ft) bgs provides COC data at depths significant to remedial action decision making and to confirm the preliminary conceptual vertical contaminant distribution model.
	Sampling from 8 m (25 ft) bgs to Groundwater	
	One deep borehole will be installed to groundwater. At a depth of 8 m (25 ft) bgs, the borehole casing size will be reduced to prevent "drag-down" of contaminants into the deeper vadose zone. Collect samples at 15-m (50-ft) intervals from 15 m (50 ft) bgs to groundwater (15, 31, 46, 61, and 73 m [50, 100, 150, 200, and 238 ft] bgs).	Soil samples are required in the deeper vadose zone (to groundwater) to confirm the preliminary conceptual vertical contaminant distribution model. The sample collected at the 72.5-m (238-ft) depth bgs is set just above the current water table.
	Borehole Spectral Logging	
	Perform borehole spectral logging in up to four boreholes installed for soil sampling. Perform neutron moisture monitoring in only the deep borehole (requires proper calibration for the borehole environment).	SGL will be performed in boreholes to expand the SGL database and to compare the SGL data with the sample analytical results. Neutron moisture logging provides a vertical vadose zone moisture profile.
	Perform borehole spectral logging in accessible boreholes and groundwater wells near the Z Ditches. Bechtel Hanford, Inc. well status records indicate that the following wells are accessible: • 299-W18-15 • 299-W23-17.	This data will be collected to expand the Z Ditches SGL database. Table 3-5 lists the existing wells being considered for spectral gamma logging and provides location information.

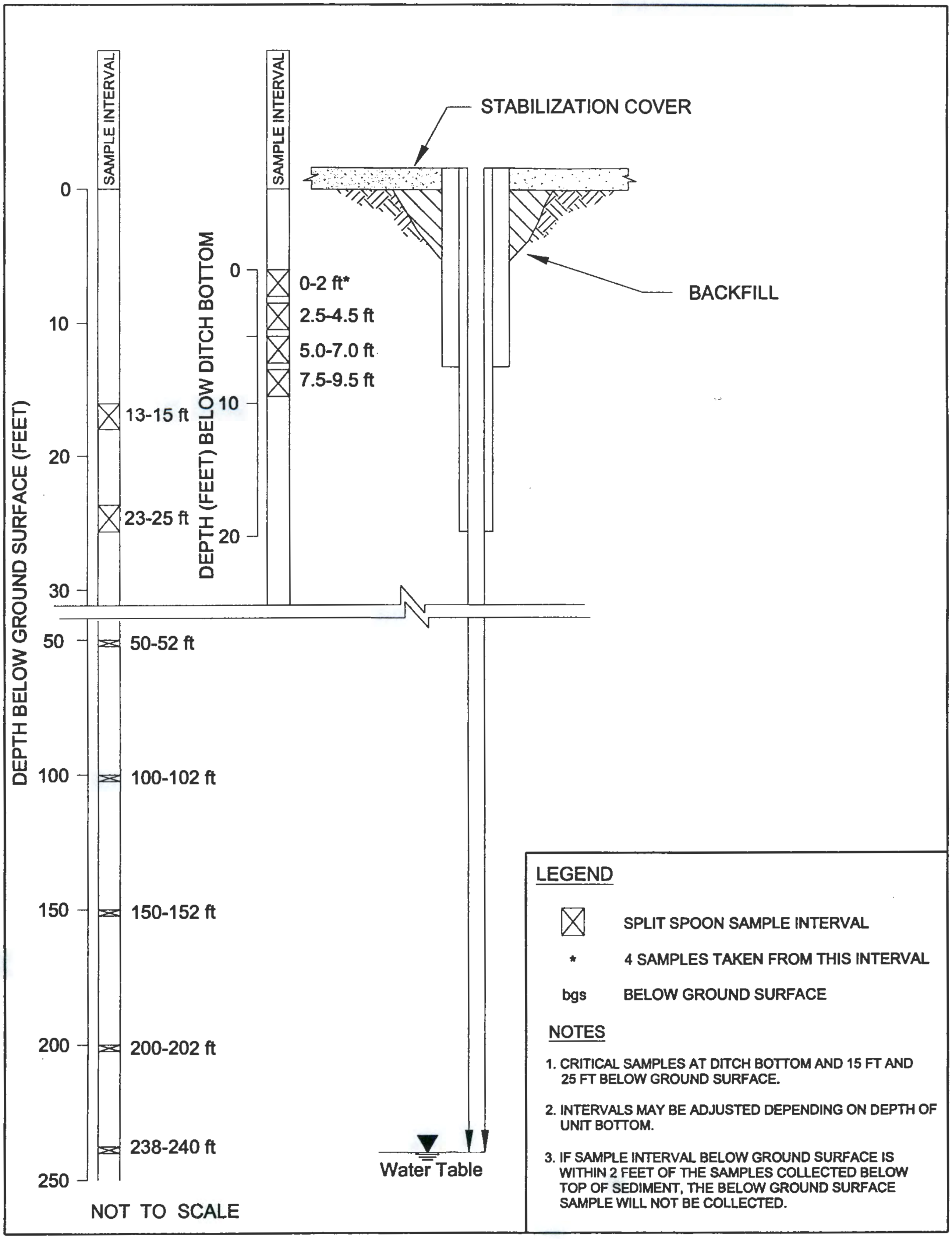
Table A3-1. Key Features of the Sampling Design for the 216-Z-11 Ditch (modified from BHI 1999, Table 7-4). (3 Pages)

Sample Collection Methodology	Key Features of Design	Basis for Sampling Design
Discharge Pipeline Characterization		
Z Ditch discharge pipe characterization	Open one of the manhole access in the 46-cm- (18-in.) diameter VCP Z Ditch discharge pipe from the 231-Z Plant (Figures A3-3 and A3-4) for remote video inspection and spectral gamma assay using NaI and/or HPGe detectors.	The manhole ports will be characterized to assess impacts on remedial decision making and for health and safety purposes.
	Open one of the manhole access ports in the 38-cm- (15-in.) diameter VCP Z Ditch discharge pipe from the 234-5Z/291-Z Plants (Figures A3-3 and A3-4) for remote video inspection and spectral gamma assay using NaI and/or HPGe detectors.	

bdb = below ditch bottom
bgs = below ground surface
COC = contaminant of concern
EMI = electromagnetic induction
GPR = ground penetrating radar
HPGe = high-purity germanium
NaI = sodium iodide
SGL = spectral gamma logging
VCP = vitrified clay pipeline

Figure A3-1. Location of Planned Surface Geophysical Surveys at the 216-Z Ditches (216-Z-19 Ditch Shown as Open).

Figure A3-2. Example Illustration of Borehole Sampling Intervals to Groundwater in the 216-Z-11 Ditch.



2E:111799A

Table A3-2. Field Screening Methods.

Measurement Type	Emission Type	Method/Instrument	Detection Limit
Exposure/dose rate	Beta/gamma	RO-20/RO-03 portable ionization chamber	0.5 mR/hr
Contamination level	Alpha/beta-gamma	E-600 rate meter with SHP380-A/B scintillation probe	100 dpm α 1921 dpm[a] $\beta-\gamma$
	Volatile organic compounds	Photoionization detector	2 ppm; may be higher for some compounds
Spectral gamma logging	Gamma isotopic emissions	HPGe	~25 nCi/g for Am-241 and Pu-239. ~100 pCi/g for Np-237

[a]Detection limit rating is for 100 cm^2 at a scan rate of 2-in./sec.

Table A3-3. 216-Z-11 Ditch Soil Sampling Schedule.

Sample Collection Methodology	Sample Location	Maximum Depth of Investigation	Sample Interval Depth (ft)		Onsite Laboratory Analyte List	Offsite Laboratory Analyte List[b]	Physical Properties	
			bdb	bgs[a]			Sample Interval, bgs	Parameters
Split-Spoon Borehole Soil Sampling	Soil sampling shallow borehole #1[c]	25 ft bgs	0 to 6 in., 6 to 12 in., 12 to 18 in., 18 to 24 in. 2.5-4.5, 5.0-7.0, 7.5-9.5	13.5-15.5 23.5-25.5	Isotopic Am/Pu, Gamma-spec, ICP-metals, PCBs	All COCs in Table A1-1 in accordance with the deep zone distinction made in footnote a and uranium footnote d	N/A	N/A
	Soil sampling shallow borehole #2[c]							
	Soil sampling shallow borehole #3[c]						1 sample from Hanford formation, Unit 1	Moisture content, particle size distribution, lithology
	Soil sampling deep borehole	Just above the groundwater table	0 to 6 in, 6 to 12 in., 12 to 18 in., 18 to 24 in. 2.5-4.5, 5.0-7.0, 7.5-9.5	13.5-15.5, 23.5-25.5 50-52, 100-102, 150-152, 200-202, 238-240			1 sample from Hanford formation, Unit 1 1 sample from Hanford formation, Unit 2	Moisture content, particle size distribution, lithology
Maximum Number of Samples	42							
Approximate Number of Field QC Samples	12[e]							
Approximate Total Number of Physical Samples	3							
Approximate Total Number of Samples	57							

[a]If sample interval bdb intersects with interval bgs, the bdb sample interval will not be collected.
[b]See Table A2-1 for detection limits and other analytical parameters.
[c]Based on results of SGL borehole logging, up to three shallow boreholes will be installed.
[d] Uranium will be analyzed for total abundance in all samples; any samples with values significantly above background levels will be analyzed for the individual species.
[e]See Table A3-4 for QC sampling details.
bdb = below ditch bottom
bgs = below ground surface
N/A = not applicable

Table A3-4. Summary of Projected Sample Collection Requirements for the 216-Z-11 Ditch.

Chemical Parameters	
Maximum number of characterization samples	42
Detail of quality control samples	
Co-located duplicates	4
Splits	1
Equipment blanks	4
Trip blanks	3
Approximate number of field quality control samples	12
Approximate total number of rad/chem samples	54
Physical Properties	
Moisture content, particle size distribution, lithology	3
Approximate total number of samples	57

Table A3-5. Existing Wells Considered for Spectral Gamma Logging.

Borehole Number	Approximate Location	Coordinates (Wash. State Plane, NAD83[91])	
		Northing	Easting
299-W18-15[a]	At the junction of the Z Ditch delta and the U-10 Pond	134733.478	566380.033
299-W23-17[a]	Within the U-10 Pond, just south of the junction with the U-14 Ditch	134630.756	566532.111

[a] Planned boreholes.

NOTE: Initial selection of existing wells was based on a review of well construction as-built diagrams. A single casing in contact with the formation is the preferred configuration for logging. A field inspection of the well configuration will be performed for final selection of boreholes.

Figure A3-3. Z Ditch Discharge Pipeline Area and Manhole Locations.

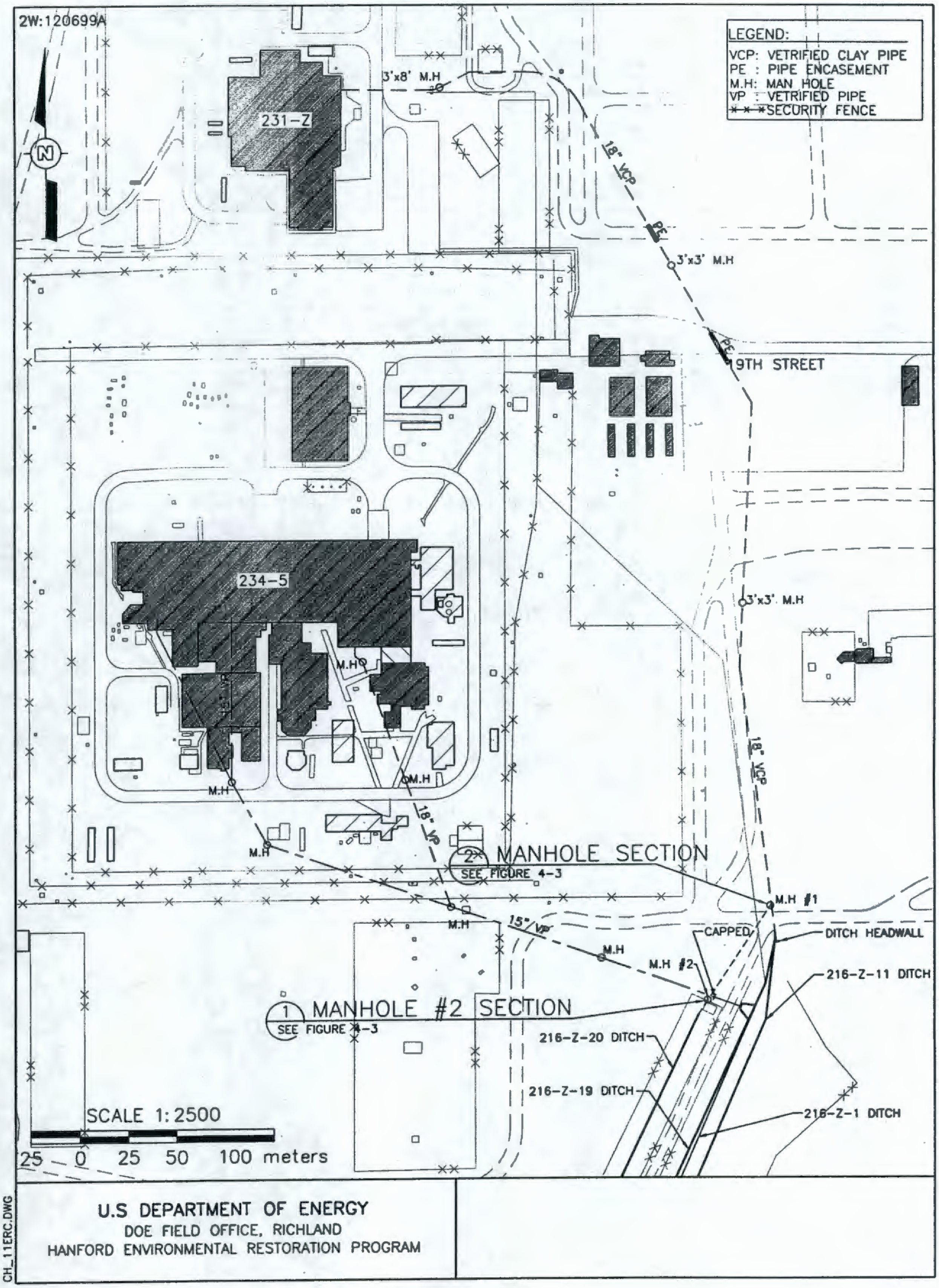
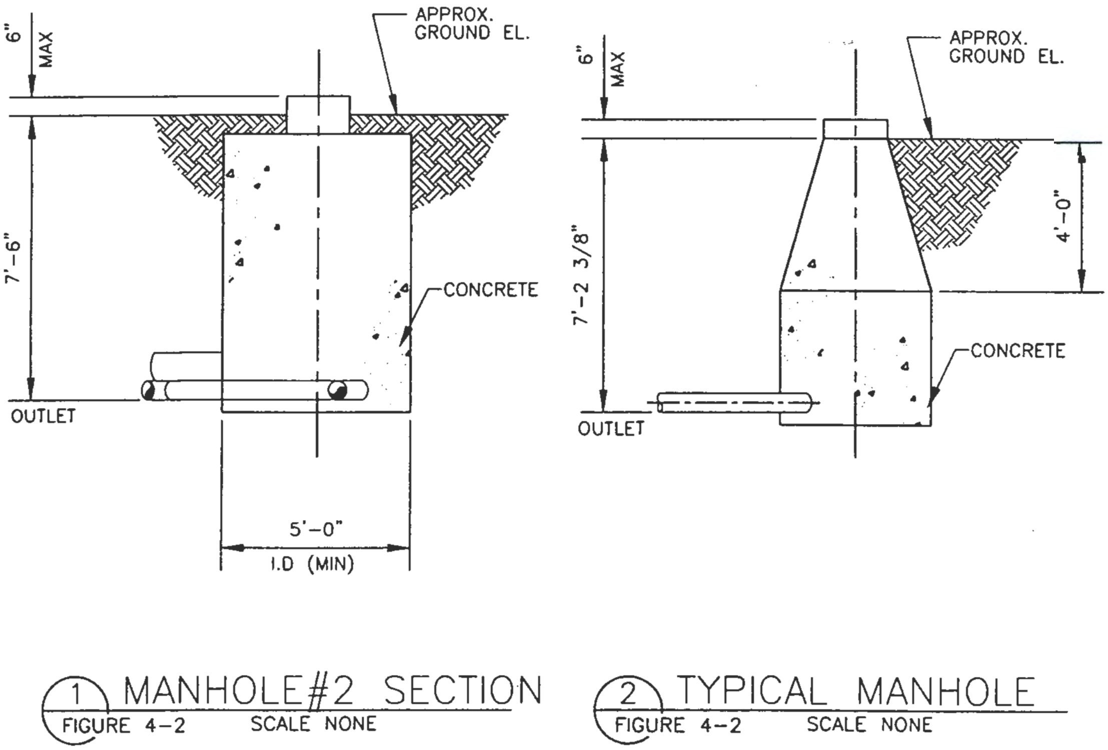


Figure A3-4. Typical Section Views of Manholes in Z Ditch Pipelines.

2W:120699B



NOTES.
1. ALL DIMENSION SHOWN ARE REFERENCED IN FEET AND INCHES

U.S DEPARTMENT OF ENERGY
DOE FIELD OFFICE, RICHLAND
HANFORD ENVIRONMENTAL RESTORATION PROGRAM

CH_11ERC.DWG

A4.0 HEALTH AND SAFETY

All field operations will be performed in accordance with Bechtel Hanford, Inc. health and safety requirements outlined in BHI-SH-01, *Hanford ERC Environmental, Safety, and Health Program*, and in accordance with the requirements of the *Hanford Site Radiological Control Manual* (DOE-RL 1996b). In addition, a work control package will be prepared in accordance with BHI-MA-02, *ERC Project Procedures*, which will further control site operations. This package will include an activity hazard analysis, site-specific health and safety plan, and applicable radiological work permits.

The sampling procedures and associated activities will take into consideration exposure reduction and contamination control techniques that will minimize the radiation exposure to the sampling team, as required by BHI-QA-01, *ERC Quality Program*, and BHI-SH-01.

As noted in Section A3.4, the Z Ditch discharge pipelines and the 216-Z-11 Ditch soils represent significant radiological control challenges because they are expected to contain significant concentrations of plutonium and americium. For this reason, characterization efforts in the discharge pipeline manhole access ports and borehole drilling and soil sampling activities will likely require detailed pre-job planning and preparation that includes the use of mockup staging. In addition, the work will likely be aided by the use of tent enclosures and glovebags with HEPA ventilation exhaust.

An air monitoring plan will be developed for drilling activities at the 216-Z-11 Ditch. This plan will be provided in a separate document to the EPA, who will then seek concurrence from the Washington State Department of Health. The plan will address the substantive applicable or relevant and appropriate requirements for these activities. The plan will also include quantification of radioactive emissions, implementation of best available radionuclide control technology, and will define air monitoring.

A5.0 MANAGEMENT OF INVESTIGATION-DERIVED WASTE

Investigation-derived waste generated by characterization activities will be managed in accordance with BHI-EE-10, *Waste Management Plan*, and Appendix E of the Implementation Plan. Containment, labeling, and tracking requirements are specified in BHI-FS-03, *Field Support Waste Management Instructions*, Section W-011, "Control of CERCLA and Other Past Practice Investigation Derived Waste." Management of investigation-derived waste, minimization practices, and waste types applicable to 200-CW-5 waste control will be described in the Waste Control Plan.

Unused samples and associated laboratory waste for the analysis will be dispositioned in accordance with the laboratory contract, which in most cases will require the laboratory to dispose of this material. Transuranic-contaminated soil will be returned to the project for disposition. The approval of the remedial project manager is required before returning unused samples or waste from offsite laboratories.

A6.0 REFERENCES

40 CFR 830.120, "Quality Assurance Requirements," *Code of Federal Regulations*, as amended.

40 CFR, "Transportation," *Code of Federal Regulations*, as amended.

ASTM, 1993, *1993 Annual Book of ASTM Standards*, Vol. 04.08, American Society for Testing and Materials, Philadelphia, Pennsylvania.

BHI, 1999, *Data Quality Objectives Summary Report for the 200-CW-5 U Pond/Z Ditches System Waste Sites*, BHI-01294, Rev. 0, Bechtel Hanford, Inc., Richland, Washington.

BHI-EE-01, *Environmental Investigations Procedures*, Bechtel Hanford, Inc., Richland, Washington.

BHI-EE-02, *Environmental Requirements*, Bechtel Hanford, Inc., Richland, Washington.

BHI-EE-05, *Field Screening Procedures*, Bechtel Hanford, Inc., Richland, Washington.

BHI-EE-10, *Waste Management Plan,* Bechtel Hanford, Inc., Richland, Washington.

BHI-FS-03, *Field Support Waste Management Instructions*, Bechtel Hanford, Inc., Richland, Washington.

BHI-MA-02, *ERC Project Procedures*, Bechtel Hanford, Inc., Richland, Washington.

BHI-QA-01, *ERC Quality Program*, Bechtel Hanford, Inc., Richland, Washington.

BHI-QA-03, *ERC Quality Assurance Program Plans*, Bechtel Hanford, Inc., Richland, Washington.

BHI-SH-01, *Hanford ERC Environmental, Safety, and Health Program*, Bechtel Hanford, Inc., Richland, Washington.

BHI-SH-02, *Safety and Health Procedures*, Bechtel Hanford, Inc., Richland, Washington.

BHI-SH-04, *Radiological Control Work Instructions*, Bechtel Hanford, Inc., Richland, Washington.

BHI-SH-05, *Industrial Hygiene Work Instructions*, Bechtel Hanford, Inc., Richland, Washington.

DOE Order 5700.6c, *Quality Assurance*, as amended, U.S. Department of Energy, Washington, D.C.

DOE-RL, 1992, *Z Plant Source Aggregate Area Management Study Report*, DOE/RL-91-58, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE-RL, 1996a, *Hanford Analytical Services Quality Assurance Requirements Documents* (HASQARD), DOE/RL-96-68, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE-RL, 1996b, *Hanford Site Radiological Control Manual* (HSRCM), DOE/RL-96-109, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE-RL, 1999, *200 Areas Remedial Investigation/Feasibility Study Implementation Plan – Environmental Restoration Program*, DOE/RL-98-28, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

Ecology, EPA, and DOE, 1995, *Strategy for Management of Investigation Derived Waste* (letter from R. Stanley, Washington State Department of Ecology, D. R. Sherwood, U.S. Environmental Protection Agency, and K. M. Thompson, U.S. Department of Energy, Richland Operations Office, July 26), Richland, Washington.

Ecology, EPA, and DOE, 1998, *Hanford Federal Facility Agreement and Consent Order*, 2 vols., as amended, Washington State Department of Ecology, U.S. Environmental Protection Agency, and U.S. Department of Energy, Olympia, Washington.

EPA, 1994a, *Guidance for the Data Quality Objectives Process*, EAP QA/G-4, U.S. Environmental Protection Agency, Washington, D.C.

EPA, 1994b, *EPA Requirements for Quality Assurance Project Plans for Environmental Data Operations*, QA/R-5, U.S. Environmental Protection Agency, Quality Assurance Division, Washington, D.C.

Last, G. V., D. W. Duncan, M. J. Graham, M. D. Hall, V. W. Hall, D. S. Landeen, J. G. Leitz, and R. M. Mitchell, 1994, *216-U-10 Pond and 216-Z-19 Ditch Characterization Studies*, WHC-EP-0707, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

WHC, 1993a, *Data Validation Procedures for Radiological Analysis*, WHC-SD-EN-SPP-001, Rev. 1, Westinghouse Hanford Company, Richland, Washington.

WHC, 1993b, *Data Validation Procedures for Chemical Analysis*, WHC-SD-EN-SPP-002, Rev. 2, Westinghouse Hanford Company, Richland, Washington.

WMNW, 1998, *Sampling Services Procedures Manual*, ES-SSPM-001, Rev.0, Waste Management Northwest, Richland, Washington.

APPENDIX B

WASTE CONTROL PLAN FOR THE 200-CW-5 OPERABLE UNIT

THIS PAGE INTENTIONALLY
LEFT BLANK

CONTENTS

FIGURE

TABLE

WASTE CONTROL PLAN

Page 1 of 2

Work Scope Description: 200-CW-5 U Pond/Z Ditches Cooling Water Group Operable Unit (OU) characterization. Characterization will be performed at the 216-Z-11 Ditch. The scope of work involves three vadose zone characterization activities and one characterization activity for the Z Ditches discharge piping. Vadose Zone Characterization Step 1, surface geophysical surveys (ground penetrating radar [GPR] and electromagnetic induction [EMI] surveys); Vadose Zone Characterization Step 2, spectral gamma logging (SGL) of driven shallow casings; Vadose Zone Characterization Step 3, drilling of up to three shallow boreholes and one deep borehole for soil sampling and SGL; and characterization of the Z Plant discharge piping through manhole access ports by remote video camera and in situ spectral gamma detector measurements. Soil samples from the vadose zone will be collected and analyzed for radiological and chemical contaminants of concern and physical properties. See Attachment 1 for additional information.

List Constituents of Concern: Contaminants of concern at the 216-Z-11 Ditch include radionuclides, metals, and volatile and semi-volatile organic compounds.

Site Description: Waste sites in the 200-CW-5 OU are located in the 200 West Area of the Hanford Site in southeastern Washington State. There are 16 waste sites in this OU, which received mostly cooling water and steam condensate from U Plant and Z Plant operations. Figure B1-1 shows the locations of the waste site to be characterized. Investigation-derived waste will only be generated at the 216-Z-11 Ditch. Additional information on this site is presented in the 200-CW-5 Work Plan (DOE-RL 2000) and the Sampling and Analysis Plan.

Reference : 200-CW-5 Work Plan (DOE-RL 2000) **Rev.** 0 **Date Approved** ____________

Preparer: R. G. Bauer ____________ **Date** ________
Print/Sign Name

Impact Level
N/A

Project Task Lead: B. H. Ford ____________ **IDW Coordinator:** R.H. Bidstrup ____________

Planned Drilling Start and Finish Dates: From: TBD ____________ **To:**TBD ____________

Waste Storage Facility ID Number(s) N/A ____________

Field Screening Methods

Method	Frequency	Reference	Detection Range	Analyst
Ground penetrating radar, electromagnetic induction	Prior to intrusive characterization.	DOE/RL-99-66, App A	Qualitative	Geologist
Alpha/beta-gamma detector	Continuous	DOE/RL-99-66, App A	100 dpm alpha 1921 dpm gamma-beta	RCT
Dose rate, gamma	Continuous	DOE/RL-99-66, App A	0.5 mR/hr	RCT

Laboratory Methods (Contaminants of concern)

Method	Frequency	Reference	Detection Range	Analyst
Table A2-1	Tables A3-3	DOE/RL-99-66, App A	Table A2-1	Off site Laboratory

BHI-FS-068 (05/99)

WASTE CONTROL PLAN	Page 2 of 2

Drill Site Coordinate Location: 216-Z-11 Ditch. Headend; 566729.8, 135475.8. Outfall; 566435.4, 134732.4

Waste Container Storage Area(s) Coordinate Location(s): 200 West Bioremediation Central Waste Container Storage Area; 567354.8, 136841.9 (Refer to Figure B1-1).

Requirements for Soil Pile Sampling (if any): Not applicable – No spoils piles will be generated.

Nonregulated Material Disposal Location(s): A Subtitle "D" landfill. Nonregulated soil and liquid (decontamination fluid) may be returned/disposed to the ground at or near the point of excavation, the location of which will be documented in the field logbook.

Sketch of Work Site:

Figure B1-1 identifies sample locations and waste container storage area(s) at the 216-Z-11 Ditch.

APPROVALS (Print/Sign Name and Date)

_______________	_______________
Lead Regulatory Agency Representative	**IDW Coordinator**
_______________	_______________
DOE-RL	**Cognizant Field Engineer**

BHI-FS-068 (05/99)

B1.0 DESCRIPTION OF WORK

This waste control plan governs the management of investigation-derived waste (IDW) at the 216-Z-11 Ditch (Figure B1-1). This waste site is located in the 200-CW-5 U Pond/Z Ditches Cooling Water Waste Group Operable Unit (OU). This site is being characterized to provide data needed to refine the site conceptual model, support an assessment of risk, and select a remedial alternative(s). The scope of work involves vadose zone and discharge piping characterization activities. Step 1, Vadose Zone Characterization, includes surface geophysical surveys of the site using ground penetrating radar (GPR) and electromagnetic induction (EMI). Step 2, Vadose Zone Characterization, involves the installation of shallow drill casings for spectral gamma logging (SGL) methods to locate high-contamination areas. Step 3, Vadose Zone Characterization, consists of drilling up to three shallow boreholes and one deep borehole for soil sampling and SGL. The Discharge Piping Characterization involves remote visual inspection of the Z Plant discharge piping through the manhole access ports, and in situ assays by spectral gamma detectors. No IDW will be generated during activities in the Step 1 Vadose Zone Characterization because it is nonintrusive. Drill casings will need to be removed from Vadose Zone Characterization Steps 2 and 3, and soil samples will be collected and analyzed for radiological and chemical contaminants of concern and physical properties in Vadose Zone Characterization Step 3. The Discharge Piping Characterization will likely only generate personal protective clothing and temporary containment wastes.

Any wastes generated in this project will be managed in accordance with BHI-FS-03, *Field Support Waste Management Instructions*, Work Instruction W-011, "Control of CERCLA and Other Past Practice Investigation-Derived Waste," which identifies the requirements and responsibilities for containment, labeling, and tracking of IDW. This procedure was developed to comply with the *Strategy for Management of Investigation-Derived Waste* (Ecology et al. 1999). An overview of the strategy is presented in Appendix E of the *200 Areas Remedial Investigation/Feasibility Study Implementation Plan – Environmental Restoration Program* (DOE-RL 1999). The control of soil, decontamination fluid, and IDW from the soil borings is detailed in BHI-EE-01, *Environmental Investigations Procedures*, Section 1.11, "Purgewater Management," Section 6.1, "Drilling and Sampling in Radiological Contaminated Areas," and Section 6.2, "Field Cleaning and/or Decontamination of Drilling Equipment." No purgewater will be generated during these characterization activities.

Waste will be minimized by returning nonregulated soils (below dangerous waste designation limits and *Model Toxics Control Act* [MTCA] soil cleanup standards) to the ground at or near the waste site, decontamination of equipment for reuse, and compaction of miscellaneous solid waste (MSW, as defined in the *Strategy for Management of Investigation-Derived Waste,* Ecology et al. 1999), to the extent practicable.

B1.1 WASTE STREAM

Expected waste streams include contaminated soils, decontamination fluids, and MSW such as disposable personal protection equipment, sampling equipment, wipes, rags, paper, and plastic.

Materials will be screened in the field with instruments, and wastes will be segregated and managed in accordance with requirements presented below.

B1.2 WASTE GENERATION AND MANAGEMENT

All waste generated will be recorded in a logbook, with such details as the location and type of waste, depth of sample, date of initial placement into container, date the container was sealed, and Package Identification Number (PIN).

Wastes will be stored at the 200-W Bioremediation Central Waste Container Storage Area (CWCSA), as shown in Figure B1-1. IDW will be stored at this area until analytical data are evaluated for proper waste designation and will be disposed of at the Environmental Restoration Disposal Facility (ERDF) if it meets the waste acceptance criteria. If transuranic (TRU) waste is encountered, it will be sent to the Hanford Central Waste Complex (CWC) for storage. Waste destined for the Project Hanford Management Contractor (PHMC) will be designated and characterized in accordance with BHI-EE-02, Section 12, and *Hanford Site Solid Waste Acceptance Criteria* (WHC 1996).

Details on the types and management of expected wastes are provided in the following subsections.

B1.2.1 Miscellaneous Solid Waste

MSW will be placed into plastic bags and taped closed. The bags will be labeled with the borehole number where the waste was generated and placed in appropriately labeled drums or boxes in the designated storage area. The containers will be managed as potentially hazardous waste and will be dispositioned using analytical results or process knowledge associated with the contaminated media contacted.

B1.2.2 Vadose Zone Drill Cuttings

Drill cuttings will be screened using field instruments and containerized in mid-performance coated drums with 10-mil reinforced plastic liners as required for potentially mixed waste. If screening levels indicated that the cuttings may be characterized as TRU waste, the cutting containers will also have vented lids. Contaminated soil is expected to be intercepted in discrete intervals in the boreholes, the screening results will be used to segregate the waste. The waste drums will be staged at the designated storage areas and dispositioned using analytical results and/or process knowledge.

B1.2.3 Decontamination Fluids

Fluids (water) will generally be used to field decontaminate drilling equipment and sampling tools. Water generated from the decontamination of drilling equipment will be containerized and managed according to the Purgewater Agreement.

B1.3 MANAGEMENT OF WASTE CONTAINERS

Drums containing drill cuttings and decontamination fluids will be stored inside the applicable waste storage area. Containers awaiting analytical results will be marked and labeled as prescribed in BHI-FS-011. Monthly inspections will occur to assess integrity, container marking/labeling, physical container placement, storage area boundaries/identification/warning signs, and spill control. Containers showing signs of deterioration will be identified on the container inspection form (BHI-FS-0136) and immediately overpacked or repackaged. Spills or releases will be reported in accordance with BHI-MA-02, *ERC Project Procedures*. In the event of a spill or release, appropriate immediate action will be taken to protect human health and the environment.

B1.4 FINAL DISPOSAL/STORAGE

IDW will be stored in a CWCSA until the receipt of analytical results from the remedial investigation and during completion of the waste profiling. Waste profiling provides information concerning each waste stream on a Waste Profile Sheet and is reviewed against the Hanford Site Solid Waste Acceptance Criteria. Characterization and designation will be conducted in accordance with Attachment 1 of BHI-EE-10, *Waste Management Plan*. This activity requires determinations on the following criteria: listed dangerous waste (WAC 173-303-080, -081, and -082), applicability of characteristic waste codes (WAC 173-303-090 [2]–[8]), toxic dangerous waste (WAC 173-303-100[5]), persistent waste (WAC 173-303-100), regulated for land disposal, applicability of waste codes (WAC 173-300-090 [2]–[8]), and presence of polychlorinated biphenyl (*Toxic Substances Control Act of 1976* and WAC 173-303-9904). Final disposal and storage must be in accordance with ERDF acceptance criteria. Process knowledge may be used to include/exclude a radiological or chemical contaminant from the project and must be documented in an auditable manner. Radiological wastes will be determined to be acceptable for near surface (onsite) disposal if the concentrations of radionuclides are below those specified in Table B1 or column 3 of Table 2 of Section 61.55 of 10 CFR 61.

IDW waste will be radiologically released when the waste meets applicable release levels. Nonradiologically contaminated dangerous waste may be shipped to an offsite facility, contingent upon the waste meeting the offsite disposal facilities' waste acceptance criteria and offsite determination of acceptability by the U.S. Environmental Protection Agency. Waste above release levels that meets the ERDF waste acceptance criteria will be transported to ERDF for disposal.

TRU waste will be sent to the CWC for storage and will be designated/characterized in accordance with BHI-EE-02, Section 12, and *Hanford Site Solid Waste Acceptance Criteria* (WHC 1996). Soil sample(s) designated as TRU waste will be returned and placed back into the stored waste drum associated with the interval from which the sample was taken.

Nonradioactive IDW containing hazardous waste constituents below dangerous waste designation limits and MTCA Method B soil cleanup standards will be disposed to the ground at or near point of generation and documented in a field logbook. Waste that exceeds dangerous waste release or MTCA Method B limits and meets the ERDF waste acceptance criteria will be disposed at ERDF. IDW that does not meet the ERDF waste acceptance criteria will remain at the centralized storage area pending disposal at an appropriate facility. A case-by-case disposal determination will be made in instances where IDW exceeds the ERDF waste acceptance criteria. IDW requiring treatment, prior to disposal, requires approval by the lead regulatory agency.

MSW that does not require disposal at ERDF will be disposed in an appropriate solid waste disposal facility (Subtitle "D" landfill).

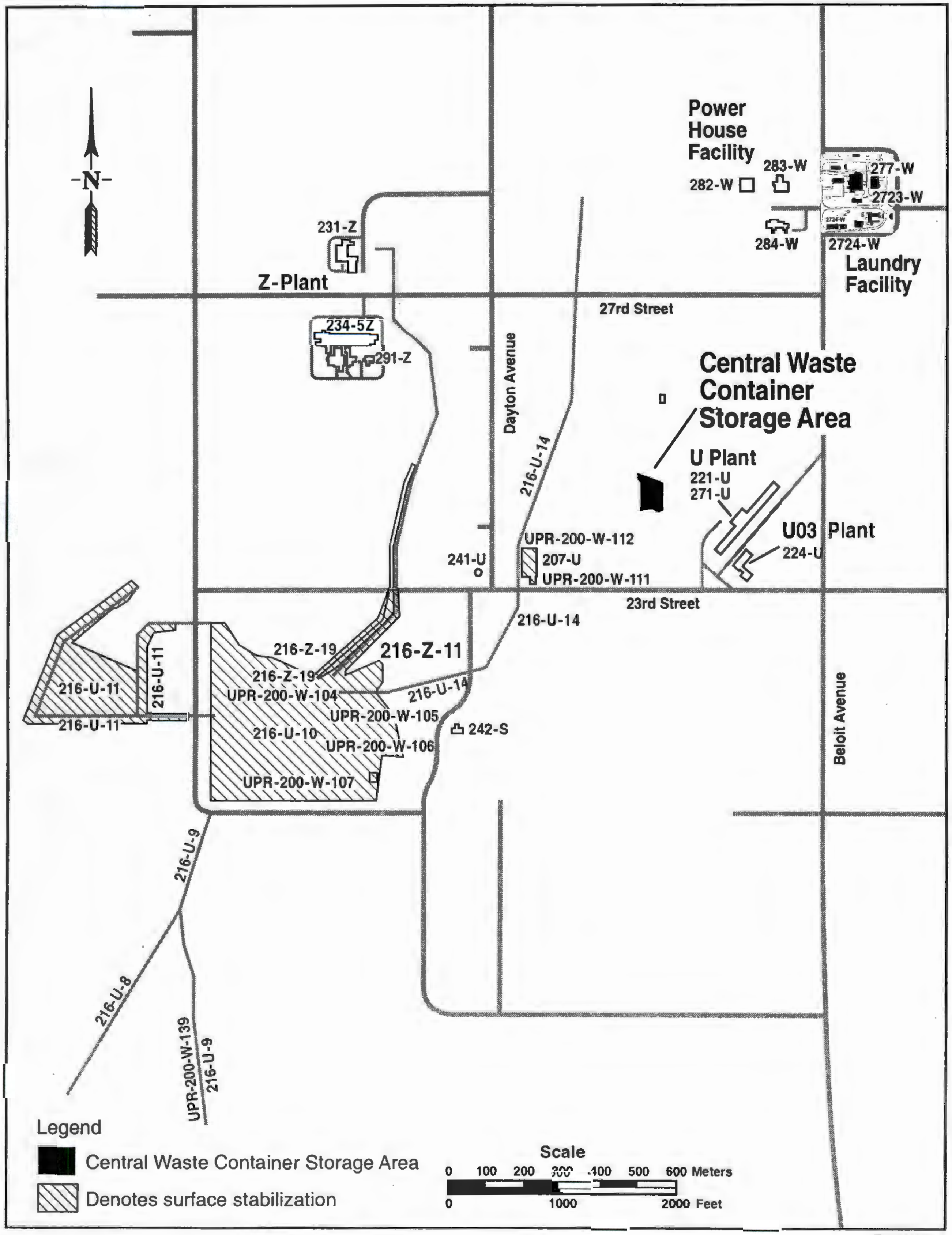
B1.5 RECORDS

Original copies of all sampling and waste inventory documentation (BHI-FS-038) will be forwarded to the assigned waste transportation specialist to be included in the waste file and to initiate waste tracking in the Solid Waste Information Tracking System (SWITS). The waste file will be submitted to Document and Information Services for inclusion into the project file following final waste disposition.

B1.6 ESTIMATE OF IDW QUANTITIES

Estimates of the amount of waste that will be generated during this field investigation are given in Table B1-1. These quantities are based on IDW generated during previous 200 Area drilling activities.

Figure B1-1. 200-CW-5 Location Map and Waste Container Storage Area.



E9911098.2

Table B1-1. Estimate of Investigation-Derived Waste Quantities.

Site	Media	Method	Soil and Waste			Miscellaneous Solid Waste		
			Cuttings (gal)	Trench Spoils (gal)	Total (gal)	PPE/ Trash (gal)	Disposable Equipment (gal)	Total Solid Waste (gal)
200-CW-5	Soil	Drilling	2,100	0	2,100	600	225	825
	Liquid	Drilling	350	0	350	0	0	0
					2,450			825

B2.0 REFERENCES

10 CFR 61, "Licensing Requirements for Land Disposal of Radioactive Waste," *Code of Federal Regulations*, as amended.

BHI-EE-01, *Environmental Investigations Procedures*, Bechtel Hanford, Inc., Richland, Washington.

BHI-EE-10, *Waste Management Plan*, Bechtel Hanford, Inc., Richland, Washington.

BHI-FS-03, *Field Support Waste Management Instructions*, Bechtel Hanford, Inc, Richland, Washington.

BHI-MA-02, *ERC Project Procedures*, Bechtel Hanford, Inc., Richland, Washington.

DOE-RL, 1999, *200 Areas Remedial Investigation/Feasibility Study Implementation Plan – Environmental Restoration Program*, DOE/RL-98-28, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

Ecology, EPA, and DOE, 1999, *Strategy for Management of Investigation Derived Waste*, (letter from G. H. Sanders, U.S. Department of Energy, Richland Operations, D. R. Sherwood, U.S. Environmental Protection Agency, and M. Wilson, Washington State Department of Ecology, dated March 17, 1999), Richland, Washington.

Toxic Substances Control Act of 1976, 15 U.S.C. 2601, et seq.

WAC 173-303, "Dangerous Waste Regulations," *Washington Administrative Code*, as amended.

WHC, 1996, *Hanford Site Solid Waste Acceptance Criteria*, WHC-EP-0063-4, Westinghouse Hanford Company, Richland, Washington.

DISTRIBUTION

U.S. Department of Energy
Richland Operations Office

B. L. Foley	A5-13
R. E. Gerton	H0-12

ERC Team

K. A. Anselm	H9-03
R. G. Bauer (5)	H9-03
R. J. Fabre	X5-50
B. H. Ford	H0-19
G. B. Mitchem	H0-17
D. A. St. John	H9-03
L. C. Swanson	H9-02
C. D. Wittreich (2)	H9-03

PNNL

S. P. Luttrell	K6-81
J. M. Zachara	K8-96

Document and Information Services (3)	H0-09
DOE-RL Public Reading Room	H2-53
Hanford Technical Library	P8-55