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U Plant Source Aggregate Area Management Study Report

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U PLANT SOURCE AAMS EXECUTIVE SUMMARY

This report presents the results of an aggregate area management study (AAMS) for the U Plant Aggregate Area in the 200 Areas of the U.S. Department of Energy (DOE) Hanford Site in Washington State. This scoping level study provides the basis for initiating Remedial Investigation/Feasibility Study (RI/FS) activities under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) or Resource Conservation and Recovery Act (RCRA) Facility Investigations (RFI) and Corrective Measures Studies (CMS) under RCRA. This report also integrates select RCRA treatment, storage, or disposal (TSD) closure activities with CERCLA and RCRA past practice investigations.

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Through the experience gained to date on developing work plans, closure plans, and permit applications at the Hanford Site, the parties to the *Hanford Federal Facility Agreement and Consent Order* (Tri-Party Agreement) have recognized that all past practice investigations must be managed and implemented under one characterization and remediation strategy, regardless of the regulatory agency lead (as defined in the Tri-Party Agreement). In particular, the parties have identified a need for greater efficiency over the existing RI/FS and RFI/CMS investigative approaches, and have determined that, to expedite the ultimate goal of cleanup, much more emphasis needs to be placed on initiating and completing waste site cleanup through interim measures.

This streamlined approach is described and justified in *The Hanford Federal Facility Agreement and Consent Order Change Package*, dated May 16, 1991 (Ecology et al. 1991). To implement this approach, the three parties have developed the *Hanford Site Past-Practice Strategy* (DOE/RL 1992a) for streamlining the past practice remedial action process. This strategy provides new concepts for:

- Accelerating decision-making by maximizing the use of existing data consistent with data quality objectives (DQOs)
- Undertaking expedited response actions (ERAs) and/or interim remedial measures (IRMs), as appropriate, to either remove threats to human health and welfare and the environment, or to reduce risk by reducing toxicity, mobility, or volume of contaminants.

The *Hanford Site Past-Practice Strategy* (DOE/RL 1992a) describes the concepts and framework for the RI/FS (or RFI/CMS) process in a manner that has a bias-for-action through optimizing the use of interim remedial actions, culminating with decisions on final remedies on both an operable-unit and aggregate-area scale. The strategy focuses on reaching early decisions to initiate and complete cleanup projects, maximizing the use of existing data, coupled with focused short time-frame investigations, where necessary. As

more data become available on contamination problems and associated risks, the details of the longer term investigations and studies will be better defined.

The strategy includes three paths for interim decision-making and a final remedy-selection process for the operable unit that incorporates the three paths and integrates sites not addressed in those paths. The three paths for interim decision-making include the ERA, IRM, and limited field investigation (LFI) paths. The strategy requires that aggregate area management study reports (AAMSRs) be prepared to provide an evaluation of existing site data to support initial path decisions. This AAMSR is one of ten reports that will be prepared for each of the ten aggregate areas defined in the 200 Areas.

The near-term past practice strategy for the 200 Areas provides for ERAs, IRMs, and LFIs for individual waste management units, waste management unit groups, and groundwater plumes, and recommends separate source and groundwater operable units. Initial site-specific recommendations for each of the waste management units within the U Plant Aggregate Area are provided in the report. Work plans starting with the 200-UP-2 Work Plan will initially focus on limited intrusive investigations at the highest priority waste management units or waste management unit groups as established in the AAMSR. The goal of this initial focus is to establish whether IRMs are justified. Waste management units identified as candidate ERAs in Section 9.0 of the AAMS will be further evaluated following the *Site Selection Process for Expedited Response Actions at the Hanford Site* (Gustafson 1991).

While these elements may mitigate specific contamination problems through interim actions, the process of final remedy selection must be completed for the operable unit or aggregate area to reach closure. The aggregation of information obtained from the LFIs and interim actions may be sufficient to perform the cumulative risk assessment and to define the final remedy for the operable unit or aggregate area. If the data are not sufficient, additional investigations and studies will be performed to the extent necessary to support final remedy selection. These investigations would be performed within the framework and process defined for RI/FS programs.

Several integration issues exist that are generic to the overall past practice process for the 200 Areas and include the following:

Future Work Plan Scope. Although the current practice for implementing RI/FS (RFI/CMS) activities is through operable unit based work plans, individual LFI/IRMs may be more efficiently implemented using LFI/IRM-specific work plans.

Groundwater Operable Units. A general strategy recommended for the 200 Areas is to define separate operable units for groundwater affected by 200 Areas source terms. This requires that groundwater be removed from the scope of existing source operable

units and new groundwater-specific operable units be established. Recommendations for groundwater operable units will be developed in the groundwater AAMSRs.

Work Plan Prioritization. Although priorities are established in the AAMSR for operable units within the aggregate area, priorities between aggregate areas have yet to be established. The integration of priorities at the 200 Areas level is considered a prerequisite for establishing a schedule for past practice activities in the 200 Areas.

It is intended that these integration issues be resolved following the completion of all ten AAMSRs (Draft A) scheduled for September 1992. Resolution of these issues will be based on a decisions/consensus process among the Washington State Department of Ecology (Ecology), U.S. Environmental Protection Agency (EPA), and DOE. Following resolution of these issues a schedule for past practice activities in the 200 Areas will be prepared.

Background, environmental setting, and known contamination data are provided in Sections 2.0, 3.0, and 4.1. This information provides the basis for development of the preliminary conceptual model in Section 4.2 and for assessing health and environmental concerns in Section 5.0. Preliminary applicable or relevant and appropriate requirements (ARARs) (Section 6.0) and preliminary remedial action technologies (Section 7.0) are also developed based on this data. Section 8.0 provides a discussion of the DQOs. Data needs identified in Section 8.0 are based on data gaps determined during the development of the conceptual model, human health and environmental concerns, ARARs, and remedial action technologies. Recommendations in Section 9.0 are developed using all the information provided in the sections which precede it.

The Hanford Site, operated by the DOE, occupies about 1,450 km² (560 mi²) of the southeastern part of Washington north of the confluence of the Yakima and Columbia Rivers. The Hanford Site was established in 1943 to produce plutonium for nuclear weapons using production reactors and chemical processing plants. The U Plant Aggregate Area is located within the 200 West Area, near the middle of the Hanford Site. There are three operable units within the U Plant Aggregate Area.

Between 1952 and 1958, uranium was recovered from single-shell tank wastes which resulted from the bismuth phosphate process. A solvent extraction process which used tributyl phosphate in normal paraffin hydrocarbon (kerosene) solvent to recover uranium from a nitric acid solution was employed at the 221-U Building. The 224-U (UO₃) Building operated between 1955 and the present, converting uranyl nitrate hexahydrate to powdered uranium trioxide (UO₃).

The U Plant Aggregate Area contains a large variety of waste disposal and storage facilities. High-level wastes were stored in underground single-shell tanks. Low-level wastes such as cooling and condensate water were allowed to infiltrate into the ground

through cribs, ditches, and open ponds. Based on construction, purpose, or origin, the U Plant Aggregate Area waste management units fall into one of ten subgroups as follows:

- 1 (No. of waste management units) Plant, Building and Storage Area
- 22 Tanks and Vaults
- 12 Cribs and Drains
- 1 Reverse Well
- 10 Ponds, Ditches and Trenches
- 4 Septic Tanks and Associated Drain Fields
- 13 Transfer Facilities, Diversion Boxes, and Pipelines
- 1 Basin
- 2 Burial Sites
- 34 Unplanned Releases.

Detailed descriptions of these waste management units are provided in Section 2.3.

There are several ongoing programs that affect buildings and waste management units in the U Plant Aggregate Area (Section 2.7). These programs include RCRA, the Hanford Decommissioning and RCRA Closure Program, the Radiation Area Remedial Action (RARA) Program, the Single-Shell Tank Closure Program, and the Waste Management Program. Forty-two units (primarily single-shell tanks and associated transfer facilities) fall completely within the scope of one of these programs and, therefore, recommendations on these units will be made by the respective programs rather than in this AAMSR. An additional ten waste management units will be partially addressed by an ongoing program in addition to the actions recommended in the U Plant AAMSR.

Discussions of surface hydrology and geology are provided on a regional, Hanford Site, and aggregate area basis in Section 3.0. The interpretation is based on a limited number of wells and this limitation does not support a detailed delineation of waste management unit specific features. The section also describes the flora and fauna, land use, water use, and human resources of the 200 West Area and vicinity. Groundwater of the 200 West Area is described in detail in a separate 200 West Groundwater AAMSR.

A preliminary site conceptual model is presented in Section 4.0. Section 4.1 presents the chemical and radiological data that are available for the different media types (including surface soil, vadose zone soil, air, surface water and biota) and site-specific data for each waste management unit and unplanned release.

A preliminary assessment of potential impacts to human health and the environment is presented in Section 4.2. This assessment includes a discussion of release mechanisms, potential transport pathways, and a preliminary conceptual model of human and ecological exposure based on these pathways. Physical, radiological, and toxicological characteristics of the known and suspected contaminants at the aggregate area are also discussed.

Health and environmental concerns are presented in Section 5.0. The preliminary qualitative evaluation of potential human health concerns is intended to provide input to the waste management unit recommendation process. The evaluation includes (1) an identification of contaminants of potential concern for each exposure pathway that is likely to occur within the U Plant Aggregate Area, (2) identification of exposure pathways applicable to individual waste management units and (3) estimates of relative hazard based on four available indicators of risk; the CERCLA Hazard Ranking System (HRS) and modified HRS (mHRS), surface radiation survey data, and Westinghouse Environmental Protection Group site scoring.

Potentially ARARs to be used in developing and assessing various remedial action alternatives at the U Plant Aggregate Area are discussed in Section 6.0. Specific potential requirements pertaining to hazardous and radiological waste management, remediation of contaminated soils, surface water protection, and air quality are discussed.

Preliminary remedial action technologies are presented in Section 7.0. The process includes identification of remedial action objectives (RAOs), determination of general response actions, and identification of specific process options associated with each option type. The process options are screened based on their effectiveness, implementability and cost. The screened process options are combined into alternatives and the alternatives are described.

Data quality is addressed in Section 8.0. Identification of chemical and radiological constituents associated with the units and their concentrations, with a view to determine the contaminants of concern and their action levels, is a major requirement to execute the *Hanford Site Past-Practice Strategy*. There was found to be a limited amount of data in this regard. The section provides a summary of data needs identified for each of the waste management units in the U Plant Aggregate Area. The data needs provide the basis for development of detailed DQOs in subsequent work plans.

Section 9.0 provides management recommendations for the U Plant Aggregate Area based on the *Hanford Site Past-Practice Strategy*. Criteria for selecting appropriate *Hanford*

Site Past-Practice Strategy paths (ERA, IRM, and final remedy selection) for individual waste management units and unplanned releases in the U Plant Aggregate Area are developed in Section 9.1. As a result of the data evaluation process, one waste management unit was recommended for an ERA, 7 units were recommended for IRMs, 14 units were recommended for LFIs which could lead to IRMs and 24 units were recommended for final remedy selection. A discussion of the data evaluation process is provided in Section 9.2. Table ES-1 provides a summary of the results of the data evaluation assessment of each unit. Table ES-2 provides the decision matrix patterns each unit followed in reaching the recommendation. Recommendations for redefining operable unit boundaries and prioritizing operable units for work plan development are provided in Section 9.3. Included in Section 9.3 are the interactions with RCRA required to disposition the 216-U-12 RCRA TSD facility. All recommendations for future characterization needs will be more fully developed and implemented through work plans. Sections 9.4 and 9.5 provide recommendations for focused feasibility study (FFS) and treatability study, respectively.

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Table ES-1. Summary of the Results of Data Evaluation Process Assessment.

Waste Management Unit or Unplanned Release Site	Operable Unit	ERA	IRM	LFI	RA	RI	OPS	Remarks
Tanks and Vaults								
241-U-361 Settling Tank	200-UP-2	--	X	X	--	--	--	
Cribs and Drains								
216-S-21 Crib	200-UP-1	--	X	X	--	--	X	RARA - Cave-in potential Redefined to S Plant Aggregate Area
216-U-1 and 216-U-2 Cribs	200-UP-2	--	X	X	--	--	X	RARA - Cave-in potential
216-U-8 Crib	200-UP-2	--	X	X	--	--	X	RARA - Cave-in potential
216-U-12 Crib	200-UP-2	--	X	X	--	--	--	
216-U-16 Crib	200-UP-2	--	X	X	--	--	--	
216-U-17 Crib	200-UP-2	--	X	X	--	--	X	Active - Waste management
216-Z-20 Crib	200-UP-1	--	X	X	--	--	X	Active - Waste management Redefined to Z Plant Aggregate Area
216-S-4 French Drain	200-UP-1	--	X	X	--	--	--	Redefined to S Plant Aggregate Area
216-U-3 French Drain	200-UP-2	--	X	X	--	--	--	
216-U-4A French Drain	200-UP-2	--	X	X	--	--	--	
216-U-4B French Drain	200-UP-2	--	X	X	--	--	--	
216-U-7 French Drain	200-UP-2	--	X	X	--	--	X	RARA - Surface contamination
Reverse Well								
216-U-4 Reverse Well	200-UP-2	--	X	X	--	--	--	

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Table ES-1. Summary of the Results of Data Evaluation Process Assessment.

Waste Management Unit or Unplanned Release Site	Operable Unit	ERA	IRM	LFI	RA	RI	OPS	Remarks
Ponds, Ditches, and Trenches								
216-U-10 Pond	200-UP-1	--	X	--	--	--	--	Redefined to 200 UP-2 Operable Unit
216-U-14 Ditch	200-UP-2	--	X	--	--	--	X	Active - Waste management RARA - surface contamination
216-Z-1D Ditch	200-UP-1	--	X	--	--	--	--	Redefined to 200-UP-2 Operable Unit
216-Z-11 Ditch	200-UP-1	--	X	--	--	--	--	Redefined to 200-UP-2 Operable Unit
216-Z-19 Ditch	200-UP-1	--	X	--	--	--	--	Redefined to 200-UP-2 Operable Unit
216-U-5 Trench	200-UP-2	--	--	--	--	X	--	
216-U-6 Trench	200-UP-2	--	--	--	--	X	--	
216-U-11 Trench	200-UP-1	--	X	--	--	--	--	Redefined to 200-UP-2 Operable Unit
216-U-13 Trench	200-UP-1	--	--	--	--	X	--	Redefined to 200-UP-2 Operable Unit
216-U-15 Trench	200-UP-2	--	--	--	--	X	--	
Septic Tanks and Associated Drain Fields								
2607-W-5 Septic Tank/ Drain Field	200-UP-2	X	--	--	--	X	--	Active - Potential for mobilizing nearby contaminants
2607-W-7 Septic Tank/ Drain Field	200-UP-2	--	--	--	--	X	--	Active

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Table ES-1. Summary of the Results of Data Evaluation Process Assessment.

Waste Management Unit or Unplanned Release Site	Operable Unit	ERA	IRM	LFI	RA	RI	OPS	Remarks
2607-W-9 Septic Tank/ Drain Field	200-UP-2	--	--	--	--	X	--	Active
Basins								
207-U Retention Basin	200-UP-2	--	X	--	--	--	X	RARA - Surface contamination Redefined to 200-UP-2 Operable Unit
Burial Sites								
Burial Ground/ Burning Pit	200-UP-2	--	--	--	--	X	--	
200-W Construction Surface Laydown Area	200-UP-2	--	--	--	--	X	--	
Unplanned Releases								
UN-200-W-6	200-UP-2	--	--	--	--	X	--	
UN-200-W-19	200-UP-2	--	--	--	--	X	--	
UN-200-W-33	200-UP-2	--	--	--	--	X	--	
UN-200-W-39	200-UP-2	--	--	--	--	X	--	
UN-200-W-46	200-UP-2	--	--	--	X	--	--	
UN-200-W-48	200-UP-2	--	--	--	--	X	--	
UN-200-W-55	200-UP-2	--	--	--	--	X	--	
UN-200-W-60	200-UP-2	--	--	--	--	X	--	
UN-200-W-68	200-UP-1	--	--	--	--	X	--	Redefined to 200-UP-2 Operable Unit
UN-200-W-78	200-UP-2	--	--	--	--	X	--	

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Table ES-1. Summary of the Results of Data Evaluation Process Assessment.

Waste Management Unit or Unplanned Release Site	Operable Unit	ERA	IRM	LFI	RA	RI	OPS	Remarks
Unplanned Releases (Continued)								
UN-200-W-86	200-UP-2	--	--	--	X	--	--	
UN-200-W-101	200-UP-2	--	--	--	--	X	X	RARA - Surface contamination
UN-200-W-117	200-UP-2	--	--	--	--	X	--	
UN-200-W-118	200-UP-2	--	--	--	--	X	--	
UN-200-W-161	200-UP-2	--	--	--	--	X	X	RARA - Surface contamination

ERA - Expedited Response Action

RI - Remedial Investigation/Feasibility Study

LFI - Limited Field Investigation

RA - Risk Assessment

IRM - Interim Remedial Measure

OPS - Operational Programs

Table ES-2. U Plant Aggregate Area Data Evaluation Decision Matrix.

Waste Management Unit	ERA Evaluation Path								IRM Evaluation Path			LFI Path	Final Remedy
	Is an ERA Justified?	Release?	Pathway ?	Quantity?	Concentration	Technology Available?	Adverse Consequences?	Operational Programs?	High Priority?	Data Adequate?	No Adverse Consequences?	Collect Data?	Data Adequate?
Tanks and Vaults													
241-U-361	Y	N	-	-	-	-	-	-	Y	N	-	Y	-
Cribs and Drains													
216-S-21	Y	Y	Y	Y	Y	Y	N	Y	Y	N	-	Y	-
216-U-1, -2	Y	Y	Y	Y	Y	Y	N	Y	Y	N	-	Y	-
216-U-8	Y	Y	Y	Y	Y	Y	N	Y	N ^M	N	-	Y	-
216-U-12	Y	Y	N	-	-	-	-	-	Y	N	-	Y	-
216-U-16	Y	Y	N	-	-	-	-	-	Y	N	-	Y	-
216-U-17	Y	Y	Y	Y	Y	Y	N	Y	Y	N	-	Y	-
216-Z-20	Y	Y	Y	Y	Y	Y	N	Y	Y	N	-	Y	-
216-S-4	Y	Y	N	-	-	-	-	-	Y	N	-	Y	-
216-U-3	Y	Y	N	-	-	-	-	-	Y	N	-	Y	-
216-U-4A	Y	Y	N	-	-	-	-	-	Y	N	-	Y	-
216-U-4B	Y	Y	N	-	-	-	-	-	Y	N	-	Y	-
216-U-7	Y	Y	Y	Y	Y	Y	N	Y	Y	N	-	Y	-
Reverse Well													
216-U-4	Y	Y	N	-	-	-	-	-	Y	N	-	Y	-

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Table ES-2. U Plant Aggregate Area Data Evaluation Decision Matrix.

Waste Management Unit	ERA Evaluation Path								IRM Evaluation Path			LFI Path	Final Remedy
	Is an ERA Justified?	Release?	Pathway ?	Quantity?	Concentration	Technology Available?	Adverse Consequences?	Operational Programs?	High Priority?	Data Adequate?	No Adverse Consequences?	Collect Data?	Data Adequate?
Ponds, Ditches, and Trenches													
216-U-10	Y	Y	N	--	--	--	--	--	Y	Y	Y	--	--
216-U-11	Y	Y	N	--	--	--	--	--	Y	Y	Y	--	--
216-U-14	Y	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	--	--
216-Z-1D	Y	Y	N	--	--	--	--	--	Y	Y	Y	--	--
216-Z-11	Y	Y	N	--	--	--	--	--	Y	Y	Y	--	--
216-Z-19	Y	Y	N	--	--	--	--	--	Y	Y	Y	--	--
216-U-5	Y	Y	N	--	--	--	--	--	N	--	--	--	N
216-U-6	Y	Y	N	--	--	--	--	--	N	--	--	--	N
216-U-13	Y	Y	N	--	--	--	--	--	N	--	--	--	N
216-U-15	Y	Y	N	--	--	--	--	--	N	--	--	--	N
Septic Tanks and Associated Drain Fields													
2607-W-5	Y	Y	Y	Y	Y	Y	N	N	N	--	--	--	N
2607-W-7	Y	N	--	--	--	--	--	--	N	--	--	--	N
2607-W-9	Y	N	--	--	--	--	--	--	N	--	--	--	N
Basins													
207-U	Y	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	--	--

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Table ES-2. U Plant Aggregate Area Data Evaluation Decision Matrix.

Waste Management Unit	ERA Evaluation Path								IRM Evaluation Path			LFI Path	Final Remedy
	Is an ERA Justified?	Release?	Pathway ?	Quantity?	Concentration	Technology Available?	Adverse Consequences?	Operational Programs?	High Priority?	Data Adequate?	No Adverse Consequences?	Collect Data?	Data Adequate?
Burial Sites													
Burial Ground/ Burning Pit	N	N	--	--	--	--	--	--	N	--	--	--	N
200-W Construction Surface Laydown Area	N	N	--	--	--	--	--	--	N	--	--	--	N
Unplanned Releases													
UN-200-W-6	N	N	--	--	--	--	--	--	N	--	--	--	N
UN-200-W-19	N	N	--	--	--	--	--	--	N	--	--	--	N
UN-200-W-33	N	N	--	--	--	--	--	--	N	--	--	--	N
UN-200-W-39	N	N	--	--	--	--	--	--	N	--	--	--	N
UN-200-W-46	N	N	--	--	--	--	--	--	N	--	--	--	Y
UN-200-W-48	N	N	--	--	--	--	--	--	N	--	--	--	N
UN-200-W-55	N	N	--	--	--	--	--	--	N	--	--	--	N

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Table ES-2. U Plant Aggregate Area Data Evaluation Decision Matrix.

Waste Management Unit	ERA Evaluation Path								IRM Evaluation Path			LFI Path	Final Remedy
	Is an ERA Justified?	Release?	Pathway ?	Quantity?	Concentration	Technology Available?	Adverse Consequences?	Operational Programs?	High Priority?	Data Adequate?	No Adverse Consequences?	Collect Data?	Data Adequate?
Unplanned Releases (Continued)													
UN-200-W-60	N	N	--	--	--	--	--	--	N	--	--	--	N
UN-200-W-68	N	N	--	--	--	--	--	--	N	--	--	--	N
UN-200-W-78	N	N	--	--	--	--	--	--	N	--	--	--	N
UN-200-W-86	N	N	--	--	--	--	--	--	N	--	--	--	Y
UN-200-W-101	Y	Y	Y	Y	Y	Y	N	Y	Y	N	--	--	N
UN-200-W-117	N	N	--	--	--	--	--	--	N	--	--	--	N
UN-200-W-118	N	N	--	--	--	--	--	--	N	--	--	--	N
UN-200-W-161	Y	Y	Y	Y	Y	Y	N	Y	Y	N	--	--	N

^{a/} Evaluated as high priority site because of similarities with other cribs.

-- Indicates decision point not reached.

Y Yes

N No

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ACRONYMS AND ABBREVIATIONS

AAMS	aggregate area management study
AAMSR	aggregate area management study report
Agreement	Hanford Federal Facility Agreement and Consent Order
AKART	all known, available, and reasonable treatment technologies
ARARs	applicable or relevant and appropriate requirements
ASIL	acceptable source impact level
BAT	best available treatment technologies
BDATs	best demonstrated available treatment technologies
BRC	below regulatory concern
BWID	Buried Waste Integrated Demonstration
BWIP	Basalt Waste Isolation Project
CERCLA	<i>Comprehensive Environmental Response, Compensation, and Liability Act of 1980</i>
CFR	Code of Federal Regulations
CLP	Contract Laboratory Program
CMS	corrective measures studies
CWA	Clean Water Act
DCG	Derived Concentration Guide
DOE	U.S. Department of Energy
DOE/RL	U.S. Department of Energy, Richland Field Office
DQO	data quality objective
Ecology	Washington State Department of Ecology
EDMC	Environmental Data Management Center
EHPSS	Environmental Health and Pesticide Services Section
EHW	extremely hazardous waste
EII	environmental investigations instructions
EIMP	Environmental Information Management Plan
EPA	U.S. Environmental Protection Agency
ER	environmental restoration
ERA	expedited response actions
ERRA	Environmental Restoration Remedial Action
FFS	focused feasibility study
FOMP	Field Office Management Plan
FS	feasibility study
FWQC	Federal Water Quality Criteria
GIS	geographic information system
Health	Washington State Department of Health
HEAST	Health Effects Assessment Summary Tables
HEDL	Hanford Engineering and Development Laboratory
HEHF	Hanford Environmental Health Foundation
HEIS	Hanford Environmental Information System
HEPA	high efficiency particulate air

ACRONYMS AND ABBREVIATIONS (cont.)

HISS	Hanford Inactive Site Survey
HMS	Hanford Meteorological Station
HRA-EIS	Hanford Remedial Action Environmental Impact Statement
HRS	Hazard Ranking System
HSP	health and safety plan
HWOP	Hazardous Waste Operations Permit
HWSA	Hazardous Waste Staging Area
IMO	Information Management Overview
INEL	Idaho National Engineering Laboratory
IRM	interim remedial measure
LDR	land disposal restriction
LFI	limited field investigation
LSC	liquid scintillation counting
MCL	maximum contaminant levels
MEPAS	Multimedia Environmental Pollution Assessment System
mHRS	modified Hazard Ranking System
MIBK	methyl isobutyl ketone
MTCA	Model Toxics Control Act
NAAQS	National Ambient Air Quality Standards
NCP	National Contingency Plan
NEPA	National Environmental Policy Act
NESHAPs	National Emission Standards for Hazardous Air Pollutants
NIOSH	National Institute for Occupational Safety and Health
NPDES	National Pollutant Discharge Elimination System
NPL	National Priorities List
NSPS	New Source Performance Standards
OSM	Office of Sample Management
PA	preliminary assessment
PARCC	precision, accuracy, representativeness, completeness, comparability
PMP	Project Management Plan
PNL	Pacific Northwest Laboratory
PSPL	Puget Sound Power and Light Company
PUREX	plutonium uranium extraction
PVC	polyvinyl chloride
QA	quality assurance
QAPjP	Quality Assurance Project Plan
QC	quality control
RA	risk assessment
RAO	remedial action objective
RARA	Radiation Area Remedial Action
RAS	Routine Analytical Services

ACRONYMS AND ABBREVIATIONS (cont.)

RCRA	<i>Resource Conservation and Recovery Act of 1976</i>
RCW	Revised Code of Washington
REDOX	reduction and oxidation
RFI	RCRA facility investigations
RI	remedial investigation
RLS	Radionuclide Logging System
ROD	record of decision
RTECS	Registry of Toxic Effects of Chemical Systems
RWP	Radiation Work Permit
SARA	Superfund Amendments and Reauthorization Act
SAS	Special Analytical Services
SCBA	self-contained breathing apparatus
SCIR	Surveillance and Compliance Inspection Report
SDWA	Safe Drinking Water Act
SI	site inspection
SRW	Sodium Reactor Experiment
T-BACT	toxic best available control technology
TBC	to-be-considered material
TCLP	toxicity characteristic leaching procedure
TLD	thermoluminescent dosimeter
TOC	total organic carbon
TRAC	Tracks Radioactive Components
Tri-Party	
TRU	transuranic
TSD	treatment, storage, or disposal
UO ₃	uranium trioxide
USC	U.S. Code
USGS	U.S. Geological Survey
VOC	volatile organic compound
WAC	Washington Administrative Code
WIDS	Waste Information Data System
WIPP	Waste Isolation Pilot Plant
WISHA	Washington Industrial Safety and Health Act
WPCA	Washington State Water Pollution Control Act
WPPSS	Washington Public Power Supply System

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1.0 INTRODUCTION

The U.S. Department of Energy (DOE) Hanford Site in Washington State is organized into numerically designated operational areas including the 100, 200, 300, 400, 600, and 1100 Areas (Figure 1-1). The U.S. Environmental Protection Agency (EPA), in November 1989, included the 200 Areas of the Hanford Site on the National Priorities List (NPL) under the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) of 1980. Inclusion on the NPL initiates the Remedial Investigation (RI) and Feasibility Study (FS) process for characterizing the nature and extent of contamination, assessing risks to human health and the environment, and selection of remedial actions.

This report presents the results of an aggregate area management study (AAMS) for the U Plant Aggregate Area located in the 200 Areas. The study provides the basis for initiating RI/FS under CERCLA or under the Resource Conservation and Recovery Act (RCRA) Facility Investigations (RFI) and Corrective Measures Studies (CMS). This report also integrates RCRA treatment, storage, or disposal (TSD) closure activities with CERCLA and RCRA past-practice investigations.

This chapter describes the overall AAMS approach for the 200 Areas, defines the purpose, objectives and scope of the AAMS, and summarizes the quality assurance (QA) program and contents of the report.

1.1 OVERVIEW

The 200 Areas, located near the center of the Hanford Site, encompasses the 200 West, East and North Areas which contain reactor fuel processing and waste management facilities.

Under the *Hanford Federal Facility Agreement and Consent Order* (Tri-Party Agreement), signed by the Washington State Department of Ecology (Ecology), DOE, and EPA (Ecology et al. 1990), the 200 NPL Site encompasses the 200 Areas and selected portions of the 600 Area. The 200 NPL Site is divided into 8 waste area groups largely corresponding to the major processing plants (e.g., B Plant and T Plant), and a number of isolated operable units located in the surrounding 600 Area. Each waste area group is further subdivided into one or more operable units based on waste disposal information, location, facility type, and other site characteristics. The 200 NPL Site includes a total of 44 operable units including 20 in the 200 East Area, 17 in the 200 West Area, 1 in the 200 North Area, and 6 isolated operable units. The intent of defining operable units was to group associated waste management units together, so that they could be effectively characterized and remediated under one work plan.

The Tri-Party Agreement also defines approximately 25 RCRA TSD groups within the 200 Areas which will be closed or permitted (for operation or postclosure care) in accordance with the Washington State Dangerous Waste Regulations (Washington Administrative Code [WAC] 173-303). The TSD facilities are often associated with an operable unit and are required to be addressed concurrently with past-practice activities under the Tri-Party Agreement.

This AAMS is one of ten studies that will provide the basis for past practice activities for operable units in the 200 Areas. In addition, the AAMS will be collectively used in the initial development of an area-wide groundwater model, and conduct of an initial site-wide risk assessment. Recent changes to the Tri-Party Agreement (Ecology et al. 1991), and the *Hanford Site Past-Practice Strategy* document (DOE/RL 1992a) establish the need and provide the framework for conducting AAMS in the 200 Areas.

1.1.1 Tri-Party Agreement

The Tri-Party Agreement was developed and signed by representatives from the EPA, Ecology, and DOE in May 1989, and revised in 1990 and 1991. The scope of the agreement covers all CERCLA past-practice, RCRA past-practice, and RCRA TSD activities on the Hanford Site. The purpose of the Tri-Party Agreement is to ensure that the environmental impacts of past and present activities are investigated and appropriately remediated to protect human health and the environment. To accomplish this, the Tri-Party Agreement provides a framework and schedule for developing, prioritizing, implementing, and monitoring appropriate response actions.

The 1991 revision to the Tri-Party Agreement requires that an aggregate area approach be implemented in the 200 Areas based on the *Hanford Site Past-Practice Strategy* (DOE/RL 1992a). This strategy requires the conduct of AAMS which are similar in nature to an RI/FS scoping study. The Tri-Party Agreement change package (Ecology et al. 1991) specifies that 10 Aggregate Area Management Study Reports (AAMSR) (major milestone M-27-00) are to be prepared for the 200 Areas. Further definition of aggregate areas and the AAMS approach is provided in Sections 1.2 and 1.3.

1.1.2 Hanford Site Past-Practice Strategy

The *Hanford Site Past-Practice Strategy* was developed between Ecology, EPA, and DOE to streamline the existing RI/FS and RFI/CMS processes. A primary objective of this strategy is to develop a process to meet the statutory requirements and integrate CERCLA RI/FS and RCRA Past Practice RFI/CMS guidance into a singular process for the Hanford Site that ensures protection of human health and welfare and the environment. The strategy refines the existing past practice decision-making process as defined in the Tri-Party

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Agreement. The fundamental principle of the strategy is a bias-for-action by optimizing the use of existing data, integrating past practice with RCRA TSD closure investigations, focusing the RI/FS process, conducting interim remedial actions, and reaching early decisions to initiate and complete cleanup projects on both operable-unit and aggregate-area scale. The ultimate goal is the comprehensive cleanup or closure of all contaminated areas at the Hanford Site at the earliest possible date in the most effective manner.

The process under this strategy is a continuum of activities whereby the effort is refined based upon knowledge gained as work progresses. Whereas the strategy is intended to streamline investigations and documentation to promote the use of interim actions to accelerate cleanup, it is consistent with RI/FS and RFI/CMS processes. An important element of this strategy is the application of the observational approach, in which characterization data are collected concurrently with cleanup.

For the 200 Areas the first step in the strategy is the evaluation of existing information presented in AAMSR. Based on this information, decisions are made regarding which strategy path(s) to pursue for further actions in the aggregate area. The strategy includes three paths for interim decision making and a final remedy-selection process that incorporates the three paths and integrates sites not addressed in those paths. As shown on Figure 1-2, the three paths for decision making are the following:

- Expedited response action (ERA) path, where an existing or near-term unacceptable health or environmental risk from a site is determined or suspected, and a rapid response is necessary to mitigate the problem
- Interim remedial measure (IRM) path, where existing data are sufficient to indicate that the site poses a risk through one or more pathways and additional investigations are not needed to screen the likely range of remedial alternatives for interim actions; if a determination is made that an IRM is justified, the process proceeds to select an IRM remedy and a focused feasibility study (FFS), if needed, to select a remedy
- Limited field investigation (LFI) path, where minimum site data are needed to support IRM or other decisions, and are obtained in a less formal manner than that needed to support a final Record of Decision (ROD). Data generated from a LFI may be sufficient to directly support an interim ROD. Regardless of the scope of the LFI, it is a part of the RI process, and not a substitute for it.

The process of final remedy selection must be completed for the aggregate area to reach closure. The aggregation of information obtained from LFI and interim actions may be sufficient to perform the cumulative risk assessment and to define the final remedy for the aggregate area or associated operable units. If the data are not sufficient, additional

investigations and studies will be performed to the extent necessary to support final remedy selection. These investigations would be performed within the framework and process defined for RI/FS or RFI/CMS programs.

1.2 200 NPL SITE AGGREGATE AREA MANAGEMENT STUDY PROGRAM

The overall approach and scope of the 200 Areas AAMS program is based on the Tri-Party Agreement and the *Hanford Site Past-Practice Strategy*.

1.2.1 Overall Approach

As defined in the 1991 revision to the Tri-Party Agreement, the AAMS program for the 200 Areas consists of conducting a series of ten AAMS for eight source (Figures 1-3, 1-4, and 1-5) and two groundwater aggregate areas delineated in the 200 East, West, and North Areas. Table 1-1 lists the aggregate areas, the type of study, and associated operable units. With the exception of 200-IU-6, isolated operable units associated with the 200 NPL site (Figure 1-5) are not included in the AAMS program. Generally, the quantity of existing information associated with isolated operable units is not considered sufficient to require study on an aggregate area basis prior to work plan development. Operable unit 200-IU-6 is addressed as part of the B Plant AAMS because of similarities in waste management units (i.e., ponds).

The eight source AAMS are designed to evaluate source terms on a plant-wide scale. Source AAMS are conducted for the following aggregate areas (waste area groups) which largely correspond to the major processing plants including the following:

- U Plant
- Z Plant
- S Plant
- T Plant
- PUREX
- B Plant
- Semi-Works
- 200 North.

The groundwater beneath the 200 Areas is investigated under two groundwater AAMS on an area-wide scale (i.e., 200 West and 200 East Areas). Groundwater aggregate areas were delineated to encompass the geography necessary to define and understand the local hydrologic regime, and the distribution, migration and interaction of contaminants emanating from source terms. The groundwater aggregate areas are considered an appropriate scale for developing conceptual and numerical groundwater models.

The U.S. Department of Energy, Richland Field Office (DOE/RL) functions as the "lead agency" for the 200 AAMS program. Depending on the specific AAMS, EPA and/or Ecology function as the "Lead Regulatory Agency" (Table 1-1). Through periodic (monthly) meetings information is transferred and regulators are informed of the progress of the AAMS such that decisions established under the *Hanford Site Past-Practice Strategy* (e.g., is an ERA justified?) (Figure 1-2) can be quickly and collectively made between the three parties. These meetings will continually refine the scope of AAMS as new information is evaluated, decisions are made and actions taken. Completion milestones for AAMS are defined in Ecology et al. (1991) and duplicated in Table 1-1. All AAMSR are submitted as Secondary Documents which are defined in the Tri-Party Agreement as informational documents.

1.2.2 Process Overview

Each AAMS consists of three steps: (1) the analysis of existing data and formulation of a preliminary conceptual model, (2) identification of data needs and evaluation of remedial technologies, and (3) conduct of limited field characterization activities. Steps 1 and 2 are components of an AAMSR. Step 3 is a parallel effort for which separate reports will be produced.

The first and primary task of the AAMS investigation process involves the search, compilation and evaluation of existing data. Information collected for these purposes includes the following:

- Facility and process descriptions and operational histories for waste sources
- Waste disposal records defining dates of disposal, waste types, and waste quantities
- Sampling events of waste effluents and affected media
- Site conditions including the site physiography, geology, hydrology, meteorology, ecology, demography, and archaeology
- Environmental monitoring data for affected media including air, surface water, sediment, soil, groundwater and biota.

Collectively this information is used to identify contaminants of concern, to determine the scope of future characterization efforts, and to develop a preliminary conceptual model of the aggregate area. Although data collection objectives are similar, the types of information collected depend on whether the study is a source or groundwater AAMS. The data collection step serves to avoid duplication of previous efforts and facilitates a more focused investigation by the identification of data gaps.

Topical reports referred to as Technical Baseline Reports are initially prepared to summarize facility information. These reports describe individual waste management units and unplanned releases contained in the aggregate area as identified in the Waste Information Data System (WIDS) (WHC 1991a). The reports are based on review of current and historical Hanford Site reports, engineering drawings and photographs and are supplemented with site inspections and employee interviews. Information contained in the reports is summarized in the AAMSR. Other topical reports are used as sources of information in the AAMSR. These reports are as follows:

- U Plant Geologic and Geophysics Data Package
- Z Plant Geologic and Geophysics Data Package
- S Plant Geologic and Geophysics Data Package
- T Plant Geologic and Geophysics Data Package
- PUREX Geologic and Geophysics Data Package
- B Plant Geologic and Geophysics Data Package
- 200 N Geologic and Geophysics Data Package
- Semiworks Geologic and Geophysics Data Package
- Hydrologic Model for the 200 West Groundwater Aggregate Area
- Hydrologic Model for the 200 East Groundwater Aggregate Area
- Unconfined Aquifer Hydrologic Test Data Package for the 200 West Groundwater Aggregate Area
- Unconfined Aquifer Hydrologic Test Data Package for the 200 East Groundwater Aggregate Area

- Confined Aquifer Hydrologic Test Data Package for the 200 Groundwater Aggregate Area Management Studies
- Groundwater Field Characterization Report
- 200 West Area Borehole Geophysics Field Characterization
- 200 East Area Borehole Geophysics Field Characterization.

The general scope of the topical reports related to this AAMSR is described in Section 8.0.

Information on waste sources, pathways, and receptors is used to develop a preliminary conceptual model of the aggregate area. In the preliminary conceptual model, the release mechanisms and transport pathways are identified. If the conceptual understanding of the site is considered inadequate, limited field characterization activities can be undertaken as part of the study. Field characterization activities occurring in parallel with and as part of the AAMS process include the following:

- Expanded groundwater monitoring programs (non Contract Laboratory Program [CLP]) at approximately 80 select existing wells to identify contaminants of concern and refine groundwater plume maps
- In situ assaying of gamma-emitting radionuclides at approximately 10 selected existing boreholes per aggregate area to develop radioelement concentration profiles in the vadose zone.

Wells, boreholes, and analytes are selected based on a review of existing environmental data which is undertaken early in the AAMS process. Field characterization results will be presented later in topical reports.

After the preliminary conceptual model is developed, health and environmental concerns are identified. The purpose of this determination is to provide one basis for determining recommendations and prioritization for subsequent actions at waste management units. Potential applicable or relevant and appropriate requirements (ARARs) and potential remedial technologies are identified. In cases where the existing information is sufficient, the *Hanford Site Past-Practice Strategy* allows for a focused FS or CMS to be initiated prior to the completion of the study.

Data needs are identified by evaluating the sufficiency of existing data and by determining what additional data are necessary to adequately characterize the aggregate area, refine the preliminary conceptual model and potential ARARs, and/or narrow the range of remedial alternatives. Determinations are made regarding the level of uncertainty associated

with existing data and the need to verify or supplement the data. If additional data are needed, the intended data uses are identified, data quality objectives (DQO) established and data priorities set.

Each AAMSR results in management recommendations for the aggregate area including the following:

- The need for ERA, IRM, and LFI or whether to remain in the final remedy selection path
- Definition and prioritization of operable units
- Prioritization of work plan activities
- Integration of RCRA TSD closure activities
- The conduct of field characterization activities
- The need for treatability studies
- Identification of waste management units addressed entirely under other operational programs.

The waste management units recommended for ERA, IRM, or LFI actions are considered higher priority units. Lower priority waste management units will generally follow the conventional process for RI/FS. In spite of this distinction in the priority of sites, RI/FS activities will be conducted for all the waste management units. In the case of the higher priority waste management units, response operations will be followed by conventional RI/FS activities, although these activities may be modified because of knowledge gained through the remediation activities. In the case of the lower priority waste management units, an area-wide RI/FS will be prepared which encompasses these units.

Based on the AAMSR, a decision is made on whether the study has provided sufficient information to forego further field investigations and prepare a FS. An RI/FS work plan (which may be limited to LFI activities) will be developed and executed. The background information normally required to support the preparation of a work plan (e.g., site description, conceptual model, DQO, etc.) is developed in the AAMSR. The future work plans will reference information from the AAMSR. They will also include the rationale for sampling and analysis, will present detailed, unit-specific DQO, and will further develop physical site models as the data allows. In some cases, there may be insufficient data to support any further analysis than is provided in the AAMSR, so an added level of detail in the work plan may not be feasible.

All ten AAMS are scheduled to be completed by September 1992. This will facilitate a coordinated approach to prioritizing and implementing future past practice activities for the entire 200 Areas.

1.3 PURPOSE, SCOPE, AND OBJECTIVES

The purpose of conducting an AAMS is to compile and evaluate the existing body of knowledge and conduct limited field characterization work to support the *Hanford Site Past-Practice Strategy* decision-making process for an aggregate area. The AAMS process is similar in nature to the RI/FS scoping process prior to work plan development and is intended to maximize the use of existing data to allow a more focused RI/FS. Deliverables for an AAMS consist of the AAMSR and Health and Safety, Project Management, and Information Management Overview (IMO) Plans.

Specific objectives of the AAMS include the following:

- Assemble and interpret existing data including operational and environmental data
- Describe site conditions
- Conduct limited new site characterization work if data or interpretation uncertainty could be reduced by the work (results from this work may not be available for the AAMSR, but will be included in subsequent topical reports).
- Develop a preliminary conceptual model
- Identify contaminants of concern, and their distribution
- Identify potential ARARs
- Define preliminary remedial action objectives, screen potential remedial technologies, and if possible provide recommendations for focused FS
- Recommend treatability studies to support the evaluation of remedial action alternatives
- Define data needs, establish general DQOs and set data priorities
- Provide recommendations for ERA, IRM, LFI or other actions
- Redefine and prioritize, if necessary, operable unit boundaries

- Define and prioritize, as data allow, work plan and other past practice activities with emphasis on supporting early cleanup actions and records of decisions
- Integrate RCRA TSD closure activities with past-practice activities.

Information on single-shell and double-shell tanks is presented in Sections 2.0 and 4.0 of selected AAMSRs. The AAMSR is not intended to address remediation related to the tanks. Nonetheless, the tank information is presented because known and suspected releases from the tanks may influence the interpretation of contamination data at nearby waste management units. Information on other facilities and buildings is also presented for this same reason. However, because these structures are addressed by other programs, the AAMSR does not include recommendations for further action at these structures.

Depending on whether an aggregate area is a source or groundwater aggregate area, the scope of the AAMS varies. Source AAMS focus on source terms, and the environmental media of interest include air, biota, surface water, surface soil, and the unsaturated subsurface soil. Accordingly, detailed descriptions of facilities and operational information are provided in the source AAMSR. In contrast, groundwater AAMS focus on the saturated subsurface and on groundwater contamination data. Descriptions of facilities in the groundwater AAMSR are limited to liquid disposal facilities and reference is made to source AAMSR for detailed descriptions. The description of site conditions in source AAMSR concentrate on site physiography, meteorology, surface water hydrology, vadose zone geology, ecology, and demography. Groundwater AAMSR summarize regional geohydrologic conditions and contain detailed information regarding the local geohydrology on an area-wide scale. Correspondingly, other sections of the AAMSR vary depending on the environmental media of concern.

1.4 QUALITY ASSURANCE

A limited amount of field characterization work is performed in parallel with preparation of the AAMSR. To help ensure that data collected are of sufficient quality to support decisions, all work will be performed in compliance with *Quality Assurance*, DOE Order 5700.6C (DOE 1991), as well as Westinghouse Hanford's existing QA manual WHC-CM-4-2 (WHC 1988a), and with procedures outlined in the QA program plan WHC-EP-0383 (WHC 1990a), specific to CERCLA RI/FS activities. This QA program plan describes the various plans, procedures, and instructions that will be used by Westinghouse Hanford to implement the QA requirements. Standard EPA guidance documents such as the *USEPA Contract Laboratory Program Statement of Work for Organic Analysis* (EPA 1988a) will also be followed.

1.5 ORGANIZATION OF REPORT

In addition to this introduction, the AAMSR consists of the following nine sections and appendices:

- Section 2.0, Facility, Process and Operational History Descriptions, describes the major facilities, waste management units and unplanned releases within the aggregate area. A chronology of waste disposal activities is established and waste generating processes are summarized.
- Section 3.0, Site Conditions, describes the physical, environmental, and sociological setting including, geology, hydrology, ecology, meteorology, and demography.
- Section 4.0, Preliminary Conceptual Model, summarizes the conceptual understanding of the aggregate area with respect to types and extent of contamination, exposure pathways and receptors.
- Section 5.0, Health and Environmental Concerns, identifies chemicals used or disposed within the aggregate area that could be of concern regarding public health and/or the environment and describes and applies the screening process for determining the relative priority of follow-up action at each waste management unit.
- Section 6.0, Potentially Applicable or Relevant and Appropriate Requirements, identifies federal and state standards, requirements, criteria, or limitations that may be considered relevant to the aggregate area.
- Section 7.0, Preliminary Remedial Action Technologies, identifies and screens potential remedial technologies and establishes remedial action objectives for environmental media.
- Section 8.0, Data Quality Objectives, reviews QA criteria on existing data, identifies data gaps or deficiencies, and identifies broad data needs for field characterization and risk assessment. The DQO and data priorities are established.
- Section 9.0, Recommendations, provides guidance for future past practice activities based on the results of the AAMS. Recommendations are provided for ERA at problem sites, IRM, LFI, refining operable unit boundaries, prioritizing work plans, and conducting field investigations and treatability studies.
- Section 10.0, References, list reports and documents cited in the AAMSR.

- **Appendix A, Supplemental Data, provides supplemental data supporting the AAMSR.**

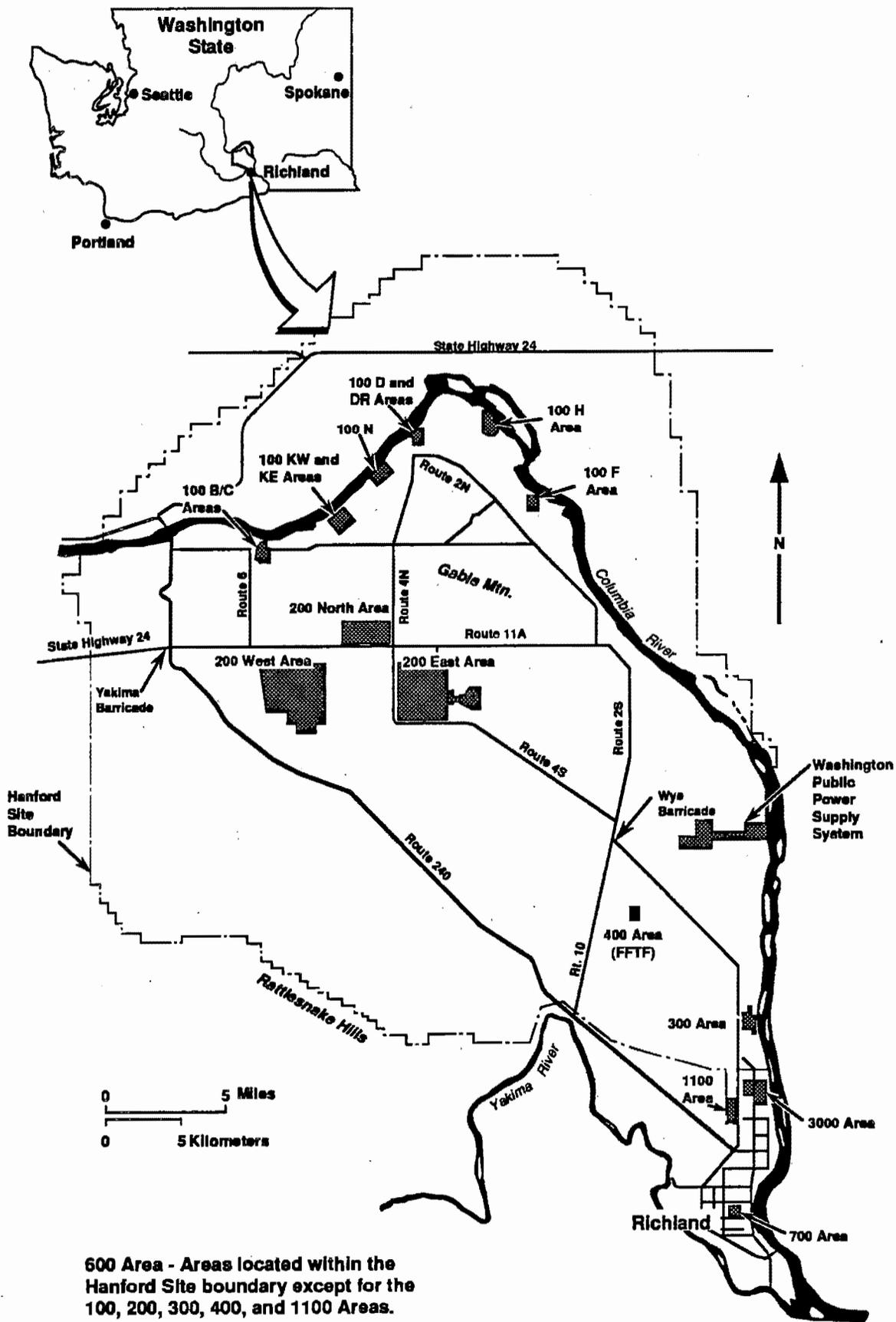
The following plans are included and will be used to support past-practice activities in the aggregate area:

- **Appendix B: Health and Safety Plan**
- **Appendix C: Project Management Plan**
- **Appendix D: Information Management Overview**

Community relations requirements for the U Plant Aggregate Area can be found in the *Community Relations Plan for the Hanford Federal Facility Agreement and Consent Order* (Ecology et al. 1989).

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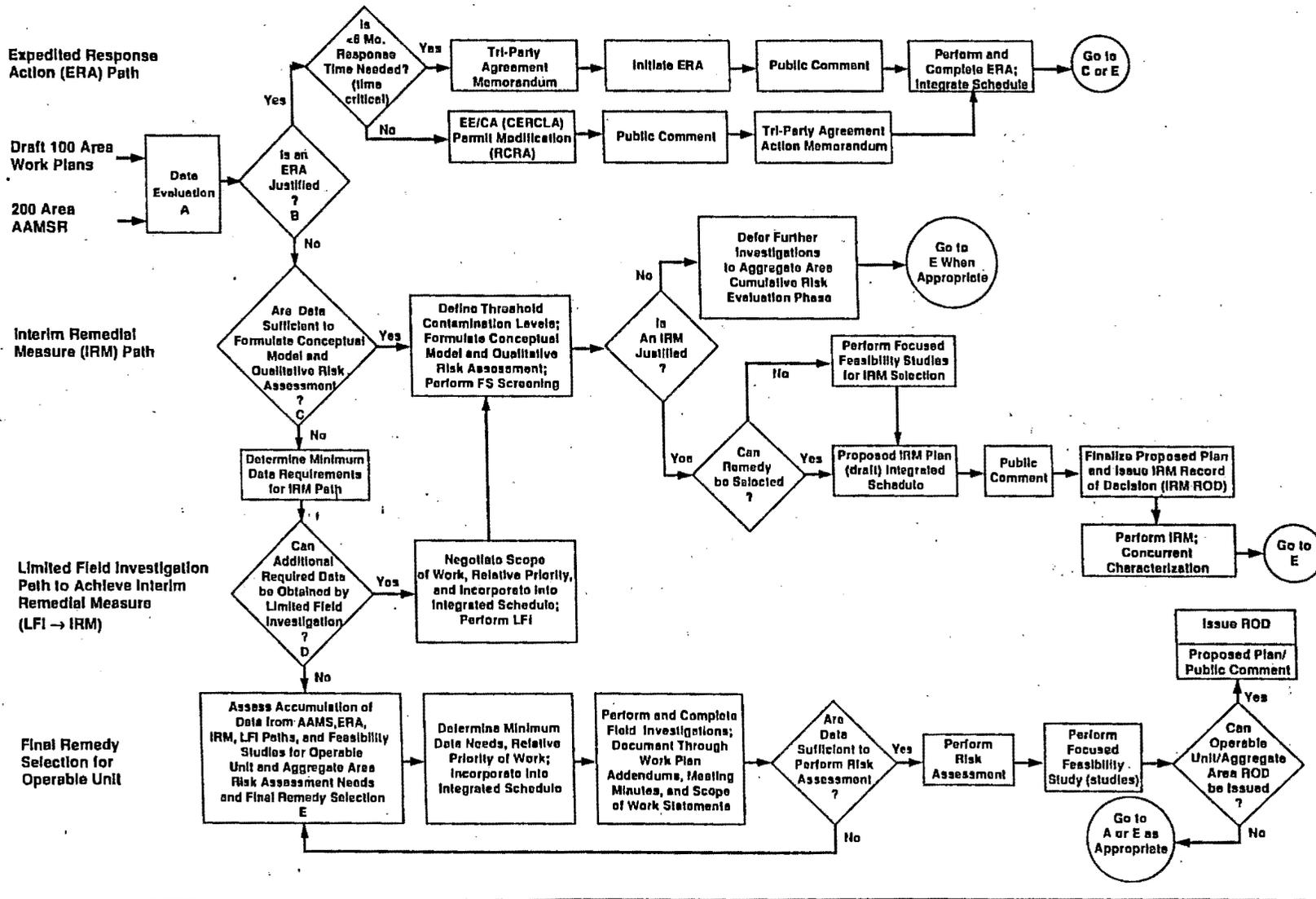
600 Area - Areas located within the Hanford Site boundary except for the 100, 200, 300, 400, and 1100 Areas.

Figure 1-1. Hanford Site Map.

FIG. 1-1

Hanford Past Practice RI/FS (RFI/CMS) Process

The process is defined as a combination of interim cleanup actions (involving concurrent characterization), field investigations for final remedy selection where interim actions are not clearly justified, and feasibility/treatability studies.

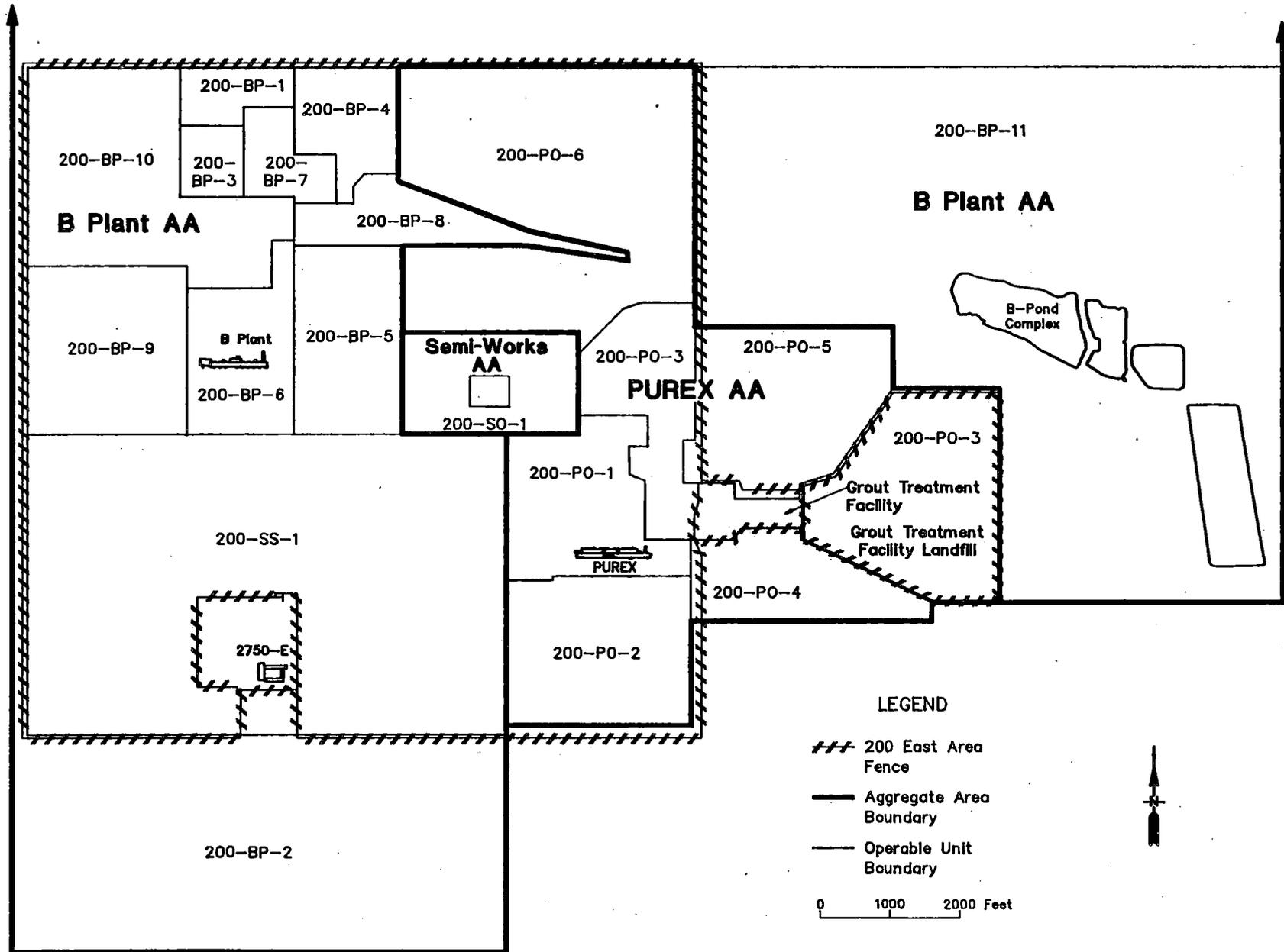


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DOE/RL-91-52, Rev. 0

Figure 1-2. Hanford Past-Practice Strategy Flow Chart (DOE/RL 1992a).

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DOE/RL-91-52, Rev. 0

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Figure 1-3. 200 East Aggregate Areas.

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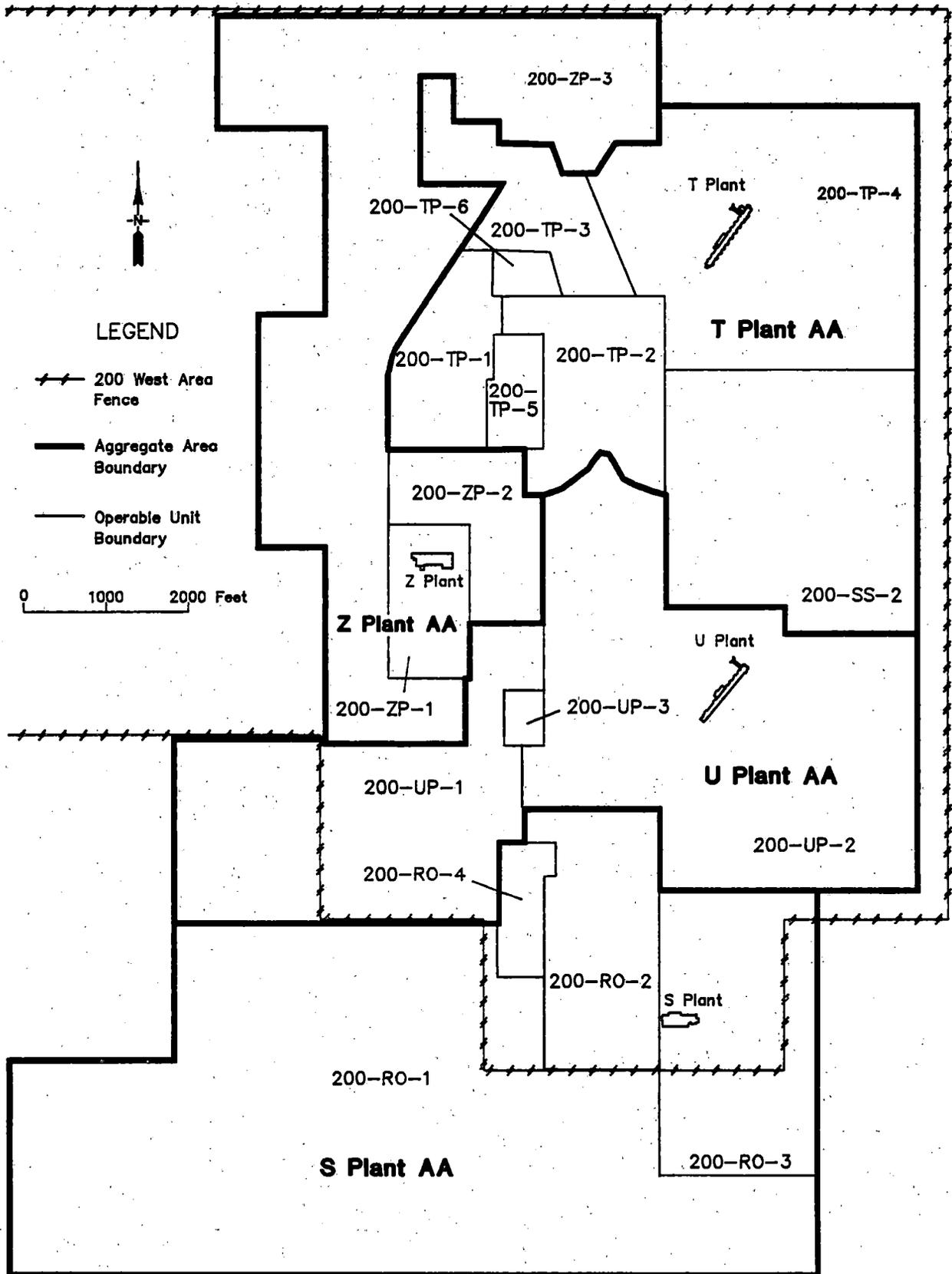


Figure 1-4. 200 West Aggregate Areas.

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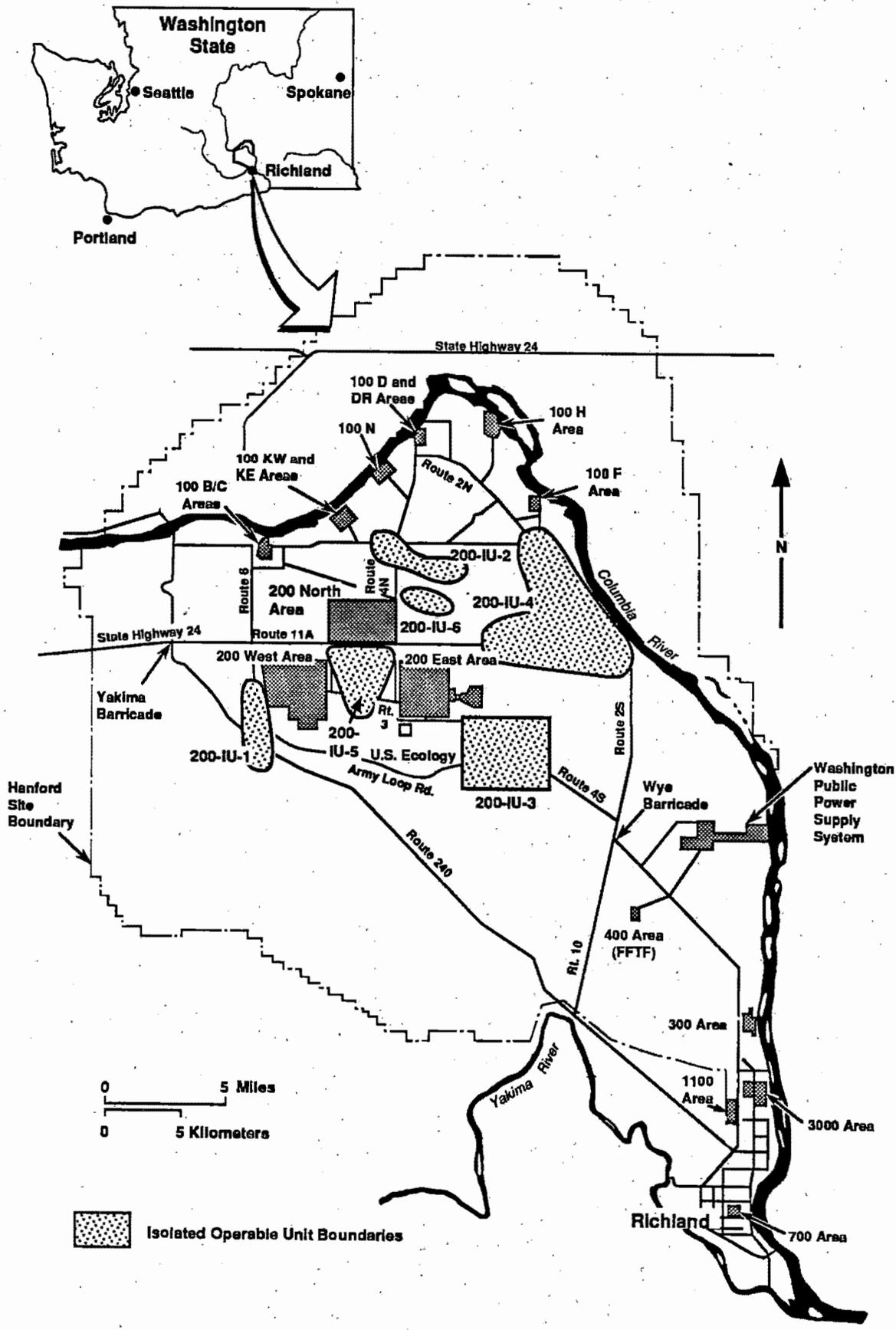


Figure 1-5. 200 NPL Site Isolated Operable Units.

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Table 1-1. Overall Aggregate Area Management Study (AAMS) Schedule for the 200 NPL Site.

AAMS Title	Operable Units	AAMS Type	Lead Regulatory Agency	M-27-00 Interim Milestones
U Plant	200-UP-1 200-UP-2 200-UP-3	Source	Ecology	M-27-02, January 1992
Z Plant	200-ZP-1 200-ZP-2 200-ZP-3	Source	EPA	M-27-03, February 1992
S Plant	200-RO-1 200-RO-2 200-RO-3 200-RO-4	Source	Ecology	M-27-04, March 1992
T Plant	200-TP-1 200-TP-2 200-TP-3 200-TP-4 200-TP-5 200-TP-6 200-SS-2	Source	EPA	M-27-05, April 1992
PUREX	200-PO-1 200-PO-2 200-PO-3 200-PO-4 200-PO-5 200-PO-6	Source	Ecology	M-27-06, May 1992
B Plant	200-BP-1 200-BP-2 200-BP-3 200-BP-4 200-BP-5 200-BP-6 200-BP-7 200-BP-8 200-BP-9 200-BP-10 200-BP-11 200-IU-6 200-SS-1	Source	EPA	M-27-07, June 1992
Semi-Works	200-SO-1	Source	Ecology	M-27-08, July 1992
200 North	200-NO-1	Source	EPA	M-27-09, August 1992
200 West	NA	Groundwater	EPA/Ecology	M-27-10, September 1992
200 East	NA	Groundwater	EPA/Ecology	M-27-11, September 1992

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2.0 FACILITY, PROCESS AND OPERATIONAL HISTORY DESCRIPTIONS

Section 2.0 of the aggregate area management study (AAMS) presents historical data on the U Plant Aggregate Area and detailed physical descriptions of the individual waste management units and unplanned releases. These descriptions include historical data on waste sources and disposal practices and are based on a review of current and historical Hanford Site reports, engineering drawings, site inspections, and employee interviews. Section 3.0 describes the environmental setting of the waste management units. The waste types and volumes are qualitatively and quantitatively assessed at each waste management unit in Section 4.0. Data from these three sections are used to identify contaminants of concern (Section 5.0), potential applicable or relevant and appropriate requirements (ARARs) (Section 6.0) and current data gaps (Section 8.0).

This section describes the location of the U Plant Aggregate Area (Section 2.1), summarizes the history of operations (Section 2.2), describes the facilities, buildings, and structures of the U Plant Aggregate Area (Section 2.3), and describes U Plant Aggregate Area waste generating processes (Section 2.4). Section 2.5 discusses interactions with other aggregate areas or operable units. Sections 2.6 and 2.7 discuss interactions with the Resource Conservation and Recovery Act (RCRA) program and other Hanford programs.

2.1 LOCATION

The Hanford Site, operated by the U.S. Department of Energy (DOE), occupies about 1,450 km² (560 mi²) of the southeastern part of Washington State north of the confluence of the Yakima and Columbia Rivers (Figure 1-1). The 200 West Area is a controlled area of approximately 8.3 km² (3.2 mi²) near the middle of the Hanford Site. The 200 West Area is about 8 km (5 mi) from the Columbia River and 11 km (6.8 mi) from the nearest Hanford boundary. There are 17 operable units grouped into four aggregate areas in the 200 West Area (Figure 1-4). The U Plant Aggregate Area (consisting of operable units 200-UP-1, 200-UP-2, and 200-UP-3) lies in the southern portion of the 200 West Area (Figure 1-4). The location of the buildings and waste management units are shown on Plate 1. Plate 2 shows the topography of the U Plant Aggregate Area. The media sampling locations are depicted on Plate 3.

2.2 HISTORY OF OPERATIONS

The Hanford Site, established in 1943, was originally designed, built, and operated to produce plutonium for nuclear weapons using production reactors and chemical reprocessing plants. In March 1943, construction began on three reactor facilities (B, D, and F Reactors) and three chemical processing facilities (B, T, and U Plants). After World War II, six more

reactors were built (H, DR, C, KW, KE, and N Reactors). Beginning in the 1950's, energy research and development, isotope use, and other activities were added to the Hanford operation. In early 1964, a presidential decision was made to begin shut down of the reactors. Eight of the reactors were shut down by 1971. The N Reactor operated through 1987; and was placed on cold standby status in October 1989. Westinghouse Hanford was notified September 20, 1991 that they should cease preservation and proceed with activities leading to a decision on ultimate decommissioning of the reactor. These activities are scoped within a N Reactor shutdown program which is scheduled to be completed in 1999.

Operations in the 200 Areas (West and East) are mainly related to separation of special nuclear materials from spent nuclear fuel. Spent nuclear fuel is fuel that has been withdrawn from a nuclear reactor following irradiation. The 200 West Area consists of four main processing areas (Figure 1-4):

- S Plant and T Plant, where initial processing to separate uranium and plutonium from irradiated fuel rods took place
- U Plant, where uranium recovery operations took place
- Z Plant, where plutonium separation and recovery operations took place.

The 200 Areas also contain nonradioactive support facilities, including transportation maintenance buildings, service stations, and coal-fired powerhouses for process steam production, steam transmission lines, raw water treatment plants, water-storage tanks, electrical maintenance facilities, and subsurface sewage disposal systems.

The major processes conducted in the U Plant Aggregate Area have been involved with uranium recovery. A U Plant Aggregate Area timeline is schematically illustrated in Figure 2-1.

The 221-U Building is one of the primary U Plant Aggregate Area facilities. Between 1952 and 1958 uranium was recovered from bismuth phosphate process wastes by means of the tributyl phosphate process in this building.

The 224-U Building began operation in 1952 as a uranium reduction facility. It was converted in 1955 to support PUREX Plant activities. The 224-U Building is not currently operating although a stabilization run is scheduled for 1992.

The 222-U Laboratory operated from about 1947 to 1970 and provided analytical services in support of the 221-U and 224-U Building operations.

The 241-U Tank Farm contains 16 single-shell tanks constructed in 1943 and 1944. These tanks received high-level waste from the U Plant Aggregate Area and other facilities.

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The U Pond was constructed in 1944 to receive low-level liquid effluent from the plutonium processing facilities. It was serviced by a succession of ditches until its closure in 1985.

2.3 FACILITIES, BUILDINGS, AND STRUCTURES

The U Plant Aggregate Area contains a large variety of waste disposal and storage facilities that were associated with the aggregate area and, to a lesser extent, Z Plant Aggregate Area operations. Radiologically contaminated processing wastes were discharged to the soil column through cribs, trenches, and other facilities. Wastes which were not normally contaminated, but have the potential to contain radionuclides, such as cooling water and condensate water, were allowed to infiltrate into the ground through ponds and open ditches. Radiologically contaminated waste types are defined in DOE Order 5820.2(A) (DOE 1988a):

- High-level waste is defined as: highly radioactive waste material that results from the reprocessing of spent nuclear fuel, including liquid waste produced directly in reprocessing and any solid waste derived from the liquid, that contains a combination of transuranic (TRU) waste and fission products in concentrations as to require permanent isolation.
- TRU waste is defined as: without regard to source or form, radioactive waste that at the end of institutional control periods is contaminated with alpha-emitting transuranium radionuclides with half-lives greater than 20 years and concentrations greater than 100 nCi/g. Heads of Field Elements can determine that other alpha contaminated wastes peculiar to a specific site must be managed as a TRU waste.
- Low-level waste is defined as: radioactive waste not classified as high-level waste, TRU waste, spent nuclear fuel, or IIe(2) byproduct material as defined by this Order. Test specimens of fissionable material irradiated for research and development only, and not for the production of power or plutonium, may be classified as low-level waste, provided the concentration of TRU waste is less than 100 nCi/g.
- Byproduct Material is defined as: (a) Any radioactive material (except special nuclear material) yielded in, or made radioactive by, exposure to the radiation incident or to the process of producing or utilizing special nuclear material. For purposes of determining the applicability of RCRA to any radioactive waste, the term "any radioactive material" refers only to the actual radionuclides dispersed or suspended in the waste substance. The nonradioactive hazardous waste component of the waste substance will be subject to regulation under RCRA; (b) The tailings or waste produced by the extraction or concentration of uranium or

thorium from any ore processed primarily for its source material content. Ore bodies depleted by uranium solution extraction operations and which remain underground do not constitute "byproduct material."

Based on construction, purpose, or origin, the U Plant Aggregate Area waste management units fall into one of ten subgroups as follows:

- Plants, Buildings, and Storage Areas (Section 2.3.1)
- Tanks and Vaults (Section 2.3.2)
- Cribs and Drains (Section 2.3.3)
- Reverse Wells (Section 2.3.4)
- Ponds, Ditches, and Trenches (Section 2.3.5)
- Septic Tanks and Associated Drain Fields (Section 2.3.6)
- Transfer Facilities, Diversion Boxes, and Pipelines (Section 2.3.7)
- Basins (Section 2.3.8)
- Burial Sites (Section 2.3.9)
- Unplanned Releases (Section 2.3.10).

Table 2-1 presents a list of the waste management units within the aggregate area. In addition, the aggregate area contains several unplanned release sites. The locations of these waste management units are shown on separate figures for each waste management group and Plate 1. Figure 2-1 summarizes the operational history of each of the waste management units (WHC 1991a; DOE/RL 1991a). Tables 2-2 and 2-3 summarize data available regarding the quantity and types of wastes disposed of to the waste management units. These data have been compiled from the Waste Information Data System (WIDS) inventory sheets (WHC 1991a) and from the Hanford Inactive Site Survey (HISS) database (DOE 1986a). These inventories include all of the contaminants reported in the databases, but do not necessarily include all of the contaminants disposed of at each waste management unit. In the following sections, each waste management unit is described within the context of one of the waste management unit types.

9 3 1 2 7 3 9 0 4 1 6

2.3.1 Plants, Buildings, and Storage Areas

Plants and buildings are not generally identified as past-practice waste management units according to the *Hanford Federal Facility Agreement and Consent Order* (Tri-Party Agreement) and will generally be addressed under the Decommissioning and RCRA Closure Program. The program is responsible for the surveillance, maintenance, and decommissioning of surplus facilities within the Environmental Restoration Program. Section 2.7 details the interaction of the Hanford programs. Because several of the U Plant Aggregate Area plants or buildings were the primary generators of waste disposed of within the U Plant Aggregate Area, a description of these is provided in Section 2.3.1.1. The U Plant Aggregate Area plants and buildings that are also waste management units are addressed in Section 2.3.1.2. Some plants and buildings are or contain RCRA treatment, storage, or disposal (TSD) facilities. A description of such facilities is provided in Section 2.6. The locations of plants, buildings, and storage areas in the aggregate area are shown on Figure 2-2.

The 221-U Building (U Plant), the 224-U Building (Uranium Oxide Plant or UO_3 Plant), the 222-U Laboratory, and the Plutonium Finishing Plant in the adjacent Z Plant Aggregate Area were the primary generators of waste within the aggregate area. These plants, and the buildings associated with them, will be described in the following sections.

Other buildings and structures located within the aggregate area are not addressed in this document because they are not thought to have released contaminants and will be closed through a separate decontamination and decommissioning process. These structures include:

- 224-U Condensate Neutralization Tank (used to neutralize process condensate with NaOH)
- 224-U Hazardous Waste Staging Area (HWSA) (storage of paints and solvents)
- 271-U Building (annex to 221-U Building)
- 276-U Solvent Facility (tanks containing organic solvent used in 221-U Building)
- 291-U Fan and Filter Building (exhaust ventilation for 221-U Building)
- 291-U-1 Stack (main process stack for 221-U Building)
- 296-U-10 Stack (originally built to ventilate plutonium storage area in 271-U Building; currently not operating)
- 2727-WA Sodium Reactor Experiment (SRE) Sodium Storage Building (RCRA TSD) (contains 158 drums of radiation-contaminated sodium in metallic form)

- 202-R Foundation (located south of the 221-U Building, no building was constructed at this location).

2.3.1.1 Process Facilities

2.3.1.1.1 221-U Building. The 221-U Building (U Plant) was one of the primary sources of waste in the U Plant Aggregate Area and it is the dominant physical structure within the area.

The 221-U Building was constructed in 1944 as one of the three original chemical separation plants (221-B, 221-T, and 221-U Buildings) to support plutonium production during World War II. The plants were built to extract plutonium from fuel rods irradiated in the Hanford production reactors. Each plant was equipped to use the bismuth phosphate fuels-separation process, but the 221-U Building was never used for that purpose because the 221-B and 221-T Buildings were sufficient to meet plutonium production needs. The 221-U Building was used to train B and T Plant operators until 1952 when 221-U Building was converted to the tributyl phosphate process for uranium recovery from bismuth phosphate process wastes.

The bismuth phosphate process wastes were stored in tank farms in the 200 East and 200 West Areas, including the 241-U Tank Farm within the U Plant Aggregate Area. From 1952 to 1958, waste slurry was pumped to the 221-U Building from tank farms by underground lines. The waste sludge was dissolved in nitric acid and the uranium extracted using tributyl phosphate in a paraffin hydrocarbon diluent. This process left the fission products, sulfate, nitrate, and phosphate ions in aqueous solution. The uranium was partitioned into the organic phase. Uranium was then stripped from the organic solvent with nitric acid. The resulting uranyl nitrate hexahydrate was converted to uranium trioxide (UO₃) by calcination at high temperatures in the 224-U Building.

The same underground lines used to pump bismuth phosphate process wastes from the tank farms to the 221-U Building were used to pump 221-U Building tributyl phosphate process waste to disposal facilities (ultimately cribs) near B Plant, about 4.9 km (3 mi) east in the 200 West Area. The 221-U Building non-tributyl phosphate waste was disposed of in nearby cribs, trenches, dry wells, sanitary sewers, reverse wells, a ditch, and the 216-U-10 Pond. The 221-U Building was placed on standby in 1958 and has not been used for fuels separation since that date. The 221-U Building is currently used to store contaminated equipment from plutonium uranium extraction (PUREX).

Several unplanned release locations are in the vicinity of the 221-U Building. These are UN-200-W-46, UN-200-W-48, UN-200-W-60, UN-200-W-86, UN-200-W-101, UN-200-W-117, UN-200-W-118, UN-200-W-125, and UN-200-W-138. These unplanned releases range from contaminated pigeon feces around the 221-U Building to spills of material along the railroad tracks.

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2.3.1.1.2 224-U Building. The 224-U Building (UO₃ Plant) is immediately southeast of the 221-U Building and is a complex of several buildings, tank farms, storage areas, and loading facilities. The 224-U Building itself is not part of the U Plant Aggregate Area, but is a source of wastes for many of the waste management units within the area.

The 224-U Building was constructed in 1944 for plutonium processing, but was not used for that purpose. It was operated as a training facility from 1944 to 1950 and was converted in 1952 to a uranium reduction facility. It was converted again in 1955 in support of the PUREX Plant. The 224-U Building converted PUREX-generated liquid uranyl nitrate hexahydrate to powdered UO₃. The PUREX uranyl nitrate hexahydrate was transferred to the 224-U Building by tanker truck. The 224-U Building produces process condensate waste from the concentration and calcination of uranyl nitrate hexahydrate. The process condensate consists mainly of condensed water and also includes rain water collected within the radiation zone sumps and nitric acid vapor, which is neutralized prior to discharge to cribs. Phosphoric acid and potassium hydroxide are used as buffering and neutralizing agents (DeFord 1991). Currently no condensate is being discharged to the cribs.

Liquid waste from the 224-U Building has been disposed underground in the U Plant Aggregate Area since 1955. Liquid waste from the 224-U Building contributed to the 216-U-1, -2, -8, -12, -16, and -17 Cribs waste inventories. Currently, noncorrosive steam condensate from building heating systems, process equipment cooling water from the condensers, and rain water from the nonradiation areas goes through the 207-U Retention Basin to the 216-U-14 Ditch (WHC 1990b). Other condensate and cooling water from within the facility goes to the 241-U-301 Catch Tank. The 224-U Building is not currently operating although a stabilization run is scheduled for 1992.

Several unplanned releases are reported in the vicinity of the 224-U Building. These are: UN-200-W-33, UN-200-W-39, UN-200-W-55, and UN-200-W-78. The unplanned releases are summarized in Section 2.3.10.

2.3.1.2 Waste Management Unit Buildings

2.3.1.2.1 222-U Laboratory. The 222-U Laboratory located directly southeast of the 221-U Building was used from about 1947 to 1970 for laboratory analysis in support of the uranium recovery process and the UO₃ process. Various small scale experiments and soil tests were done inside the facility. The 222-U Laboratory is within the U Plant Aggregate Area and is a source of wastes, but it will be addressed under the Decommissioning and RCRA Closure Program. This facility disposed liquid waste effluent to the 216-U-4 Reverse Well, 216-U-4A French Drain, and 216-U-4B French Drain.

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2.3.2 Tanks and Vaults

Tanks and vaults were constructed on the Hanford Site to handle and store liquid wastes generated by uranium and plutonium processing activities. Several types of tanks are present in the U Plant Aggregate Area including two catch tanks, one settling tank, one receiver tank, two vaults, four septic tanks, and sixteen single-shell tanks. Catch tanks are generally associated with diversion boxes and other transfer units and were designed to accept overflows and spills. The settling tank was used for settling suspended solids in fluid wastes prior to transfer to cribs. The receiver tank (frequently called a double-contained receiver tank, or vault) received waste from single-shell tanks. The vaults are concrete structures that house several small tanks that served a variety of functions. Single-shell tanks were used to collect and store large quantities of mixed wastes. The catch tanks, settling tank, receiver tank, and vaults will be discussed individually in this section. The septic tanks are discussed in Section 2.3.6. The single-shell tanks will be addressed as a group below.

All single-shell tanks will be evaluated under the Single-Shell Tank Closure Program as discussed in Section 9.0 and, therefore, do not need to be discussed in detail in this AAMSR. General information related to the tanks will be described in this report but investigation and remediation strategies will be deferred to the Single-Shell Tank Closure Program. Tables 2-1 and 2-4 list single-shell tank information that is of importance to this report, including source description, tank integrity, waste volume remaining, and drainable waste volume. Timeline data is presented in Figure 2-1 and a reference locator for additional single-shell tank information is provided in Table 2-5.

The sixteen single-shell tank waste management units in the U Plant Aggregate Area are contained within the 241-U Tank Farm, which is located at the northwest corner of the Camden Avenue and 16th Street intersection. The location of the tanks is shown on Figures 2-3 and 2-4.

The 241-U Tank Farm tanks were constructed from 1943 to 1944 using two different designs. In both designs the tanks are vertical cylinders with a domed top and are constructed of reinforced concrete with a carbon steel liner on the base and sides of the vessel. The tanks are all underground with at least 1.8 m (6 ft) of earth cover above the dome. Twelve tanks, each with the same design, numbered 241-U-101 through 241-U-112, have a 23 m (75 ft) diameter and a capacity of 2,017,000 L (533,000 gal). Four smaller tanks, each with the same design, numbered 241-U-201 through 241-U-204, have a 6.1 m (20 ft) diameter and a capacity of 208,000 L (55,000 gal). The current waste volumes and drainable waste volumes for each tank are listed in Table 2-4. Figure 2-5 depicts a typical 2,017,000 L (533,000 gal) single-shell tank.

Single-shell tank stabilization and isolation are two objectives of single-shell tank engineering. Interim Stabilization criteria for single-shell waste storage and auxiliary tanks is set forth in *Tank Farms Facility Interim Stabilization Evaluation* (Hamrick 1988). Generally,

a 100 series tank (tanks greater than 2,000,000 L) is considered interim stabilized if the tank contains less than 19,000 L (5,000 gal) of supernatant and less than 189,000 L (50,000 gal) of drainable liquid (Hanlon 1992). A 200 series tank (specifically, a 208,000 L tank) is considered interim stabilized if it contains less than 1500 L (400 gal) supernatant. Interim isolation is an administrative designation reflecting the completion of the physical effort required to minimize the unplanned addition of liquids into a tank. Partially interim isolated is an administrative designation reflecting the completion of the physical effort required for interim isolation except for isolation of risers and piping that are required for stabilization (pumping) efforts. Interim isolation and stabilization have been performed on the single-shell tanks to varying degrees as listed in Table 2-4.

All single-shell tanks are classified as either "sound" or as an "assumed leaker," as listed in Table 2-4. A "sound" tank is an integrity classification of a waste storage tank for which surveillance data indicate no loss of liquid attributed to a breach of integrity. An "assumed leaker" is an integrity classification of a waste storage tank for which surveillance data indicate a loss of liquid attributed to a breach of integrity (Hanlon 1992).

All single-shell tanks have been inactive (have not received waste) since at least 1980. However, several activities continue on, in, and/or around the single-shell tanks on a case-by-case basis and, therefore, the status of any individual single-shell tank may change. These activities include pumping of liquid waste (stabilization), sealing tank pits, blanking penetrations and piping (isolation), surface level monitoring, liquid level monitoring, temperature monitoring, waste sampling; core sampling; in-tank photography; filter changing; surveying; and day-to-day operations activities. The current status of the single-shell tanks are documented in several "living" documents with two of the most informative being, *Tank Farm Surveillance and Waste Status Summary Report* (Hanlon 1992), and *Waste Storage Tank Status and Leak Detection Criteria* (Welty 1989). The *Tank Farm Surveillance and Waste Status Summary Report* is updated monthly and the *Waste Storage Tank Status and Leak Detection Criteria* is revised as needed. General single-shell tank information found in these two documents, and others, is listed in Table 2-5.

2.3.2.1 241-U-361 Settling Tank. The 241-U-361 Settling Tank is located southwest of U Plant and 30 m (100 ft) east of the 216-U-1 Crib. The tank is a circular 6.1 m (20 ft) diameter by 5.8 m (19 ft) deep structure made of 15 cm (6 in.) steel reinforced, pre-stressed concrete. Its top is 2 m (6 ft) below grade. Several vent and liquid level measurement risers penetrate the surface.

The 241-U-361 Settling Tank served as a settling tank for fluid wastes enroute to the 216-U-1 and 216-U-2 Cribs from 1951 through 1967, receiving waste as follows:

From 3/52 to 6/57, the site received cell drainage from Tank 5-6 in the 221-U Building and waste from the UO₃ Plant. . . From 6/57 to 7/57, the site received waste from the UO₃ Plant. . . and contaminated solvent from the 276-U Settling Tank Storage Area.

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The discharge of 221-U waste was discontinued during shutdown of production operations. From 7/57 to 5/67, the site received waste from the UO₃ Plant and equipment decontamination and reclamation wastes from CPD Services Operations in the 221-U Building canyon. The waste was low salt and neutral/basic (WHC 1991a; Maxfield 1979).

Records indicate that 4,000 kg (8,900 lb) of uranium were discharged to this waste management unit between 1957 and 1967, the bulk of which flowed into the 216-U-1 and 216-U-2 Crib. It is currently estimated to contain 104,000 L (27,500 gal) of sludge of unknown plutonium content estimated at 2,125 Ci beta/gamma (WHC 1991a; DOE/RL 1991b).

A spill, unplanned release UN-200-W-19 (see Section 2.3.10), occurred in the vicinity of the 241-U-361 Tank. Baldrige (1959) reports as follows:

Organic wastes and cell drainage from the TBP and UO₃ plants overflowed to the ground by way of the tank and crib vents in the spring of 1953. Ground contamination up to 11.5 rads/h at three inches was found over an area of approximately 50 ft². Decontamination was attempted and the area was then backfilled, delimited with a wooden fence, and posted with radiation zone signs.

2.3.2.2 241-U-301 Catch Tank. The 241-U-301 Catch Tank is located at the south end of the 241-U Tank Farm, immediately east of the 241-U-252 Diversion Box to which it is connected by an underground drain line. It also served as a catch tank for the 241-U-152 Diversion Box.

Constructed in 1946, 241-U-301 is an active waste management unit. It is a 6.1 m (20 ft) diameter by about 5.5 m (18 ft) high concrete tank buried to a depth which places its upper surface between 3 and 3.5 m (10 and 11.5 ft) below grade. It has a 107 cm (42 in.) manhole centered in its top. Four 10.2 cm (4 in.) and four 30.5 cm (12 in.) pipes extend from its top to the surface. Two 15 cm (6 in.) stainless steel inlet pipes enter the tank near its top. It received waste fluids which may have spilled to the floor of either diversion box. It now contains 18,500 L (4,900 gal) of waste (WHC 1991a).

2.3.2.3 241-U-302 Catch Tank (241-UX-302A Catch Tank). The 241-UX-302A Catch Tank appears to be synonymous with the 241-U-302 Catch Tank. It is an active waste management unit located 15.2 m (50 ft) southeast of the 221-U building and 8 m (25 ft) southwest of the 241-UX-154 Diversion Box. The tank is 11 m (36 ft) long, has a diameter of approximately 3 m (9 ft) and is buried at a depth of about 1.2 m (4 ft). The tank supports the 241-UX-154 Diversion Box, accepting spilled liquid wastes that move through the diversion box floor drain. A firm service date for the tank is not available, but it may be assumed to approximate the diversion box which it supports, i.e., 1946 to present.

No radionuclide or hazardous chemical inventories are available for this unit; however, the WIDS database lists a total volume of 26,500 L (7,000 gal) of liquid in the tank. Possible constituents of the waste include high-level process and decontamination wastes that may have leaked into the diversion box. Surface contamination in the vicinity of the tank is indicated. Steel chain barricades and surface contamination warning signs are in place around this waste management unit.

2.3.2.4 244-U Receiver Tank. The 244-U Receiver Tank is in an underground steel-lined concrete vault at the south end of the 241-U Tank Farm. It is a 6.4 m (21 ft) diameter by 12.5 m (41 ft) long carbon steel tank with a capacity of 117,000 L (31,000 gal). The structure is buried at a depth which places the upper surface of its cover about 0.3 m (1 ft) above ground level. The 244-U Receiver Tank started operating in 1987 and is still active.

The tank was used to transport waste solutions from processing and decontamination operations (WHC 1991b). This is understood to mean that the tank received and held waste fluids pumped from salt wells in various 241-U Tanks. This unit will not be considered for remediation as part of the AAMS, but is described here because of its operational link with the 241-U Tank Farm.

2.3.2.5 244-UR Vault. The 244-UR Vault is located in the 241-U Tank Farm area, approximately 60 m (197 ft) north of the 241-U-102 Tank, and 75 m (246 ft) west of Camden Avenue.

The vault houses 4 stainless steel tanks used in the transfer and interim storage of wastes being pumped to or from the 241-U Tank Farm. It is a 27 x 8 x 14 m (90 x 26 x 45 ft) deep underground concrete structure that is divided into 4 sections to house its four tanks. The TK-UR-001 Tank is a 189,000 L (50,000 gal) slurry accumulator tank, 6.1 m (20 ft) in diameter. The TK-UR-002 and -003 Tanks are identical 57,000 L (15,000 gal) blend tanks, 4.3 m (14 ft) in diameter. The TK-UR-004 Tank is a process tank 3 m (10 ft) in diameter and 4.3 m (14 ft) high (WHC 1991a).

The vault is buried to a depth that places the upper surface of its lid about 30 cm (12 in.) above ground level. It is an inactive unit and all above ground surfaces have been sealed with plasticized foam.

The vault interior and a large surface area around and to the north of the vault is contaminated from a violent chemical reaction that occurred in the TK-UR-002 Tank in 1953. It also contains asbestos (WHC 1991a) (see Section 2.3.10, UPR-200-W-24). Conversations with tank farm employees reveal that the above contamination included "yellowcake" and was stabilized by laying sheets of lead over the contaminated soil and covering with 30.5 cm (12 in.) or more of clean soil. Verification of the employee's descriptions, however, cannot be documented. Contamination continues to appear in this general area and has spread beyond the northern tank farm boundary fence. This

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contaminated area is roped off and routinely surveyed under the Operational Environmental Monitoring Program administered by Westinghouse Hanford Environmental Assurance. Because the 244-UR Vault is in a low area, water intrusion problems are thought to exist that may have flooded the vault resulting in contamination spreads. Berms were built in 1979/80 to divert runoff.

2.3.2.6 241-WR Vault. The 241-WR Vault is located approximately 300 m (1,000 ft) northeast of the 221-U Building and southeast of the 216-U-5 Trench. The vault, also known as the 241-WR Diversion Station Vault and the Thorium Vault, was constructed in 1952 as part of the U Plant uranium recovery program modification. The vault is a 39 x 20 x 14 m (128 x 66 x 45 ft) deep underground concrete structure that contains nine 189,000 L (50,000 gal) storage tanks and associated pumps, valves, and agitators.

Throughout its operational life, the 241-WR Vault has had uranyl nitrate hexahydrate, nitric acid, and tributyl phosphate wastes transferred to the resident storage tanks. During U Plant operation (1952 to 1958) uranyl nitrate hexahydrate was stored and used as feed for 221-U, recovered nitric acid was temporarily stored and tributyl phosphate wastes were stored before routing to B Plant cribs and trenches. Following termination of U Plant operations in 1958, the vault was used to store nitric acid and thorium from reduction and oxidation (REDOX) and PUREX.

A contamination incident reportedly occurred in the early 1960's when a tank overflowed and filled its cell. The tank may have held thorium. When the tank was subsequently pumped out it floated loose from its base, rupturing its lines, jumpers, and mechanical connections. A significant cleanup effort was required to return the facility to service (DOE/RL 1991b).

The facility ceased operating in 1976 and is currently inactive. Above-ground structures, entry ports and vents have been dismantled and plasticized foam has been used to seal the vault. All tanks and related equipment remain in place and are estimated to bear a contamination burden of 60 Ci beta (DOE/RL 1991b).

2.3.3 Cribs and Drains

The cribs and drains were all designed to inject or percolate wastewater into the ground without exposing it to the open air. The locations of cribs and drains in the aggregate area are shown on Figure 2-6. Cribs are shallow excavations that are either backfilled with permeable material or held open by wood structures. Both types of cribs are covered with an impermeable layer. Water flows directly into the backfilled material or covered open space and percolates into the vadose zone soils. A typical crib is illustrated in Figure 2-7. French drains are generally constructed of steel or concrete pipe and may either be open or filled

with gravel. A typical french drain is illustrated in Figure 2-8. The U Plant Aggregate Area contains 8 cribs and 5 french drains.

The cribs and drains received low-level waste for disposal. Most cribs, drains, and trenches were designed to receive liquid until the unit's specific retention or radionuclide capacity was met. The term "specific retention" is defined as that volume of waste liquid that may be disposed to the soil and be held against the force of gravity by the molecular attraction between sand grains and the surface tension of the water, when expressed as a percent of the packed soil volume (Bierschenk 1959). Experimental work performed by Bierschenk (1959) indicated that due to the time varying nature of the specific retention capacity of the soil, a potential exists for long-term gravity drainage to the groundwater. Radionuclide capacity refers to a specific number of curies of radioactivity the waste management units were allowed to receive until they were shut down (Fecht et al. 1977). The following sections describe each crib and french drain in the U Plant Aggregate Area.

2.3.3.1 216-U-1 and 216-U-2 Cribs. The 216-U-1 and 216-U-2 Cribs are located 61 m (200 ft) north of 16th Street and 305 m (1,000 ft) east of the 207-U Retention Basin. Each crib is comprised of a 3.6 x 3.6 x 1.2 m (12 x 12 x 4 ft) deep wooden structure constructed of 15 x 15 cm (6 x 6 in.) timbers on undisturbed soil at the bottom of 6.1 m (20 ft) deep backfilled excavations with 1:1 side slopes. The cribs were backfilled with native soil. The cribs are 18 m (60 ft) apart and are connected by a 8.9 cm (3.5 in.) diameter stainless steel pipe. Overflow from the 216-U-1 Crib flows to the 216-U-2 Crib. All wastes flowed to the 216-U-1 and 216-U-2 Cribs from the 241-U-361 Settling Tank, which is 24 m (80 ft) east of 216-U-1 Crib.

The cribs operated from 1951 until 1967. Reportedly, 4,000 kg (8,900 lb) of uranium were discharged to the cribs between 1957 and 1967 (DeFord 1991). The uranium reacted with the sediments to form carbonate-phosphate compounds. After 1967, other cribs (notably 216-U-12) were used to dispose of this wastewater.

In 1984, a newer crib (216-U-16) was installed south of the 216-U-1 and 216-U-2 Cribs. Liquid discharges to 216-U-16 were enough by 1985 to form a perched groundwater zone above a caliche layer. The perched groundwater moved north under the 216-U-1 and 216-U-2 Cribs. Acid wastes discharged to the cribs reacted with the uranium complexes to form compounds that are soluble and relatively nonsorbing in the sediments. The uranium was transported through the caliche layer, possibly conducted by insufficiently sealed boreholes, to the unconfined aquifer and, consequently, uranium concentrations rose from about 166 pCi/L to about 72,000 pCi/L in monitoring wells at the 216-U-1 and 216-U-2 Cribs. About 30,000,000 L (7,900,000 gal) of groundwater were subsequently pumped and treated between June and August 1985, removing 685 kg (1,510 lb) of uranium via an ion exchange column and resulting in a decrease of uranium activity in the groundwater concentration to 17,000 pCi/L (Baker et al. 1988). In addition to pumping and treating the groundwater, portions of existing wells (299-W19-3, 299-W19-9, and 299-W19-11) were

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grouted to prevent vertical communication, and new monitoring wells (299-W19-15, 299-W19-16, 299-W19-17, and 299-W19-18) were installed to help characterize the uranium plume (Baker et al. 1988). The location of existing monitoring wells is shown on Plate 3.

2.3.3.2 216-U-8 Crib. The 216-U-8 Crib consists of three underground timber crib structures within a north-south oriented trench that is about 49 x 15.2 m (160 x 50 ft) backfilled with gravel. Each crib is a 4.9 x 4.9 x 3 m (16 x 16 x 10 ft) box constructed of 0.15 x 0.20 m (6 x 8 in.) Douglas fir timbers that rest on a 0.9 m (3 ft) thick gravel bed, about 9.4 m (31 ft) below grade. The 216-U-8 Crib is located 137 m (450 ft) west of Beloit Avenue and 229 m (750 ft) south of 16th Street.

The crib operated from 1952 until 1960. Approximately 379,000,000 L (100,000,000 gal) of acidic process condensate from the 221-U and 224-U Buildings, and the 291-U Stack Drainage System were discharged to the crib. In 1960, the surface above the 216-U-8 Crib began to subside. In response to this subsidence, the incoming line was blanked off and waste diverted to the 216-U-12 Crib (Maxfield 1979). The 216-U-8 Crib reportedly holds the largest inventory of waste uranium of any 200 West Area crib.

2.3.3.3 216-U-12 Crib. The 216-U-12 Crib (a RCRA TSD facility scheduled to undergo closure in November 1994) is southwest of the intersection of Beloit Avenue and 16th Street and consists of a 46 m (150 ft) long, gravel-filled drain field. The 216-U-12 Crib, constructed in 1960, measures 30 x 3 m (100 x 10 ft) at the base, has earthen sides with a 2:1 slope, and contains no internal structure. The bottom 2.1 m (7 ft) are filled with layers of sand and gravel that are covered with a polyethylene barrier.

The 216-U-12 Crib was constructed in 1960 when the 216-U-8 Crib began to subside. The 216-U-12 Crib reportedly received 150,000,000 L (40,000,000 gal) of liquid waste during 28 years of use. Drainage was received from the 291-U Stack Drainage System, the acidic ($\text{pH} \leq 1$) UO_3 Process Condensate System, wastes from the C-5 and C-7 tanks, and storm drain wastes from the 224-U Building. Approximately 3.1 kg (6.9 lb) of thorium were received from the 241-WR Vault in October 1965. The 216-U-12 Crib was taken out of service in January, 1988 as the 216-U-17 Crib was placed into service.

2.3.3.4 216-U-16 Crib. The 216-U-16 Crib is south of 16th Street and midway between Beloit Avenue and Cooper Avenue. The 216-U-16 Crib is a large, gravel-filled, drain field-type crib with no major structure. It is 19 m (62 ft) long, 58 m (191 ft) wide and 4.6 to 5.2 m (15 to 17 ft) deep. Liquid wastes entered a 2 m (6.7 ft) square distribution box and flowed into a pair of 20 cm (8 in.) diameter polyvinyl chloride (PVC) header pipes which form the north, east and west borders of the drain field. The bottom is filled with gravel to a depth of 1.5 m (5 ft) covered with 25 μm (1 mil) reinforced polyethylene liner.

The crib operated from 1984 until 1987. The 216-U-16 Crib received UO_3 Laboratory process condensate, 271-U Compressor cooling water, 221-U Building chemical sewer waste,

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and, for a period of several months 224-U Building process condensate and chemical sewer waste. By 1985, enough liquid waste had been discharged to the 216-U-16 Crib to create a perched groundwater zone on top of a relatively impermeable caliche layer. The perched water moved north below the 216-U-1 and 216-U-2 Crips and mobilized uranium, which entered the unconfined aquifer through the caliche layer. Pump and treat techniques (ion exchange) were used at the 216-U-1 and 216-U-2 Crips to treat 30,000,000 L (7,900,000 gal) of groundwater (Baker et al. 1988).

2.3.3.5 216-U-17 Crib. The 216-U-17 Crib is an active waste management unit constructed in 1988 to replace the 216-U-12 Crib which had received its maximum allowed inventory of radioactive wastes. The 216-U-17 Crib is partially within the old Construction Surface Laydown Area. The area was cleaned before construction of the 216-U-17 Crib. It is a drain field-type unit situated 5.5 m (18 ft) below the surface. It is covered with a 6 μ m (0.25 mil) PVC membrane vapor barrier and is backfilled with native soil.

The only waste discharged to the 216-U-17 Crib is 224-U Building process condensate stream via a 15 cm (6 in.) polyethylene drain pipe. A neutralization system maintains the pH within a range of 2.0 to 12.5.

After a brief cessation of effluent disposal to the crib in 1991, flow resumed on January 20, 1992. The current discharge is limited to a rate of 10 gal/min as stated in TPA milestone M-17-19A (Ecology et al. 1992). Milestone M-17-19 requires cessation of disposal to the crib in June 1995. In the interim, effluent sampling is required and quality standards and sampling requirements are addressed in the *UO₂ Plant Process Condensate Effluent to 216-U-17 Sampling and Analysis Plan* (Clark and Adams 1991).

2.3.3.6 216-S-21 Crib. The 216-S-21 Crib is an inactive crib located 834 m (2,736 ft) northwest of the 202-S Building, 46 m (150 ft) north of 13th Street, and west of the 241-S Tank Farm. From 1954 to 1969, the waste management unit received 241-SX Tank Farm condensate from the condensers in the 401-SX Condenser Facility via the 241-SX-206 Single-Shell Tank in the 241-SX Tank Farm. The unit was retired in February 1969.

The unit is a 4.9 m x 4.6 m x 3 m 25 cm (16 ft x 15 ft x 9 ft 10 in.) wooden structure, 2.5 m (8.3 ft) below grade with a side slope of 1:1. The bottom of the wooden structure is 1.2 m (4 ft) above the bottom of the unit, suspended in gravel fill. The unit dimensions are 15.2 x 15.2 x 6.4 m (50 x 50 x 21 ft) deep. The unit received 87,100,000 L (23,000,000 gal) of low salt and neutral/basic liquid waste. The chemicals disposed were sodium and ammonium nitrate.

2.3.3.7 216-Z-20 Crib. The 216-Z-20 Crib is an active waste facility constructed in 1981 to replace the 216-Z-19 Ditch as a low-level liquid waste disposal site for various Plutonium Finishing Plant facilities in the Z Plant Aggregate Area. The crib lies to the west of, and is parallel to, the Z Plant Aggregate Area ditches. The 216-Z-20 Crib is included in the U

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Plant Aggregate Area even though it receives waste from the Plutonium Finishing Plant in the Z Plant Aggregate Area.

The crib is constructed of three parallel PVC distribution lines (two 15 cm [6 in.] lines and one 25 cm [10 in.] line) lying 1.1 m (3.5 ft) apart. They are perforated and run parallel for the entire 463 m (1,519 ft) length of the crib. Depth below grade varies from 3.6 to 4.6 m (12 ft to 15 ft). Sets of risers extend from the distribution lines to a point 0.5 m (1.5 ft) above grade at four locations. The distribution lines lie in a 0.8 m (2.5 ft) deep bed of gravel that had been covered with PVC sheeting before backfilling.

The crib received 3,800,000,000 L (1,004,000,000 gal) of cooling water, steam condensate, storm sewer, building drain, Hanford Engineering and Development Laboratory (HEDL) RADTU cooling water, and chemical drains from the 234-5Z Building; cooling water, steam condensate, and lab drain wastes from the 231-Z Building; and miscellaneous drain waste from 291-Z, 232-Z, 236-Z, and 2736-Z Buildings. The crib currently receives potentially contaminated non-contact cooling water from the Plutonium Reclamation Facility and the Remote Mechanical C Line, miscellaneous wastewater from laboratory activities, condensates from heating, ventilation and air conditioning systems, and storm sewer runoff from the area south of the main Plutonium Finishing Plant complex. The crib also receives effluents from the 234-5Z, 236-Z, 2736-ZB, 291-Z and 231-Z Buildings. Several known releases have occurred at this unit, including a January 23, 1986 release of .02 $\mu\text{Ci/L}$ alpha (amount unknown) from 236-Z Building tank leakage. On December 20, 1984, a release of 1.07 $\mu\text{Ci/L}$ of ^{239}Pu (over an 8-hr shift) occurred to this unit from 236-Z Building tank leakage, and a spill of 3445 kg (7,594 lb) of nitric acid on September 26, 1984 (WHC 1991a).

In September 1991, discharge of the Plutonium Finishing Plant wastewater to the 216-Z-20 Crib was limited to 600 L/min (160 gal/min), or less, averaged over the calendar month. This discharge limit satisfied Tri-Party Agreement milestone M-17-16A. Another milestone, M-17-16, requires cessation of all discharge to the crib by June 1995 (Ecology et al. 1992).

High liquid levels were recorded in 216-Z-20 Crib observation wells in the fall of 1986. A geological evaluation indicated that the crib is underlain by a layer of silty fine sand. Beneath that layer, a layer of coarse sand exists that appears to start at a depth of 4.6 to 6.1 m (15 to 20 ft) beneath the ground surface. To improve the crib percolation rate, crib drains were drilled to direct effluent to the layer of coarse sand.

2.3.3.8 216-U-3 French Drain. The 216-U-3 French Drain is located just south of the 241-U Tank Farm. The 216-U-3 French Drain is a 3.6 m (12 ft) deep, rock-filled excavation with a 1.8 m (6 ft) diameter bottom and side slopes of 3:1. The drain is a state of Washington-registered underground injection well.

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From 1954 until 1955, the 216-U-3 French Drain received condensate from the 241-U steam condenser on waste tanks at the 241-U Tank Farm. Approximately 791,000 L (209,000 gal) of low salt, neutral-basic condensate has reportedly been pumped into the drain.

2.3.3.9 216-U-4A French Drain. The 216-U-4A French Drain was installed to receive 222-U Laboratory hood sink wastes when the 216-U-4 Reverse Well began to plug (1955). The drain was installed 2.4 m (8 ft) north of the well and the 216-U-4A French Drain and well were connected by an overflow line. The 216-U-4A French Drain is a 130 cm (51 in.) diameter concrete pipe extending downward at least 1.2 m (4 ft) and the upper surface is 1.5 m (5 ft) below grade. The drain rests on undisturbed soil and is not gravel filled. From 1955 to 1970, the 216-U-4A French Drain received 545,000 L (144,000 gal) of acidic plutonium and fission product decontamination waste.

2.3.3.10 216-U-4B French Drain. The 216-U-4B French Drain is located 9.1 m (30 ft) south of the 222-U Laboratory and was installed to receive liquid waste from the 222-U Laboratory. The 216-U-4B French Drain is a 91 cm (36 in.) diameter concrete pipe that extends 3 m (10 ft) beneath the surface and is a state of Washington-registered injection well. The 216-U-4B French Drain operated from 1960 to 1968 and received 33,000 L (8,700 gal) of low salt, neutral/basic 222-U Laboratory hot cell and hood wastes.

2.3.3.11 216-U-7 French Drain. The 216-U-7 French Drain is connected to the U Plant counting box and is located 2.4 m (8 ft) south of the 221-U Building. The 216-U-7 French Drain is a gravel-filled 76 cm (30 in.) diameter concrete pipe extending to a depth of 5.2 m (17 ft). From 1952 to 1957, the 216-U-7 French Drain received liquid wastes from a counting box floor drain during the metal recovery program at the 221-U Building. It is possible that about 140 kg (300 lb) of uranium in the form of uranyl nitrate hexahydrate were introduced to the soil. The uranyl nitrate hexahydrate introduced to the soil through the 216-U-7 French Drain is also denoted as Unplanned Release UN-200-W-138.

2.3.3.12 216-S-4 French Drain. This waste management unit consists of two French drains with 76 cm (30 in.) diameter rock-filled encasements. The encasements are metal culvert pipe placed end to end to a depth of 6.1 m (20 ft). It was active from August 1953 to August 1956 and received 1,000,000 L (264,000 gal) of waste from the condensers on the 241-S-101 and 241-S-104 Tanks. It is located in the 200 West Area, 93.6 m (307 ft) north of 13th Street, between the 241-S Tank Farm and the 216-U-10 Pond.

Until 1953, the waste management unit received condensate and cooling water from condensers on the 241-S-101 and 241-S-104 Tanks. After 1953, it received only cooling water. It was retired when the tank air condensers were reactivated in August 1956 and was deactivated by removing the above-ground piping.

2.3.4 Reverse Wells

2.3.4.1 216-U-4 Reverse Well. The 216-U-4 Reverse Well is the only reverse well in the U Plant Aggregate Area and is located 5.2 m (17 ft) west and 0.6 m (2 ft) north of the west corner of the 222-U Laboratory Building (Figure 2-6). This state of Washington-registered underground injection well is a 7.6 cm (3 in.) diameter steel pipe extending 23 m (75 ft) beneath the surface. The bottom 2.4 m (8 ft) are perforated.

From 1947 to 1955 the 216-U-4 Reverse Well received 300,000 L (80,000 gal) of decontamination waste from the 222-U Laboratory hood sinks (acidic plutonium and fission product waste). In 1955, when the 216-U-4 Reverse Well began to plug, it was "deactivated" and an overflow line installed to the new 216-U-4A French Drain. Evidence has been located that documents that the well was sealed off (DeFord 1991).

2.3.5 Ponds, Ditches, and Trenches

The ponds, ditches, and trenches in the aggregate area were designed to percolate wastewater into the ground. Until its closure in 1985, the 216-U-10 Pond was at the center of this disposal system and was fed by ditches that originated at the various waste generation facilities. Figure 2-9 is a map of this disposal system. In this report, the 216-U-10 Pond and the ditches which transferred wastewater to it are collectively called the 216-U-10 Pond System. Generally, low-level liquid waste was disposed of into the 216-U-10 Pond system, and no attempt was made to isolate the wastewater from the open air. The following sections describe the 216-U-10 Pond and its associated trenches and ditches. Several small unrelated ditches and trenches are also described.

2.3.5.1 216-U-10 Pond System. The 216-U-10 Pond System was constructed in 1944 to receive low-level liquid effluent from the plutonium processing facilities. It originally consisted of two drainage ditches (the 216-U-14 and the 216-Z-1D Ditches), which carried water to a slight natural depression (216-U-10 Pond). Two additional drainage ditches (the 216-Z-11 and 216-Z-19 Ditches) were later constructed to replace the 216-Z-1D Ditch. Several additional overflow ditches were constructed during the system's operation. These include the 216-U-11 Trench and Unplanned Releases UPR-200-W-104, UPR-200-W-105, and UPR-200-W-106. These unplanned releases are associated with three leach trenches connected to the 216-U-10 Pond.

The pond system was active from 1944 to 1985 and received a total of 1.65×10^{11} L (4.3×10^{10} gal) of contaminated liquid. The site received the following effluents at various times:

- 284-W Powerhouse process cooling water

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- Steam condensate from 231-Z and 234-5Z Buildings via 216-Z-1 Ditch
- Wastewater from 2723-W mask cleaning station and 2724-W laundry via 216-U-14 Ditch
- Chemical sewer wastes from 221-U Building
- Cooling water from 224-U Building
- 231-Z Laboratory wastes via 216-Z-1D Ditch
- 241-U-110 Tank condenser water via 216-U-14 Ditch and PNL operations waste from the 231-Z Laboratory via the 216-U-14 Ditch
- 242-S Evaporator steam condensate via 216-U-14 Ditch.

In 1980, the site stopped receiving 231-Z condensate waste. After 1981, the site also stopped receiving waste from 221-U, 224-U and 271-U. After 1984, the site received only 242-S Evaporator cooling water (WHC 1991a).

The large volumes of low-level wastewater and occasional isolated releases of considerably higher level, non-routine discharges have resulted in the accumulation of TRU, fission product and activation product inventories. According to one estimate a total of 130,000,000,000 L (34,346,000,000 gal) of liquid had been discharged to the system through 1982, with a radionuclide inventory estimated to include 8.2 kg (18 lb) plutonium, 1,500 kg (3,300 lb) uranium, 15.3 Ci ¹³⁷Cs, and 22.6 Ci ⁹⁰Sr. The large number of discharge sources, their operational service dates, and the operational service dates of the 216-U-10 Pond system components complicate any attempt to derive total inventories for the individual 216-U-10 Pond components.

One estimate also reports that of the 8.2 kg (18 lb) of plutonium released to the 216-U-10 Pond system, "all but negligible amounts" were released to the 216-Z-1D, 216-Z-11 and 216-Z-19 Ditches. A comparison of the annual plutonium discharges and the service dates of the Z Ditches indicates that the 216-Z-1D Ditch received 0.14 kg (0.31 lb), the 216-Z-11 Ditch received 8.07 kg (17.8 lb) and the 216-Z-19 Ditch received 0.14 kg (0.31 lb).

2.3.5.1.1 216-U-10 Pond. The 216-U-10 Pond was located in the southwest corner of the 200 West Area. At its maximum extent, including the overflow trenches, the pond covered approximately 12 hectares (30 acres). The unplanned release site, UPR-200-W-107, was an area south and west of the pond that was flooded when it was at its maximum extent.

The 216-U-10 Pond was deactivated in 1985 and no longer contains water. The deactivation and interim stabilization of the pond area is described in a Rockwell Hanford

Standard Operating Procedure. During closure, some peripheral areas were scraped to a depth of 0.3 m (1 ft) or greater to remove contaminated soil. This soil was stockpiled near the middle of the pond. It is unknown whether contaminated soil was removed from the UPR-200-W-104, -105, and -106 leach trenches and the UPR-200-W-107 area. 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 was reseeded. In 1990, 0.6 m (2 ft) of fill soil were added to an additional 1.5 acres of contaminated land on the south side of the 216-U-10 Pond where surface radiation had been detected (Schmidt et al. 1992).

2.3.5.1.2 216-U-14 Ditch. The 216-U-14 Ditch has been used since 1944 and is an open ditch running from northeast to southwest across about 1.6 km (1 mi) of the 200 West Area. It originates 500 m (1,600 ft) north of the U Plant and terminates at the 216-U-10 Pond. This ditch has a minimum bottom width of 2.4 m (8 ft), side slopes at 2.5:1 and was originally 1,700 m (5,600 ft) long. Approximately three-fourths of the 216-U-14 Ditch has been backfilled. It remains open for a small distance at the north boundary of the 200-UP-2 Operable Unit (the Powerhouse Pond) and in a segment just east and south of the 241-U Tank Farm. 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 which passes under 19th Street.

The 216-U-14 Ditch was originally known as the "laundry ditch" because it received wastewaters from the 2724-W Laundry Building. The 216-U-14 Ditch has received other waste types that have varied over time and include the following:

- Wastewater from the 284-W Powerhouse
- Chemical sewer waste from the 221-U Building
- Cooling water from the 224-U Building, the 241-U-110 Condenser Tank and 271-U Building
- 207-U Retention Basin wastewater
- Evaporator condensate and cooling water from the 242-S Evaporator Building
- Wastewater from mask cleaning operations.

One report states 570,000 L (150,000 gal) of laundry wastewater per day were discharged to 216-U-14 Ditch. On August 6, 1986, about 3,000 L (800 gal) of 50% reprocessed nitric acid were released to the 216-U-14 Ditch. The total release, which included dilution water, was reported to be about 100,000 kg (225,000 lb) of corrosive solution (pH < 2.0) and 45 kg (100 lb) of uranium. This release is the same one reported for

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the 207-U Retention Basin because the 224-U Building discharge to the 216-U-14 Ditch is via the basins.

Until March 1992, a 230 m (750 ft) segment of the ditch west of Cooper Avenue was continuously filled with 0.63 to 1.26 L/s (10 to 20 gal/min) of cooling water flow from the 242-S Evaporator and an additional 18.9 L/s (300 gal/min) of raw water from a nearby fire hydrant. This was done to control windblown contaminated dust from the ditch. In March 1992 this portion of the ditch was stabilized in response to the Tri-Party Agreement milestone 17-17B which mandated that the raw water supply be turned off.

Stabilization activities began with the removal of all vegetation from along the ditch. This vegetation was placed in the bottom of the ditch along with contaminated soil from the ditch bottom and a nearby spoils pile. This material was then covered with 0.6 to 1.2 m (2 to 4 ft) of coarse river gravel. Continuing herbicide treatment will be used to control future vegetation growth. The remaining small water flow from the 242-S Evaporator percolates into the gravel. Ditch usage will cease in June 1995 when the W-049H project to collect and treat all radioactive 200 Areas plant streams becomes operational.

2.3.5.1.3 216-Z-1D Ditch. The 216-Z-1D Ditch operated from December 1944 until March 1959 as a liquid waste disposal site for the Plutonium Finishing Plant in the Z Plant Aggregate Area. It was deactivated and replaced by the 216-Z-11 Ditch in 1959.

The 216-Z-1D Ditch received approximately 1,000,000 L (264,000 gal) of process cooling water, steam condensate, and vacuum pump sealant waters from the 231-Z, 234-5Z, and 291-Z Buildings. It is classified as a TRU-Contaminated Soil Site and has a Hazard Ranking System (HRS) score of 45.3 (WHC 1991a).

The 216-Z-1D Ditch ran from a point immediately east of the 231-Z Building to the 216-U-10 Pond into which it drained. It was a long, shallow ditch; 1,300 m (4,300 ft) long, 0.6 m (2 ft) deep, and 1.2 m (4 ft) wide at its bottom with side slopes of 2.5:1 and a .05% grade.

The site was deactivated and backfilled to grade in stages. The northernmost 526 m (1,725 ft) were backfilled and replaced with a pipeline in July 1949 as part of the 234-5Z Building construction project. The next 611 m (2,005 ft) were backfilled in 1959 after a plutonium and americium contamination release from the 231-Z Building with clean soil. This contaminated area was mistakenly excavated during the digging of the 216-Z-19 Ditch in 1971 (see 216-Z-19 and UPR-200-W-110) (WHC 1991a). The lower 203 m (665 ft) of the ditch continued to be used until May 1971 as part of the 216-Z-11 Ditch. The first 36.6 m (120 ft) downstream from the 231-Z Building outfall was also in common with the 216-Z-11 and 216-Z-19 Ditches.

The site is 204 m (669 ft) above msl and about 55 m (180 ft) above groundwater. Its contamination burden includes 137 Ci ^{239}Pu and 37 Ci ^{240}Pu . For purposes of WIDS records keeping, its chemical inventory is included in that of the 216-U-10 Pond (WHC 1991a).

Aliases for the 216-Z-1D Ditch include 216-Z-1, 216-Z-11, Drain Ditch to U Swamp, and Z Plant Ditch. It should not be confused with the 216-Z-1 Crib.

2.3.5.1.4 216-Z-11 Ditch. The 216-Z-11 Ditch began operations in 1959 and served as a replacement ditch for the 216-Z-1D Ditch. It paralleled the earlier ditch, from a point immediately east of the 241-Z Building to the 216-U-10 Pond. The 216-Z-11 Ditch received liquid waste from Plutonium Finishing Plant operations until it was deactivated and replaced by the 216-Z-19 Ditch in 1971. The site was backfilled to grade when it was retired and additional fill was added during the deactivation of the 216-Z-19 Ditch in 1981 (described in Section 2.3.5.1.5).

The ditch received process cooling water and steam condensate from the 234-5Z Building, cooling and seal water from the 291-Z Building, and lab wastes from the 231-Z Building. Total volumes are not reported. It is reported as a TRU-Contaminated Soil Site and has a HRS score of 45.3 (WHC 1991a).

The ditch ran from a point immediately east of the 216-Z-1A Drain Field to the 216-U-10 Pond into which it drained. It was a long, shallow ditch; 797 m (2,615 ft) long, 0.6 m (2 ft) deep, and 1.2 m (4 ft) wide at its bottom with side slopes of 2.5:1 and a .05% grade.

Its southernmost 202.7 m (665 ft) was part of the deactivated 216-Z-1D Ditch. The first 36.6 m (120 ft), starting at N39420 W75991, was also in common with the 216-Z-1D and 216-Z-19 Ditches. For a short time in 1971, liquid waste from the 216-Z-19 Ditch flowed through a 274 m (900 ft) section of this unit, which includes the 202.7 m (665 ft) section mentioned above (WHC 1991a).

The site is 198 m (651 ft) above msl and 55 m (180 ft) above groundwater. Its contamination burden includes 137 Ci ^{239}Pu and 37 Ci ^{240}Pu . Its chemical inventory is reported as part of the 216-U-10 Pond inventory (WHC 1991a). Aliases for the 216-Z-11 Ditch include the Z Plant Ditch and the 216-Z-1D Ditch (WHC 1991a).

2.3.5.1.5 216-Z-19 Ditch. The 216-Z-19 Ditch operated from May 1971 until September 1981, replacing the 216-Z-11 Ditch as a liquid waste disposal site for various Plutonium Finishing Plant facilities. It ran from a point immediately east of the 241-Z Building to the 216-U-10 Pond. It has since been deactivated and backfilled.

The ditch received process cooling waste and steam condensate from the 234-5Z Building, vacuum pump seal water from the 291-Z Building, and cooling water from the

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231-Z Building. Total volumes are not reported (Maxfield 1979). This site is reported as a TRU-Contaminated Soil/Mixed Site. It has no HRS score (WHC 1991a).

The ditch began at a point about 231.6 m (760 ft) southeast of the 234-5Z Building and 137 m (450 ft) west of Camden Avenue and ran in a southwesterly direction to the 216-U-10 Pond into which it emptied. It is parallel to and between the 216-Z-1D Ditch and the 216-Z-20 Crib. 216-Z-19 is described as an open ditch, 842.8 m (2,765 ft) long and 1.2 m (4 ft) wide at the bottom. It was 1.2 m (4 ft) deep, 202.9 m (666 ft) above msl, and about 54.9 m (180 ft) above groundwater (WHC 1991a).

Its first 36.6 m (120 ft) from the outfall of the 231-Z cooling water pipeline is common with the old 216-Z-1D and 216-Z-11 Ditches. The next 129.5 m (425 ft) to the south is common with the 216-Z-1D Ditch. Its history is described by Maxfield (1979) as follows:

In April of 1971, excavation was started on the 216-Z-19 Ditch as a replacement for the contaminated 216-Z-11 Ditch in use at that time. The excavation was mistakenly started directly over the old buried 216-Z-1 Ditch near the confluence of the 234-5Z cooling water stream with the 216-Z-11 Ditch [just south of the water sampler station and 36.6 m (120 ft) south of the 231-Z stream outfall]. Approximately 129.5 m (425 ft) of the contaminated 216-Z-1 covered ditch was dug up before the mistake was noticed. At that point, the new 216-Z-19 Ditch was turned to the west from the 216-Z-1 covered ditch and followed a new route approximately 10.7 m (35 ft) west of and parallel to the 216-Z-1 Ditch. It continued on this course until just before reaching 16th Street where it was redirected east under the 216-Z-11 Ditch road culvert. This routing was used with moderate success until October 1971 when a new culvert was installed 15.2 m (50 ft) west of the 216-Z-11 culvert. The remainder of the 216-Z-19 Ditch was then dug from that point to the 216-U-10 Pond, a distance of approximately 305 m (1,000 ft). Soil from the 216-Z-19 Ditch excavation was used to cover the old 216-Z-11 Ditch.

According to Maxfield (1979) the head end of the ditch is grossly contaminated with plutonium and americium, but contamination decreases to a few hundred dis/min per 100 cm² surface as it approaches the 216-U-10 Pond.

Deactivation and stabilization of the Z Ditch complex north of 16th Street was brought about by the construction of the new 216-Z-20 Crib. Preliminary work on the active 216-Z-19 Ditch was initiated in August 1981. At this time, the live woody vegetation growing in and along the ditch was treated with a herbicide mixture of glyphosate and dicamba. This application, intended to provide an in-place kill of the trees and shrubs, appeared quite effective just before backfilling the ditch.

An existing groundwater monitoring well located between the buried 216-Z-1 and 216-Z-11 Ditches was extended and retained for future use. Shallow dry wells installed near

the Z Ditch complex for past characterization studies were either removed or grouted closed in place (well casings west of the ditches were removed while those to the east were grouted closed). All salvageable equipment remaining in the sampling station at the 234-5Z Building outfall to the ditch was removed before backfilling.

The concrete headwall and vegetation were incorporated into the ditch bottom and approximately 122 m (400 ft) of the ditch was backfilled before effluent diversion to the 216-Z-20 Crib. In addition, approximately 305 m (1,000 ft) of the posted zone to the east (the previously buried 216-Z-1D and 216-Z-11 Ditches) was covered with 15 to 20 cm (6 to 8 in.) of clean soil and backfill stockpiled along the eastern side of the 216-Z-19 Ditch.

Once Plutonium Finishing Plant effluents were diverted to the new crib, backfilling over the 216-Z-19 Ditch was resumed. As the water level at the headend of the ditch receded, the concrete headwall of the 231-Z outfall and metal at the 231-Z outfall and metal shed at the 234-5Z outfall were incorporated into the ditch bottom and the upper portion of the ditch backfilled.

The only problem encountered during backfilling occurred while attempting to cover the last open section of the ditch approximately 60 m (200 ft) south of the ditch head end. Standing water and a large amount of organic material has been entrapped by backfilling from both ends of the ditch. This area was left alone for about two and one-half days until it appeared that all the water had infiltrated into the ditch bottom. However, as soon as backfill was pushed into this area, it was discovered that the organic material was still quite fluid and rose over the top of the clean fill. At completion, some of this organic material was very near the surface of the backfilled ditch. A survey of the area by Radiation Monitoring resulted in detectable alpha contamination even though the moisture content of the contaminated material remained quite high. The following day a trench was dug parallel to the contaminated area and the material deposited in the bottom of the excavation. Upon completion of the initial cover, a single application of time released herbicide and rodent deterrent was sprayed over the 216-Z-19 Ditch only (approximately 0.4 hectare [1 acre]).

Final backfilling operations and stabilization on the Z Ditch complex were completed in October 1981. At this time, the 216-Z-19 Ditch had received between 0.6 and 0.9 m (2 and 3 ft) of clean soil, while the depth of cover over the eastern edge of the posted zone (216-Z-1 and 216-Z-11 Ditches) tapered to 0.3 m (1 ft). The Z Ditch complex has been reposted to Underground Radioactive Material. Aliases for the 216-Z-19 Ditch include the 216-U-10 Ditch and the Z Plant Ditch.

One unplanned release (UPR-200-W-110) occurred at this site when a trench filled with contaminated soil was mistakenly excavated (see Table 2-6).

2.3.5.1.6 216-U-11 Trench. The 216-U-11 Trench was located immediately west of the 216-U-10 Pond. It was active from 1944 to 1957 to receive overflow from the 216-U-10

Pond. In its original form, it was 573 m (1,880 ft) long with a 1.5 m (5 ft) wide bottom. A new trench, constructed in 1955, was 1,048 m (3,440 ft) long and included 247 m (810 ft) of the original trench. The new trench was U-shaped in plan view and sometimes formed a pond when adequate water was introduced.

The new unit received the 216-U-10 Pond overflow until it was retired and filled with clean soil in 1957. The site contains less than 0.1 Ci beta activity.

The site surface has been stabilized with grass. Surface contamination has been noted in periodic surveys and a HRS score of 37.75 has been assigned. Aliases for this site are U Swamp Extension Ditch, 216-U-12, 216-U-11 Ditch, 216-U-11 Old Ditch, and 216-U-11 New Ditch (Maxfield 1979).

2.3.5.2 "Dry" Trenches. Some sites designated as trenches actually received only small quantities of water, contaminated or otherwise. Rather, they were used for equipment decontamination (216-U-13 Trench) or for disposal of sludge types of waste (216-U-5, -U-6, and -U-15).

2.3.5.2.1 216-U-13 Trench. The 216-U-13 Trench was used from 1952 until 1956 for equipment decontamination. Located immediately west of the 241-U Tank Farm, 216-U-13 consists of two sites, each 61 m (200 ft) long, 7.6 m (25 ft) deep, and 5.5 m (18 ft) wide at the bottom. Both ends of the trenches were sloped so that the vehicles could be driven down to the decontamination station at the bottom. The site received drainage from the equipment decontamination processes within the trenches.

The site was deactivated by backfilling the trenches. Decontamination operations were transferred to the 269-W Decontamination Pit. Contaminated soils were removed from the bottom of the pit and taken to the 200 West Burial Ground (WHC 1991a).

A comprehensive radiation survey was made in 1981 of the ground and surface vegetation in the zoned area of the trenches which disclosed readings of less than background except for two spots (WHC 1991a). The area has since been released as a radiation zone and no markers or barriers exist.

According to WIDS, there are 640 m³ (840 yd³) of contaminated soil and 11,400 m³ (14,900 yd³) of overburden soil at this site. This site has a HRS score of 0.10 (WHC 1991a). The alias for this site is 241-UR Steam Cleaning Pit (WHC 1991a).

2.3.5.2.2 216-U-5 and 216-U-6 Trenches. The 216-U-5 and 216-U-6 Trenches are located immediately northwest of the 241-WR Vault, and north of the east end of the U Plant. The trenches were excavated in March 1952 to receive nonirradiated uranium waste from the cold startup run at U Plant by way of above-ground pipes. The pipes were removed when waste transfer operations were concluded and the trenches backfilled. The

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216-U-5 Trench had a 12 x 12 m (40 x 40 ft) bottom and was 3 m (10 ft) deep; 216-U-6 Trench had a 3 x 23 m (10 x 75 ft) bottom and was also 3 m (10 ft) deep. During the cold startup operations, 2,250,000 L (595,000 gal) of liquid waste containing 360 kg (800 lb) of unirradiated uranium are reported to have been pumped into each trench (WHC 1991a). Another report states a total of 7,300 kg (16,000 lb) of uranium was pumped into the trenches (Baldrige 1959).

2.3.5.2.3 216-U-15 Trench. The 216-U-15 Trench is a 6.1 x 6.1 x 4.6 m (20 x 20 x 15 ft) deep excavation opened in May 1957 and backfilled immediately after receiving wastes. The 216-U-15 Trench is located 170 m (550 ft) north of 16th Street and 150 m (500 ft) west of the 271-U Building. The exact location is unknown. The trench was opened to receive about 26,500 L (7,000 gal) of "interface crud" (DeFord 1991), activated charcoal and diatomaceous earth containing about 1 Ci of fission products from 338-U Tank in the 276-U Solvent Storage Area. Reports of disposed waste vary. One report indicates that 40,000 kg (88,000 lb) of hexone and 13,000 kg (29,000 lb) of tributyl phosphate were disposed and another source reports the former material as "paraffin hydrocarbon." The material was likely to be paraffin hydrocarbon, since this was the diluent used in the U Plant Process. Waste was pumped to the trench through above-ground lines which were removed after the waste transfer operation was completed. This trench is also denoted as Unplanned Release UN-200-W-125 (DeFord 1991).

2.3.6 Septic Tanks and Associated Drain Fields

The location of the septic tanks and drain fields are shown on Figure 2-10. The U Plant Aggregate Area contains four septic tanks, described as follows.

2.3.6.1 2607-W-5 Septic Tank and Drain Field. The 2607-W-5 Septic Tank and Drain Field was installed in 1944 and is an active waste management unit. The 2607-W-5 Septic Tank and Drain Field is about 122 m (400 ft) west of the southwest corner of the 222-U Laboratory and receives sanitary sewage from the 221-U Building, 222-U Laboratory, 224-U Building, and the 271-U Plutonium Storage and Services Building. The unit is comprised of an underground concrete septic tank (9.1 x 4.0 x 3.4 m; 30 x 13 x 11 ft deep), two distribution boxes, and two drain fields. The current drain field dimensions are 41 x 30 m (136 x 100 ft). The drain field is backfilled to a depth of approximately 0.8 m (2.5 ft) below grade. The drain field is easily recognized as a large rectangular depressed area. A similar abandoned drain field is located west of the existing field in the 200-UP-2 Operable Unit. The rate of sanitary waste and sewage discharged to the 2607-W-5 system is reported as 12,100 L (3,200 gal) per day.

2.3.6.2 2607-W-7 Septic Tank and Drain Field. The 2607-W-7 Septic Tank and Drain Field was installed apparently in 1954 and is located about 76 m (250 ft) north of the northeast corner of the 221-U Building. The 2607-W-7 waste management unit has been in

operation since 1954 and still receives sanitary wastewater and sewage from the 221-U Building. The specific location of the drain field is not documented. The rate of sanitary and sewage discharged to 2607-W-7 Septic Tank and Drain Field is reported as 1,000 L (264 gal) per day.

2.3.6.3 2607-W-9 Septic Tank and Drain Field. The 2607-W-9 Septic Tank and Drain Field began service in 1950 and is currently active. It has served the 2707-SX Building since 1950. The estimated rate of waste generation is 1,000 L/day (264 gal/day).

The septic tank and drain field are northwest of the 2707-SX Change House. A gravel surface covers the septic tank and drain field.

The septic tank has a capacity of 1,900 L (502 gal). The drain field is about 10.7 m (35 ft) long and 3 m (10 ft) wide. It is about 1.8 m (6 ft) deep, the bottom 0.6 m (2 ft) being filled with gravel. It is backfilled to grade. A single 15 cm (6 in.) pipe runs down the center of the drain field.

2.3.6.4 2607-WUT Septic Tank and Drain Field. The 2607-WUT Septic Tank and Drain Field is an active nonhazardous and nonradioactive waste management unit constructed in 1951 to receive sanitary wastewater and sewage from the 241-U Tank Farm buildings. It is capable of receiving 1,020 L/day (270 gal/day) of waste (WHC 1991a). Located at the north end of the tank farm, immediately north of (outside) the security fence, it is within the boundaries of a contaminated surface area resulting from spills from the 241-UR-151 Diversion Box and the 244-UR Vault. See Section 2.3.2.25, 244-UR Vault, for a description of contaminants.

The 2607-WUT Septic Tank and Drain Field consists of a 2,600 L (687 gal) steel septic tank and a drain field made up of a 7.3 m (24 ft) main trunk with seven 3 m (10 ft) laterals arranged in a herringbone pattern. All drain field lines are perforated 20 cm (8 in.) vitrified clay pipes buried in a 86 cm (34 in.) bed of gravel.

2.3.7 Transfer Facilities, Diversion Boxes, and Pipelines

High-level waste transfer lines (also referred to as process lines) connect the major processing facilities with each other and with the various waste disposal and storage facilities. Most high-level waste transfer lines are 7.6 cm (3 in.) diameter stainless steel pipes with welded joints. These lines are generally enclosed in steel reinforced concrete encasements and are set below grade. The major process lines in the U Plant Aggregate Area, and the facilities that they connect are shown on Figure 2-11 and Plate 1. The high-level waste pipelines are not waste management units according to the Tri-Party Agreement and they will be addressed in detail under the Decommissioning and RCRA Closure Program. However, a limited study is proposed as part of U Plant Past Practice

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investigations (see Section 8.3.3.8) to determine if the lines are leaking and if they have contaminated the surrounding soil.

Transfer lines to liquid effluent disposal facilities (e.g. cribs) were constructed of a variety of materials including vitreous clay and galvanized metal. For the purpose of the AAMS, these transfer lines are considered part of the waste management unit into which they discharged and will be investigated as a part of their respective units.

Diversion boxes house the switching facilities where waste can be routed from one process line to another. They are concrete boxes that were designed to contain any waste that leaks from the high-level waste transfer line connections. The diversion boxes generally drain by gravity to nearby catch tanks where any spilled waste is stored. There are nine diversion boxes and one valve pit in the U Plant Aggregate Area.

2.3.7.1 241-U-151 Diversion Box. The 241-U-151 Diversion Box is an active waste management unit associated with the 241-U Tank Farm. It is located about 30 m (100 ft) northeast of the intersection of Camden Avenue and 16th Street. It is a 6.1 x 3 x 5.2 m (20 x 9 x 17 ft) high concrete box with a floor drain connected to the 241-U-301 Catch Tank. It is buried to a depth of 5.2 m (17 ft) and the upper surface of its 0.9 m (3 ft) thick lid is at ground level. Multiple encased liquid waste transfer lines enter the box through its north wall. Liquid waste routing is made possible through the use of changeable jumper assemblies that connect pairs of waste transfer lines. Any leaks that occur are drained through the floor drain and, by gravity, through the drain line to the 241-U-301 Catch Tank located about 140 m (460 ft) to the west.

High-level wastes passing to and from the 241-U Tank Farm pass through this waste management unit. It has operated since 1946 (WHC 1991a).

Fourteen 7.6 cm (3 in.) stainless steel transfer lines enter the diversion box. Two are connected directly to the 241-U-101 Tank in the 241-U Tank Farm. Others run to the 241-U-153 Diversion Box, to other tank farm facilities, and to various 200 West Area operations facilities. An additional 7.6 cm (3 in.) drain line runs from the floor drain to the catch tank.

Baldrige (1959) reports surface contamination around this waste management unit. He states, "The ground around these boxes was contaminated in the spring of 1950 to a maximum observed dose rate of 20 mRads/h at surface. The contamination was covered with 1 ft [0.3 m] of clean soil and the area above ground delimited by a rope barricade posted with radiation zone signs" (see also Section 2.3.10, UN-200-W-6).

2.3.7.2 241-U-152 Diversion Box. The 241-U-152 Diversion Box is an active waste management unit associated with the 241-U Tank Farm. It is located about 15 m (50 ft) northeast of the intersection of Camden Avenue and 16th Street. This unit is a 8.5 x 3 x 5.2 m (28 x 9 x 17 ft) high concrete box with a floor drain connected to the 241-U-301 Catch

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Although referred to by WIDS as diversion boxes, these facilities are actually valve pits which house the valves necessary for regulation of process flow between waste tanks and the evaporator building. They are 3.6 x 3.6 x 2.1 m (12 x 12 x 7 ft) deep concrete vaults with concrete lids. Each is buried to a depth which places its upper surface about 0.3 m (1 ft) above grade.

The 241-U-A and -B Valve Pits are installed between the 241-U-104 and 241-U-105 Single-Shell Tanks and 241-U-C and -D are installed between the 241-U-110 and 241-U-111 Single-Shell Tanks.

2.3.7.6 241-UR-151 Diversion Box. The 241-UR-151 Diversion Box is an inactive waste management unit located at the north end of the 241-U Tank Farm. This unit was the master diversion box for the tank farm. It is 16.5 x 8.2 x 3.4 m (54 x 27 x 11 ft) high concrete box with a floor drain connected to the 244-UR Vault. It is buried to a depth that places the upper surface of its 0.9 m (3 ft) thick lid a few inches above ground level. Multiple encased liquid waste transfer lines enter the box through its south wall. Liquid waste routing is made possible through the use of changeable jumper assemblies that connect pairs of waste transfer lines. Any leaks that occur are drained through the floor drain and, by gravity, through the drain line to a tank in the 244-UR Vault to the west. High-level wastes passing to and from the 241-U Tank Farm pass through this waste management unit.

Fourteen stainless steel transfer lines, ranging between 7.6 and 15.2 cm (3 and 6 in.), enter the diversion box to connect it to the 241-UR-152, -153, and -154 Diversion Boxes and to the 244-UR Vault. Others run to the 241-U-151 Diversion Box near the 221-U Canyon Building, to other tank farm facilities, and to various 200 West Area operations facilities.

Stemming from a 1953 contamination incident at the 244-UR Vault, significant surface contamination exists around and to the north of this waste management unit. The facility has been sealed with plasticized foam and clean soil has been spread to stabilize contaminants. See Section 2.3.10, UPR-200-W-24, and Section 2.3.2.5, 244-UR Vault, for additional comments on contamination spread.

2.3.7.7 241-UR-152 Diversion Box. The 241-UR-152 Diversion Box is an inactive waste management unit at the 241-U Tank Farm, located south of the 241-UR-151 Diversion Box and immediately east of the 241-U-101 Single-Shell Tank. It connects the 241-UR-151 Diversion Box to the 241-U Tank Farm, especially the 241-U-101, -102, and -103 single-shell tanks, for the transfer of waste solutions from process decontamination operations. Fifteen stainless steel lines, mostly 15.2 cm (6 in.), enter the box through its west wall.

Isolated and weather covered, it is a 11.3 x 10.1 x 3.6 m (37 x 33 x 12 ft) high concrete box buried to a depth that places the upper surface of its lid at ground level. It is 204.2 m (670 ft) above msl (WHC 1991a).

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2.3.7.8 241-UR-153 Diversion Box. The 241-UR-153 Diversion Box is similar to the 241-UR-152 Diversion Box except that it primarily supports the 241-U-104, -105, and -106 Single-Shell Tanks. It operated from 1946 until 1983 and is located south of the 241-UR-151 Master Diversion Box and east of the 241-U-104 Tank. Fifteen stainless steel lines, mostly 15.2 cm (6 in.), enter the box through its west wall.

2.3.7.9 241-UR-154 Diversion Box. The 241-UR-154 Diversion Box is essentially similar to the 241-UR-152 Diversion Box except that it primarily supports the 241-U-107, -108, and -109 single-shell tanks. It is located south of the 241-U-151 Diversion Box and east of the 241-U-107 Tank. Fifteen stainless steel lines, mostly 15.2 cm (6 in.), enter the box through its west wall.

2.3.7.10 241-UX-154 Diversion Box. The 241-UX-154 Diversion Box is an active waste management unit located about 15.2 m (50 ft) southeast of the 221-U Building near its R-7 exit. Associated with the 221-U Building, it provides liquid waste routing to the 241-WR Vault and various tank farms, including waste management units in the 200 East Area via the inter-area transfer line. It is a 15.8 x 1.8 x 3.4 m (52 x 6 x 11 ft) high concrete box with a floor drain connected to the 241-U-302 Catch Tank. It is buried to a depth of 3.4 m (11 ft) and the upper surface of its 1.5 m (5 ft) thick lid is at ground level. Multiple encased liquid waste transfer lines enter the box through its southeast wall. Liquid waste routing is made possible through the use of changeable jumper assemblies that connect pairs of waste transfer lines. Any leaks that occur are drained through the floor drain and, by gravity, through a drain line to a catch tank that is located 8 m (25 ft) to the southwest. The diversion box and its catch tank are aligned in a southwest to northeast orientation (WHC 1991a).

High-level process and decontamination wastes pass through this diversion box. Operating since 1946, it serves as a waste transfer hub for not only 200 West Area, but also for cross site waste transfers through the inter-area transfer line.

Twenty-seven 7.6 cm (3 in.) stainless steel waste transfer lines connect the diversion box to the 221-U Building, 241-U-302 Catch Tank, 241-U Tank Farm, 241-WR Vault, inter-area transfer lines, and 241-TX-155 Diversion Box. All lines except the floor drain line to the catch tank are encased in concrete encasements (WHC 1991a). Steel chain barricades and surface contamination warning signs are in place around this waste management unit.

2.3.8 Basins

Basins are generally rubber-lined, open, settling ponds where wastewater was held before overflowing into a ditch. The locations of the basin in the U Plant Aggregate Area is shown on Figure 2-12.

2.3.8.1 207-U Retention Basin. The 207-U Retention Basin is the only basin within the U Plant Aggregate Area. The 207-U Retention Basin consists of two concrete-lined, open, settling ponds where wastewater was held before overflowing into a ditch.

The basin is located approximately 91.4 m (300 ft) east of the 241-U Tank Farm. The 207-U Retention Basin is 205.4 m (674 ft) above msl and 61 m (200 ft) above the water table (WHC 1991a). The concrete settling ponds are each about 2 m (6.5 ft) deep and contain about 2,000,000 L (500,000 gal). The bottom dimensions of each basin are 32 m (106 ft) in each direction. Total dimensions of the unit are 75 x 37 m (246 x 123 ft) (DOE-RL 1991a). Associated structures include inlet and outlet structures on the east and west sides, respectively, located outside of the basins. Also included are two sections of 41 cm (16 in.) concrete pipe, about 4 m (13 ft) long, running to two 0.9 x 0.9 m (3 x 3 ft) sumps, one for each settling pond.

The 207-U Retention Basin started operating in 1952 and is still active. Until 1972, the 207-U Retention Basin received steam condensate and cooling water from UO₂ Plant and chemical sewer waste from 221-U Building. Since that year, the basin had received only cooling water from the 224-U Building. It was temporarily replaced by the 216-U-16 Crib but was reactivated when the 216-U-16 Crib shut down. Effluent is routed from the basin to the 216-U-14 Ditch (DOE-RL 1991b; Maxfield 1979).

In the 1960's, sludge was scraped from the north basin and buried in a 12 x 3 x 2.4 m (40 x 10 x 8 ft) deep trench on the north side of the north basin (UN-200-W-111). A similar action was taken to clean out the south basin and a similar burial trench is located immediately south of the south basin (UN-200-W-112) (Maxfield 1979).

On August 6, 1986, about 3,000 L (800 gal) of 50% reprocessed nitric acid was released to the basin and subsequently to the 216-U-14 Ditch. The total release to the environment consisted of about 102,000 kg (225,000 lb) of corrosive solution (pH less than 2.0) and 45 kg (100 lb) of uranium (DOE-RL 1991b).

The north basin is overgrown with aquatic plant life. Surface contamination is measured at 200 to >100,000 ct/min. No change in activity is reported since July 1987. No aliases are known for this waste management unit.

There are two unplanned releases associated with the 207-U Retention Basin. Unplanned Releases UN-200-W-111 and UN-200-W-112 both occurred sometime after 1952,

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though the date is uncertain. Table 2-6 includes detailed information regarding these and other unplanned releases.

2.3.9 Burial Sites

There are two identified solid waste burial sites in the U Plant Aggregate Area. Construction materials were disposed of in the Construction Surface Laydown Area, and contaminated coveralls and soil are reportedly buried at the Burial Ground/Burning Pit. The locations of the burial sites are shown on Figure 2-13.

2.3.9.1 Construction Surface Laydown Area. The Construction Surface Laydown Area was a 122 x 53 x 4.6 m (400 x 175 x 15 ft) deep excavation into which trucks were driven to dump materials. The laydown area is located southeast of the intersection of 16th Street and Beloit Avenue. The area of the pit was cleared in 1987 prior to construction of the 216-U-17 Crib whose dimensions partially encompass those of the Construction Surface Laydown Area. There is no evidence that any of the materials disposed in this area were radioactively or chemically contaminated.

2.3.9.2 Burial Ground/Burning Pit. According to Baldrige (1959), in a report titled *Unconfined Underground Radioactive Waste and Contamination in the 200 Areas - 1959*, contamination was discovered in the spring of 1950 in the "old burning ground" (hereafter referred to as the "Burning Pit") located approximately 460 m (1,500 ft) east of the 221-U Building. This site should not be confused with another burning ground located northeast of the 200-UP-2 Operable Unit. The area is described as having been 14 m² (150 ft²) contaminated to a maximum dose rate of 45 rads/h at 5 cm (2 in.). Contaminated coveralls and contaminated soil reportedly existed at the site. This area was later covered with about 3 m (10 ft) of "clean earth" and posted with "Underground Contamination" signs. Upon covering the area it was called the "Burial Ground." Hence the "Burning Ground" (or "Burning Pit") and "Burial Ground" are not separate sites and the location for this investigation is called the "Burial Ground/Burning Pit."

The *200-UP-2 Operable Unit Technical Baseline Report* (DeFord 1991) states that known contaminated material was removed (probably in 1950) and the areas are no longer classified as a radiation zone. The signs for the Burning Ground no longer exist.

2.3.10 Unplanned Releases

Thirty-two unplanned releases are included in the U Plant Aggregate Area. Their locations are shown on Figure 2-14. Unplanned releases designated with a "UPR" are releases from or within the operations of specific waste management units and are considered part of that unit for remediation purposes. Releases designated with a "UN" are a distinct waste management unit for remediation purposes. The "UPRs" are not included as independent sites in the Tri-Party Agreement, however, because they are closely associated with existing waste management units. These unplanned releases and their associated waste management units will be addressed together in this study. Table 2-6 summarizes the known information for each unplanned release and, where applicable, lists the waste management unit to which it is related. Most of the information available for the unplanned releases is derived from the WIDS sheets (WHC 1991a).

Two additional, potentially significant, release sites are known in the U Plant Aggregate Area but have not been officially documented as unplanned releases. More information will be compiled on these sites in the future to assess their potential impacts to the environment. A formal evaluation of the regulatory status of these sites will be made in accordance with EII 1-10 (WHC 1988c). If the available data indicate that these releases are Reference significant enough, they will be submitted for listing as official unplanned releases. These are described in the following paragraphs.

The first potentially new site is a release of uranium contaminated water (uranium contamination leak) at the 224-U Building which is documented in an Unusual Occurrence report. In September 1989, approximately 16,730 L (4,420 gal) of water leaked from a concrete sump (C cell) into the surrounding soil. The water had a pH of 3.5 and contained about 12.1 kg of uranium.

The second potentially new site is an area where painting wastes have reportedly been emptied onto the ground immediately east of the 2715-UA Building Paint Shop (paint waste spill). The quantities of waste disposed of at this site are not known at this time.

2.4 WASTE GENERATING PROCESSES

The primary waste generating processes in the U Plant Aggregate Area are associated with the operation of the 221-U Building and its ancillary support facilities. Operations in the 221-U Building complex have included uranium reclamation, uranyl nitrate calcination, and decontamination and reclamation of process equipment. This section describes the primary waste generating processes and the associated building locations in the U Plant Aggregate Area including the following:

- 221-U-Building (Uranium Recovery Process)

- 224-U Building (UO₃ Conversion Process)
- 276-U Solvent Facility (Solvent Treatment)
- 222-U Laboratory (Analytical Laboratory Programs)
- Condensers in the 241-U Tank Farm (Tank Farm Condensate).

In addition, some waste management units within the aggregate area received wastes from outside facilities. The 216-S-4 French Drain and the 216-S-21 Crib received condensate and cooling water waste from condensers in the 241-S and 241-SX Tank Farm areas, respectively. The 216-U-10 Pond and the Z Plant ditches received cooling water and steam condensate waste from various Z Plant Aggregate Area facilities.

Table 2-7 summarizes the available information about the waste streams produced within the aggregate area. The chemicals or radionuclides which are known or suspected to be in U Plant Aggregate Area waste streams are listed in Table 2-8; Table 2-9 lists the chemicals used in the 222-U Laboratory; and Table 2-10 lists radionuclides, organic and inorganic chemicals disposed of at U Plant Aggregate Area waste management facilities. These lists have been compiled from inventory data, sampling data and process descriptions. Sections 2.4.1 through 2.4.5 describe the U Plant Aggregate Area waste generating processes that are listed above.

2.4.1 Uranium Recovery Process

The 221-U Building was the primary location of the uranium recovery program. The 221-U Building was originally designed as a bismuth phosphate separations facility but was not operated in that manner because B and T Plants had enough capacity to meet plutonium production requirements. The U Plant complex was converted in 1952 to support the uranium recovery process. The process was designed to use an organic solvent to extract uranium from waste generated by the bismuth phosphate process.

Bismuth phosphate waste sludge was sluiced from underground single-shell tanks in both the 200 West and 200 East Areas. The sludge was transferred to U Plant where it was dissolved with nitric acid. The uranium in the acidified feed was separated from the bulk of the fission products and small amounts of plutonium in the solvent extraction process. The solvent extraction process used a light phase solvent, tributyl phosphate in a kerosene (paraffin hydrocarbon) diluent, to extract the uranium from the aqueous phase in countercurrent extraction columns. The aqueous phase waste stream from the solvent extraction process was neutralized with sodium hydroxide and transferred to cribs in the 216-B Crib complex. The uranium from the organic phase was stripped with nitric acid and then concentrated to a uranyl nitrate hexahydrate feed to the 224-U Building.

Within the extraction process an evaporator condensate stream containing radioactive and chemical contaminants was generated in evaporators which concentrated process solutions. An offgas stream containing radioactive and chemical contaminants was also generated in the evaporation process and the vessel vent system. A steam condensate stream was produced from heating of process equipment and tanks. The steam condensate stream was generally uncontaminated. Cooling water from evaporator condensers and process equipment were additional sources of uncontaminated waste. An additional stream source of waste was from spillage of process liquids within the building. Sumps collected spilled liquids and other cell drainage and discharged the materials to the cribs.

Process wastes were discharged to various waste management units including the following:

- 216-B Crib complex
- 216-U-1 and 216-U-2 Cribs
- 216-U-7 French Drain
- 216-U-8 Crib
- 216-U-10 Pond
- 216-U-14 Ditch
- 216-U-16 Crib.

2.4.2 UO₃ Conversion Process

The UO₃ conversion process was carried out in the 224-U Building. A concentrated uranyl nitrate hexahydrate stream was sent to the 224-U Building from the 221-U Building for conversion to UO₃ by calcination. A process waste stream was generated which included the condensate recovered from the calcining process. Uncontaminated cooling water was generated in the process waste condensers. An offgas waste stream was also generated from the calcining process. Similar waste streams were generated from both operations supporting the uranium recovery operations in the 1950's and PUREX operations in later years.

Process wastes were discharged to various waste management units including the following:

- 216-U-10 Pond

- 216-U-1 and 216-U-2 Cribs
- 216-U-8 Crib
- 216-U-12 Crib
- 216-U-14 Ditch
- 216-U-16 Crib
- 216-U-17 Crib.

2.4.3 Solvent Treatment

Organic solvents used in the uranium extraction processes at the 221-U Building were sent to the 276-U Solvent Facility for treatment and makeup. There the solvents (particularly tributyl phosphate) were cleaned by a carbonate scrub process and returned to the 221-U Building. A carbonate scrub solution waste was generated which also contained sludge materials (soils and materials picked up during processing) cleaned from the solvents and discharged to the aggregate area cribs. Spent solvents were also a part of this waste stream.

2.4.4 Analytical Laboratory Programs

The 222-U Laboratory supported operations at the 221-U Building complex and other 200 Area facilities with laboratory services. A liquid waste stream was generated from the laboratory facility which included sample disposal waste and hood and hot cell cleanup waste. Sampling and testing equipment, gloves, empty containers and other materials were buried as solid waste. Laboratory liquid wastes were largely directed to the 216-U-4 Reverse Well and the 216-U-4A and 216-U-4B French Drains.

2.4.5 Tank Farm Condensate

Condensate waste from condensers on the 241-U-104 and 241-U-110 Tanks was directed to the 216-U-3 French Drain. The condensate was primarily water and included entrained radionuclides and chemicals from the waste in the tanks.

2.5 INTERACTIONS WITH OTHER AGGREGATE AREAS OR OPERABLE UNITS

The U Plant Aggregate Area is bordered by the S Plant Aggregate Area on the south, the Z Plant Aggregate Area to the northwest, and the T Plant Aggregate Area to the northeast.

- The REDOX process (S Plant) succeeded the bismuth phosphate and preceded the PUREX process for fuel separation. It was in operation from 1951 to 1967. The final product from this process, plutonium nitrate was sent to the Plutonium Finishing Plant for separation.
- The major processes conducted at the Plutonium Finishing Plant included producing metallic plutonium, and recovering plutonium and americium from plutonium scrap solutions.
- The T Plant was one of the original bismuth phosphate fuels separation facilities and was in operation from 1944 to 1956. The final concentration processing to final plutonium product from T Plant was done in the 234-5Z Building and the 231-Z Building.

Several U Plant waste management units have received wastes from one of the these surrounding aggregate areas. The 216-S-4 French Drain and the 216-S-21 Crib have both received condensate wastes from 241-S Tank Farm condensers. The Z ditches and the 216-U-10 Pond have all received wastes from the plutonium processing facilities of the Z Plant Aggregate Area. This wastewater was generally derived from condensation and cooling water from the 231-Z, 234-5Z and 291-Z Buildings. The single-shell tanks of the 241-U Tank Farm have received wastes from many different 200 Area facilities. Direct air emissions from stacks, and windblown dust may also have moved contaminants from adjacent aggregate areas into the U Plant Aggregate Area.

The Powerhouse Pond is located on the northern boundary of the U Plant Aggregate Area. However, it was mistakenly included in the T Plant Aggregate Area.

Some wastes that were generated in the U Plant Aggregate Area were sent outside of the area for disposal. These include uranium recovery process wastes that were sent to 216-B Crib complex, and various types of solid wastes that were sent away for burial at the 200 West Burial Grounds.

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2.6 INTERACTION WITH RESOURCE CONSERVATION RECOVERY ACT PROGRAM

Appendixes B and C of the Tri-Party Agreement (Ecology et al. 1990) list RCRA TSD facilities on the Hanford Site which have entered interim status and, thus, will require final permitting or closure. Within the geographical extent of the U Plant Aggregate Area there are three facilities which fall into this category: the 216-U-12 Crib, the 2727-WA SRE Sodium Storage Building, and the 241-U Tank Farm.

The 216-U-12 Crib was identified as a RCRA TSD facility because of the disposal of corrosive ($\text{pH} < 1$) UO_3 process condensate wastes after November 1980. The crib is not active and is planned to be closed. The Closure Plan/Post-Closure Plan is scheduled for submittal by November 1994 (Table D-18 of the Tri-Party Agreement).

The 2727-WA SRE Sodium Storage Building is a prefabricated metal storage shed. A petition has been made to withdraw the Part A Application for this facility. By definition in the Tri-Party Agreement, there are no RCRA past practice units in the U Plant Aggregate Area.

The single-shell tanks will be closed under RCRA rather than seeking a RCRA operating permit. The preferred closure option will be resolved through the preparation and completion of a supplemental environmental impact statement. The sixteen tanks in the 200-UP-3 Operable Unit are grouped with other Hanford Site single-shell tanks into RCRA TSD facility group S-2-4. Tri-Party Agreement milestone M-08-01 requires submission of tank farm selection criteria, closure methods, tank farm selection rationale, and recommended tank farm selection to Ecology for approval in January 1999. Milestone M-08-03 requires submission of tank farm closure plans to Ecology for approval by December 2003. Closure of all 149 single-shell tanks, including the tanks in the U Plant Aggregate Area is scheduled to be completed by June 2018, according to Tri-Party Agreement milestone M-09-00.

2.7 INTERACTIONS WITH OTHER HANFORD PROGRAMS

In addition to RCRA, there are several other ongoing programs that affect buildings and waste management units in the U Plant Aggregate Area. These programs are the Environmental Restoration Program and the Waste Management Program. The Environmental Restoration Program is responsible for the Decommissioning and RCRA Closure Program, the Radiation Area Remedial Action Program, and Single-Shell Tank Closure Program.

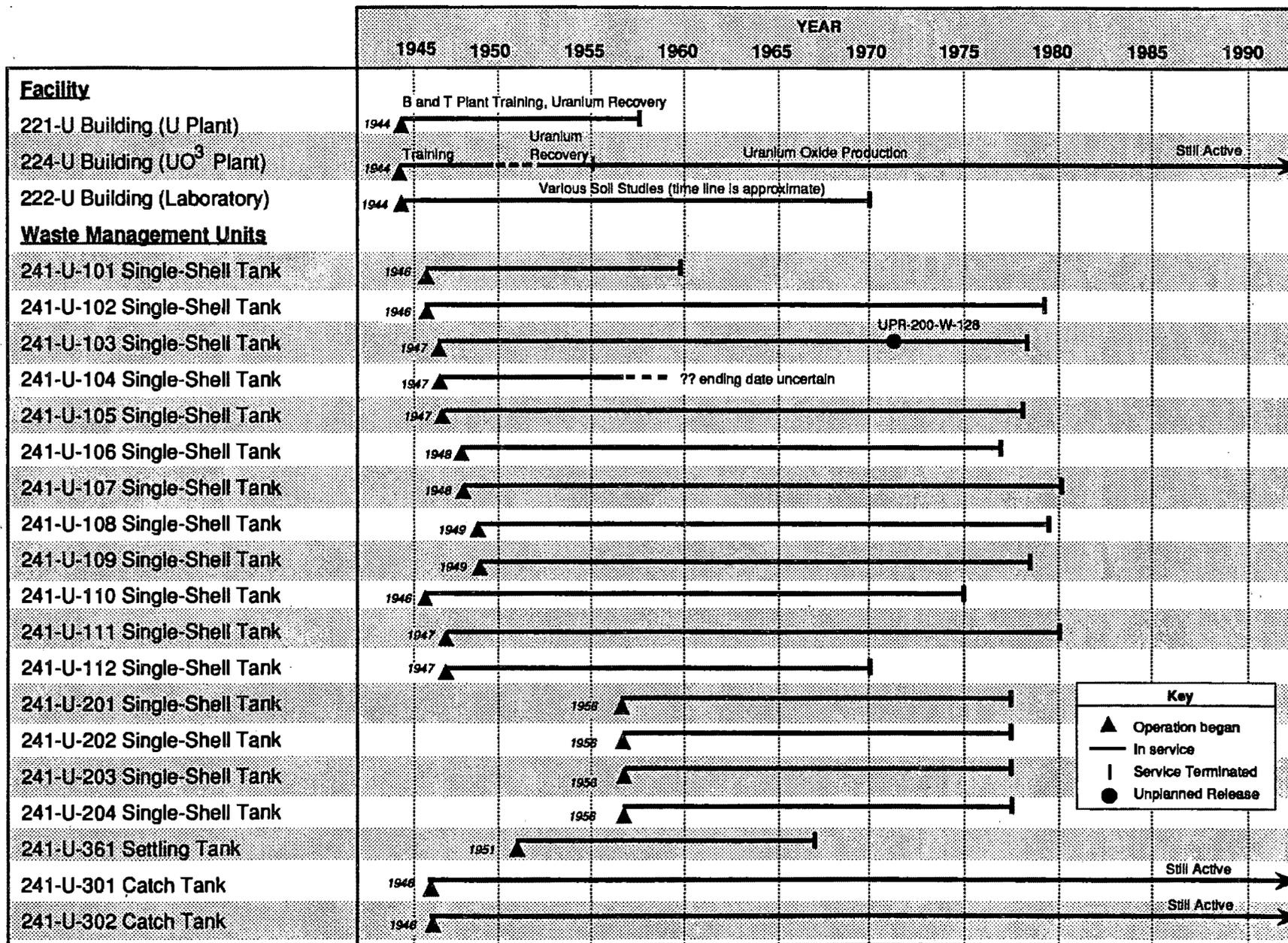
The Decommissioning and RCRA Closure Program is responsible for the safe and cost-effective surveillance, maintenance, and decommissioning of surplus facilities at the Hanford Site. All of the major inactive buildings within the U Plant Aggregate Area are covered

under this program. These facilities include the 221-U Building, the 222-U Laboratory and the 241-WR Vault. This program is also responsible for managing the RCRA closure activities. It establishes the cost, schedule, and technical baselines for individual projects and provides the program management for completing the work. The work activities relative to projects are completed by various functional organizations through a matrix management system. Performing organizations are assigned work by the program office using cost account authorizations and cost account plans. Project status is reported to the program office using an earned-value system. The majority of decommissioning and RCRA closure field work at the Hanford Site is performed by Hanford Restoration Operations (Winship and Hughes 1991).

The Radiation Area Remedial Action (RARA) Program is responsible for the surveillance, maintenance, decontamination, and/or interim stabilization of inactive burial grounds, cribs, ponds, trenches and unplanned releases at the Hanford Site. A major concern associated with these requirements is the management and control of surface soil contamination. All of the controlled access surface radiation zones and the cribs with collapse potential in the U Plant Aggregate Area are covered by this program.

The Single-Shell Tank Closure Program covers near-term waste management activities to ensure safe interim storage of waste in the tanks. It also addresses the environmental restoration activities to close the 6 single-shell tank operable units, including the 241-U Tank Farm. The primary regulatory drivers of this program are the Tri-Party Agreement and RCRA.

The Waste Management Program is responsible for all actively operating waste management units in the U Plant Aggregate Area. These facilities include the 244-U Receiver Tank, the 216-U-17 Crib, the 216-Z-20 Crib, the 216-U-14 Ditch, the 207-U Retention Basin, and all high-level waste process lines and their associated diversion boxes and catch tanks.



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DOE/RI-91-52, Rev. 0

Figure 2-1. U Plant Aggregate Area Timeline.

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DOE/RL-91-52, Rev. 0

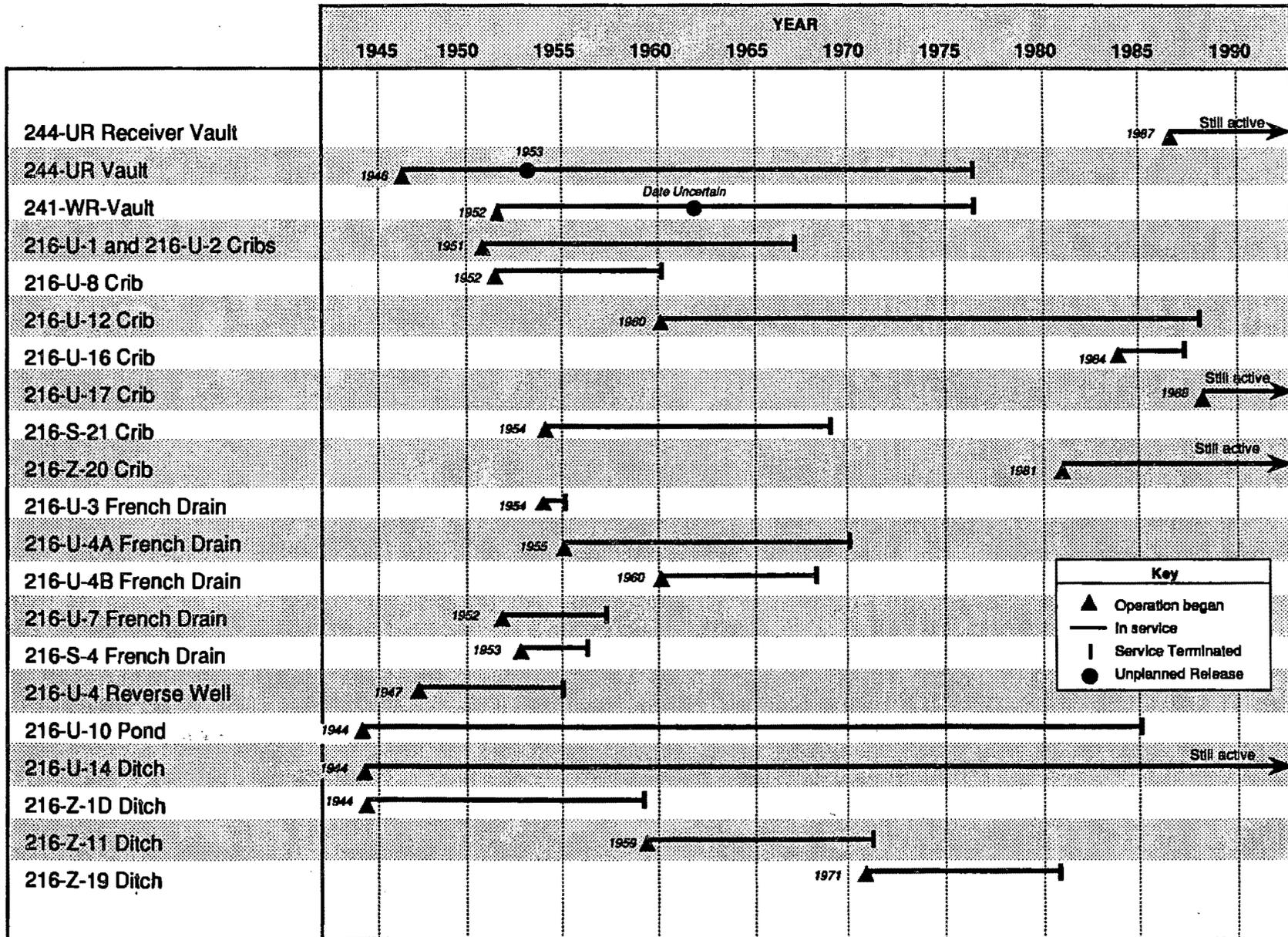


Figure 2-1. U Plant Aggregate Area Timeline (continued).

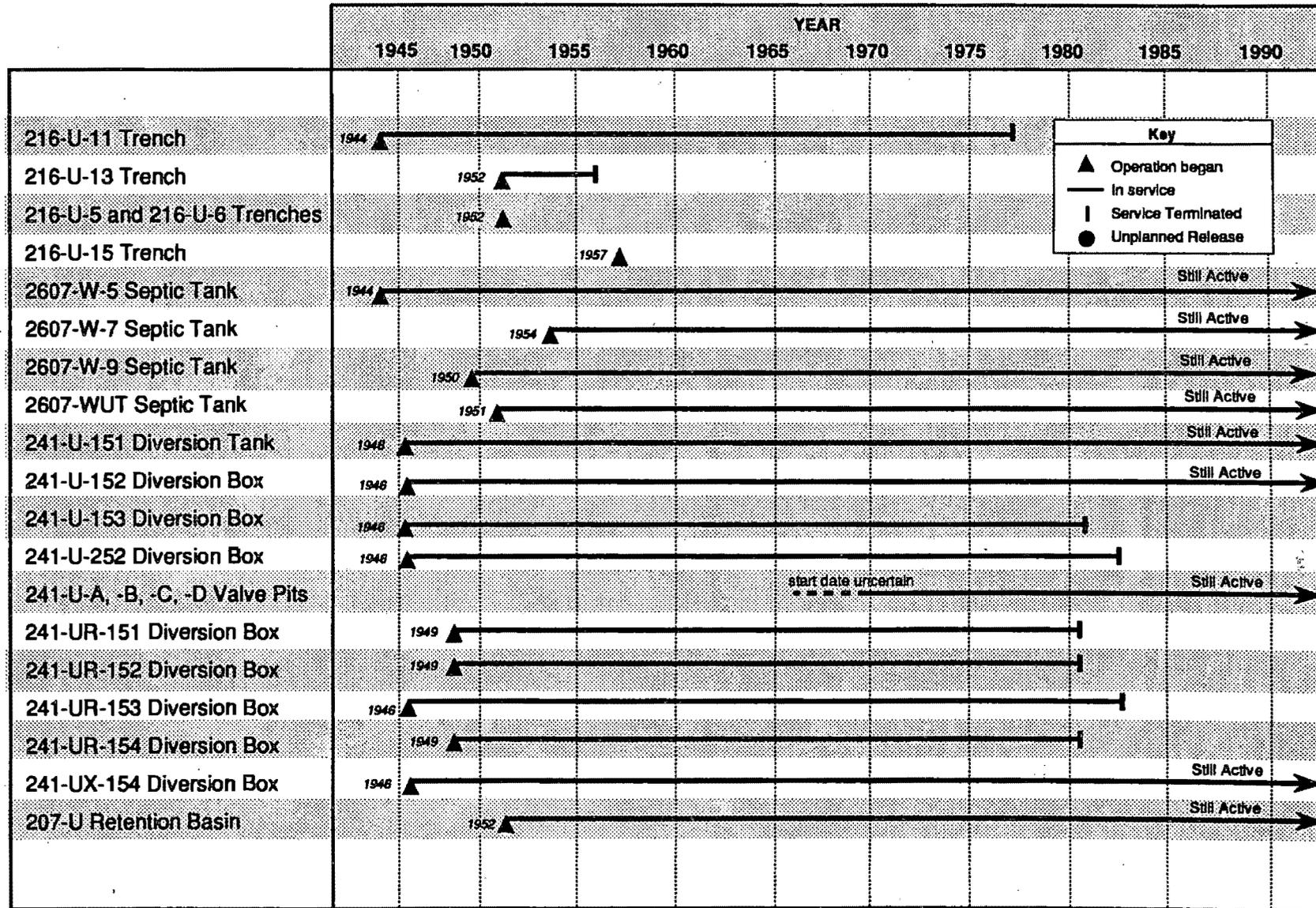


Figure 2-1. U Plant Aggregate Area Timeline (continued).

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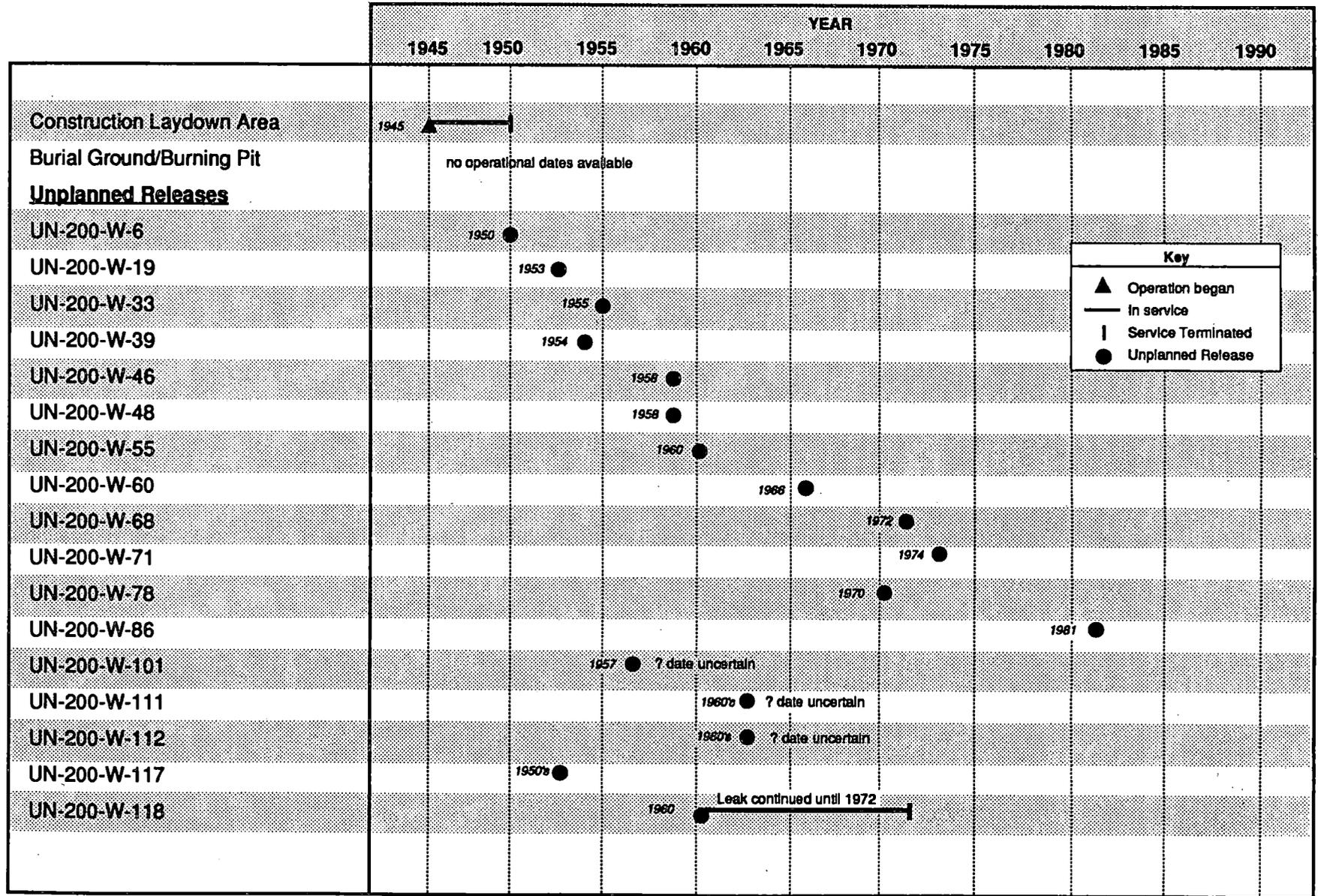
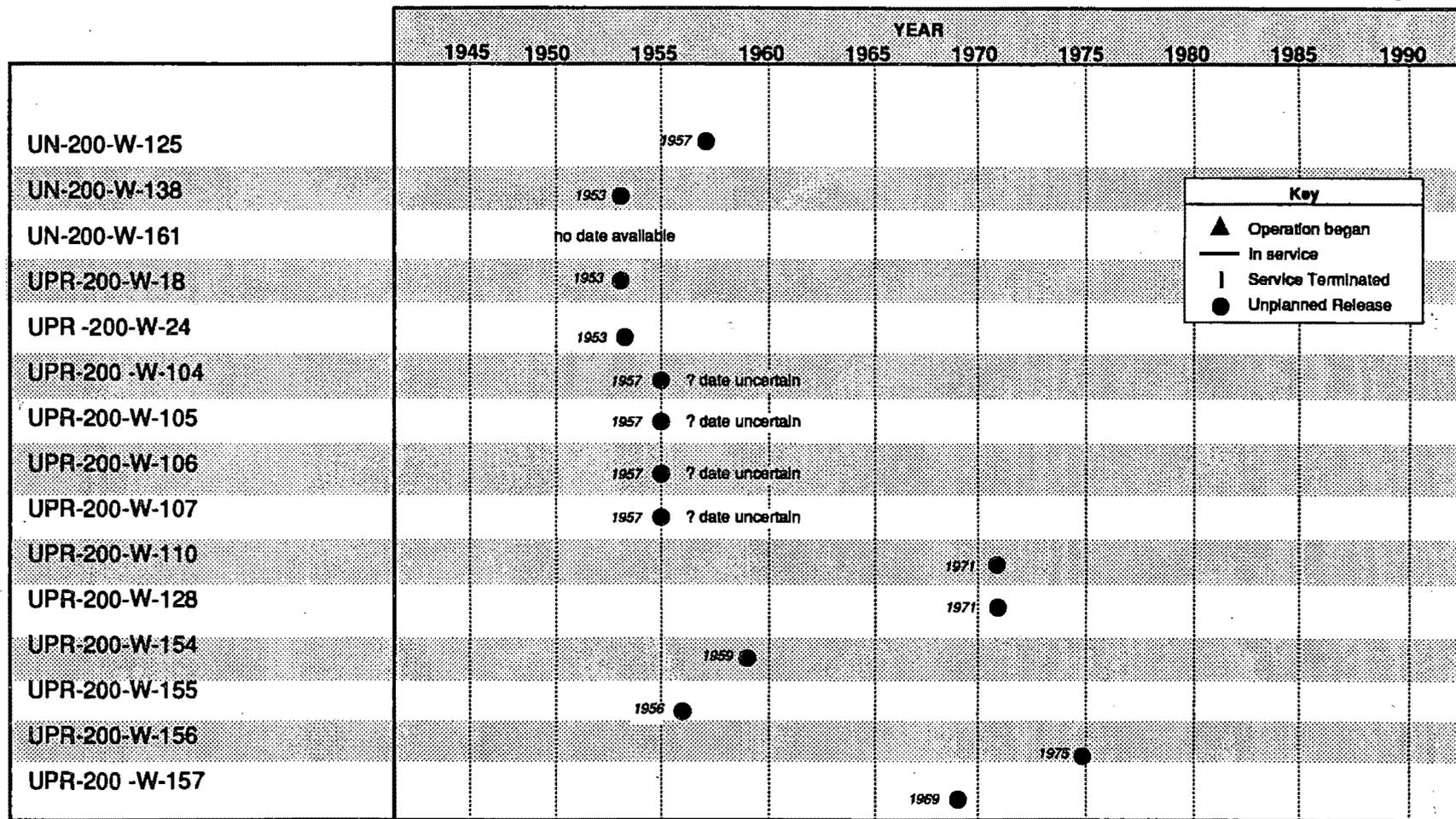


Figure 2-1. U Plant Aggregate Area Timeline (continued).

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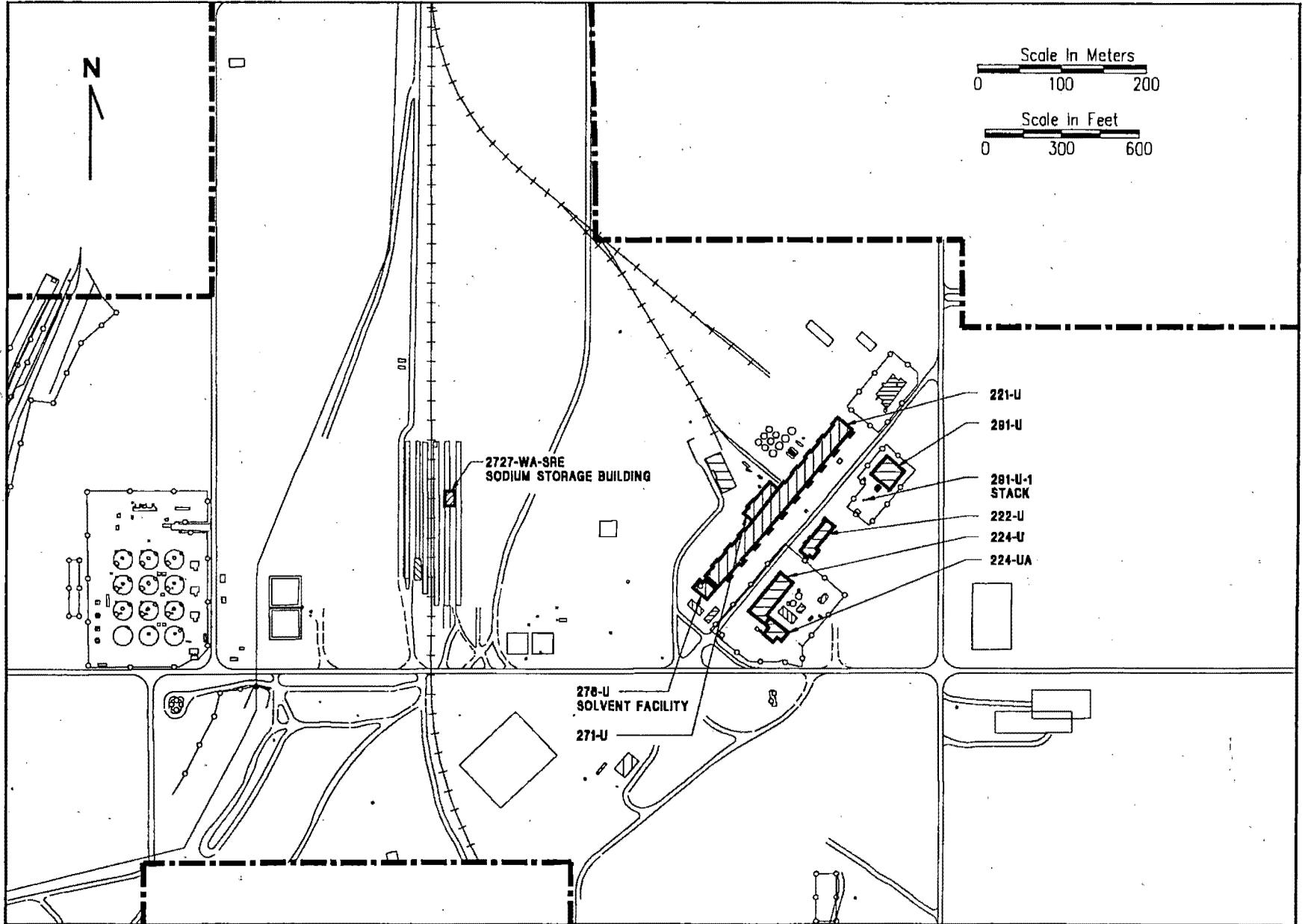


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DOE/RL-91-52, Rev. 0

Figure 2-1. U Plant Aggregate Area Timeline (continued).

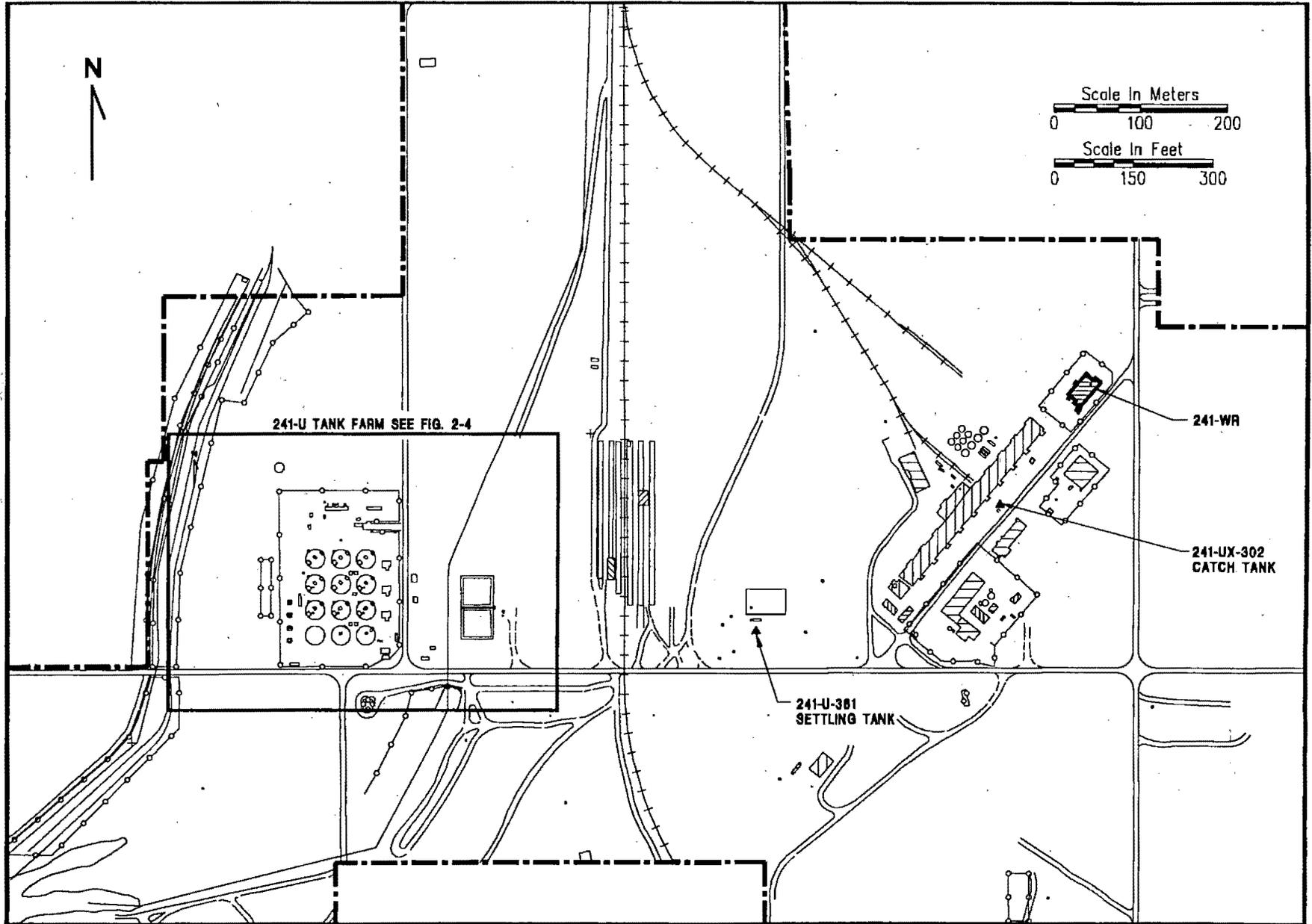
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Figure 2-2. Location of Plants, Buildings, and Storage Areas.

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Figure 2-3. Location of Tanks and Vaults.

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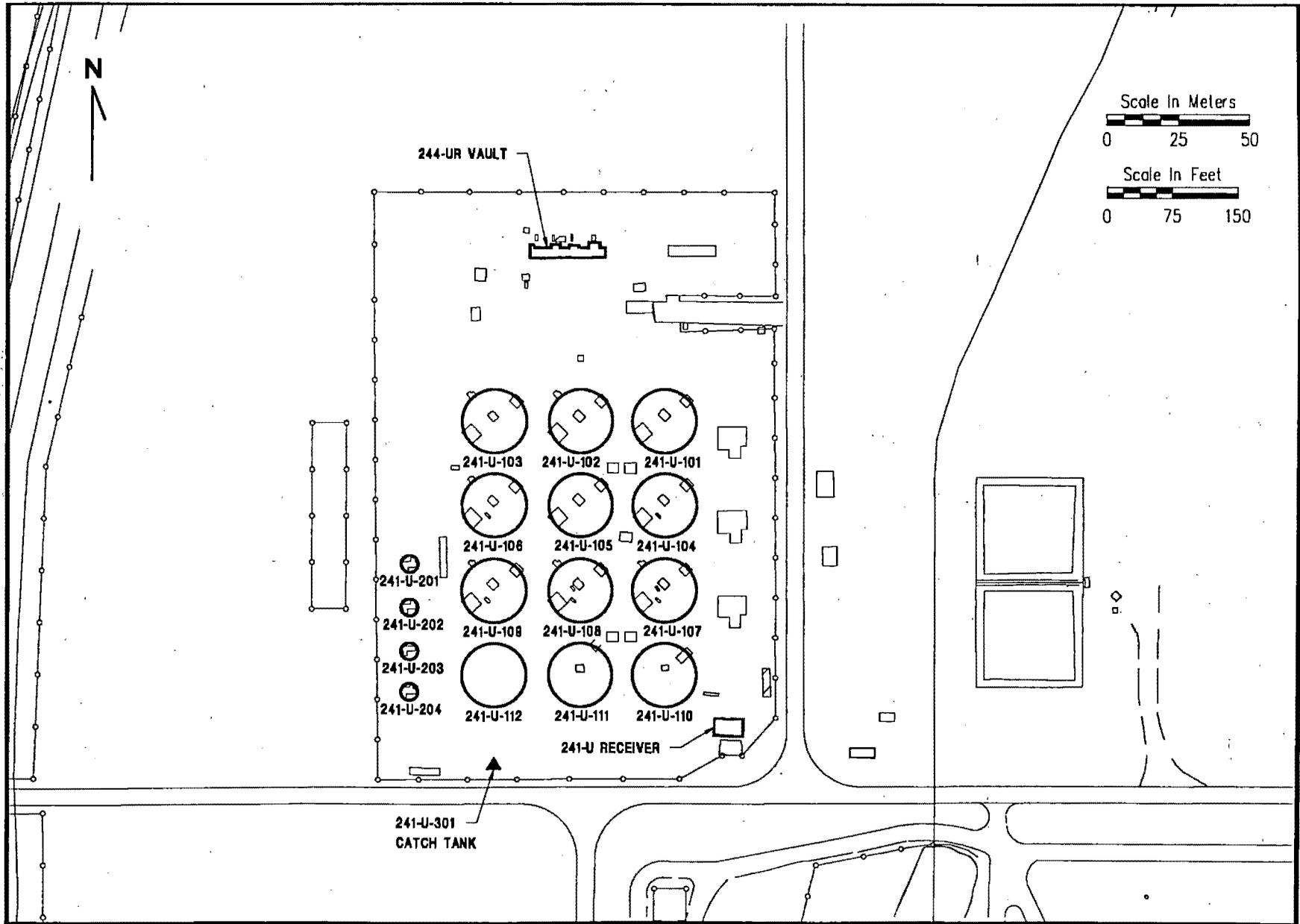
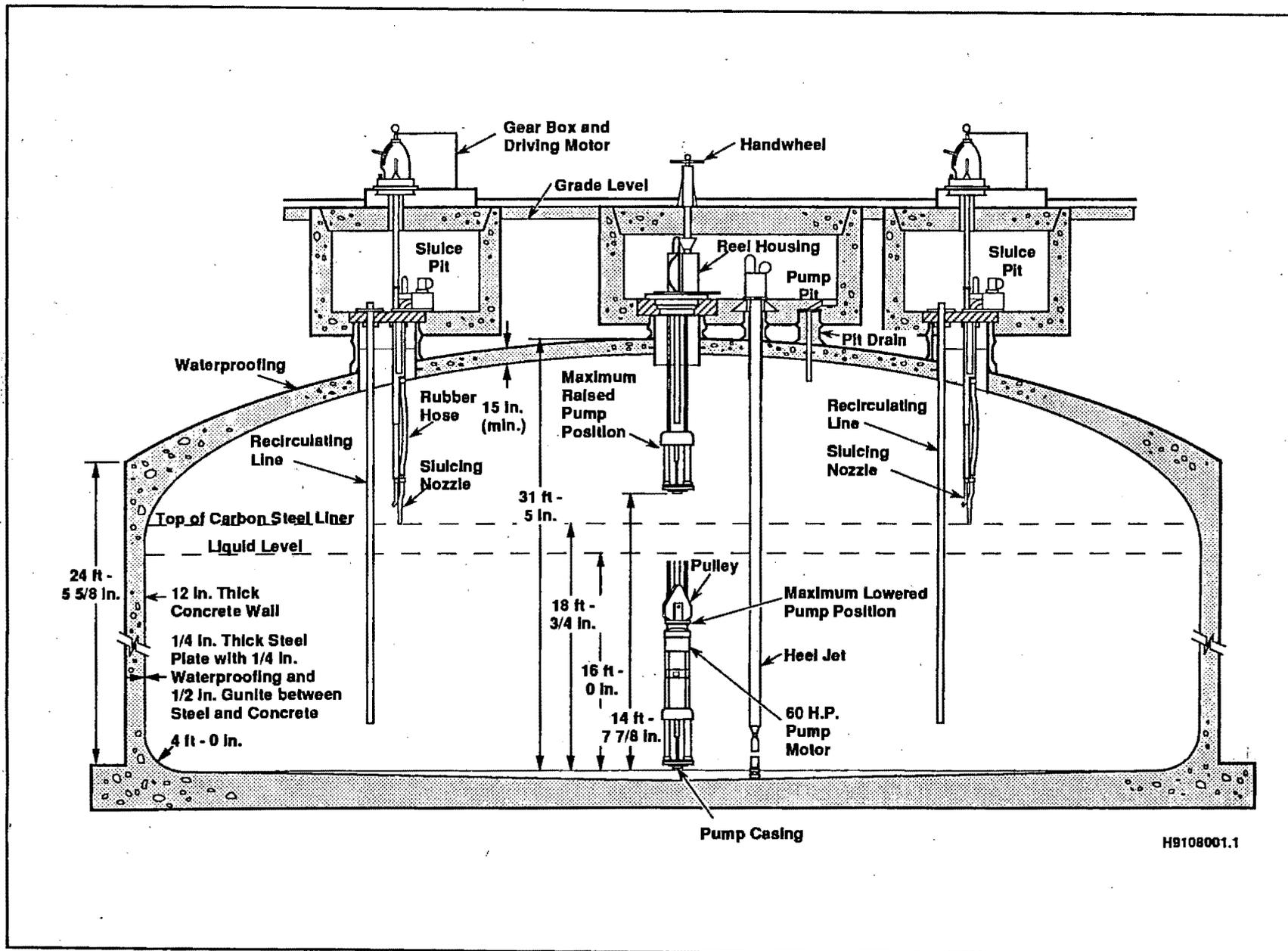


Figure 2-4. Location of 241-U Tank Farm.

2F-5

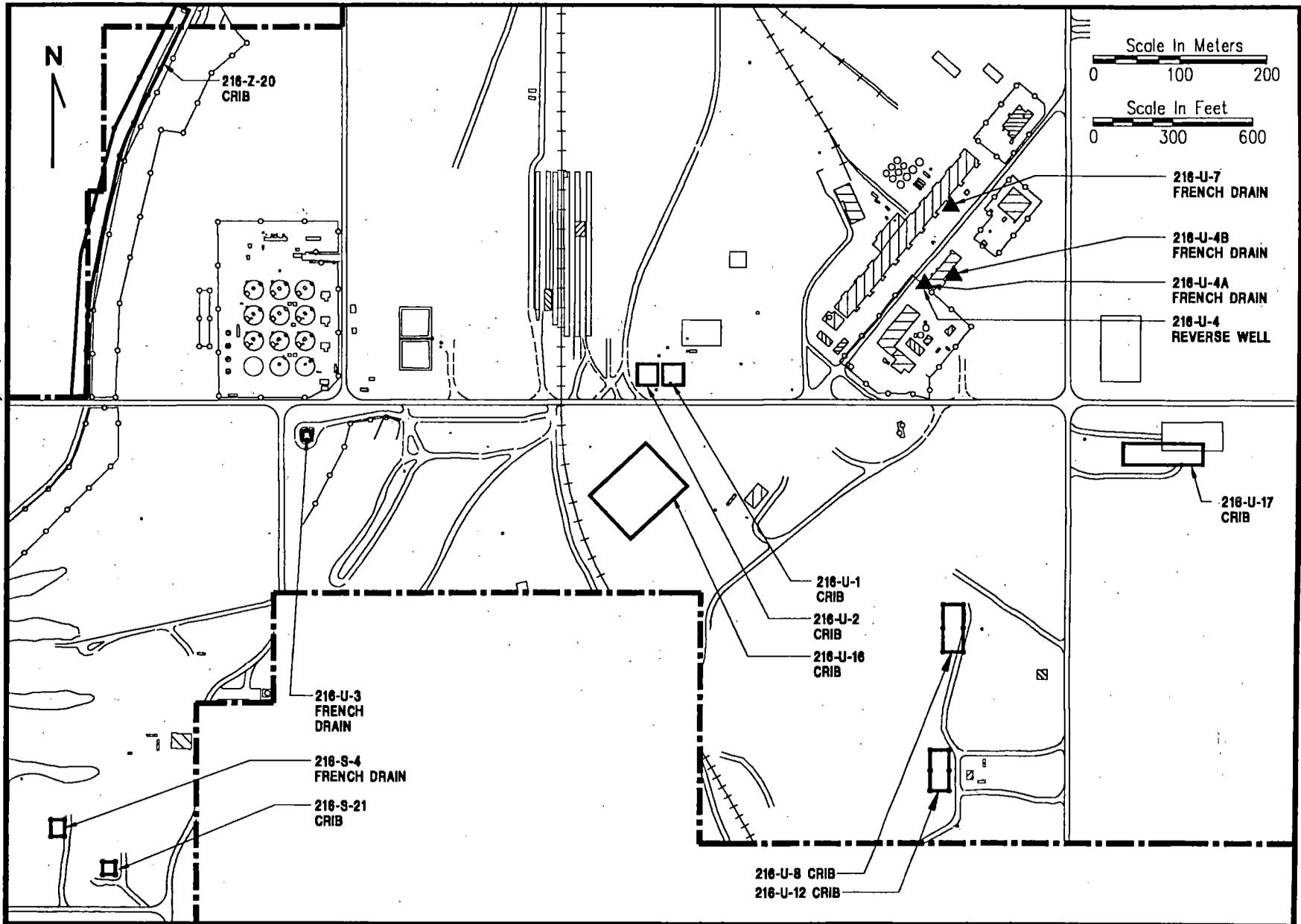


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Figure 2-5. Typical Tank.

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Figure 2-6. Location of Cribs, Drains, and Reverse Well.

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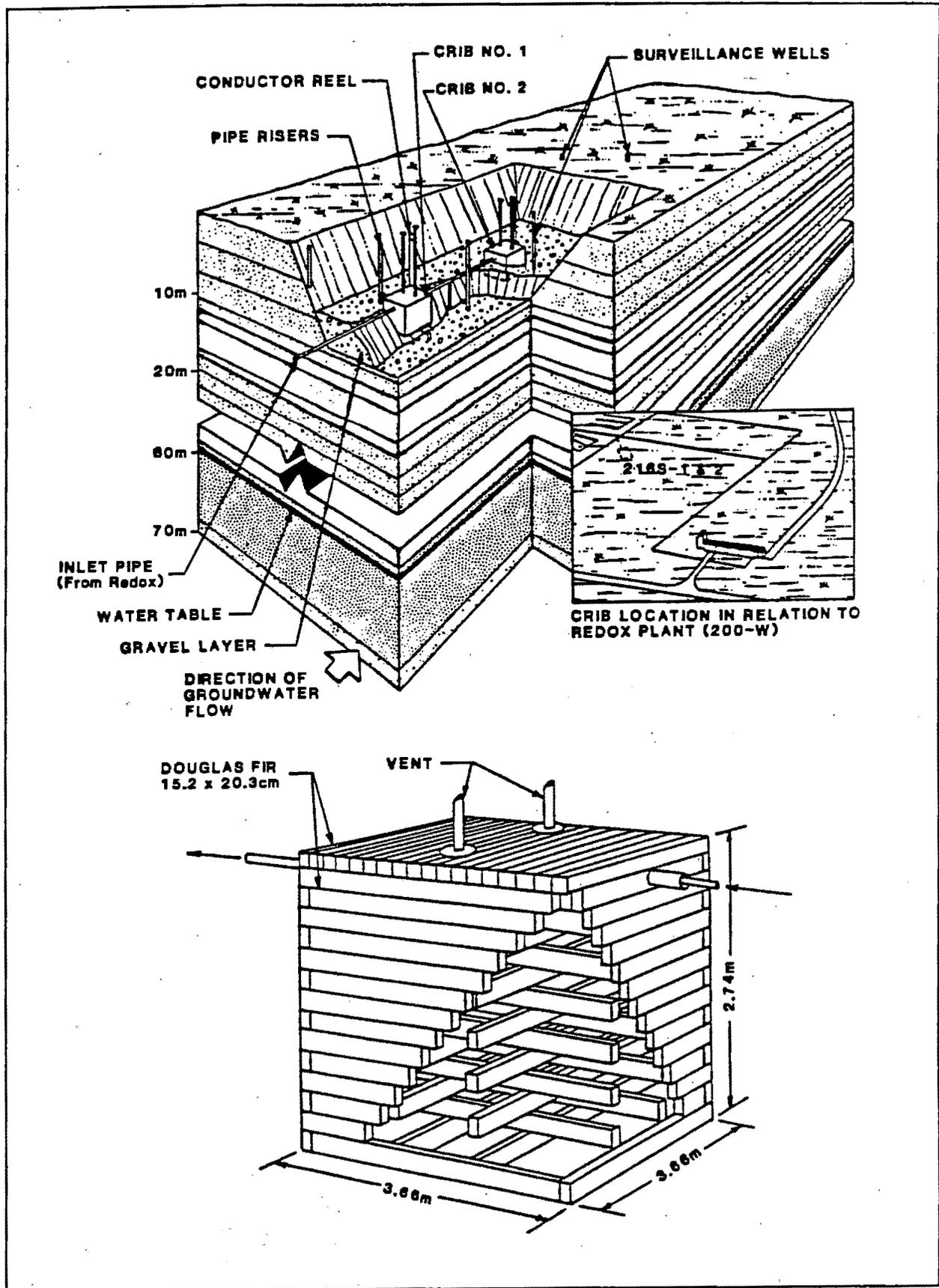


Figure 2-7. Typical Crib.

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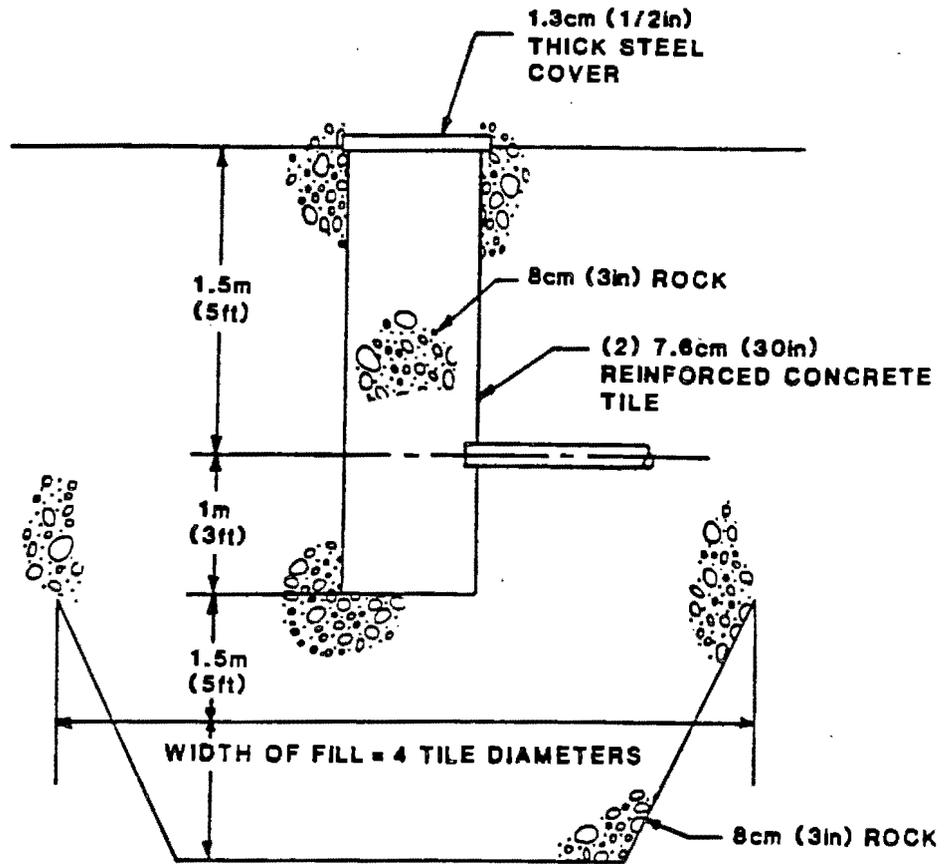
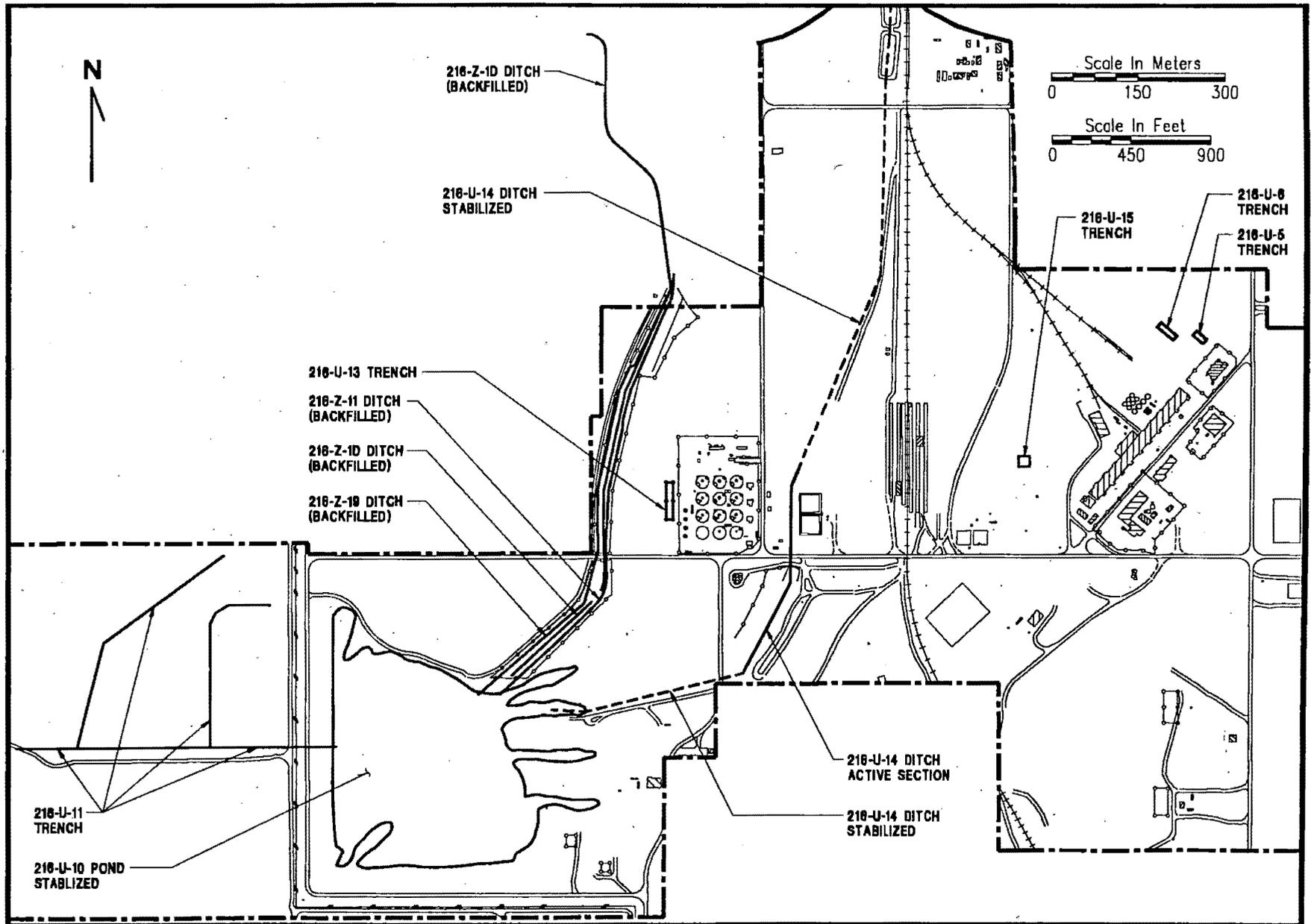


Figure 2-8. Typical French Drain.



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Figure 2-9. Locations of Ditches and Trenches.

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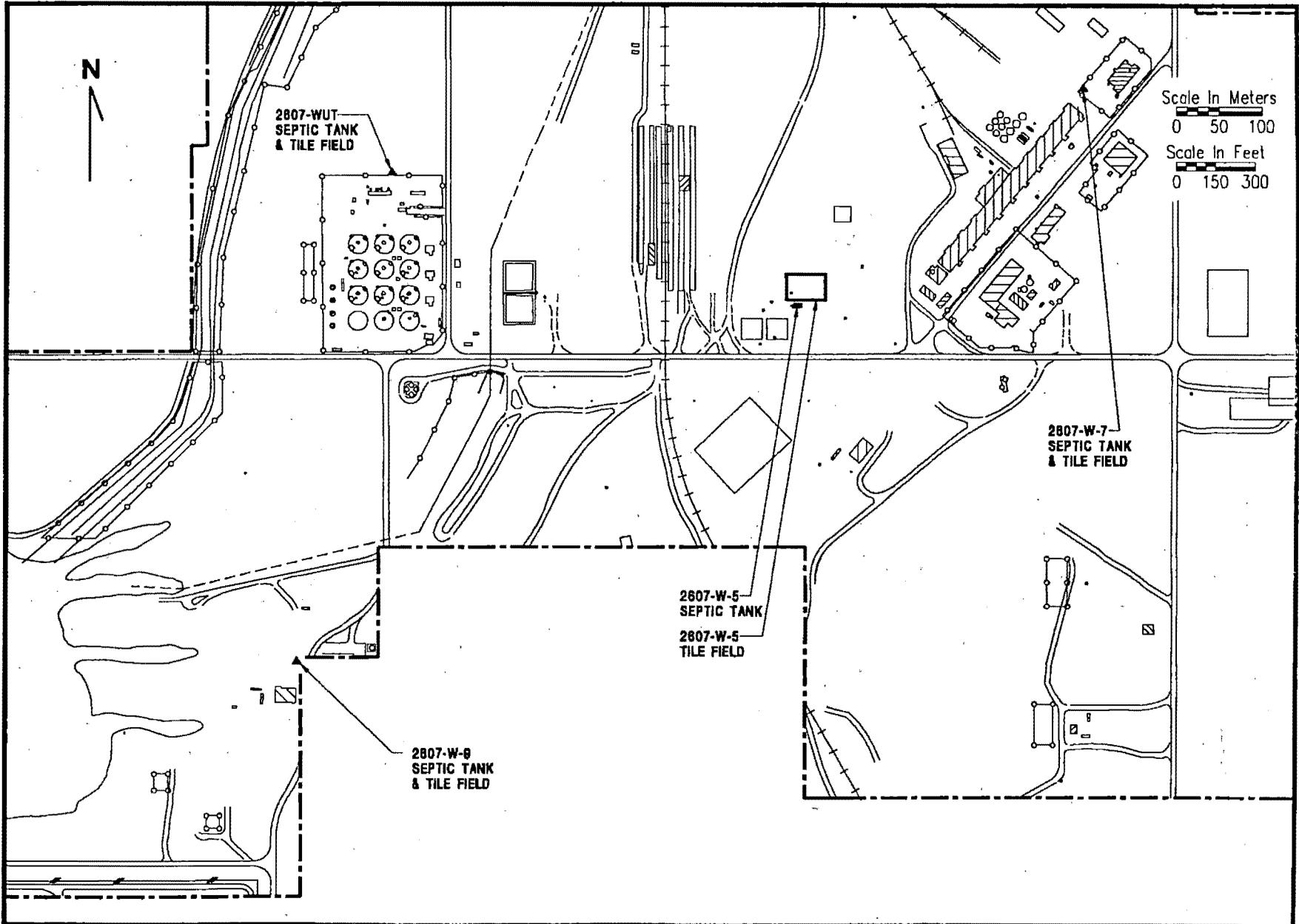


Figure 2-10. Location of Septic Tanks and Associated Drain Fields.

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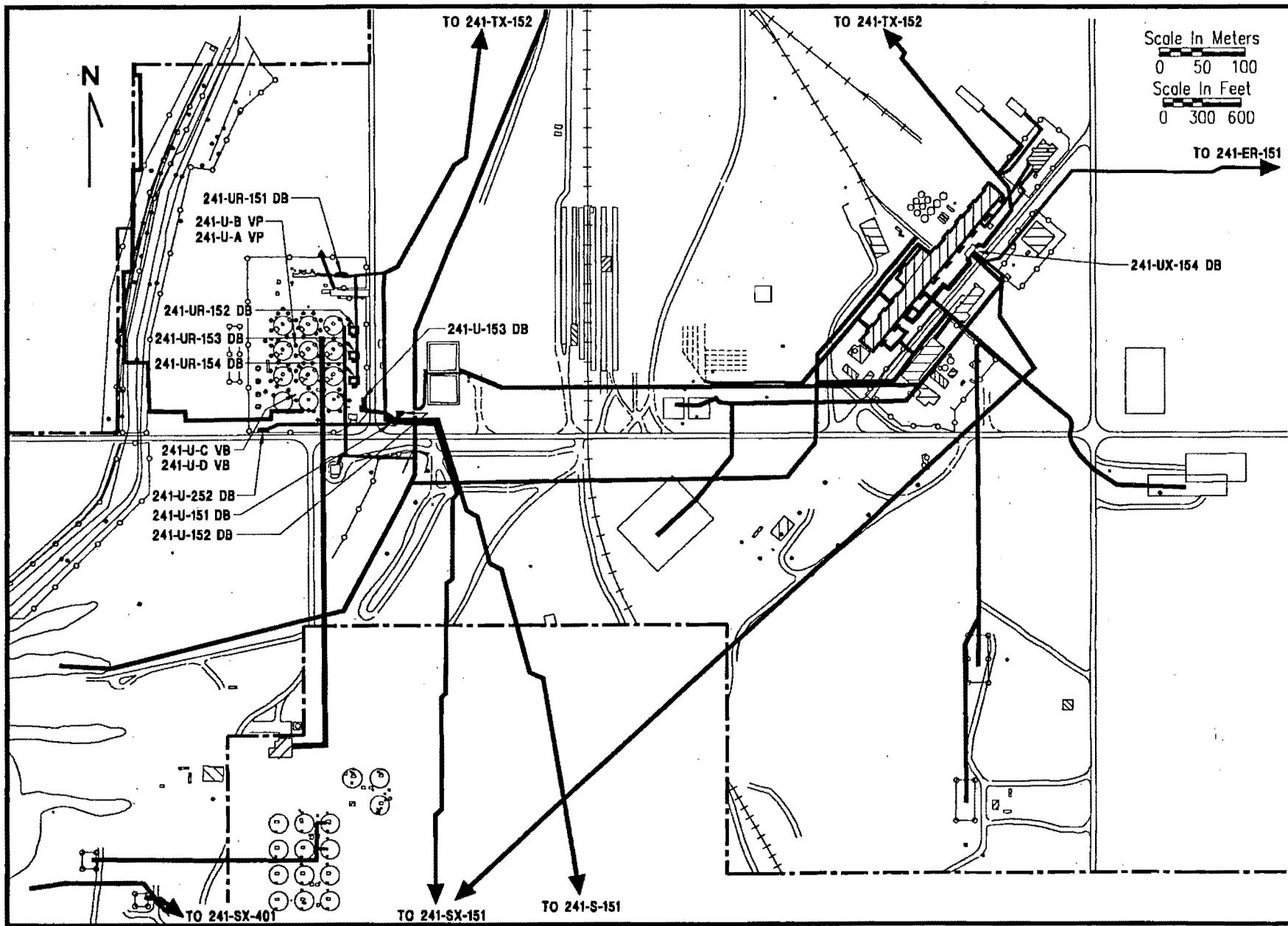
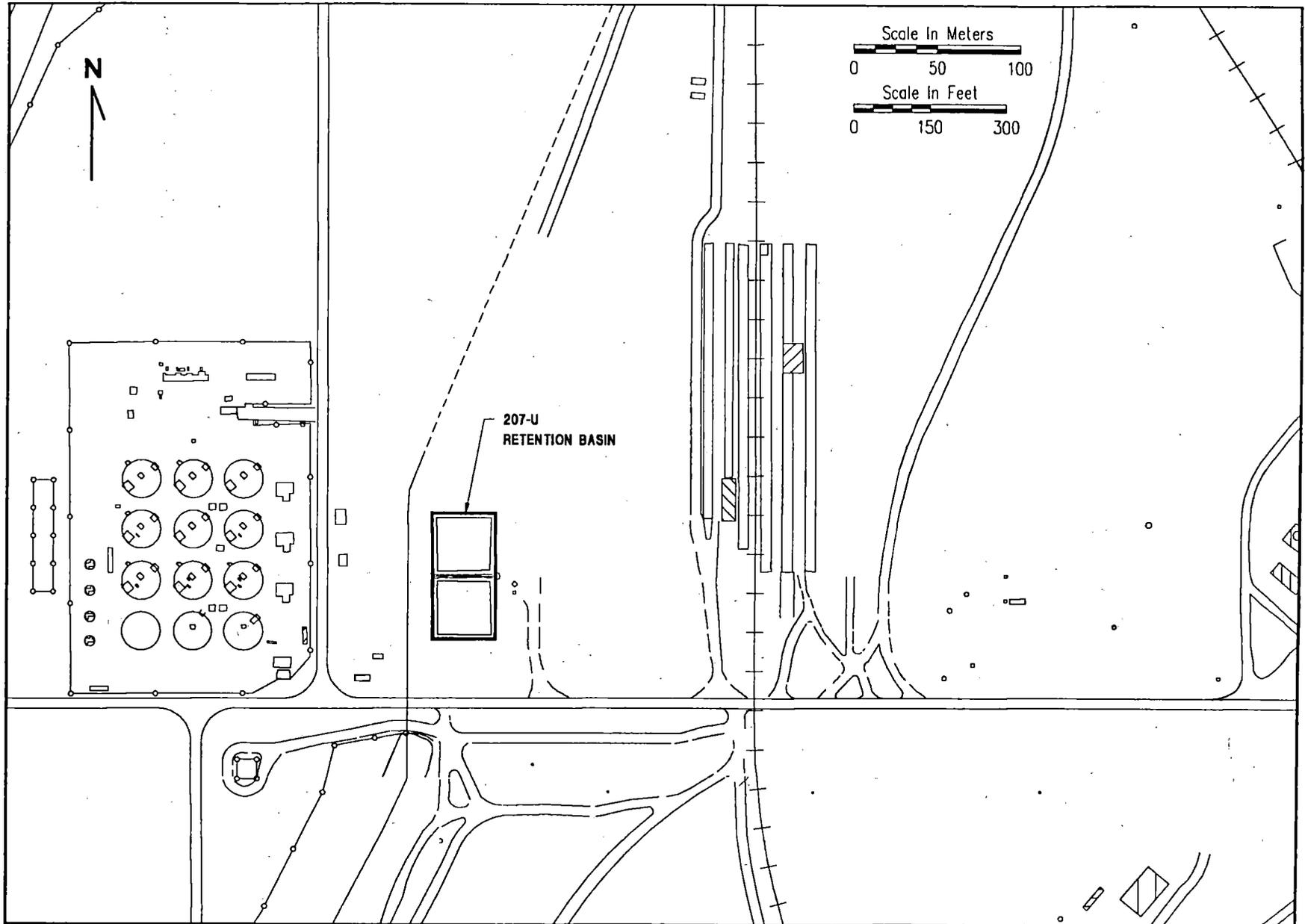


Figure 2-11. Location of Transfer Facilities, Diversion Boxes, and Pipelines.

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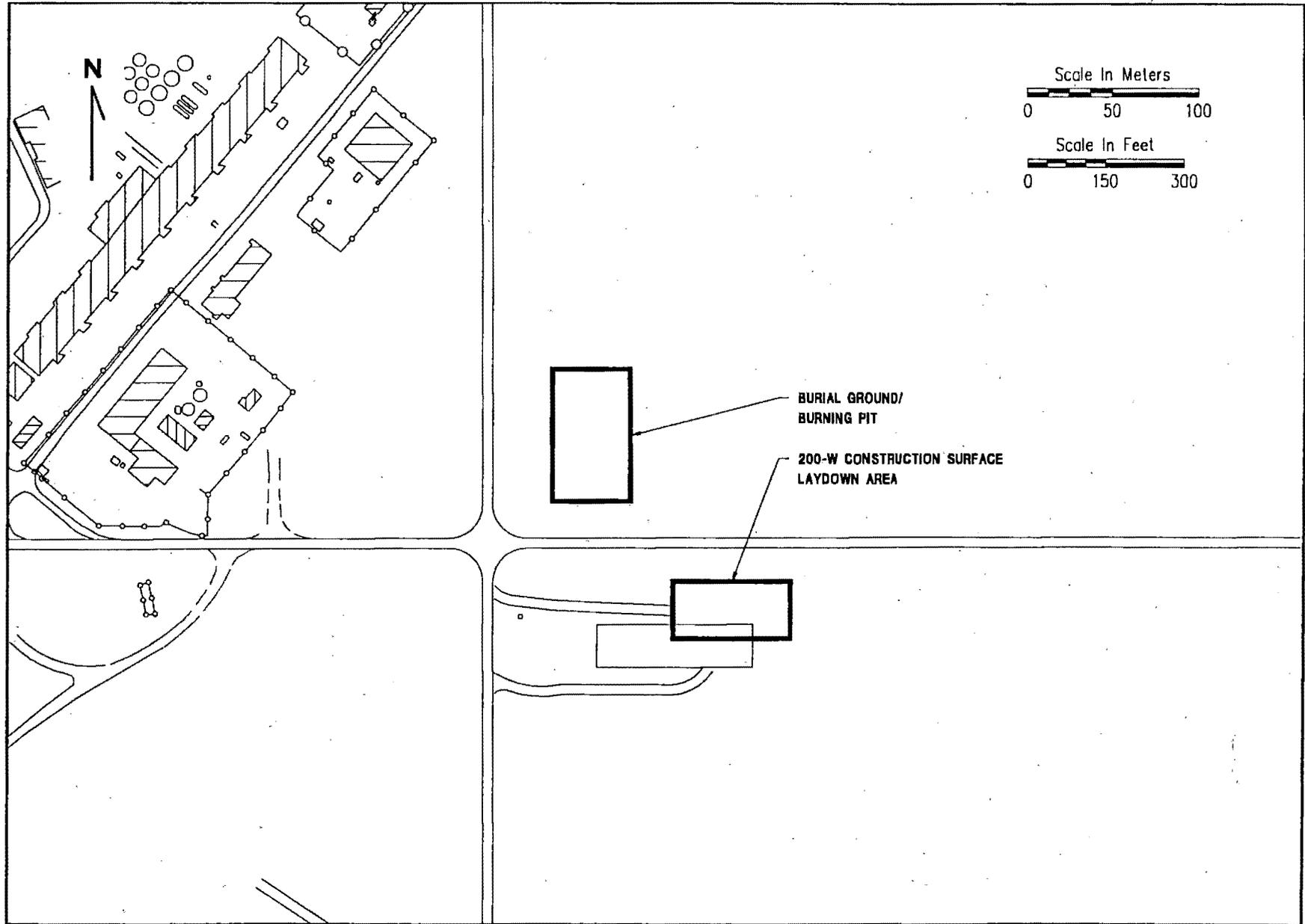
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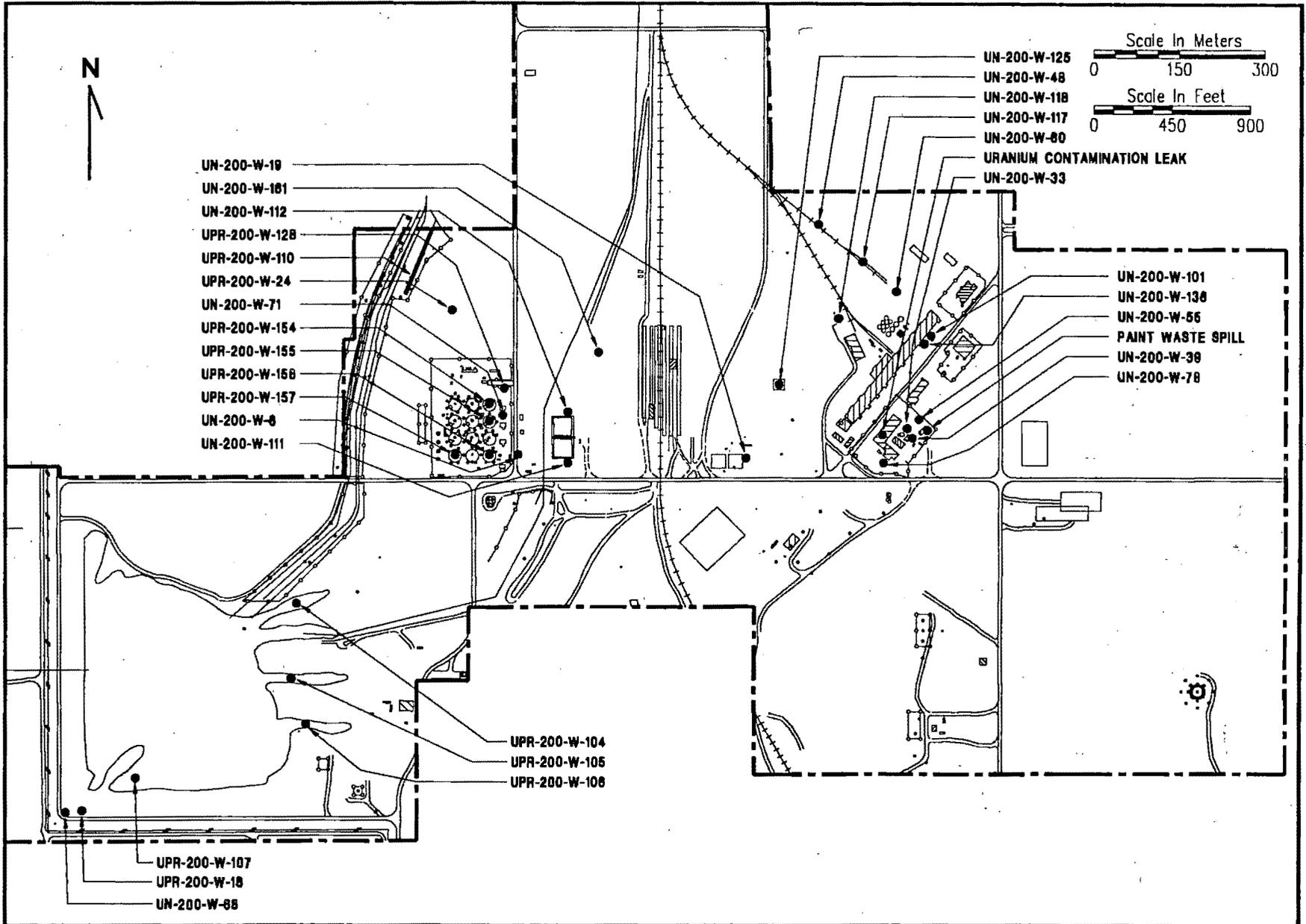
Figure 2-12. Location of Basins.

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Figure 2-13. Location of Burial Sites.



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Figure 2-14. Location of Unplanned Releases.

Table 2-1. Summary of Waste Management Units.^{a/}

Waste Management Unit	Source Description/Type	Waste Volume Received (L)	Contaminated Soil Volume (m ³)	Operable Unit
Tanks and Vaults				
241-U-101 Single-Shell Tank	BiPO ₄ metal waste, REDOX high-level waste, fuel elements, shroud tubes, and samarium balls/HLW	95,000 ^{b/}	NR	200-UP-3
241-U-102 Single-Shell Tank	BiPO ₄ metal waste, 242-T evaporator waste, HNO ₄ /KMnO ₄ solution, REDOX high-level waste/HLW	1,416,000 ^{b/}	NA	200-UP-3
241-U-103 Single-Shell Tank	BiPO ₄ metal waste, 242-T evaporator waste, HNO ₄ /KMnO ₄ solution, REDOX high-level waste/HLW	1,771,000 ^{b/}	NA	200-UP-3
241-U-104 Single-Shell Tank	BiPO ₄ metal waste/HLW	462,000 ^{b/}	NR	200-UP-3
241-U-105 Single-Shell Tank	BiPO ₄ metal waste, 242-T evaporator waste and coating waste from 241-U Tank Farm/HLW	1,582,000 ^{a/}	NA	200-UP-3
241-U-106 Single-Shell Tank	BiPO ₄ metal waste, REDOX high-level waste, PUREX and B Plant low-level waste/HLW	855,000 ^{b/}	NA	200-UP-3
241-U-107 Single-Shell Tank	BiPO ₄ metal waste, HNO ₄ /KMnO ₄ solution, N Reactor and PNL waste, coating, lab and REDOX waste/HLW	1,537,000 ^{b/}	NA	200-UP-3

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Table 2-1. Summary of Waste Management Units.^{a/}

Waste Management Unit	Source Description/Type	Waste Volume Received (L)	Contaminated Soil Volume (m ³)	Operable Unit
241-U-108 Single-Shell Tank	BiPO ₄ metal waste, REDOX coating waste, N Reactor, decon. lab, PNL waste, evaporator bottoms/HLW	1,771,000 ^{b/}	NA	200-UP-3
241-U-109 Single-Shell Tank	BiPO ₄ metal waste, REDOX high-level waste, coating waste, and evaporator bottoms/HLW	1,752,000 ^{b/}	NA	200-UP-3
241-U-110 Single-Shell Tank	BiPO ₄ metal waste, REDOX coating and high-level waste, lab waste and PNL waste/HLW	704,000 ^{b/}	NR	200-UP-3
241-U-111 Single-Shell Tank	BiPO ₄ first cycle waste, REDOX high level waste, HNO ₄ /KMnO ₄ ; N Reactor, PNL, decon. waste/HLW	1,245,000 ^{b/}	NA	200-UP-3
241-U-112 Single-Shell Tank	BiPO ₄ first-cycle waste, REDOX high-level waste from 241-U Tank Farm/HLW	185,000 ^{b/}	NR	200-UP-3
241-U-201 Single-Shell Tank	REDOX high-level wastes from 241-U Tank Farm/HLW	19,000 ^{b/}	NA	200-UP-3
241-U-202 Single-Shell Tank	REDOX high-level wastes from 241-U Tank Farm/HLW	19,000 ^{b/}	NA	200-UP-3
241-U-203 Single-Shell Tank	REDOX high-level wastes from 241-U Tank Farm/HLW	12,000 ^{b/}	NA	200-UP-3

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Table 2-1. Summary of Waste Management Units.^{a/}

Waste Management Unit	Source Description/Type	Waste Volume Received (L)	Contaminated Soil Volume (m ³)	Operable Unit
241-U-204 Single-Shell Tank	REDOX high-level wastes from 241-U Tank Farm/HLW	12,000 ^{b/}	NA	200-UP-3
241-U-301 Catch Tank	Processing and decon. wastes/HLW	18,500 ^{b/}	NA	200-UP-3
241-U-302 Catch Tank	Processing and decon. wastes/HLW	26,500 ^{b/}	NA	200-UP-3
241-U-361 Settling Tank	Radioactive liquid, plutonium sludge/HLW	104,000 ^{b/}	NA	200-UP-2
244-U Receiver Tank	Processing and decon. wastes/HLW	NA	NA	200-UP-2
241-WR Vault	Contains radioactive equipment and structure/HLW	NA	NA	200-UP-2
244-UR Vault	Contains radioactive tank and concrete surfaces and asbestos/HLW	NA	NA	200-UP-3
Cribs and Drains				
216-S-21 Crib	Received 241-SX Tank Farm condensate/LLW	87,100,000	1,100	200-UP-1
216-U-1/216-U-2 Cribs	Various wastes from 221-U and 224-U Buildings/LLW	46,200,000	220	200-UP-2

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Table 2-1. Summary of Waste Management Units.^{a/}

Waste Management Unit	Source Description/Type	Waste Volume Received (L)	Contaminated Soil Volume (m ³)	Operable Unit
216-U-8 Crib	Process condensate from 221-U and 224-U Buildings and 291-U Stack drainage/LLW	379,000,000	3,900	200-UP-2
216-U-12 Crib	Stack drainage, vault waste, process condensate/LLW	150,000,000	2,200	200-UP-2
216-U-16 Crib	224-U Building steam condensate, chemical sewer waste, cooling water/LLW	409,000,000	NR	200-UP-2
216-U-17 Crib	UO ₃ Plant process condensate/LLW	2,110,000	NR	200-UP-2
216-Z-20 Crib	Cooling water, steam condensate, storm sewer, chemical drains/LLW	3,800,000,000	2,400	200-UP-1
216-S-4 French Drain	Condensate and cooling waste from 241-S-101 and 241-S-104 Single-Shell Tanks/LLW	1,000,000	NR	200-UP-1
216-U-3 French Drain	Condensed vapors from 110-U/LLW	791,000	10	200-UP-2
216-U-4A French Drain	Decon. waste from 222-U Laboratory and PNL operations decon. waste/LLW	545,000	4.4	200-UP-2
216-U-4B French Drain	Waste from hot cell and hood in 222-U Laboratory, PNL operation wastes from hot cell and hood/LLW	33,000	0.68	200-UP-2
216-U-7 French Drain	Counting Box floor drainage/LLW	7,000	NR	200-UP-2

Table 2-1. Summary of Waste Management Units.^{a/}

Waste Management Unit	Source Description/Type	Waste Volume Received (L)	Contaminated Soil Volume (m ³)	Operable Unit
Reverse Wells				
216-U-4 Reverse Well	Decon. waste from 221-U Laboratory/LLW	300,000	NR	200-UP-2
Ponds, Ditches, and Trenches				
216-U-10 Pond	Cooling water, waste water, steam condensate, laboratory wastes/LLW	165,000,000,000	190	200-UP-1
216-U-14 Ditch	Powerhouse wastewater, laundry wastewater, chemical sewer waste/LLW	Volume included with 216-U-10 Pond	4,900	200-UP-2
216-Z-1D Ditch	Process cooling water and steam condensate from several buildings/LLW	1,000,000	38	200-UP-1
216-Z-11 Ditch	Process cooling water and steam condensate, seal water/LLW	Volume included with U-Pond	550	200-UP-1
216-Z-19 Ditch	Process cooling water and steam condensate, seal water/LLW	Volume included with 216-U-10 Pond	73	200-UP-1
216-U-5 and 216-U-6 Trenches	Unirradiated uranium waste from cold start-up of U Plant/LLW	2,250,000 each	69	200-UP-2
216-U-11 Trench	Overflow from 216-U-10 Pond/LLW	Volume included with 216-U-10 Pond	3,400	200-UP-1
216-U-13 Trench	Drainage from equipment decon. processes within trenches/LLW	11,400	640	200-UP-1

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Table 2-1. Summary of Waste Management Units.^{a/}

Waste Management Unit	Source Description/Type	Waste Volume Received (L)	Contaminated Soil Volume (m ³)	Operable Unit
216-U-15 Trench	Interface crud, activated charcoal diatomaceous earth/LLW	68,100	54	200-UP-2
Septic Tanks and Associated Drain Fields				
2607-W-5 Septic Tank/Drain Field	Sanitary wastewater and sewage/NRH	12,100/day	NA	200-UP-2
2607-W-7 Septic Tank/Drain Field	Sanitary wastewater and sewage/NRH	1,000/day	NA	200-UP-2
2607-W-9 Septic Tank/Drain Field	Sanitary wastewater and sewage/NRH	1,000/day	NA	200-UP-1
2607-WUT Septic Tank/Drain Field	Sanitary wastewater and sewage/NRH	1,020/day	NA	200-UP-3
Transfer Facilities, Diversion Boxes, and Pipelines				
241-U-A Valve Pit	Processing and decon. wastes/HLW	NA	NA	200-UP-3
241-U-B Valve Pit	Processing and decon. wastes/HLW	NA	NA	200-UP-3
241-U-C Valve Pit	Processing and decon. wastes/HLW	NA	NA	200-UP-3
241-U-D Valve Pit	Processing and decon. wastes/HLW	NA	NA	200-UP-3
241-U-151 Diversion Box	Processing and decon. wastes/HLW	NA	NA	200-UP-2

Table 2-1. Summary of Waste Management Units.^{a/}

Waste Management Unit	Source Description/Type	Waste Volume Received (L)	Contaminated Soil Volume (m ³)	Operable Unit
241-U-152 Diversion Box	Processing and decon. wastes/HLW	NA	NA	200-UP-2
241-U-153 Diversion Box	Processing and decon. wastes/HLW	NA	NA	200-UP-3
241-U-252 Diversion Box	Processing and decon. wastes/HLW	NA	NA	200-UP-3
241-UR-151 Diversion Box	Processing and decon wastes/HLW	NA	NA	200-UP-3
241-UR-152 Diversion Box	Processing and decon. wastes/HLW	NA	NA	200-UP-3
241-UR-153 Diversion Box	Processing and decon. wastes/HLW	NA	NA	200-UP-3
241-UR-154 Diversion Box	Processing and decon. wastes/HLW	NA	NA	200-UP-3
241-UX-154 Diversion Box	Processing and decon. wastes/HLW	NA	NA	200-UP-2
Basins				
207-U Retention Basin	Received steam condensate and cooling water from 224-U Building/LLW	NA	NA	200-UP-2

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Table 2-1. Summary of Waste Management Units.^{a/}

Waste Management Unit	Source Description/Type	Waste Volume Received (L)	Contaminated Soil Volume (m ³)	Operable Unit
Burial Sites				
Burial Ground/Burning Pit	Unsure, contaminated coveralls and soil discovered at the site/LLW	NA	NA	200-UP-2
200-W Construction Surface Laydown Area	Unusable valves, piping, and other pumping material/NRH	NA	NA	200-UP-2

^{a/} Data taken from WHC 1991a

^{b/} Waste volume remaining (Hanlon 1992)

NA - Not applicable

NR - No value reported

Waste Type: HLW - high-level waste
 TRU - transuranic waste
 LLW - low-level waste
 BYM - by-product material
 NRH - non-radiological, non-hazardous waste

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Table 2-2. Radionuclide Waste Inventory Summary. Page 1 of 3

Waste ^{b/} Management Unit No.	Quantity of Reported Radionuclides (CI) ^{d/}						
	Co-60	Sr-90	Cs-137	Pu ^{d/} Total	Pu-238	Pu-239	Pu-240
Cribs and Drains							
216-S-4							
216-U-21	0.3333 ^{cl}	21.80	85.50	2.080		0.119 ^{cl}	0.0320 ^{cl}
216-U-1 & 216-U-2	0.00157 ^{cl}	2.11	4.36	42.60		2.43 ^{cl}	0.656 ^{cl}
216-U-3	0.00157 ^{cl}	0.041	0.434	0.100		0.00571 ^{cl}	0.00154 ^{cl}
216-U-4A		0.0159	.185	0.0090		0.00051 ^{cl}	0.00013 ^{cl}
216-U-4B		.00165	0.197	0.0540		0.00308 ^{cl}	0.00083 ^{cl}
216-U-7							
216-U-8	0.00204 ^{cl}	0.0431	0.0455	370.0		21.8 ^{cl}	5.7 ^{cl}
216-U-12		55.90	0.0566	1.00		0.0123	
216-U-16		0.0092	0.0165			0.0902	
216-U-17						.00002960	
Reverse Well							
216-U-4							
Ponds, Ditches, and Trenches							
216-U-5 & 216-U-6	0.0006 ^{cl}	0.0195	0.0207	0.0500		0.00285 ^{cl}	0.00077 ^{cl}
216-U-10		11.00	11.00	8,000		0.7680	
216-U-11							
216-U-13 (same as UN-200-W- 125)	0.00179 ^{cl}	0.04200	0.04440	0.100		0.00571 ^{cl}	0.00154 ^{cl}
216-U-14							
216-U-15	0.00233 ^{cl}	0.0442	0.0465	0.100		0.00571 ^{cl}	0.00154 ^{cl}
216-Z-1D						137.0	37.00
216-Z-11						137.0	37.00
216-Z-19							
216-Z-20		.0630	.0864	0.1480	.01530	2.030	

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Table 2-2. Radionuclide Waste Inventory Summary.

Waste ^{b/} Management Unit No.								Reported Waste
	Pu-241	Ru-106	Total U	Am-241	H-3	Alpha	Beta	Volume Recorded (L)
Cribs and Drains								
216-S-4					0.02			1,000,000
216-U-21		.00000139	0.00140 ^{c/el}			0.128	208.0	87,100,000
216-U-1 & 216-U-2		.0000006	0.7020			2.62	12.6	46,200,000
216-U-3			0.00606 ^{c/}			0.00614	0.1917	791,000
216-U-4A		.00000012	0.00297 ^{c/}			.000553	0.387	545,000
216-U-4B						.00332	0.381	33,000
216-U-7								7,000
216-U-8		.00000001	8.04 ^{c/el}			22.700	0.650	379,000,000
216-U-12		.00000218	0.6770	0.00645	0.00188	.105	112.0	150,000,000
216-U-16			0.00592		0.233	0.00739	0.0515 0	409,000,000
216-U-17			0.000478	.000053	69.70	.000195		2,110,000
Reverse Well								
216-U-4								300,000
Ponds, Ditches, and Trenches								
216-U-5 & 216-U-6			0.122 ^{c/el}			.00307	0.0792	2,250,000
216-U-10		.0000278	1.880	0.4920	196.0	505.0	44.20	165,000,000,0 00
216-U-11								
216-U-13 (same as UN-200- W-125)			0.00012 ^{c/el}			0.00614	0.1760	11,400
216-U-14								
216-U-15			0.00076 ^{c/el}			.00614	0.180	68,100
216-Z-1D								1,000,000
216-Z-11								//
216-Z-19								

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Table 2-2. Radionuclide Waste Inventory Summary.

Waste ^{b/} Management Unit No.								Reported Waste
	Pu-241	Ru-106	Total U	Am-241	H-3	Alpha	Beta	Volume Recorded (L)
216-Z-20	2.510	.000107		1.010		2.220	0.4090	3,800,000,000
Uranium contamination leak			12,100 ^{e/}					

^{a/} Values decayed through December 31, 1989 unless otherwise noted.

^{b/} Only cribs and drains, reverse wells, and ponds, ditches, and trenches are included on this table. No inventory data are available for the other types of waste management units.

^{c/} Values are decayed through April 1, 1986.

^{d/} Values are reported in grams.

^{e/} Values are for U-238. Other U isotopes exist that probably are not listed in inventory.

^{f/} Volume included in 216-U-10 Pond.

Table 2-3. Chemical Waste Inventory Summary.

Waste Management Unit No.	Quantity of Reported Chemicals (kg) ^{a/}								
	Nitrate	Nitric Acid	Phosphate	Sodium	Sulfate	Tributyl Phosphate	Hexone	Ammonium Nitrate	Volume Recorded (L)
Cribs and Drains									
216-S-4	1								1,000,000
216-S-21				130				800	87,100,000
216-U-1 & 216-U-2	1,200,000		70,000	500,000	100,000				46,200,000
216-U-3	9								791,000
216-U-4A	900		30	400					545,000
216-U-4B	10								33,000
216-U-7	70								7,000
216-U-8		200,000							379,000,000
216-U-12									150,000,000
216-U-16									409,000,000
216-U-17									2,110,000
Reverse Well									
216-U-4	400								300,000
Ponds, Ditches, and Trenches									
216-U-5 & 216-U-6	200								2,250,000
216-U-10									165,000,000,000
216-U-13									11,400
216-U-15 (same as UN-200-W-125)						13,000	40,000		68,100
216-Z-1D									1,000,000
216-Z-11									w
216-Z-20	3,400								3,800,000,000
216-U-14									
216-Z-19									
216-U-11									

^{a/} Not all sites have reported inventories. These inventories do not necessarily list all of the contaminants disposed of at a site.

^{b/} Volume included in 216-U-10 Pond.

Table 2-4. Description of 241-U Tank Farm.

Name	Type	Integrity	Interim Stabilized	Isolation	Total Waste Volume (L) Remaining	Drainable Waste Volume (L)
241-U-101	single-shell	assumed leaker	IS	II	94,600	11,400
241-U-102	single-shell	sound	no	PI	1,415,600	545,000
241-U-103	single-shell	sound	no	PI	1,771,400	715,400
241-U-104	single-shell	assumed leaker	IS	II	461,800	26,500
241-U-105	single-shell	sound	no	PI	1,582,100	677,500
241-U-106	single-shell	sound	no	PI	855,400	314,200
241-U-107	single-shell	sound	no	PI	1,536,700	673,700
241-U-108	single-shell	sound	no	PI	1,771,400	741,900
241-U-109	single-shell	sound	no	PI	1,752,500	688,900
241-U-110	single-shell	assumed leaker	IS	PI	704,000	56,800
241-U-111	single-shell	sound	no	PI	1,245,300	461,800
241-U-112	single-shell	assumed leaker	IS	II	185,500	15,100
241-U-201	single-shell	sound	IS	II	18,900	3,800
241-U-202	single-shell	sound	IS	II	18,900	3,800
241-U-203	single-shell	sound	IS	II	11,400	3,800
241-U-204	single-shell	sound	IS	II	11,400	3,800

Notes: IS - interim stabilized
 II - interim isolated
 PI - partially interim isolated

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Table 2-5. General 200 West Single-Shell Tank Information
Reference Locator.

Desired Single-Shell Tank Information	Reference Document
Watch List Tanks: Identification per Public Law 101-510, Section 3137, "Safety Measures for Waste Tanks at Hanford Nuclear Reservation." (Wyden Bill Amendment)	WHC-EP-0182, <i>Tank Farm Surveillance and Waste Status Summary Report</i> , Table 1
Definitions: Definitions include Interim Stabilized (IS), Partial Interim Isolated (PI), Interim Isolated (II), Tank Integrity (Sound or Assumed Leaker), Intrusion, Drywells, Laterals, Surface Levels, Automatic FIC, Liquid Observation Well (LOW), Thermocouple (TC), Sludge, and Salt Cake.	WHC-EP-0182, Appendix A
Tank Schematic: Quick reference for tank capacities and relative dimensions.	WHC-EP-0182, Figure B-1
Tank Information: Tank waste material, tank integrity ("sound" or "assumed leaker" stabilization/isolation status, total waste, supernatant waste, drainable interstitial, sludge volume, salt cake volume, last in-tank photo date.	WHC-EP-0182, Table C-5
Single-Shell Tank Leak Volume Estimates	WHC-EP-0182, Table H-1
Leak Detection Equipment: Type and description of leak detection devices for each tank, and detection criteria.	WHC-SD-WM-TI-357, <i>Waste Storage Tank Status and Leak Detection Criteria</i>
West Area Waste Storage Tank Criteria: Criteria is discussed by tank farm and includes leak detection drywells (type of probe used, radiation criteria, well location, well depths and monitoring frequency), surface level measurement (decrease/increase criteria, monitoring frequency).	WHC-SD-WM-TI-357, Section 6.0

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Table 2-5. General 200 West Single-Shell Tank Information
Reference Locator.

Desired Single-Shell Tank Information	Reference Document
Tank Farms Facility Interim Stabilization Evaluation: Provides the stabilization criteria for single-shell tanks and auxiliary tanks.	WHC-CM-5-7 Section 1.11
Single-Shell Tank Operating Specifications: Information includes structural limitations (tank content composition, dome loading, waste temperatures, vapor space pressures), radiological containment requirements, cross-connection requirements, and leak detection control.	OSD-T-151-00013

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Table 2-6. Description of Unplanned Releases.^{a/}

Unplanned Release No.	Location	Date	Associated Waste Management Unit ^{b/}	Reported Waste-Related History Operable Unit
UN-200-W-6	Adjacent to 241-U-151 and 241-U-152 Diversion Boxes	Spring 1950	NA	<ul style="list-style-type: none"> • Work done on the 241-U-151 and 241-U-152 Diversion Boxes resulted in contamination. • Unknown beta/gamma with max dose rate of 20 mr/h at surface. • Covered with 0.3 m of clean soil. • Area delimited with rope and radiation zone signs.
UN-200-W-19	Near 241-U-361 Settling Tank and 216-U-1 and 216-U-2 Cribs	Spring 1953	NA	<ul style="list-style-type: none"> • Drainage overflowed from U Plant (tributyl phosphate) and UO₃ Plant. • Organic waste and cell drainage with readings to 11.5 R/h at 80 mm. • Site area is approximately 5.0 m². • Decontamination attempted, then backfilled.
UN-200-W-33	27 m east of UO ₃ Plant	March 1955	NA	<ul style="list-style-type: none"> • A flange leak in the C-5 condensate line caused contamination of about 0.3 m² • Top 0.10 m of soil removed and filled with clean soil. • Removed from radiation zone status in December 1970.

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Table 2-6. Description of Unplanned Releases.^{a/}

Unplanned Release No.	Location	Date	Associated Waste Management Unit ^{b/}	Reported Waste-Related History Operable Unit
UN-200-W-39	Southeast of UO ₃ Plant	March 1954	NA	<ul style="list-style-type: none"> • Uranium leak at UO₃ Plant. • Less than 0.02 Ci/m³ • Contamination buried in a trench (15 x 3 x 1 m) and covered with 1 m of soil. • Area removed from radiation zone status in July 1972 and is now under the 224-UA addition.
UN-200-W-46	Z and U Plant Aggregate Areas	January 21, 1958	NA	<ul style="list-style-type: none"> • Burial operation of an H-2 centrifuge from REDOX resulted in spotty contamination in the Z and U Plant Aggregate Areas. • Contamination on all outside horizontal surfaces. • Contamination was limited to within the 234-5Z and 224-U areas. • Note: not located on Figure 2-14 due to non-specific location.
UN-200-W-48	U Plant railroad crossing	July 9, 1958	NA	<ul style="list-style-type: none"> • Leakage from a contaminated jumper in transit. • Unknown beta/gamma - readings to 9 R/h. • Approximately 93 m².

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Table 2-6. Description of Unplanned Releases.^{a/}

Unplanned Release No.	Location	Date	Associated Waste Management Unit ^{b/}	Reported Waste-Related History Operable Unit
UN-200-W-55	UO ₃ Plant asphalt loading ramp and nearby roadway	April 12, 1960	NA	<ul style="list-style-type: none"> • A broken loading hose caused 1.3 metric tons of uranium powder to spill. • Most powder swept up and placed into drums, remainder washed off asphalt onto ground surface.
UN-200-W-60	Area extending (69m) along U Plant railroad cut from tunnel door	February 25, 1966	NA	<ul style="list-style-type: none"> • A defective transfer box containing PUREX equipment was contaminated. • Unknown beta/gamma with readings up to 1 R/h. • Contamination was isolated and cleaned.
UN-200-W-68	Near the intersection of Dayton Avenue and 13th Street	February 8, 1972	NA	<ul style="list-style-type: none"> • Cause of the contamination was not conclusively determined. • Unknown beta/gamma with readings from 5,000 to 80,000 cts/min.
UN-200-W-71	Spots along the route from the 241-U Tank Farm to the 200 West Burial Ground, including 16th Street and Dayton Avenue	January 24, 1974	NA	<ul style="list-style-type: none"> • A heel jet from the 241-U-102 Single-Shell Tank in transit to the burial ground. • The roadway was cleaned and released.
UN-200-W-78	South of UO ₃ Plant storage area	August 21, 1970	NA	<ul style="list-style-type: none"> • A spill of UO₃ powder from a loading pallet contaminated a 4 m² area • Up to 20,000 ct/min. • Contaminated soil was removed.

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Table 2-6. Description of Unplanned Releases.^{a/}

Unplanned Release No.	Location	Date	Associated Waste Management Unit ^{b/}	Reported Waste-Related History Operable Unit
UN-200-W-86	200 West Area environment, specifically around U Plant and the 204-S Retention Basin (outside the northwest unit boundary)	October 27, 1981 (date contamination was documented)	NA	<ul style="list-style-type: none"> • Contaminated pigeon feces containing ¹³⁴Cs, ¹³⁷Cs, ⁹⁰Sr, and ¹⁰⁶Ru. • Readings from 10,000 dis/min beta/gamma to 40 mr/h. • Note: not located on Figure 2-14 due to non-specific location. • Radioactive contamination has been removed to background levels; north 204-S Retention Basin was decontaminated to background levels. • Affected area around U Plant was chained off and posted as a radiation area.
UN-200-W-101	Northeast end of 221-U Building	March 1957	NA	<ul style="list-style-type: none"> • Reclaimed acid containing ⁹⁰Sr fission products to about 1 Ci spilled onto the ground. • Ground surface was covered with 80 mm of sand and gravel. • Approximate area is 27 x 20 x 1 m. • 1967 - approximately 1,800 m² behind U Plant was covered with tar to reseal an area of old decomposed tar seal; "soil sterilizing" agent was applied before resealing. • Contamination of 250 ct/min to 35,000 ct/min detected during second quarter 1991 survey.

Table 2-6. Description of Unplanned Releases.^{a/}

Unplanned Release No.	Location	Date	Associated Waste Management Unit ^{b/}	Reported Waste-Related History Operable Unit
UN-200-W-111	South side of 207-U Retention Basin, within 3 m of the wall	After 1952	207-U Retention Basin	<ul style="list-style-type: none"> • Approximately 21 m³ of sludge scraped from bottom of south basin was put into a 12 x 4.5 x 3 m deep trench. • Areas of contamination up to 2 m²/h (1989). • Sludge was covered with 1.2 m of clean fill.
UN-200-W-112	North side of 207-U Retention Basin within 3 m of wall	After 1952	207-U Retention Basin	<ul style="list-style-type: none"> • Approximately 21 m³ of sludge scraped from bottom of north basin was put into a 12 x 4.5 x 3 m deep trench. • No surface contamination detected in a 1989 survey. • Sludge covered with 1.2 m of clean fill.
UN-200-W-117	Ground along railroad cut northeast of U Plant	Mid-1950's (occurrence) (Established as an unplanned release site in September 1980)	NA	<ul style="list-style-type: none"> • Contaminated liquid and particulate matter dropped from railroad cars servicing the U Plant. • Designated as a radiation zone, but has since been released as contamination has decayed to background levels.
UN-200-W-118	Railroad spur about 15 m northwest of U Plant	1960-1972	NA	<ul style="list-style-type: none"> • Drippings and spills from the reclaimed nitric acid unloading stations in the 211-U Chemical Tank Farm. • Windborne particulate spread to ground surface outside concrete unloading station. • Designated as a radiation zone, but has been released as contamination has decayed to background levels.

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Table 2-6. Description of Unplanned Releases.^{a/}

Unplanned Release No.	Location	Date	Associated Waste Management Unit ^{b/}	Reported Waste-Related History Operable Unit
UN-200-W-125 ^{c/}	170 m north of 16th St. and 150 m west of 271-U Building	May 1957	216-U-15 Trench	<ul style="list-style-type: none"> • A trench opened to receive about 26,500 L of "interface crud," activated charcoal, and diatomaceous earth containing about 1 Ci of fission products from the 388-U Tank in the 276-U Solvent Storage Area. • Nature of waste is unclear: one source reports 8,200 kg of hexone and 2,700 kg of tributyl phosphate; another source reports the former material as paraffin hydrocarbon. • Backfilled immediately after use.
UN-200-W-138 ^{d/}	Near northeast corner of U Plant	June 1953	216-U-7 French Drain	<ul style="list-style-type: none"> • Uranyl nitrate hexahydrate solution containing estimated 140 kg of uranium overflowed to the U Plant vessel vent blower pit onto the ground through the 216-U-7 French Drain. • Is within an area with surface contamination from 250 ct/min to 35,000 ct/min as determined during a second quarter 1991 survey.

Table 2-6. Description of Unplanned Releases.^{a/}

Unplanned Release No.	Location	Date	Associated Waste Management Unit ^{b/}	Reported Waste-Related History Operable Unit
UN-200-W-161	15.2 m east of 241-U Tank Farm. 30 m north of 207-U Retention Basin	NA	NA	<ul style="list-style-type: none"> • Surface contamination that covers approximately 2 acres. • General contamination of 250 to 450 ct/min with spots of contamination up to 8,000 ct/min • Strontium is the main radionuclide present. One soil sample had 2930 pCi/g. • Last survey in October 1990 reported 200 to 500 ct/min.
UPR-200-W-18	200 West Area: 216-U-9 Ditch	September 1953	216-U-9 Ditch	<ul style="list-style-type: none"> • Contamination was limited to the 216-U-9 Ditch. • This site is a duplicate of UPR-200-W-139 and is scheduled for deletion. • UPR-200-W-139 is part of another aggregate area.
UPR-200-W-24	Road near 241-U Tank Farm	April 30, 1953	244-UR Vault	<ul style="list-style-type: none"> • Contamination from a violent chemical reaction in the 002 Blending Tank, 244-UR Vault. • The contaminated area was backfilled and stabilized. • Metal waste supernate with readings of 500 to 1000 ct/min.

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Table 2-6. Description of Unplanned Releases.^{a/}

Unplanned Release No.	Location	Date	Associated Waste Management Unit ^{b/}	Reported Waste-Related History Operable Unit
UPR-200-W-104	Leach trench running NE from the NE corner of 216-U-10 Pond	Mid 1950s	216-U-10 Pond	<ul style="list-style-type: none"> • Site was a leaching trench connected to the 216-U-10 Pond. • Low-level beta/gamma activity on the ground in the bottom of the trench.
UPR-200-W-105	Leach trench running east from the center of the east side of 216-U-10 Pond	Mid 1950s	216-U-10 Pond	<ul style="list-style-type: none"> • Site was a leaching trench connected to the 216-U-10 Pond. • Low-level beta/gamma activity on the ground in the bottom of the trench.
UPR-200-W-106	Leach trench running east from the east side of 216-U-10 Pond south of UPR-200-W-105	Mid 1950s	216-U-10 Pond	<ul style="list-style-type: none"> • Site was a leaching trench connected to the 216-U-10 Pond. • Low-level beta/gamma activity on the ground in the bottom of the trench.
UPR-200-W-107	South of 216-U-10 Pond	1952-1957	216-U-10 Pond	<ul style="list-style-type: none"> • Flood plain covered with rising water from the 216-U-10 Pond. • Beta/gamma activity at ground surface up to 8,000 cts/min in 1978.
UPR-200-W-110	Adjacent and parallel to the head of the 216-Z-19 Ditch	April 14, 1971 April 21, 1971	216-Z-19 Ditch	<ul style="list-style-type: none"> • Trench filled with contaminated soil mistakenly excavated from 216-Z-1 Ditch. • Trench is filled with 2 m of contaminated soil and topped to grade level with eight feet of clean dirt. • Americium and plutonium at bottom of 216-Z-1 Ditch with readings of up to 100,000 ct/min.

Table 2-6. Description of Unplanned Releases.^{a/}

Unplanned Release No.	Location	Date	Associated Waste Management Unit ^{b/}	Reported Waste-Related History Operable Unit
UPR-200-W-128	Surrounding 241-U-103 Single-Shell Tank	January 8, 1971	241-U-103 Single-Shell Tank	<ul style="list-style-type: none"> • Rupture of a waste line in the 241-U-103 Single-Shell Tank.
UPR-200-W-154	Surrounding 241-U-101 Single-Shell Tank	1959	241-U-101 Single-Shell Tank	<ul style="list-style-type: none"> • Leak of 113,550 L of waste from 241-U-101 Single-Shell Tank. • Nearby dry wells show only background activity. • Tank was classified as "Interim Stabilized" in 1979.
UPR-200-W-155	Surrounding 241-U-104 Single-Shell Tank	1956	241-U-104 Single-Shell Tank	<ul style="list-style-type: none"> • Leak of 208,175 L of waste from 241-U-104 Single-Shell Tank. • The tank was stabilized with the addition of diatomaceous earth.
UPR-200-W-156	Surrounding 241-U-110 Single-Shell Tank	1975	241-U-110 Single-Shell Tank	<ul style="list-style-type: none"> • Leak of 30,659 L of waste from 241-U-110 Single-Shell Tank. • Increasing radiation levels detected in vadose zone well 60-10-07. • A saltwell was installed in the tank.
UPR-200-W-157	Surrounding 241-U-112 Single-Shell Tank	1969	241-U-112 Single-Shell Tank	<ul style="list-style-type: none"> • Leak of 1,892 L of waste from 241-U-112 Single-Shell Tank. • A saltwell system was installed in the tank. • Total of 32,000 L believed to have leaked.

Table 2-6. Description of Unplanned Releases.^{a/}

Unplanned Release No.	Location	Date	Associated Waste Management Unit ^{b/}	Reported Waste-Related History Operable Unit
Uranium Contamination Leak	224-U Building	1989	--	<ul style="list-style-type: none"> Leak of 16,730 L of waste from a concrete sump. Water had a pH of 3.5 and contained about 12.1 kg of uranium.
Paint Waste Spill	Immediately east of the 2715-UA Building Paint Shop	?	--	<ul style="list-style-type: none"> Painting wastes were reportedly emptied onto the ground.

^{a/} All unplanned releases reported are liquid mixed waste (except UN-200-W-68, UN-200-W-86, UN-200-W-161, UPR-200-W-110).

^{b/} If a waste management unit is listed in this column, the unplanned release is not included as a separate site in the Tri-Party Agreement Action Plan.

^{c/} Same as waste site 216-U-15 Trench.

^{d/} As stated in *The 200-UP-2 Operable Unit Technical Baseline Report* (DeFord 1991): "Confusion exists concerning the relationship between 216-U-7 French Drain and unplanned release UN-200-W-138. UN-200-W-138 describes a spill of about 140 kg of uranium, in uranyl nitrate hexahydrate form, into the 'vessel vent blower pit' and through its floor drain into the 216-U-7 French Drain." A drawing shows that the 216-U-7 French Drain is connected to the U Plant Counting Box, not to the blower pit, and the blower pit drains to Tank 1 in the 241-WR Vault. Until resolved, it should be assumed that 140 kg of uranium was introduced to the soil through the 216-U-7 French Drain.

Table 2-7. Summary of Waste-Producing Processes in the U Plant Aggregate Area.

Process	Waste Generated	Major Chemical Constituents	Ionic Strength	pH	Organic Concentration	Radioactivity
Uranium recovery	Process waste	Nitric acid Bismuth phosphate NaOH	High	Acidic (neutralized before disposal)	Low	High
	Wastewater	Nitrates	Low	Acidic to neutral/basic	Low	Low
UO ₃ conversion	Wastewater	Nitrates	Low	Acidic to neutral	Low	Low
Solvent treatment	Spent solvents	Tributyl phosphate Normal paraffin hydrocarbons	Low	Acidic to neutral	High	Intermediate
	Carbonate scrub solution	Carbonate Tributyl phosphate Normal paraffin hydrocarbons	Low	Acidic to neutral	High	Intermediate
Analytical laboratory	Laboratory process waste	Unknown	Unknown	Acidic	Low	Unknown
	Used or discarded reagents	Unknown	Unknown	Acidic	Low	Unknown
	Wastewater	Unknown	Low	Acidic to basic	Low	Low (Pu and TRU)
Tank farm condensate	Wastewater	Unknown	Low	Neutral/basic	Low	Low

Table 2-8. Chemicals Used or Produced in Separation/Recovery Processes.

RADIONUCLIDES	Polonium-214	Ferric cyanide
Actinium-225	Polonium-215	Fluoride
Actinium-227	Polonium-218	Hydroxide
Americium-241	Potassium-40	Iron
Americium-242	Protactinium-231	Lead
Americium-242m	Protactinium-233	Lithium
Americium-243	Protactinium-234m	Magnesium
Antimony-126	Radium	Manganese
Antimony-126m	Radium-223	Nitrate
Astatine-217	Radium-225	Nitric acid
Barium-135m	Radium-226	Nitrite
Barium-137m	Ruthenium-103	Phosphate
Bismuth-210	Ruthenium-106	Phosphoric Acid
Bismuth-211	Samarium-151	Potassium
Bismuth-213	Selenium-79	Silica
Bismuth-214	Silver-110m	Silicon
Carbon-14	Sodium-22	Silver
Cerium-141	Strontium-85	Sodium
Cerium-144	Strontium-90	Sodium hydroxide
Cesium-134	Technetium-99	Sulfamic Acid
Cesium-135	Thallium-207	Sulfate
Cesium-137	Thorium-227	Sulfuric Acid
Cobalt-57	Thorium-229	Thorium
Cobalt-58	Thorium-230	Tin
Cobalt-60	Thorium-231	Titanium
Curium-242	Thorium-233	Uranium
Curium-244	Thorium-234	Uranium oxide
Curium-245	Tin-126	Uranyl nitrate hexahydrate
Europium-152	Tritium	Zinc
Europium-154	Uranium-233	
Europium-155	Uranium-234	ORGANIC CHEMICALS
Francium-221	Uranium-235	Ammonium
Francium-223	Uranium-238	Bismuth phosphate
Iodine-129	Yttrium-90	Butyl alcohol
Iron-59	Zinc-65	Chloroform
Lead 211	Zirconium-93	Decane
Lead 210	Zirconium-95	Dibutyl phosphate
Lead-209		Kerosene
Lead-212	INORGANIC CHEMICALS	Monobutyl phosphate
Lead-214	Aluminum	Paraffin hydrocarbons
Manganese-54	Ammonium ion	Tributyl phosphate
Neptunium-237	Ammonium nitrate	Trichloroethane
Neptunium-239	Arsenic	
Nickel 63	Barium	
Nickel-59	Bismuth	
Niobium-93m	Bismuth phosphate	
Niobium-95	Boron	
Palladium-107	Cadmium	
Plutonium-238	Calcium	
Plutonium-239/240	Carbonate	
Plutonium-241	Chromium	
Polonium-210	Copper	
Polonium-213	Cyanide	

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Table 2-9. Chemicals Used in the 222-U Laboratory (1952-1958).

Compound Name	Formula
Ammonium Fluoride	NH_4F
Ammonium Nitrate	NH_4NO_3
Ammonium Oxalate	$(\text{NH}_4)_2\text{C}_2\text{O}_4 \cdot \text{H}_2\text{O}$
Barium Nitrate	$\text{Ba}(\text{NO}_3)_2$
Boric Acid	H_3BO_3
Carbon Tetrachloride	CCl_4
Ceric Iodate	$\text{Ce}(\text{IO}_3)_4$
Chloroplatinic Acid	$\text{H}_2\text{PtCl}_6 \cdot 6\text{H}_2\text{O}$
Chromous Sulfate	$\text{CrSO}_4 \cdot 7\text{H}_2\text{O}$
Ethanol	$\text{C}_2\text{H}_5\text{OH}$
Ethyl Ether	$(\text{CH}_3\text{CH}_2)_2\text{O}$
Hydrobromic Acid	HBr
Hydrochloric Acid	HCl
Hydrofluoric Acid	HF
Hydroiodic Acid	HI
Lanthanum Fluoride	LaF_3
Molybdate-Citrate Reagent	$\text{MoO}_3 \cdot \text{XH}_2\text{O} + (\text{NH}_4)_3\text{C}_6\text{H}_5\text{O}_7$
Oxalic Acid	$\text{HO}_2\text{CCO}_2\text{H} \cdot 2\text{H}_2\text{O}$
Phosphorous Pentoxide	P_2O_5
Potassium Carbonate	K_2CO_3
Potassium Fluoride	KF
Potassium Hydroxide	KOH
Potassium Permanganate	KMnO_4
Sodium Fluoride	NaF
Sodium Hydroxide	NaOH
Sodium Nitrate	NaNO_3
Sulfuric Acid	H_2SO_4

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Table 2-10. Radionuclides and Chemicals Disposed of to U Plant
Aggregate Area Waste Management Units. Page 1 of 2

RADIONUCLIDES		Zirconium-95
Actinium-225	Nickel-59	
Actinium-227	Niobium-93m	
Americium-241	Niobium-95	INORGANIC CHEMICALS
Americium-242	Palladium-107	Aluminum
Americium-242m	Plutonium-238	Ammonium ion
Americium-243	Plutonium-239/240	Ammonium nitrate
Antimony-126	Plutonium-241	Arsenic
Antimony-126m	Polonium-210	Barium
Astatine-217	Polonium-213	Bismuth
Barium-135m	Polonium-214	Bismuth phosphate
Barium-137m	Polonium-215	Boron
Bismuth-210	Polonium-218	Cadmium
Bismuth-211	Potassium-40	Calcium
Bismuth-213	Protactinium-231	Carbonate
Bismuth-214	Protactinium-233	Cerium
Carbon-14	Protactinium-234m	Chloride
Cerium-141	Radium	Chromium
Cerium-144	Radium-223	Copper
Cesium-134	Radium-225	Cyanide
Cesium-135	Radium-226	Ferric cyanide
Cesium-137	Ruthenium-103	Fluoride
Cobalt-57	Ruthenium-106	Hydroxide
Cobalt-58	Samarium-151	Iron
Cobalt-60	Selenium-79	Lanthanum
Curium-242	Silver-110m	Lead
Curium-244	Sodium-22	Lithium
Curium-245	Strontium-85	Magnesium
Europium-152	Strontium-90	Manganese
Europium-154	Technetium-99	Mercury
Europium-155	Thallium-207	Nickel
Francium-221	Thorium-227	Nitrate
Francium-223	Thorium-229	Nitric acid
Iodine-129	Thorium-230	Nitrite
Iron-59	Thorium-231	Phosphate
Lead 211	Thorium-233	Phosphoric Acid
Lead 210	Thorium-234	Potassium
Lead-209	Tin-126	Selenium
Lead-212	Tritium	Silica
Lead-214	Uranium-233	Silicon
Manganese-54	Uranium-234	Silver
Neptunium-237	Uranium-235	Sodium
Neptunium-239	Uranium-238	Sodium hydroxide
Nickel 63	Yttrium-90	Strontium
	Zinc-65	Sulfamic Acid
	Zirconium-93	

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Table 2-10. Radionuclides and Chemicals Disposed of to U Plant
Aggregate Area Waste Management Units.

INORGANIC CHEMICALS

(Cont.)

Sulfate
Sulfuric Acid
Thorium
Tin
Titanium
Uranium oxide
Uranium
Uranyl nitrate hexahydrate
Vanadium
Zinc
Zirconium oxide

ORGANIC CHEMICALS

Acetone
Ammonium
Butyl alcohol
Carbon tetrachloride
Chloroform
Citrate
Ethylene diamine
tetraacetate
(EDTA)
Glycolate
Kerosene
Methylene chloride
MIBK ("Hexone")
N-(2-hydroxyethyl)
ethylenediaminetriacetate
(HEDTA)
Oxalate
Paraffin hydrocarbons
Toluene
Tributyl phosphate
Trichloroethane
Other degradation products

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3.0 SITE CONDITIONS

The following sections describe the physical nature and setting of the Hanford Site, the 200 West Area, and the U Plant Aggregate Area. The site conditions are presented in the following sections:

- Physiography and Topography (Section 3.1)
- Meteorology (Section 3.2)
- Surface Hydrology (Section 3.3)
- Geology (Section 3.4)
- Hydrogeology (Section 3.5)
- Environmental Resources (Section 3.6)
- Human Resources (Section 3.7).

Sections describing topography, geology, and hydrogeology have been taken from standardized texts provided by Westinghouse Hanford (Delaney et al. 1991; Lindsey et al. 1991; and Lindsey et al. 1992) for that purpose.

3.1 PHYSIOGRAPHY AND TOPOGRAPHY

The Hanford Site (Figure 3-1) is situated within the Pasco Basin of southcentral Washington. The Pasco Basin is one of a number of topographic depressions located within the Columbia Basin Subprovince of the Columbia Intermontane Province (Figure 3-2), a broad basin located between the Cascade Range and the Rocky Mountains. The Columbia Intermontane Province is the product of Miocene continental flood basalt volcanism and regional deformation that occurred over the past 17 million years. The Pasco Basin is bounded on the north by the Saddle Mountains, on the west by Umtanum Ridge, Yakima Ridge, and the Rattlesnake Hills, on the south by Rattlesnake Mountain and the Rattlesnake Hills, and on the east by the Palouse Slope (Figure 3-1).

The physiography of the Hanford Site is dominated by the low-relief plains of the Central Plains physiographic region and anticlinal ridges of the Yakima Folds physiographic region (Figure 3-3). Surface topography seen at the Hanford Site is the result of (1) uplift of anticlinal ridges, (2) Pleistocene cataclysmic flooding, and (3) Holocene eolian activity (DOE 1988b). Uplift of the ridges began in the Miocene epoch and continues to the present.

Cataclysmic flooding occurred when ice dams in western Montana and northern Idaho were breached, allowing large volumes of water to spill across eastern and central Washington. The last major flood occurred about 13,000 years ago, during the late Pleistocene epoch. Anastomosing flood channels, giant current ripples, bergmounds, and giant flood bars are among the landforms created by the floods. Since the end of the Pleistocene epoch, winds have locally reworked the flood sediments, depositing dune sands in the lower elevations and loess (windblown silt) around the margins of the Pasco Basin. Generally, sand dunes have been stabilized by anchoring vegetation except where they have been reactivated where vegetation is disturbed (Figure 3-4).

A series of numbered areas have been delineated at the Hanford Site. The 100 Areas are situated in the northern part of the Hanford Site adjacent to the Columbia River in an area commonly called the "Horn." The elevation of the "Horn" is between 119 and 143 m (390 and 470 ft) above mean sea level (msl) with a slight increase in elevation away from the river. The 200 Areas are situated on a broad flat area called the 200 Areas Plateau. The 200 Areas plateau is near the center of the Hanford Site at an elevation of approximately 198 to 229 m (650 to 750 ft) above msl. The plateau decreases in elevation to the north, northwest, and east toward the Columbia River, and plateau escarpments have elevation changes of between 15 to 30 m (50 to 100 ft).

The 200 West Area is situated on the 200 Areas Plateau on a relatively flat prominent terrace (Cold Creek Bar) formed during the late Pleistocene flooding (Figure 3-5). Cold Creek Bar trends generally east to west and is bisected by a flood channel that trends north to south. This terrace drops off rather steeply to the north and northwest with elevation changes between 15 and 30 m (50 to 100 ft).

The topography of the 200 West Area is generally flat (Figure 3-1). The elevation in the vicinity of the U Plant Aggregate Area ranges from approximately 219 m (720 ft) in the eastern part of the unit to about 197 m (647 ft) above msl in the western part. A detailed topographic map of the area is provided as Plate 2. There are no natural surface drainage channels within the area.

3.2 METEOROLOGY

The following sections provide information on Hanford Site meteorology including precipitation (Section 3.2.1), wind conditions (Section 3.2.2), and temperature variability (Section 3.2.3).

The Hanford Site lies east of the Cascade Mountains and has a semiarid climate because of the rainshadow effect of the mountains. The weather is monitored at the Hanford Meteorology Station, located between the 200 East and 200 West Areas, and at other points

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situated through the reservation. The following sections summarize the Hanford Site meteorology.

3.2.1 Precipitation

The Hanford Site receives an annual average of 16 cm (6.3 in.) of precipitation. Precipitation falls mainly in the winter, with about half of the annual precipitation occurring between November and February. The maximum 25 yr/24 h storm event has been calculated at 3.8 cm (1.5 in.) (Stone et al. 1983). The maximum 100 yr/24 h storm event is approximately 5 cm (2 in.). Average winter snowfall ranges from 13 cm (5.3 in.) in January to 0.8 cm (0.31 in.) in March. The record snowfall of 62 cm (24.4 in.) occurred in February 1916 (Stone et al. 1983). During December through February, snowfall accounts for about 38% of all precipitation in those months.

The average yearly relative humidity at the Hanford Site for 1946 to 1980 was 54.4%. Humidity is higher in winter than in summer. The monthly averages for the same period range from 32.2% for July to 80% in December. Atmospheric pressure averages are higher in the winter months and record absolute highs and lows also occur in the winter.

3.2.2 Winds

The Cascade Mountains have considerable effect on the wind regime at the Hanford Site by serving as a source of cold air drainage. This gravity drainage results in a northwest to west-northwest prevailing wind direction. The average mean monthly speed for 1945 to 1980 is 3.4 m/s (7.7 mph). Peak gust speeds range from 28 to 36 m/s (63 to 80 mph) and are generally southwest or west-southwest winds (Stone et al. 1983).

Figure 3-6 shows wind roses for the Hanford Telemetry Network (Stone et al. 1983). The gravity drainage from the Cascades produces a prevailing west-northwest wind in the 200 West Area. In July, hourly average wind speeds range from a low of 2.3 m/s (5.2 mph) from 9 to 10 a.m. to a high of 6 m/s (13.0 mph) from 9 to 10 p.m.

3.2.3 Temperature

Based on data from 1914 to 1980, minimum winter temperatures vary from -33 °C (-27 °F) to -6 °C (+22 °F), and maximum summer temperatures vary from 38 °C (100 °F) to 46 °C (115 °F). Between 1914 and 1980, a total of 16 days with temperatures -29 °C (-20 °F) or below are recorded. There are 10 days of record when the maximum temperature failed to go above -18 °C (0 °F). Prior to 1980, there were three summers on

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record when the temperatures were 38 °C (100 °F) or above for 11 consecutive days (Stone et al. 1983).

3.3 SURFACE HYDROLOGY

3.3.1 Regional Surface Hydrology

Surface drainage enters the Pasco Basin from several other basins, which include the Yakima River Basin, Walla Walla River Basin, Palouse/Snake Basin, and Big Bend Basin (Figure 3-7). Within the Pasco Basin, the Columbia River is joined by major tributaries including the Yakima, Snake, and Walla Walla Rivers. No perennial streams originate within the Pasco Basin. Columbia River inflow to the Pasco Basin is recorded at the United States Geological Survey (USGS) gage below Priest Rapids Dam, and outflow is recorded below McNary Dam. Average annual flow at these recording stations is approximately $1.1 \times 10^{11} \text{ m}^3$ (8.7×10^7 acre-ft) at the USGS gage and $1.6 \times 10^{11} \text{ m}^3$ (1.3×10^8 acre-ft) at the McNary Dam gage (DOE 1988b).

Total estimated precipitation over the basin averages less than 15.8 cm/yr (6.2 in./yr). Mean annual runoff from the basin is estimated to be less than $3.1 \times 10^7 \text{ m}^3/\text{yr}$ (2.5×10^4 acre-ft/yr), or approximately 3% of the total precipitation. The remaining precipitation is assumed to be lost through evapotranspiration with a small component (perhaps less than 1%) recharging the groundwater system (DOE 1988b).

3.3.2 Surface Hydrology of the Hanford Site

Primary surface water features associated with the Hanford Site, located near the center of the Pasco Basin, are the Columbia and Yakima Rivers and their major tributaries, the Snake and Walla Walla Rivers. West Lake, about 4 hectares (10 acres) in size and less than 0.9 m (3 ft) deep, is the only natural lake within the Hanford Site (DOE 1988b). Wastewater ponds, cribs, and ditches associated with nuclear fuel reprocessing and waste disposal activities are also present on the Hanford Site.

The Columbia River flows through the northern part and along the eastern border of the Hanford Site. This section of the river, the Hanford Reach, extends from Priest Rapids Dam to the headwaters of Lake Wallula (the reservoir behind McNary Dam). Flow along the Hanford Reach is controlled by Priest Rapids Dam. Several drains and intakes are also present along this reach, including irrigation outfalls from the Columbia Basin Irrigation Project, the Washington Public Power Supply System (WPPSS) Nuclear Project 2, and Hanford Site intakes for onsite water use. Much of the northern and eastern parts of the Hanford Site are drained by the Columbia River.

Routine water-quality monitoring of the Columbia River is conducted by the U.S. Department of Energy (DOE) for both radiological and nonradiological parameters and has been reported by Pacific Northwest Laboratory (PNL) since 1973. Washington State Department of Ecology (Ecology) has issued a Class A (excellent) quality designation for Columbia River water along the Hanford Reach from Grand Coulee Dam, through the Pasco Basin, to McNary Dam. This designation requires that all industrial uses of this water be compatible with other uses, including drinking, wildlife habitat, and recreation. In general, the Columbia River water is characterized by a very low suspended load, a low nutrient content, and an absence of microbial contaminants (DOE 1988b).

Approximately one-third of the Hanford Site is drained by the Yakima River system. Cold Creek and its tributary, Dry Creek, are ephemeral streams on the Hanford Site that are within the Yakima River drainage system. Both streams drain areas along the western part of the Hanford Site and cross the southwestern part of the Hanford Site toward the Yakima River. Surface flow, which may occur during spring runoff or after heavier-than-normal precipitation, infiltrates and disappears into the surface sediments. Rattlesnake Springs, located on the western part of the Hanford Site, forms a small surface stream that flows for about 2.9 km (1.8 mi) before infiltrating into the ground.

3.3.3 U Plant Aggregate Area Surface Hydrology

No natural surface water bodies exist in the U Plant Aggregate Area which lies within the Yakima River System. The only existing man-made surface water bodies are the 207-U Retention Basins, the open stretches of the 216-U-14 Ditch, and the 200-W Powerhouse Pond. The 200-W Powerhouse Pond currently receives water from the 284-W Powerplant. Ongoing 200-W Powerhouse Pond monitoring is discussed in Section 4.1.1.6. The pond is an excavated portion of the 216-U-14 Ditch. The 216-U-14 Ditch runs from northeast to southwest across about one mile of the 200 West Area. It originated about 610 m (2,000 ft) north of the U Plant, terminated at the 216-U-10 Pond, and approximately three-quarters of its length between the Powerhouse Pond and the 207-U Retention Basin is backfilled. The open stretches include a small distance (the 200-W Powerhouse Pond) at the north boundary of the U Plant Aggregate Area and a segment just east and south of the 241-U Tank Farm. These discontinuous open portions of the ditch represent minor, if any, flooding potential due to the nature of the soil that allows for rapid infiltration of surface water into the ground. The ditch is also constructed with high bermed sides which also minimize the flood potential. The 207-U Retention Basin presents no threat of flooding because it discharges into the 216-U-14 Ditch.

The 200 West Area, and specifically the U Plant Aggregate Area, is not in a designated floodplain. Calculations of probable maximum floods for the Columbia River and the Cold Creek Watershed indicate that the 200 West Area is not expected to be inundated under maximum flood conditions (DOE/RL 1991b).

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3.4 GEOLOGY

The following subsections provide information pertaining to geologic characteristics of southcentral Washington, the Hanford Site, the 200 West Area, and the U Plant Aggregate Area. Topics included are the regional tectonic framework (Section 3.4.1), regional stratigraphy (Section 3.4.2), and 200 West Area and U Plant Aggregate Area geology (Section 3.4.3).

The geologic characterization of the Hanford Site, including the 200 West Area and U Plant Aggregate Area is the result of many previous site investigation activities at Hanford. These activities include the siting of nuclear reactors, characterization activities for the Basalt Waste Isolation Project (BWIP), waste management activities, and related geologic studies supporting these efforts. Geologic investigations have included regional and Hanford Site surface mapping, borehole/well sediment logging, field and laboratory sediment classification, borehole geophysical studies (including gamma radiation logging), and in situ and laboratory hydrogeologic properties testing.

3.4.1 Regional Tectonic Framework

The following sections provide information on regional (southcentral Washington) geologic structure, structural geology of the Pasco Basin and the Hanford Site, and regional and Hanford Site seismology.

3.4.1.1 Regional Geologic Structure. The Columbia Plateau is a part of the North American continental plate and lies in a back-arc setting east of the Cascade Range. It is bounded on the north by the Okanogan Highlands, on the east by the Northern Rocky Mountains and Idaho Batholith, and on the south by the High Lava Plains and Snake River Plain (Figure 3-8).

The Columbia Plateau can be divided into three informal structural subprovinces (Figure 3-9): Blue Mountains, Palouse, and Yakima Fold Belt (Tolan and Reidel 1989). These structural subprovinces are delineated on the basis of their structural fabric, unlike the physiographic provinces that are defined on the basis of landforms. The Hanford Site is located in the Yakima Fold Belt Subprovince near its junction with the Palouse Subprovinces.

The principal characteristics of the Yakima Fold Belt (Figure 3-10) are a series of segmented, narrow, asymmetric anticlines that have wavelengths between 5 and 32 km (3 and 19 mi) and amplitudes commonly less than 1 km (0.6 mi) (Reidel 1984; Reidel et al. 1989a). The northern limbs of the anticlines generally dip steeply to the north, are vertical, or even overturned. The southern limbs generally dip at relatively shallow angles to the south. Thrust or high-angle reverse faults with fault planes that strike parallel or subparallel

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to the axial trends are principally found on the north sides of these anticlines. The amount of vertical stratigraphic offset associated with these faults varies but commonly exceeds hundreds of meters. These anticlinal ridges are separated by broad synclines or basins that, in many cases, contain thick accumulations of Tertiary- to Quaternary-age sediments. The Pasco Basin is one of the larger structural basins in the Yakima Fold Belt Subprovince.

Deformation of the Yakima folds occurred under a north-south compression and was contemporaneous with the eruption of the basalt flows (Reidel 1984; Reidel et al. 1989a). Deformation occurred during the eruption of the Columbia River Basalt Group and continued through the Pliocene epoch, into the Pleistocene epoch, and perhaps to the present.

3.4.1.2 Pasco Basin and Hanford Site Structural Geology. The Pasco Basin, in which the Hanford Site is located, is a structural depression bounded on the north by the Saddle Mountains anticline, on the east by the Palouse Slope, on the west by the Umtanum Ridge, Yakima Ridge, and Rattlesnake Hills anticlines, and on the south by the Rattlesnake Mountain anticline (Figure 3-11). The Pasco Basin is divided by the Gable Mountain anticline, the easternmost extension of the Umtanum Ridge anticline, into the Wahluke syncline in the north, and the Cold Creek syncline in the south. Both the Cold Creek and Wahluke synclines are asymmetric and relatively flat-bottomed structures. The north limbs of both synclines dip gently (approximately 5°) to the south and the south limbs dip steeply to the north. The deepest parts of the Cold Creek syncline, the Wye Barricade depression, and the Cold Creek depression are approximately 12 km (7.5 mi) southeast of the Hanford Site 200 Areas, and just to the west-southwest of the 200 West Area, respectively. The deepest part of the Wahluke syncline lies just north of Gable Gap.

The 200 West Area is situated on the generally southward dipping north limb of the Cold Creek syncline 1 to 5 km (0.6 to 3 mi) north of the syncline axis. The Gable Mountain-Gable Butte segment of the Umtanum Ridge anticline lies approximately 4 km (2.5 mi) north of the 200 West Area. The axes of the anticline and syncline are separated by a distance of 9 to 10 km (5.6 to 6.2 mi) and the crest of the anticline (as now exposed) is over 200 m (656 ft) higher than the uppermost basalt layer in the syncline axis. As a result, the basalts and overlying sediments dip to the south and southwest beneath the 200 West Area.

3.4.1.3 Regional and Hanford Site Seismology. Eastern Washington, especially the Columbia Plateau region, is a seismically inactive area when compared to the rest of the western United States (DOE 1988b). The historic seismic record for eastern Washington began in approximately 1850, and no earthquakes large enough to be felt had epicenters on the Hanford Site. The closest regions of historic moderate-to-large earthquake generation are in western Washington and Oregon and western Montana and eastern Idaho. The most significant event relative to the Hanford Site is the 1936 Milton-Freewater, Oregon, earthquake that had a magnitude of 5.75 and that occurred more than 90 km (54 mi) away.

The largest Modified Mercalli Intensity for this event was felt about 105 km (63 mi) from the Hanford Site at Walla Walla, Washington, and was VII.

Geologic evidence of past moderate or possibly large earthquake activity is shown by the anticlinal folds and faulting associated with Rattlesnake Mountain, Saddle Mountain, and Gable Mountain. The currently recorded seismic activity related to these structures consists of micro-size earthquakes. The suggested recurrence rates of moderate and larger-size earthquakes on and near the Hanford Site are measured in geologic time (tens of thousands of years).

3.4.2 Regional Stratigraphy

The following sections summarize regional stratigraphic characteristics of the Columbia River Basalt and Suprabasalt sediments. Specific references to the Hanford Site and 200 West Area are made where applicable to describe the general occurrence of these units within the Pasco Basin.

The principal geologic units within the Pasco Basin include the Miocene age basalt of the Columbia River Basalt Group, and overlying late Miocene to Pleistocene suprabasalt sediments (Figure 3-12). Older Cenozoic sedimentary and volcanoclastic rocks underlying the basalts are not exposed at the surface near the Hanford Site. The basalts and sediments thicken into the Pasco Basin and generally reach maximum thicknesses in the Cold Creek syncline. The suprabasalt sedimentary sequence at the Hanford Site pinches out against the anticlinal structures of Saddle Mountains, Gable Mountain/Umtanum Ridge, Yakima Ridge, and Rattlesnake Hills.

The suprabasalt sediment sequence is up to approximately 230 m (750 ft) thick and dominated by laterally extensive deposits assigned to the late Miocene- to Pliocene-age Ringold Formation and the Pleistocene-age Hanford formation (Figure 3-13). Locally occurring strata informally referred to as the pre-Missoula gravels, the Plio-Pleistocene unit, and the early "Palouse" soil comprise the remainder of the sedimentary sequence. The pre-Missoula gravels underlie the Hanford formation in the east-central Cold Creek syncline and at the east end of Gable Mountain anticline east and south of 200 Areas. The pre-Missoula gravels have not been identified in the 200 West Area. The nature of the contact between the pre-Missoula gravels has not been identified in the 200 West Area. The nature of the contact between the pre-Missoula gravels and the overlying Hanford formation has not been completely delineated. In addition, it is unclear whether the pre-Missoula gravels overlie or interfinger with the early "Palouse" soil and Plio-Pleistocene unit. Magnetic polarity data indicate the unit is no younger than early Pleistocene in age (> 1 Ma [million years before present]) as reported in Baker et al. (1991).

Relatively thin surficial deposits of eolian sand, loess, alluvium, and colluvium discontinuously overlie the Hanford formation.

3.4.2.1 Columbia River Basalt Group. The Columbia River Basalt Group (Figure 3-12) comprises an assemblage of tholeiitic, continental flood basalts of Miocene age. These flows cover an area of more 163,700 km² (63,000 mi²) in Washington, Oregon, and Idaho and have an estimated volume of about 174,356 km³ (40,800 mi³) (Tolan et al. 1989). Isotopic age determinations indicate that basalt flows were erupted approximately 17 to 6 Ma, with more than 98% by volume being erupted in a 2.5 million year period (17 to 14.5 Myr) (Reidel et al. 1989b).

Columbia River Basalt flows were erupted from north-northwest-trending fissures of linear vent systems in north-central and northeastern Oregon, eastern Washington, and western Idaho (Swanson et al. 1979). The Columbia River Basalt Group is formally divided into five formations (from oldest to youngest): Imnaha Basalt, Picture Gorge Basalt, Grande Ronde Basalt, Wanapum Basalt, and Saddle Mountains Basalt. Of these, only the Picture Gorge Basalt is not known to be present in the Pasco Basin. The Saddle Mountains Basalt, divided into the Ice Harbor, Elephant Mountain, Pomona, Esquatzel, Asotin, Wilbur Creek and Umatilla Members (Figure 3-12), forms the uppermost basalt unit throughout most of the Pasco Basin. The Elephant Mountain Member is the uppermost unit beneath most of the Hanford Site except near the 300 Area where the Ice Harbor Member is found and north of the 200 Areas where the Saddle Mountains Basalt has been eroded down to the Umatilla Member locally. On anticlinal ridges bounding the Pasco Basin, the Saddle Mountains Basalt is locally absent, exposing the Wanapum and Grande Ronde Basalts.

3.4.2.2 Ellensburg Formation. The Ellensburg Formation consists of all sedimentary units that occur between the basalt flows of the Columbia River Basalt Group in the central Columbia Basin. The Ellensburg Formation generally displays two main lithologies: volcanoclastics (Reidel and Fecht 1981; Smith et al. 1989), and siliciclastics (DOE 1988b). The volcanoclastics consist mainly of primary pyroclastic air fall deposits and reworked epiclastics derived from volcanic terrains west of the Columbia Plateau. Siliciclastic strata in the Ellensburg Formation consists of clastic, plutonic, and metamorphic detritus derived from the Rocky Mountain terrain. These two lithologies occur as both distinct and mixed in the Pasco Basin. A detailed discussion of the Ellensburg Formation in the Hanford Site is given by Reidel and Fecht (1981). Smith et al. (1989) provides a discussion of age equivalent units adjacent to the Columbia Plateau.

The stratigraphic names for individual units of the Ellensburg Formation are given in Figure 3-12. The nomenclature for these units is based on the upper- and lower-bounding basalt flows and thus the names are valid only for those areas where the bounding basalt flows occur. Because the Pasco Basin is an area where most bounding flows occur, the names given in Figure 3-12 are applicable to the Hanford Site. At the Hanford Site the three

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uppermost units of the Ellensburg Formation are the Selah interbed, the Rattlesnake Ridge interbed, and the Levey interbed.

3.4.2.2.1 Selah Interbed. The Selah interbed is bounded on the top by the Pomona Member and on the bottom by the Esquatzel Member. The interbed is a variable mixture of silty to sandy vitric tuff, arkosic sands, tuffaceous clays, and locally thin stringers of predominantly basaltic gravels. The Selah interbed is found beneath most of the Hanford Site.

3.4.2.2.2 Rattlesnake Ridge Interbed. The Rattlesnake Ridge interbed is bounded on the top of the Elephant Mountain Member and on the bottom by the Pomona Member. The interbed is up to 33 m (108 ft) thick and dominated by three facies at the Hanford Site: (1) a lower clay or tuffaceous sandstone, (2) a middle, micaceous-arkosic and/or tuffaceous sandstone, and (3) an upper, tuffaceous siltstone to sandstone. The unit is found beneath most of the Hanford Site.

3.4.2.2.3 Levey Interbed. The Levey interbed is the uppermost unit of the Ellensburg Formation and occurs between the Ice Harbor Member and the Elephant Mountain Member. It is confined to the vicinity of the 300 Area. The Levey interbed is a tuffaceous sandstone along its northern edge and a fine-grained tuffaceous siltstone to sandstone along its western and southern margins.

3.4.2.3 Ringold Formation. The Ringold Formation at the Hanford Site is up to 185 m (607 ft) thick in the deepest part of the Cold Creek syncline south of the 200 West Area and 170 m (558 ft) thick in the western Wahluke syncline near the 100-B Area. The Ringold Formation pinches out against the Gable Mountain, Yakima Ridge, Saddle Mountains, and Rattlesnake Mountain anticlines. It is largely absent in the northern and northeastern parts of the 200 East Area and adjacent areas to the north in the vicinity of West Lake. The Ringold Formation is assigned a late Miocene to Pliocene age (Fecht et al. 1987; DOE 1988b) and was deposited in alluvial and lacustrine environments (Bjornstad 1985; Fecht et al. 1987; Lindsey et al. 1991).

Recent studies of the Ringold Formation (Lindsey and Gaylord 1989; Lindsey et al. 1992) indicate that it is best described and divided on the basis of sediment facies associations and their distribution. Facies associations in the Ringold Formation (defined on the basis of lithology, petrology, stratification, and pedogenic alteration) include fluvial gravel, fluvial sand, overbank deposits, lacustrine deposits, and alluvial fan. The facies associations are summarized as follows:

- Fluvial gravel--Clast-supported granule to cobble gravel with a sandy matrix dominates the association. Intercalated sands and muds also are found. Clast composition is very variable, with common types being basalt, quartzite, porphyritic volcanics, and greenstones. Silicic plutonic rocks, gneisses, and volcanic breccias also are found.

Sands in this association are generally quartzo-feldspathic, with basalt contents generally in the range of 5 to 25%. Low angle to planar stratification, massive channels, wide, shallow channels, and large-scale cross-bedding are found in outcrops. The association was deposited in a gravelly fluvial system characterized by wide, shallow shifting channels.

- Fluvial sand--Quartzo-feldspathic sands displaying cross-bedding and cross-lamination in outcrop dominate this association. These sands usually contain less than 15% basalt lithic fragments, although basalt contents as high as 50% may be encountered. Intercalated strata consist of lenticular silty sands and clays up to 3 m (10 ft) thick and thin (<0.5 m) gravels. Fining upwards sequences less than 1 m (3.3 ft) to several meters thick are common in the association. Strata comprising the association were deposited in wide, shallow channels.
- Overbank deposits--This association dominantly consists of laminated to massive silt, silty fine-grained sand, and paleosols containing variable amounts of calcium carbonate. Overbank deposits occur as thin lenticular interbeds (<0.5 m to 2 m, <1.6 ft to 6 ft) in the fluvial gravel and fluvial sand associations and as thick (up to 10 m, 33 ft) laterally continuous sequences. These sediments record deposition in a floodplain under proximal levee to more distal floodplain conditions.
- Lacustrine deposits--Plane laminated to massive clay with thin silt and silty sand interbeds displaying some soft-sediment deformation characterize this association. Coarsening upwards packages less than 1 m (3.3 ft) to 10 m (33 ft) thick are common in the association. Strata comprising the association were deposited in a lake under standing water to deltaic conditions.
- Alluvial fan--Massive to crudely stratified, weathered to unweathered basaltic detritus dominates this association. These basaltic deposits generally are found around the periphery of the basin. This association was deposited largely by debris flows in alluvial fan settings.

The lower half of the Ringold Formation contains five separate stratigraphic intervals dominated by fluvial gravels. These gravels, designated units, A, B, C, D, and E (also called FSA, FSB, FSC, FSD, and FSE [Lindsey and Gaylord 1989; Lindsey et al. 1991]) (Figure 3-13), are separated by intervals containing deposits typical of the overbank and lacustrine facies associations. The lowermost of the fine-grained sequences, overlying unit A, is designated the lower mud sequence. The uppermost gravel unit, unit E, grades upwards into interbedded fluvial sand and overbank deposits. These sands and overbank deposits are overlain by lacustrine-dominated strata.

Fluvial gravel units A and E correspond to the lower basal and middle Ringold units respectively as defined by DOE (1988b). Gravel units B, C, and D do not correlate to any

previously defined units (Lindsey et al. 1991). The lower mud sequence corresponds to the upper basal and lower units as defined by DOE (1988b). The upper basal and lower units are not differentiated. The sequence of fluvial sands, overbank deposits, and lacustrine sediments overlying unit E corresponds to the upper unit as seen along the White Bluffs in the eastern Pasco Basin. This essentially is the same usage as originally proposed by Newcomb (1958) and Myers et al. (1979).

3.4.2.4 Plio-Pleistocene Unit. Unconformably overlying the Ringold Formation in the western Cold Creek syncline in the vicinity of 200 West Area (Figures 3-11, 3-12, and 3-13) is the laterally discontinuous Plio-Pleistocene unit (DOE 1988b). The unit is up to 25 m (82 ft) thick and divided into two facies: (1) sidestream alluvium and (2) calcic paleosol (Stage III and Stage IV) (DOE 1988b). The calcic paleosol facies consists of massive calcium carbonate-cemented silt, sand, gravel (caliche) to interbedded caliche-rich and caliche-poor silts and sands. The basaltic detritus facies consists of weathered and unweathered basaltic gravels deposited as locally derived slope wash, colluvium, and sidestream alluvium. The Plio-Pleistocene unit appears to be correlative to other sidestream alluvial and pedogenic deposits found near the base of the ridges bounding the Pasco Basin on the north, west, and south. These sidestream alluvial and pedogenic deposits are inferred to have a late Pliocene to early Pleistocene age on the basis of stratigraphic position and magnetic polarity of interfingering loess units.

3.4.2.5 Pre-Missoula Gravels. Quartzose to gneissic clast-supported pebble to cobble gravel with a quartzo-feldspathic sand matrix underlies the Hanford formation in the east-central Cold Creek syncline and at the east end of Gable Mountain anticline east and south of the 200 East Area (Figures 3-11, 3-12, and 3-13). These gravels, called the pre-Missoula gravels (PSPL 1982), are up to 25 m (82 ft) thick, contain less basalt than underlying Ringold gravels and overlying Hanford deposits, have a distinctive white or bleached color, and sharply truncate underlying strata. The nature of the contact between the pre-Missoula gravels and the overlying Hanford formation is not clear. In addition, it is unclear whether the pre-Missoula gravels overlie or interfinger with the early "Palouse" soil and Plio-Pleistocene unit. Magnetic polarity data indicates the unit is no younger than early Pleistocene in age (> 1 Ma) (Baker et al. 1991).

3.4.2.6 Early "Palouse" Soil. The early "Palouse" soil consists of up to 20 m (66 ft) of massive, brown yellow, and compact, loess-like silt and minor fine-grained sand (Tallman et al. 1979, 1981; DOE 1988b). These deposits overlie the Plio-Pleistocene unit in the western Cold Creek syncline around the 200 West Area (Figures 3-11, 3-12, and 3-13). The unit is differentiated from overlying graded rhythmites (Hanford formation) by greater calcium carbonate content, massive structure in core, and high natural gamma response in geophysical logs (DOE 1988b). This natural gamma response is due to the inherent stratigraphic properties of the unit, rather than from effects of radionuclide contamination. The upper contact of the unit is poorly defined, and it may grade up-section into the lower

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part of the Hanford formation. Based on a predominantly reversed polarity the unit is inferred to be early Pleistocene in age (Baker et al. 1991).

3.4.2.7 Hanford Formation. The Hanford formation consists of pebble to boulder gravel, fine- to coarse-grained sand, and silt (Baker et al. 1991). These deposits are divided into three facies: (1) gravel-dominated, (2) sand-dominated, and (3) silt-dominated facies. These facies are referred to as coarse-grained deposits, plane-laminated sand facies, and rhythmite facies, respectively, in Baker et al. (1991). The silt-dominated deposits also are referred to as the "Touchet Beds," while the gravelly facies are generally referred to as the Pasco Gravels. The Hanford formation is thickest in the Cold Creek bar in the vicinity of 200 West and 200 East Areas where it is up to 65 m (213 ft) thick (Figures 3-11, 3-12, and 3-13). The Hanford formation was deposited by cataclysmic flood waters that drained out of glacial Lake Missoula (Fecht et al. 1987; DOE 1988b; and Baker et al. 1991). Hanford deposits are absent on ridges above approximately 385 m (1,263 ft) above sea level. The following sections describe the three Hanford formation facies.

In addition to the three Hanford formation facies, clastic dikes (Black 1980) also are commonly found in the Hanford formation. These dikes, while common in the Hanford formation, also are found locally in other sedimentary units in the Pasco Basin. Clastic dikes, whether in the Hanford formation or other sedimentary units, are structures that generally cross-cut bedding, although they do locally parallel bedding. The dikes generally consist of alternating vertical to subvertical layers (millimeters to centimeters thick) of silt, sand, and granules. Where the dikes intersect the ground surface, a feature known as patterned ground can be observed (Lindsey et al. 1992).

3.4.2.7.1 Pasco Gravels. The Pasco Gravels consist of two facies, a gravel-dominated facies and a silt-dominated facies. The gravel-dominated facies is dominated by coarse-grained basaltic sand and granule to boulder gravel. These deposits display massive bedding, plane to low-angle bedding, and large-scale planar cross-bedding in outcrop, while the gravels generally are matrix-poor and display an open-framework texture. Lenticular sand and silt beds are intercalated throughout the facies. Gravel clasts in the facies generally are dominated by basalt (50 to 80%). Other clast types include Ringold and Plio-Pleistocene rip-ups, granite, quartzite, and gneiss. The relative proportion of gneissic and granitic clasts in Hanford gravels versus Ringold gravels generally is higher (up to 20% as compared to less than 5%). Sands in this facies usually are very basaltic (up to 90%), especially in the granule size range. Locally Ringold and Plio-Pleistocene rip-up clasts dominate the facies comprising up to 75% of the deposit. The gravel facies dominates the Hanford formation in the 100 Areas north of Gable Mountain, the northern part of 200 East Area, and the eastern part of the Hanford Site including the 300 Area. The gravel-dominated facies was deposited by high-energy flood waters in or immediately adjacent to the main cataclysmic flood channelways.

The sand-dominated facies consists of fine-grained to coarse-grained sand and granular sand displaying plane lamination and bedding and less commonly plane cross-bedding in outcrop. These sands may contain small pebbles and rip-up clasts in addition to pebble-gravel interbeds and silty interbeds less than 1 m (3.3 ft) thick. The silt content of these sands is variable, but where it is low an open framework texture is common. These sands are typically very basaltic, commonly being referred to as black or gray or salt and pepper sands. This facies is most common in the central Cold Creek syncline, in the central to southern parts of the 200 East and 200 West Areas, and in the vicinity of the WPPSS facilities. The sand-dominated facies was deposited in channelways as flow power waned and adjacent to main flood channelways as water in the channelways spilled out of them, losing their competence. The facies is transitional between gravel-dominated facies and silt-dominated facies.

3.4.2.7.2 Touchet Beds. The Touchet Beds consist of a silt-dominated facies. The silt-dominated facies consists of thinly bedded, plane laminated and ripple cross-laminated silt and fine- to coarse-grained sand that commonly display normally graded rhythmities similar to Bouma sequences, a few centimeters to several tens of centimeters thick in outcrop (Myers et al. 1979; DOE 1988b). This facies dominates the Hanford formation throughout the central, southern, and western Cold Creek syncline within and south of 200 East and West Areas. These sediments were deposited under slackwater conditions and in backflooded areas (DOE 1988b).

3.4.2.8 Surficial Deposits. Surficial deposits consist of silt, sand, and gravel that form a thin (< 10 m, 33 ft) veneer across much of the Hanford Site. These sediments were deposited by a mix of eolian and alluvial processes.

3.4.3 200 West Area and U Plant Aggregate Area Geology

The following sections describe the occurrence of the uppermost basalt unit and the suprabasalt sediments in the 200 West Area. The subsection discuss notable stratigraphic characteristics, thickness variations, and the geometric relationships of the sediments. Stratigraphic variations pertinent to the U Plant Aggregate Area are presented in the overall context of stratigraphic trends throughout the 200 West Area.

Geologic cross sections depicting the distribution of basalt and sedimentary units within and near the U Plant Aggregate Area are presented on Figures 3-14 through 3-18. Figure 3-14 illustrates the cross sections locations. A legend for symbols used on the cross sections is provided on Figure 3-15. The cross-sections are based on geologic information from wells shown on the figures, as interpreted in Lindsey et al. (1991). To develop these stratigraphic interpretations, logs for all the wells in the U Plant Aggregate Area were reviewed and a selection was made of the most relevant to the AAMS. Chamness et al. (1991) provide a

compilation of these ten geologic logs from the U Plant Aggregate Area, and a listing of other logs which are available and additional geological, geochemical, and geophysical data available from these and other boreholes. This information was compiled in support of the U Plant Aggregate Area Management Study. The cross sections depict subsurface geology in the U Plant Aggregate Area. For each cross section, locations of U Plant Aggregate Area waste management units are identified for reference. Figures 3-19 through 3-36 present structure maps of the top of the sedimentary units, and isopach maps illustrating the thickness of each unit in the 200 West Area and U Plant Aggregate Area. The structure and isopach maps are included from Lindsey et al. (1991). Plate 1 should be consulted to identify locations of U Plant Aggregate Area buildings and waste management units referenced in the text.

3.4.3.1 Elephant Mountain Basalt. The Elephant Mountain Member of the Saddle Mountains Basalt is continuous beneath the entire 200 West Area. The top of the Elephant Mountain Member dips to the southwest and south into the Cold Creek syncline, reflecting the structure of the area (Figure 3-19). There is little evidence of significant erosion into the top of the Elephant Mountain Member and no indication of erosional "windows" through the basalt into the underlying Rattlesnake Mountain interbed.

3.4.3.2 Ringold Formation. Within the 200 West Area, the Ringold Formation includes the fluvial gravels of unit A, the paleosol and lacustrine muds of the lower mud sequence, the fluvial gravels of unit E, and the sands and minor muds of the upper unit. Ringold units B, C, and D are not found in the immediate vicinity of the 200 West Area.

Several observations can be made regarding the variation of sediment types within the Ringold units in the 200 West Area. In the Ringold unit A gravels, intercalated lenticular sand and silt are most common in the western portion of the 200 West Area (including the U Plant Aggregate Area), and in the southern part of the 200 West Area. In the overlying lower mud sequence, stratigraphic trends seen elsewhere in the Pasco Basin suggest that paleosols in the unit become more common progressing structurally up-dip (Lindsey et al. 1991). In the Ringold unit E gravels, intercalated lenticular beds of sand and silt occur throughout the 200 West Area, although predicting where they will occur is difficult. The upper unit of the Ringold in the 200 West Area tends to be dominated by sand, unlike the upper unit elsewhere in the Pasco Basin where paleosols tend to dominate the upper unit.

Beneath the 200 West Area, the fluvial gravels of Ringold unit A, and the Ringold lower mud sequence tend to thicken and dip to the south-southwest, toward the axis of the Cold Creek syncline (Figures 3-16 and 3-20 through 3-23). The top of unit A is relatively flat in the 200 Area, dipping gently to the west and southwest. Like the unit A gravels, the Ringold lower mud sequence thickens and dips to the south and southeast over the 200 West Area (Figures 3-22 and 3-23). The top of the lower mud unit is less regular, however, and the unit pinches out in the northeastern corner of the 200 West Area. Within the U Plant Aggregate Area, unit A thins in the west and northeast (Figures 3-17, 3-20 and 3-21). The

top of the unit is a relatively flat surface (Figures 3-20 and 3-21). The overbank and lacustrine deposits of the lower mud sequence also thicken and dip to the south and southwest. The lower mud unit, however, is still present in the northeastern corner of the U Plant Aggregate Area and the top shows a depression in the south and southwest of the aggregate area.

Isopach and structure contour maps of fluvial gravel unit E (Figures 3-24 and 3-25) and the upper unit (Figures 3-26 and 3-27) show trends not seen in the underlying unit A and the lower mud sequence. The gravels of unit E generally thin from north-northwest to the east-southeast. The top of the unit is irregular, displaying several highs in the northern and southern parts of the area and several lows in the central part of the 200 West Area. The top of unit E generally dips to the southeast and climbs to the northeast. Intercalated lenticular beds of sand and silt occur throughout the 200 West Area, although predicting where they will occur is very difficult. The gravels of unit E are thinnest in the southeastern corner of the U Plant Aggregate Area. Unit E gravels vary in thickness from 35 m (120 ft) in the southeastern corner to over 90 m (290 ft) in the northern part of the aggregate area.

The upper unit of the Ringold Formation is present only in the western, northern, and central portion of the 200 West Area (Figures 3-26 and 3-27). Where the upper unit is present, the top generally dips to the south-southwest. The upper unit is almost completely absent in the U Plant Aggregate Area, with only a 3 m (10 ft) thickness present on the western border of the northern section.

3.4.3.3 Plio-Pleistocene Unit. The carbonate-rich strata of the Plio-Pleistocene unit largely is restricted to the vicinity of 200 West Area, pinching out near the north, east, and west boundaries of the area (Figures 3-16, 3-17, 3-18, 3-28, and 3-29). The westernmost extent of the unit is not clear, although it seems to extend west and northwest of the 200 West Area. Thickness variations in the unit are very irregular. It is thickest in the southeast, southwest, and northcentral parts of the area while it thins in the south-central and central parts of the area. It thins through the center of the aggregate area and is absent just south of the southwest corner. Although no erosional windows through the units have been encountered in boreholes, there is a possibility they exist, especially in the areas where the unit thins. In addition, fracturing in the carbonate is potentially common and interbedded carbonate-poor lithologies are found at many locations. The top of the unit generally dips to the south and southwest although irregularities occur, especially in the center of the 200 West Area. The unit is continuous over most of the U Plant Aggregate Area. One area of greatest thickness is the eastern portion of the U Plant Aggregate Area reaching a maximum of 14 m (45 ft) (Figure 3-28).

3.4.3.4 Early "Palouse" Soil. Like the Plio-Pleistocene unit, the early "Palouse" soil is largely restricted to the vicinity of the 200 West Area (Figures 3-16, 3-17, 3-18, 3-30, and 3-31). The unit pinches out in the west-central part of the 200 West Area and near the southern, eastern, and northern boundaries. The thickness of the unit varies irregularly. It

is thickest in the southwest, southeast, and central parts of the 200 West Area. The unit is thinnest immediately adjacent to these thicker intervals, and at one location in the central part of the 200 West Area it appears to pinch out. Generally, the top of the unit dips to the south although it becomes fairly irregular in the southern half of the area. The unit thins through the center of the U Plant Aggregate Area and is thickest in the southeast and southwest sections of the area ranging from approximately 2 m (5 ft) to approximately 15 m (50 ft) (Figures 3-30 and 3-31).

3.4.3.5 Hanford Formation. As discussed in the regional geology section, the cataclysmic flood deposits of the Hanford formation are divided into three facies: (1) gravel-dominated, (2) sand-dominated, and (3) silt-dominated facies. Typical lithologic successions consist of fining upwards packages, major fine-grained intervals, and laterally persistent coarse-grained sequences. Mineralogic and geochemical data were not used in differentiating units because of the lack of a comprehensive mineralogic and geochemical data set. The Hanford formation is divided into two units, upper coarse-grained and lower fine-grained, based on lithology. These are essentially the same units as defined in Last et al. (1989). Neither of these units are continuous across the entire 200 West Area, they both display marked changes in thickness and continuity, and they are very heterogeneous.

The lower fine-grained unit of the Hanford formation in the 200 West Area is thick, but locally discontinuous (Figures 3-16, 3-17, 3-18, 3-32, and 3-33). The lower unit is 0 to 32 m (0 to 105 ft) thick and consists dominantly of silt, silty sand, and sand typical of the slackwater facies interbedded with coarser sands like those comprising the sand-dominated facies. This lower unit is cross-cut in places by vertical clastic dikes. These dikes, believed to be the product of dynamic loading from floodwaters, are distributed randomly throughout this lower unit. They are commonly filled with fine sands and silts and oriented near vertical. Thin (<3 m, 10 ft) intervals dominated by the gravel facies are found locally. The distribution of facies within the unit is variable, although the unit generally fines to the south where slackwater deposits become more common. The lower unit is not found in the northern part of the 200 West Area and it generally thickens to the south. Erosional windows through the unit are found, most notably in the central part of the 200 West Area. These erosional windows are elongated in a north-south direction. The unit appears thickest in the U Plant Aggregate Area in the east and west ends attaining a maximum thickness of 37 m (120 ft) in the east and 18 m (60 ft) in the west (Figure 3-32). The unit thins in the north central portion to a thickness of less than 3 m (10 ft) in this area.

The upper coarse-grained unit of the Hanford formation consists of interstratified gravel, sand, and lesser silt (Figures 3-16, 3-17, 3-18, 3-34, and 3-35). Gravel-dominated deposits typical of the gravel facies generally dominate the upper unit. However, at some localities the unit is dominated by deposits typical of the sand-dominated facies that consists of sand containing lesser silt and gravel. Minor silty deposits such as those forming the slackwater facies are found locally. The thickness and distribution of these facies is very variable. Fining upwards sequences going from coarser to finer gravel and gravel, sand

and/or silt are present at some locations. The upper coarse unit is up to 45 m (148 ft) thick and laterally discontinuous, being found in the northern, east-central, and eastern parts of the area (Figure 3-34). The base of the unit is incised into the underlying strata of the lower fine unit and where that unit is absent, the upper coarse unit fills an erosional window. The contact between the upper coarse unit and underlying strata is generally sharp, consisting of gravel facies strata overlying the fines of the lower unit, the early "Palouse" soil, and the Plio-Pleistocene unit. The unit is continuous in the U Plant Aggregate Area, being thickest in the east central section 34 m (113 ft) (Figure 3-34). Over most of the aggregate area the top of the upper coarse-grained unit of the Hanford formation (Figure 3-35) is at the ground surface.

3.4.3.6 Surficial Deposits. Holocene-age surficial deposits in the 200 West Area are dominated by eolian sands. These deposits have been removed from much of the area by construction activities. Where the eolian sands are found they tend to consist of thin (<3 m, 10 ft) sheets that cover the ground (Figure 3-36). Dunes are not generally well developed within the 200 West Area. In the U Plant Aggregate Area these Holocene deposits are found only in scattered portions of the northern part of the Aggregate Area.

3.5 HYDROGEOLOGY

Regional hydrogeology and hydrogeology of the 200 West Area are summarized in the following sections. Where sufficient data exists, interpretations of the hydrogeology beneath the U Plant Aggregate Area are presented. The information presented in these sections is principally taken from the standardized text (Delaney et al. 1991) provided by Westinghouse Hanford for this purpose.

3.5.1 Regional Hydrogeology

The hydrogeology of the Pasco Basin is characterized by a multiaquifer system that consists of four hydrogeological units that correspond to the upper three formations of the Columbia River Basalt Group (Grande Ronde Basalt, Wanapum Basalt, and Saddle Mountains Basalt) and the suprabasalt sediments. The basalt aquifers consist of the tholeiitic flood basalts of the Columbia River Basalt Group and relatively minor amounts of intercalated fluvial and volcanoclastic sediments of the Ellensburg Formation. Confined zones in the basalt aquifers are present in the sedimentary interbeds and/or interflow zones that occur between dense basalt flows. The main water-bearing portions of the interflow zones are networks of interconnecting vesicles and fractures of the flow tops and flow bottoms (DOE 1988b). The suprabasalt sediment or uppermost aquifer system consists of fluvial, lacustrine, and glaciofluvial sediments. This aquifer is regionally unconfined and is contained largely within the Ringold Formation and Hanford formation. The position of the water table in the southwestern Pasco Basin is generally within Ringold fluvial gravels of

unit E. In the northern and eastern Pasco Basin the water table is generally within the Hanford formation. Table 3-1 presents hydraulic parameters for various water-bearing geologic units at the Hanford Site.

Local recharge to the shallow basalt aquifers results from infiltration of precipitation and runoff along the margins of the Pasco Basin, and in areas of artificial recharge where a downward gradient from the unconfined aquifer systems to the uppermost confined basalt aquifer may occur. Regional recharge of the deep basalt aquifers is inferred to result from interbasin groundwater movement originating northeast and northwest of the Pasco Basin in areas where the Wanapum and Grande Ronde Basalts crop out extensively (DOE 1988b). Groundwater discharge from shallow basalt aquifers is probably to the overlying aquifers and to the Columbia River. The discharge area(s) for the deeper groundwater system is uncertain, but flow is inferred to be generally southeastward with discharge thought to be south of the Hanford Site (DOE 1988b).

Erosional "windows" through dense basalt flow interiors allow direct interconnection between the uppermost aquifer systems and underlying confined basalt aquifers. Graham et al. (1984) reported that some contamination was present in the uppermost confined aquifer (Rattlesnake Ridge interbed) south and east of Gable Mountain Pond. Graham et al. (1984) evaluated the hydrologic relationships between the Rattlesnake Ridge interbed aquifer and the unconfined aquifer in this area and delineated a potential area of intercommunication beneath the northeast portion of the 200 East Area.

The base of the uppermost aquifer system is defined as the top of the uppermost basalt flow. However, fine-grained overbank and lacustrine deposits in the Ringold Formation locally form confining layers for Ringold fluvial gravels underlying unit E. The uppermost aquifer system is bounded laterally by anticlinal basalt ridges and is approximately 152 m (500 ft) thick near the center of the Pasco Basin.

Sources of natural recharge to the uppermost aquifer system are rainfall and runoff from the higher bordering elevations, water infiltrating from small ephemeral streams, and river water along influent reaches of the Yakima and Columbia Rivers. The movement of precipitation through the unsaturated (vadose) zone has been studied at several locations on the Hanford Site (Gee 1987; Routson and Johnson 1990; Rockhold et al. 1990). Conclusions from these studies vary. Gee (1987) and Routson and Johnson (1990) conclude that no downward percolation of precipitation occurs on the 200 Areas Plateau where the sediments are layered and vary in texture, and that all moisture penetrating the soil is removed by evapotranspiration. These two studies analyzed data collected over a period of 12 and 14 years, respectively, and do not specifically address short-term seasonal fluctuations. Rockhold et al. (1990) suggest that downward water movement below the root zone is common in the 300 Area, where soils are coarse-textured and precipitation is above normal.

3.5.2 Hanford Site Hydrogeology

This section describes the hydrogeology of the Hanford Site with specific reference to the 200 Areas.

3.5.2.1 Hydrostratigraphy. The hydrostratigraphic units of concern in the 200 Areas are (1) the Rattlesnake Ridge interbed (confined water-bearing zone), (2) the Elephant Mountain Basalt Member (confining horizon), (3) the Ringold Formation (unconfined and confined water-bearing zones and lower part of the vadose zone), (4) the Plio-Pleistocene unit and early "Palouse" soil (primary vadose zone perching horizons and/or perched groundwater zones) and (5) the Hanford formation (vadose zone) (Figure 3-37). The Plio-Pleistocene unit and early "Palouse" soil are only encountered in the 200 West Area. Strata below the Rattlesnake Ridge interbed are not discussed because the more significant water-bearing intervals, relating to environmental issues, are primarily closer to ground surface. The hydrogeologic designations for the 200 Areas were determined by examination of borehole logs and integration of these data with stratigraphic correlations from existing reports.

3.5.2.1.1 Vadose Zone. The vadose zone beneath the 200 Areas ranges from approximately 55 m (180 ft) beneath the former U Pond to approximately 104 m (340 ft) west of the 200 East Area (Last et al. 1989). Sediments in the vadose zone consist of the (1) fluvial gravel of Ringold unit E, (2) the upper unit of the Ringold Formation, (3) Plio-Pleistocene unit, (4) early "Palouse" soil, and (5) Hanford formation. Only the Hanford formation is continuous throughout the vadose zone in the 200 Areas. The upper unit of the Ringold Formation, the Plio-Pleistocene unit, and the early "Palouse" soil only occur in 200 West Area. The unconfined aquifer water table (discussed in Section 3.5.2.1.3) lies within the Ringold unit E.

The transport of water through the vadose zone depends in complex ways on several factors, including most significantly the moisture content of the soils and their hydraulic properties. Darcy's law, although originally conceived for saturated flow only, was extended by Richards to unsaturated flow, with the provisions that the soil hydraulic conductivity becomes a function of the water content of the soil and the driving force is predominantly differences in moisture level. The moisture flux, q , in cm/s in one direction is then described by a modified form of Darcy's law commonly referred to as Richards' Equation (Hillel 1971) as follows:

$$q = K(\theta) \times \frac{\partial \phi}{\partial \theta} \times \frac{\partial \theta}{\partial x} \text{ (Richards' Equation)}$$

where

- $K(\theta)$ is the water-content-dependent unsaturated hydraulic conductivity in cm/s

- $\partial\phi/\partial\theta$ is the slope of the soil-moisture retention curve $\phi(\theta)$ at a particular volumetric moisture content θ (a soil-moisture retention curve plots volumetric moisture content observed in the field or laboratory against suction values for a particular soil, see Figure 3-39 from Gee and Heller [1985] for an example)
- $\partial\theta/\partial x$ is the water content gradient in the x direction.

More complicated forms of this equation are also available to account for the effects of more than one dimensional flow and the effects of other driving forces such as gravity.

The usefulness of Richards' Equation is that knowing the moisture content distribution in soil, having measured or estimated values for the unsaturated hydraulic conductivity corresponding to these moisture contents, and having developed a moisture retention curve for this soil, one can calculate a steady state moisture flux. With appropriate algebraic manipulation or numerical methods, one could also calculate the moisture flux under transient conditions.

In practice, applying Richards' Equation is quite difficult because the various parameters involved are difficult to measure and because soil properties vary depending on whether the soil is wetting or drying. As a result, soil heterogeneities affect unsaturated flow even more than saturated flow. Several investigators at the Hanford Site have measured the vadose zone moisture flux directly using lysimeters (e.g., Rockhold et al. 1990; Routson and Johnson 1990). These direct measurements are discussed in Section 3.5.2.2 under the heading of natural groundwater recharge.

An alternative to direct measurement of unsaturated hydraulic conductivity is to use theoretical methods which predict the conductivity from measured soil moisture retention data (Van Genuchten et al. 1991).

Thirty-five soil samples from the 200 West Area have had moisture retention data measured. These samples were collected from Wells 299-W18-21, 299-W15-16, 299-W15-2, 299-W10-13, 299-W7-9, and 299-W7-2. Eleven of these samples were reported by Bjornstad (1990). The remaining 24 were analyzed as part of an ongoing performance assessment of the low-level burial grounds (Connelly et al. 1992). For each of these samples saturated hydraulic conductivity was measured in the laboratory. Van Genuchten's computer program RETC was then used to develop wetting and drying curves for the Hanford, early "Palouse" soil, Plio-Pleistocene, upper Ringold, and Ringold gravel lithologic units. An example of the wetting and drying curves, and corresponding grain size distributions, is provided on Figure 3-38.

The unsaturated hydraulic conductivities may vary by orders of magnitude with varying moisture contents and among differing lithologies with significantly different soil textures and

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hydraulic conductivities. Therefore, choosing a moisture retention curve should be made according to the particle size analyses of the samples and the relative density of the material.

Once the relationship between unsaturated hydraulic conductivity and moisture content is known for a particular lithologic unit, travel time can also be estimated for a steady-state flux passing through each layer by assuming a unit hydraulic gradient. Under the unit gradient condition, only the force of gravity is acting on water and all other forces are considered negligible. These assumptions may be met for flows due to natural recharge since moisture differences become smoothed out after sufficient time. Travel time for each lithologic unit of a set thickness and calculated for any given recharge rate and the total travel time is equivalent to the sum of the travel times for each individual lithologic unit. To calculate the travel time for any particular site the detailed layering of the lithologic units should be considered. For sites with artificial recharge (e.g., cribs and trenches) more complicated analyses would be required to account for the effects of saturation.

Several other investigators have measured vadose zone soil hydraulic conductivities and moisture retention characteristics at the Hanford Site both in situ (i.e., in lysimeters) and in specially prepared laboratory test columns. Table 3-2 summarizes data identified for this study by stratigraphic unit. Rockhold et al. (1988) presents a number of moisture retention characteristic curves and plots of hydraulic conductivity versus moisture content for various Hanford soils. For the Hanford formation, vadose zone hydraulic conductivity values at saturation range from 10^{-4} to 10^{-2} cm/s. These saturated hydraulic conductivity values were measured at volumetric water contents of 40 to 50%. Hydraulic conductivity values corresponding to volumetric water contents ranging from 2 to 10% ranged from 2×10^{-11} to 7×10^{-7} cm/s.

An example of the potential use of this vadose zone hydraulic parameter information is presented by Smoot et al. (1989) in which precipitation infiltration and subsequent contaminant plume movement near a prototype single-shell tank was evaluated using a numerical computer code. Smoot et al. (1989) used the UNSAT-H one-dimensional finite-difference unsaturated zone water flow computer code to predict the precipitation infiltration for several different soil horizon combinations and characteristics. The researchers used statistically generated precipitation values which were based on actual daily precipitation values recorded at the Hanford Site between 1947 and 1989 to simulate precipitation infiltration from January 1947 to December 2020. The same authors also used the PORFLO-3 computer code to simulate ^{106}Ru and ^{137}Cs movement through the unsaturated zone.

Smoot et al. (1989) concluded that 68 to 86% of the annual precipitation infiltrated into a gravel-capped soil column while less than 1% of the annual precipitation infiltrated into a silt loam-capped soil column. For the gravel-capped soil column, the simulations showed the ^{106}Ru plume approaching the water table after 10 years of simulated precipitation infiltration. The simulated ^{137}Cs plume migrated a substantially shorter distance due to greater adsorption

on soil particles. In both cases, the simulated plume migration scenarios are considered to be conservative due to the relatively soil absorption coefficients used.

Graham et al. (1981) estimated that historical artificial recharge from liquid waste disposal in the 200 (Separations) Areas exceeded all natural recharge by a factor of ten. In the absence of ongoing artificial recharge, i.e., liquid waste disposal to the soil column, natural recharge could potentially be a driving force for mobilizing contaminants in the subsurface. Natural sources of recharge to the vadose zone and the underlying water table aquifer are discussed in Section 3.5.2.2. Additional discussion of the potential for natural and artificial recharge to mobilize subsurface contaminants is presented in Section 4.2.

Another facet of moisture migration in the vadose zone is moisture retention above the water table. Largely due to capillary forces, some portion of the moisture percolating down from the ground surface to the unconfined aquifer will be held against gravity in soil pore space. Finer-grained soils retain more water (against the force of gravity) on a volumetric basis than coarse-grained soils (Hillel 1971). Because unsaturated hydraulic conductivity increases with increasing moisture content, finer-grained soils may be more permeable than coarse-grained soils at the same water content. Also, because the moisture retention curve for coarse-grained soils is generally quite steep (Smoot et al. 1989), the permeability contrast between fine-grained and coarse-grained soils at the same water content can be substantial. The occurrence of interbedded fine-grained and coarse-grained soils may result in the formation of "capillary barriers" and can in turn lead to the formation of perched water zones. General conditions leading to the formation of perched water zones at the Hanford Site are discussed in Section 3.5.2.1.2. Potential perched water zones in the U Plant Aggregate Area are discussed in Section 3.5.3.1.2.

3.5.2.1.2 Perched Water Zones. Moisture moving downward through the vadose zone may accumulate on top of highly cemented horizons and may accumulate above the contact between a fine-grained horizon and an underlying coarse-grained horizon as a result of the "capillary barrier" effect. If sufficient moisture accumulates, the soil pore space in these perching zones may become saturated. In this case, the capillary pressure within the horizon may locally exceed atmospheric pressure, i.e., saturated conditions may develop. Additional input of downward percolating moisture to this horizon may lead to a hydraulic head buildup above the top of the horizon. Consequently, a monitoring well screened within or above this horizon would be observed to contain free water.

The lateral extent and composition of the Plio-Pleistocene and early "Palouse" soil units may provide conditions amenable to the formation of perched water zones in the vadose zone above the unconfined aquifer. The calcrete facies of the Plio-Pleistocene unit, consisting of calcium-carbonate-cemented silt, sand, and gravel, is a potential perching horizon due to its likely low hydraulic conductivity. However, the Plio-Pleistocene unit is typically fractured and may have erosional scours in some areas, potentially allowing deeper infiltration of groundwater, a factor which may limit the lateral extent of accumulated perched

groundwater. The early "Palouse" soil horizon, consisting of compact, loess-like silt and minor fine-grained sand, is also a likely candidate for accumulating moisture percolating downward through the sand and gravel-dominated Hanford formation.

3.5.2.1.3 Unconfined Aquifer. The uppermost aquifer system in the 200 Areas occurs primarily within the sediments of the Ringold Formation and Hanford formation. In the 200 West Area the upper aquifer is contained within the Ringold Formation and displays unconfined to locally confined or semiconfined conditions. In the 200 East Area the upper aquifer occurs in the Ringold Formation and Hanford formation. The depth to groundwater in the upper aquifer underlying the 200 Areas ranges from approximately 60 m (197 ft) beneath the former U Pond in 200 West Area to approximately 105 m (340 ft) west of the 200 East Area. The saturated thickness of the unconfined aquifer ranges from approximately 67 to 112 m (220 to 368 ft) in the 200 West Area and approximately 61 m (200 ft) in the southern 200 East Area to nearly absent in the northeastern 200 East Area where the aquifer thins out and terminates against the basalt located above the water table in that area.

The upper part of the uppermost aquifer in the 200 West Area consists of generally unconfined water-bearing zone within the Ringold unit E. The lower part of the uppermost aquifer consists of confined to a semi-confined water-bearing zone within the gravelly sediments of Ringold unit A. The Ringold unit A is generally confined by fine-grained sediments of the lower mud sequence. The thickness of this confined zone ranges from greater than 38 m (125 ft) in the southeastern portion of the 200 West Area to nearly absent where it pinches out just north of the northern 200 West Area boundary. The lower mud sequence confining zone overlying unit A is up to 30 m (100 ft) thick below the south-central section of the 200 West Area before pinching out in the northeastern corner of the 200 West Area. Where it is absent, the Ringold units A and E combine to form a single thick unconfined aquifer.

Due to its importance with respect to contaminant transport, the unconfined aquifer is generally the most characterized hydrologic unit beneath the Hanford Site. A number of observation wells have been installed and monitored in the unconfined aquifer. Additionally, in situ aquifer tests have been conducted in a number of the unconfined aquifer monitoring wells. Results of these in situ tests vary greatly depending on the following:

- Horizontal position/location between areas across the Hanford Site and even smaller areas (such as across portions of the 200 Areas)
- Depth, even within a single hydrostratigraphic unit
- Analytical methods for estimating hydraulic conductivity.

Details regarding this aquifer system can be found in the 200 West Groundwater Aggregate Area Management Study Report (AAMSR).

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3.5.2.2 Natural Groundwater Recharge. Sources of natural recharge to groundwater at the Hanford Site include precipitation infiltration, runoff from higher bordering elevations and subsequent infiltration within the Hanford Site boundaries, water infiltrating from small ephemeral streams, and river water infiltrating along influent reaches of the Yakima and Columbia Rivers (Graham et al. 1981). The principal source of natural recharge is believed to be precipitation and runoff infiltration along the periphery of the Pasco Basin. Small streams such as Cold Creek and Dry Creek, west of the 200 West Area, also lose water to the ground as they spread out on the valley plain. Considerable debate exists as to whether any recharge to groundwater occurs from precipitation falling on broad areas of the 200 Areas Plateau.

Natural precipitation infiltration at or near waste management units or unplanned releases may provide a driving force for the mobilization of contaminants previously introduced to surface or subsurface soils. For this reason, determination of precipitation recharge rates at the Hanford Site has been the focus of many previous investigations. Previous field programs have been designed to assess precipitation, infiltration, water storage changes, and evaporation to evaluate the natural water balance during the recharge process. Precipitation recharge values ranging from 0 to 10 cm/yr (0 to 4 in./yr) have been estimated from various studies.

The primary factors affecting precipitation recharge appear to be surface soil type, vegetation type, topography, and year-to-year variations in seasonal precipitation. A modeling analysis (Smoot et al. 1989) indicated that 68 to 86% of the precipitation falling on a gravel-covered site might infiltrate to a depth greater than 2 m (6 ft). As discussed below, various field studies suggest that less than 25% of the precipitation falling on typical Hanford Site soils actually infiltrates to any depth.

Examples of precipitation recharge studies include the following:

- A study by Gee and Heller (1985) described various models used to estimate natural recharge rates. Many of the models use a water retention relationship for the soil. This relates the suction required to remove (or move) water to its dryness (saturation or volumetric moisture content). Two of these have been developed by Gee and Heller (1985) for soils in lysimeters on the Hanford Site. As an example of available data, the particle size distribution and the water retention curves of these two soils are shown in Figure 3-39. Additional data and information about possible models for unsaturated flow may be found in Brownell et al. (1975), and Rockhold et al. (1990).
- Moisture contents have been obtained from a number of core-barrel samples in the 200 Areas (East and West) and varied from 1 to 18%, with most in the range of 2 to 6% (Last et al. 1989). The data appear to indicate zones of increased moisture content that could be interpreted as signs of moisture transport. None

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of the boreholes that this study used (for moisture content or other parameters) were located in the vicinity of the U Plant Aggregate Area.

- A lysimeter study reported by Routson and Johnson (1990) was conducted at a location 1.6 km south of the 200 East Area. During much of the lysimeters' 13-year study period between 1972 and 1985, the surface of the lysimeters were maintained unvegetated with herbicides. No information regarding the soil types in the lysimeters was found. To a precision of ± 0.2 cm, no downward moisture movement was observed in the instruments during periodic neutron-moisture measurements or as a conclusion of a final soil sample collection and moisture content analysis episode.
- An assessment of precipitation recharge involving the redistribution of ^{137}Cs in vadose zone soil also reported by Routson and Johnson (1990). In this study, split-spoon soil samples were collected beneath a solid waste burial trench in the T Plant Aggregate Area. The trench, apparently located just south and west of the 218-W-3AE Burial Ground, received soil containing ^{137}Cs from an unspecified spill. Cesium-137 was not detected below the bottom of the burial trench. However, increased ^{137}Cs activity was observed above the top of the waste fill which Routson and Johnson concluded indicated that net negative recharge (loss of soil moisture to evapotranspiration) had occurred during the 10-year burial period.

Sparse Russian thistle was observed at the burial trench area in 1980. Rockhold et al. (1990) noted that ^{137}Cs appears to strongly sorb to Hanford Site soils indicating that the absence of the radionuclide at depth below the burial trench may not support the conclusion that no downward moisture movement occurred.

- A weighing lysimeter study reported by Rockhold et al. (1990) which was conducted at a grassy plot approximately 5 km (3 mi) northwest of the 300 Area. The grass test site was located in a broad, shallow topographic depression approximately 900 m (2,950 ft) wide, several hundred meters long, trending southwest. The area is covered with annual grasses (cheatgrass and bluegrass). The upper 3.5 m of the soil profile consists of slightly silty to silty sand (sandy loam) with an estimated saturated hydraulic conductivity of 9×10^{-3} cm/sec. Rockhold et al. (1990) estimated that approximately 0.8 cm (0.3 in.) of downward moisture movement occurred between July 1987 and June 1988. This represents approximately 7% of the total precipitation recorded in that area during that time period.
- A gravel-covered lysimeter study discussed by Rockhold et al. (1990) which was conducted at the 622 Area Lysimeter Site, approximately 0.5 km (0.3 mi) east of the 200 West Area. Approximately 4 cm (1.6 in.) of downward moisture

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movement was observed in two gravel-covered lysimeters during 1988 and 1989. This represented approximately 25% of the total precipitation recorded in the area during the study period. The authors concluded that gravel placed on the soil surface reduces evaporation and facilitates precipitation infiltration.

The drainage (downward moisture movement) observed in these studies may represent potential recharge to deeper vadose zone soils and/or the underlying water table.

3.5.2.3 Groundwater Flow. Groundwater flow north of Gable Mountain currently trends in a northeasterly direction as a result of mounding near reactors and flow through Gable Gap. South of Gable Mountain, flow is interrupted locally by the groundwater mounds in the 200 Areas. There is also a component of groundwater flow to the north between Gable Mountain and Gable Butte from the 200 Areas. In the 200 East Area, groundwater elevations in June 1990 (Figure 3-40) for the unconfined aquifer showed little variation and were generally around 133 m (405 ft) (Kasza et al. 1990).

Temporary reversal of groundwater flow entering the Columbia River may occur during transient, high-river stages. This occurrence is known as bank storage. Correlations were made between groundwater level and river-stage fluctuations along a 81 km (50 mi) reach of the Columbia River adjacent to the Hanford Site by Newcomb and Brown (1961). They concluded that a 260 km² (100 mi²) area within the Hanford Site was affected by bank storage. During a 45 day rise in river stage, it was estimated that water infiltrated at an average rate of 4,600,000 m³/day (3,700 acre-ft/day) versus 1,200,000 m³/day (1,000 acre-ft/day) during the 165 day recession period. Since this study was conducted, dam control on the Columbia River has reduced the magnitude of bank storage on the groundwater system.

Natural groundwater inflow to the unconfined aquifer primarily occurs along the western boundary of the Hanford Site. Currently, man-made recharge occurs in several active waste management units (e.g., the 216-U-14 Ditch, 216-U-17 Crib, and the 216-Z-20 Crib) located within the U Plant Aggregate Areas in the 200 West Area. Historically, much greater recharge occurred from a number of waste management units in the 200 Areas. Man-made recharge probably substantially exceeds natural precipitation recharge in these areas. The unconfined aquifer ultimately discharges to the Columbia River, either near the 100 Areas, north of the 200 Areas through Gable Gap, or between the 100 Areas and the 300 Area, east of the 200 Areas. The precise path is strongly dependent on the hydrologic conditions in the 200 East Area (Delaney et al. 1991). If recharge in the 200 East Area is large, more of the recharge from the 200 West Area is diverted north through Gable Gap toward the 100 Areas. Generally, however, the easterly route appears to be more likely for recharge from the 200 West Area.

3.5.2.4 Historical Effects of Operations. Historical effluent disposal at the Hanford Site altered previously prevailing groundwater hydraulic gradients and flow directions. Before operations at the Hanford Site began in 1944, groundwater flow was generally toward the

east, and the groundwater hydraulic gradient in the 200 West Area was on the order of 0.001 (Delaney et al. 1991). Prior to disposing liquid waste to the soil column in the Separations Areas, groundwater elevations in the 200 West Area may have been as much as 20 m (65 ft) lower in 1944 than at present. As seen in Figure 3-40, a distinct groundwater mound is still apparent beneath the 200 West Area. The horizontal hydraulic gradient is expected to decrease and shift to the east as the mound continues to dissipate.

3.5.3 U Plant Aggregate Area Hydrogeology

This section presents additional hydrogeologic information identified with specific application to the U Plant Aggregate Area.

3.5.3.1 Hydrostratigraphy. As shown on Figure 3-41, the hydrostratigraphic units of concern beneath the U Plant Aggregate Area are (1) the Rattlesnake Ridge interbed, (2) the Elephant Mountain Basalt Member, (3) the Ringold Formation units A and E, (4) the Plio-Pleistocene unit and early "Palouse" soil, and (5) the Hanford formation. The hydrogeologic designations for the U Plant Aggregate Area were determined by examination of borehole logs from Lindsey et al. (1991) and Chamness et al. (1991) and integration of these data with stratigraphic correlations from existing reports. For the purposes of the U Plant AAMSR, this discussion will be limited to the vadose zone and possible perching horizons with the vadose zone underlying the aggregate area. Additional information on the aquifer systems in contained in the 200 West Groundwater AAMSR.

3.5.3.1.1 Vadose Zone. The vadose zone beneath the U Plant Aggregate Area ranges in thickness from about 67 m (220 ft) along the western part of the central aggregate area boundary to 57 m (194 ft) in the vicinity of the former U Pond based on December 1990 groundwater elevation data (Kasza et al. 1990). The observed variation in vadose zone thickness is the result of variable surface topography and the variable elevation of the water table in the underlying unconfined aquifer. The area of least saturated thickness generally lies above a groundwater mound identified in the unconfined aquifer south and east of the U Plant building complex (Figure 3-40). As discussed in Section 3.5.2.4, the mound apparently originated from historic discharges to the U Pond.

A report regarding the installation of Monitoring Wells 299-W22-40, 299-W22-41, 299-W22-42, and 299-W22-43, adjacent to the 216-U-12 Crib (Goodwin 1990) and at the southeastern border of the U Plant Aggregate Area, provides data which may be applicable to the vadose zone soils in the Area. The analysis indicates that moisture contents of between less than 1% and up to 24% are typically found in these borings and may be typical of the area. Of the 105 samples analyzed for moisture contents, 86% of them were between 1 and 10%. It should be noted, however, that this investigation was conducted in the vicinity of a previously active crib, and it is possible that there is some impact of disposal of liquid wastes on these moisture contents.

3.5.3.1.2 Perched Water Zones. The characteristics, extent and stratigraphic position of the Plio-Pleistocene and early "Palouse" soil units in the 200 West Area (see Figures 3-16, 3-17, 3-18, 3-28, 3-29, 3-30, and 3-31) provide conditions for collection and possible movement of vadose zone recharge water above the unit. The high cementation, laterally continuous nature and relatively gentle (1.5°) dip to the southwest of the Plio-Pleistocene unit indicate the possibility of perched water zones.

One perched zone appears to exist under the 216-U-1 and 216-U-2 Cribs area and extends at least as far as the 216-U-16 Crib because of the cause and effect connection of the disposal in 216-U-16 mobilizing the previously disposed contaminants below 216-U-1 and 216-U-2 Cribs. No wells appear to screen this zone in this portion of the site however.

Another area of known perched water is below the active portion of the 216-U-14 Ditch approximately 150 m (500 ft) southeast of the 241-U Tank Farm. Wells 299-W19-91, 299-W19-92, and 299-W19-93 are screened in the same stratigraphic position at depth of about 30 to 36 m (100 to 120 ft) below ground surface (bottom of screened interval elevation around 169 m (555 ft) above mean sea level). This elevation is about 3 m (10 ft) above the top of the early "Palouse" soil, based on the contours shown in Figures 3-25 and 3-31, and, thus, is located in the Hanford formation. Water levels in these wells were measured in December 1989 through September 1990 with the result that Wells 299-W19-91 and -92 had an average water level of 172 m (563 ft) above sea level and Well 299-W19-93 (the most southerly of the three) had a level of about 176 m (576 ft), some 4 m (13 ft) higher. The water levels measured in these wells are probably indicative of perched water zones in the early "Palouse" soil above impermeable caliche layers in the Plio-Pleistocene unit.

Apparently the calcareous cementation in the Plio-Pleistocene unit greatly reduces the permeability. The downward movement of water is thereby inhibited and perched water zones may locally form.

Another instance of perched water occurs in Well 299-W18-29. This well is located on the west edge of the U Plant Aggregate Area, approximately 150 m (500 ft) west of the 241-U Tank Farm. The well is screened between 169 m (555 ft) and 164 m (539 ft) above sea level, intersecting the Plio-Pleistocene unit. Water has been reported in this well, however a current water level is not available. The presence of water in this zone may be due to waste disposal practices at the 216-Z-20 Crib.

There are liquid disposal sites within or in the vicinity of the U Plant Aggregate Area where perched water has not been found. These include the following:

- An area between the two areas of perched water beneath the 216-U-14 Ditch and the 216-U-1 and 216-U-2 Cribs where Well 299-W19-22 was completed to a bottom of screen elevation of about 168 m (550 ft) above sea level in the vadose zone without finding water.

- The vicinity of the 216-Z-20 Crib outside of the operable unit to the west of the 216- U-14 Ditch in the areas of Wells 299-W18-17, -18, -19, and -20 but not 299-W-18-29.
- In the vicinity of the 216-U-17 Crib at the eastern end of the operable unit.

These disposal sites may be underlain by areas in which the caliche layer is absent. As described in Section 3.4.3.3 the caliche layer is not laterally continuous and its thickness is quite variable.

The evidence for the absence of perched water at these liquid disposal sites is presently anecdotal. Information about hydraulic properties of the perched water zones is very limited and will vary depending upon the stratigraphic position of the perched zone.

Goodwin (1990) presents the results of slug tests in four wells installed at the 216-U-12 Crib in 1990, although review of the screen depths and well logs indicates that these wells may be screened in a small section of the upper Ringold which is likely to be different (and lower in conductivity) than the main aquifer in the middle Ringold.

3.5.3.2 Natural Groundwater Recharge. As discussed in Section 3.3.3, no natural surface water bodies exist within the U Plant Aggregate Area. Therefore, the potential for natural groundwater recharge within the U Plant Aggregate Area is limited to precipitation infiltration. No precipitation infiltration data were identified with specific reference to the U Plant Aggregate Area. However, the amount of precipitation infiltration is likely comparable to the range of values identified for various Hanford test sites, i.e., 0 to 10 cm/yr.

As suggested in Section 3.5.2.2, precipitation infiltration rates probably vary with respect to location within the U Plant Aggregate Area. Higher infiltration rates are expected in unvegetated areas or areas with shallow rooting plants, in areas with gravelly soils exposed at the surface, and in areas where the topography is flat.

3.5.3.3 Groundwater Flow Beneath the U Plant Aggregate Area. Within the U Plant Aggregate Area, groundwater flow is generally toward the east, based on December 1990 Hanford wells groundwater elevation data (Kasza et al. 1990) (Figure 3-40). Flow is generally away from the groundwater mound located below the former U Pond in the southern part of the aggregate area. A review of groundwater maps of the unconfined aquifer (Kasza et al. 1990) indicates relatively steep decreases in groundwater elevations directly east of the mound and more gradual elevation decreases to the west. Flow in the northern and eastern sections of the aggregate area is generally easterly with gradual elevation decreases.

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3.5.3.4 Historical Effects of Operations. The early period of monitoring (1958 to 1967) was characterized as a period of rising water tables. This effect can be attributed to the operations of both U Plant (1952 to 1958) and the Reduction and Oxidation (REDOX) Plant (1951 to 1967), which contributed recharge through sizable discharges to the cribs in the area. After the shutdown of the REDOX Plant in 1967, water levels dropped several feet, through 1973. The return to these earlier water levels started in about 1974 that must be attributable to 216-U-10 Pond discharges, although the major contributor to this facility, the 242-S Evaporator, did not go online until 1975. The shutdown of the 242-S Evaporator in about 1980 had only a minor effect on groundwater tables, but the subsequent decommissioning of 216-U-10 Pond in 1984 began a steady decline in water levels that has continued through the period of record and is anticipated to continue for the foreseeable future until natural groundwater levels (without any additional recharge on the Hanford Site) are eventually reached.

3.6 ENVIRONMENTAL RESOURCES

The Hanford Site is characterized as a cool desert or a shrub-steppe and supports a biological community typical of this environment.

3.6.1 Flora and Fauna

The 200 Areas Plateau is represented by a number of plant, mammal, bird, reptile, amphibian, and insect species as discussed below.

3.6.1.1 Vegetation of the 200 Areas Plateau. The vegetation of the 200 Areas Plateau is characterized by native shrub steppe interspersed with large areas of disturbed ground with a dominant annual grass component. The native stands are classified as an *Artemisia tridentata/Poa sandbergii - Bromus tectorum* community (Rogers and Rickard 1977) meaning that the dominant shrub is big sagebrush (*Artemisia tridentata*) and the understory is dominated by the native Sandberg's bluegrass (*Poa sandbergii*) and the introduced annual cheatgrass (*Bromus tectorum*). Other shrubs that are typically present include gray rabbitbrush (*Chrysothamnus nauseosus*), green rabbitbrush (*C. viscidiflorus*), spiny hopsage (*Grayia spinosa*), and occasionally antelope bitterbrush (*Purshia tridentata*). Other native bunchgrasses that are typically present include bottlebrush squirreltail (*Sitanion hystrix*), Indian ricegrass (*Oryzopsis hymenoides*), needle-and-thread (*Stipa commode*), and prairie junegrass (*Koeleria cristata*). Common and important herbaceous species include turpentine cymopteris (*Cymopteris terebinthinus*), globemallow (*Sphaeraica munroana*), balsamroot (*Balsamorhiza careyana*), several milk vetch species (*Astragalus carcinus*, *A. sclerocarpus*, *A. succumbens*), long-leaf phlox (*Phlox longifolia*), the common yarrow (*Achillea millifolium*), pale evening-primrose (*Oenothera pallida*), thread-leaf phacelia (*Phacelia linearis*), and several daisy/fleabane species (*Erigeron poliospermus*, *E. Filifolius*, and *E.*

pumilus). In all, well over 100 plant species have been documented to occur in native stands on the 200 Areas Plateau.

Disturbed communities on the 200 Areas Plateau are primarily the result of either mechanical disturbance or range fires. Mechanical disturbance, including construction activities, soil borrow areas, road clearings, and fire breaks, results in drastic changes to the plant community. This type of disturbance usually entails a complete loss of soil structure and total disruption of nutrient cycling. The principal colonizers of mechanically disturbed areas are the annual weeds Russian thistle (*Salsola kali*), Jim Hill mustard (*Sisymbrium altissimum*), and bur-ragweed (*Ambrosia acanthicarpa*). If no further disturbance occurs, the areas will eventually become dominated by cheatgrass. All of these annual weeds are occasionally found in native stands, but only at relatively low frequencies.

Range fires also have dramatic effects on the overall ecosystem, the most obvious being the complete removal of sagebrush from the community, and the rapid increase in cheatgrass coverage. Unlike the native grasses, the other important shrubs, and many of the perennial herbaceous species, sagebrush is unable to resprout from rootstocks after being burned. Therefore, there is no dominant shrub component in burned areas until sagebrush is able to become re-established from seed. Burning also opens the community to the invasion by cheatgrass which is capable of quickly utilizing the nutrients that are released through burning. The extensive cover of cheatgrass may then prevent the re-establishment of many of the native species, including sagebrush. The species richness in formerly burned areas is usually much lower than in native stands, often consisting of only cheatgrass, Sandberg's bluegrass, Russian thistle, and Jim Hill mustard, with very few other species.

The vegetation in and around the ponds and ditches on the 200 Areas Plateau is significantly different from that of the surrounding dryland areas. Several tree species are present, especially cottonwood (*Populus trichocarpa*) and willows (*Salix* spp.). A number of wetland species are also present including several sedges (*Carex* spp.), bulrushes (*Scirpus* spp.), cattails (*Typha latifolia* and *T. angustifolia*), and pond-weeds (*Potamogeton* spp.).

3.6.1.2 Plant Species of Concern. The Washington State Department of Natural Resources, Natural Heritage Program classifies rare plants in the state of Washington in three different categories, depending on the overall distribution of the taxon and the state of its natural habitat. These categories are: *Endangered*, which is a "vascular plant taxon in danger of becoming extinct or extirpated in Washington within the near future if factors contributing to its decline continue. Populations of these taxa are at critically low levels or their habitats have been degraded or depleted to a significant degree"; *Threatened*, which is a "vascular plant taxon likely to become endangered within the near future in Washington if factors contributing to its population decline or habitat degradation or loss continue"; and *Sensitive*, which is a taxon that is "vulnerable or declining, and could become endangered or threatened in the state without active management or removal of threats" (definitions taken from Washington Natural Heritage Program 1990). Of concern to the Hanford Site, there

are two Endangered taxa, two Threatened taxa, and at least eleven Sensitive taxa; these are listed in Table 3-3. All four of the Threatened and Endangered taxa are presently candidates for the Federal Endangered Species List.

Of the two Endangered taxa, persistent-sepal yellowcress is well documented along the banks of the Columbia River throughout the 100 Areas, it is unlikely to occur in the 200 Areas. The northern wormwood (*Artemisia campestris* spp. *borealis*) is known in the state of Washington by only two populations, one across from The Dalles, Oregon, and the other near Beverly, Washington, just north of the Hanford Site. This taxon has not been found on the Hanford Site, but would probably occur only on rocky areas immediately adjacent to the Columbia River if it were present. Neither of the Threatened taxa listed in Table 3-3 have been observed on the Hanford Site. The Columbia milk vetch (*Astragalus columbianus*) is known to be relatively common on the Yakima Firing Range, and has been documented to occur within 1.6 to 3.2 km (1 to 2 mi) to the west of the Hanford Site on both sides of Umptanum Ridge. This species could occur on the 200 Areas Plateau. Hoover's desert parsley (*Lomatium tuberosum*) inhabits the steep talus slopes near Priest Rapids Dam. Potentially, it could be found on similar slopes on Gable Mountain and Gable Butte, but has yet to be documented in these areas.

Of the Sensitive species, five are inhabitants of aquatic or moist habitats and the other six are inhabitants of dry upland habitats. Dense sedge (*Carex densa*), shining flatsedge (*Cyperus rivularis*), southern mudwort (*Limosella acoulis*) and false-pimpernel (*Lindernia anagallidea*) are all known to occur in the 100 Areas, especially near the 100 B-C Area, in or near the Columbia River. Some of these species could be present in or near ponds and ditches in the 200 Areas. The few-flowered collinsia (*Collinsia sparsiflora* var. *bruciae*) may also occur in these habitats. The gray cryptantha (*Cryptantha leucophaea*) occurs on open dunes throughout the Hanford Site. Piper's daisy (*Erigeron piperianus*) is fairly common on Umptanum Ridge and Rattlesnake Ridge, but has also been documented in the vicinity of B Pond, the A-24 Crib, and 100-H Area. Bristly cryptantha (*Cryptantha interrupta*), dwarf evening-primrose (*Oenothera pygmaea*) have been found at the south end of the White Bluffs, approximately 3.2 km (2 mi) upstream from the 300 Area. The Palouse milk vetch (*Astragalus arrectus*) and coyote tobacco (*Nicotiana attenuata*) are not as well documented but are known to inhabit dry sandy areas such as the 200 Areas Plateau.

In addition to the three classifications for species of concern listed above, the Natural Heritage Program also maintains a "Monitor" list, which is divided into three groups. Group 1 consists of taxa in need of further field work before a formal status can be assigned. The tooth-sepal dodder (*Cuscuta denticulata*), which has been found in the state of Washington only on the Hanford Site is the only taxon in this group that is of concern to Hanford operations. This parasitic species has been found in the area west of McGee Ranch. Group 2 of the Monitor list includes species with unresolved taxonomic questions. Thompson's sandwort (*Arenaria franklinii* var. *thompsonii*) is of concern to Hanford operations. However, the representatives of this species in the state of Washington are now believed to

all be variety *franklinii* which is not considered particularly rare. Group 3 of the Monitor list includes taxa that are either more abundant or less threatened than previously believed. There are approximately 15 taxa on the Hanford Site that are included on this list.

3.6.1.3 Fauna of the 200 Areas Plateau. The mammals, birds, reptiles, amphibians inhabiting the 200 Areas Plateau are discussed below.

3.6.1.3.1 Mammals. The largest mammal occurring on the 200 Areas Plateau is the mule deer (*Odocoileus hemionus*). Although mule deer are much more common to riparian sites along the Columbia River they are frequently observed foraging throughout the 200 Areas. Elk (*Cervus elaphus*) also occur at Hanford but they have only been observed at the Arid Lands Ecology Reserve. Other mammal species common to the 200 Areas include badgers (*Taxidea taxus*), coyotes (*Canis latrans*), blacktail jackrabbits (*Lepus californicus*), Townsend ground squirrels (*Spermophilus townsendii*), Great Basin pocket mice (*Perognathus parvus*), pocket gophers (*Thomomys talpoides*), and deer mice (*Peromyscus maniculatus*). Badgers are known for their digging capability and have been implicated several times for encroaching into inactive burial grounds throughout the 200 Areas. The majority of the badger excavations in the 200 Areas are a result of badgers searching for prey (mice and ground squirrels). Coyotes are the principal predators, consuming such prey as rodents, insects, rabbits, birds, snakes and lizards. The Great Basin pocket mouse is the most abundant small mammal, which thrives in sandy soils and lives entirely on seeds from native and revegetated plant species. Townsend ground squirrels are not abundant in the 200 Areas but they have been seen at several different sites.

Other small mammals that occur in low numbers include the western harvest mouse (*Reithrodontomys megalotis*) and the grasshopper mouse (*Onychomys leucogaster*). Mammals associated more closely with buildings and facilities include Nuttall's cottontails (*Sylvilagus nuttallii*), house mice (*Mus musculus*), Norway rats (*Rattus norvegicus*), and some bat species. Bats probably play a minor role in the 200 Areas' ecosystem but no documentation is available on bat populations at Hanford. Mammals such as skunks (*Mephitis mephitis*), raccoons (*Procyon lotor*), weasels (*Mustela* spp.), porcupines (*Erethizon dorsatum*), and bobcats (*Lynx rufus*) have only been observed on very few occasions.

3.6.1.3.2 Birds. Over 235 species of birds have been documented to occur at the Hanford Site (Landeem et al. 1991). At least 100 of these species have been observed in the 200 Areas. The most common passerine birds include starlings (*Sturnus vulgaris*), horned larks (*Ermophila alpestris*), meadowlarks (*Sturnella neglecta*), western kingbirds (*Tyrannus verticalis*), rock doves (*Columba livia*), barn swallows (*Hirundo rustica*), cliff swallows (*Hirundo pyrrhonota*), black-billed magpies (*Pica pica*) and ravens (*Corvus corax*). Common raptors include the northern harrier (*Circus cyaneus*), American kestrel (*Falco sparverius*), and red tailed hawk (*Buteo jamaicensis*). Swainson's hawks (*Buteo swainsoni*) sometimes nest in the trees located at some of the army bunker sites that were used in the 1940's. Golden eagles (*Aquila chrysaetos*) are observed infrequently. Burrowing owls (*Athene*

cunicularia) nest at several locations throughout the 200 Areas. The most common upland game birds found in the 200 Areas are California quail (*Callipepla californica*) and Chukar partridge (*Alectoris chukar*), however, ring-necked pheasants (*Phasianus colchicus*) and gray partridge (*Perdix perdix*) may be found in limited numbers. The only native game bird common to the 200 Areas Plateau is the mourning dove (*Zenaida macroura*) which migrates south each fall. Other species of note which nest in undisturbed sagebrush habitats in the 200 Areas include sage sparrows (*Amphispiza belli*), and loggerhead shrikes (*Lanius ludovicianus*). Long-billed curlews (*Numenius americanus*) also use the sagebrush areas and revegetated burial grounds for nesting and foraging.

Waterfowl and aquatic birds inhabit 216-B-3 Pond and other areas where there is running or standing water. However many of these areas such as 216-A-29 Ditch are becoming more scarce due to stabilization and remedial action cleanup activities. Aquatic birds and waterfowl common to 216-B-3 Pond on a seasonal basis include Canada geese (*Branta canadensis*), American coot (*Fulica americana*), mallard (*Anas platyrhynchos*), ruddy duck (*Oxyura jamaicensis*), redhead (*Aythya americana*), bufflehead (*Bucephala albeola*) and great blue heron (*Ardea herodias*).

3.6.1.3.3 Reptiles and Amphibians. Common reptiles include gopher snakes (*Pituophis melanoleucus*) and sideblotched lizards (*Uta stansburiana*). Other reptiles and amphibians which are infrequently observed include sagebrush lizards (*Sceloporus graciosus*), horned toads (*Phrynosoma douglassii*), western spadefoot toads (*Scaphiopus intermontana*), yellow-bellied racer (*Coluber constrictor*), Pacific rattlesnake (*Crotalus viridis*), and striped whipsnake (*Masticophis taeniatus*). Both lizards and snakes are prey items of mammalian and avian predators.

3.6.1.3.4 Insects. There are hundreds of insect species which inhabit the 200 Areas. Two of the most common groups of insects include several species of darkling beetles and grasshoppers. Harvester ants are also common and have been implicated in the uptake of radionuclides from some of the burial grounds in the 200 East Area. Harvester ants can excavate and bring up material from as far down as 5 to 6 m (15 to 20 ft). Other major groups of insects include bees, butterflies and scarab beetles. Insects impact the surrounding plant community as well as serving as the prey base for many species of birds, reptiles and mammals.

3.6.1.4 Wildlife Species of Concern. Some animals which inhabit the Hanford Site have been given special status designations by the state and federal government. Some of these designations include state and federal threatened and endangered species, federal candidate, state monitor, state sensitive, and state candidate species. Species listed in Table 3-3 as state and/or federal threatened and endangered such as the bald eagle (*Haliaeetus leucocephalus*), peregrine falcon (*Falco peregrinus*), American white pelican (*Pelecanus erythrorhynchos*), ferruginous hawk (*Buteo regalis*), and sandhill crane (*Grus canadensis*) do not inhabit the 200 Areas. The bald eagle and American white pelican utilize the Columbia River and

associated habitats for roosting and feeding. Peregrine falcons and sandhill cranes fly over the Hanford Site during migration. Ferruginous hawks nest on the Hanford Site but nesting has not been documented for this species on the 200 Areas Plateau. Other species listed in Table 3-4 as state and/or federal candidates and state monitor species such as burrowing owls, great blue herons, prairie falcons (*Falco mexicanus*), sage sparrows, and loggerhead shrikes are not uncommon to the 200 Areas Plateau.

3.6.2 Land Use

The U Plant Aggregate Area is the location of the U Plant and its attendant facilities and structures (Uranium Trioxide (UO₃) Plant, 271-U Building, 222-U Laboratory, etc.).

Past activities at U Plant and related facilities were mainly uranium extraction processes and the conversion of uranyl nitrate hexahydrate to UO₃, at the UO₃ Plant. Other buildings within the unit served mainly as storage or office space. Currently, the UO₃ building is on standby status and is expected to begin operations again in 1992. Waste management units that remain active are noted on Figure 2-1, Operational and Waste-Related History.

Access to the entire Hanford Site is administratively controlled and is expected to remain this way to ensure public health and safety and for reasons of national security.

3.6.3 Water Use

The 216-U-14 Ditch is a man-made structure, also known as the Laundry Ditch because wastewater from laundry facilities and mask cleaning operations to the north has historically been discharged to the ditch for disposal, either by infiltration through the streambed or by conveyance to the 216-U-10 Pond to the southwest. Water from the ditch has never been used for any purpose.

About three-fourths of the original ditch has been backfilled and the remaining open portions continue to serve only as infiltration facilities for water from the 207-U Retention Basin and the 284-W Powerplant. Water from a nearby fire hydrant had been pumped into the southern open part of the ditch to maintain a prescribed water level as a method of dust control. However, in March 1992 this rainwater flow ceased as a result of stabilization of a portion of the ditch.

There is no consumptive use of groundwater within the U Plant Aggregate Area. Water for drinking and emergency use, and facilities process water is drawn from the Columbia River, treated, and imported to the 200 West Area. The nearest wells used to supply drinking water are located at the Yakima Barricade (Well 699-49-100-C) about 5 km

(3.1 mi) west of the 200 West Area; at the Hanford Safety Patrol Training Academy (Well 699-528-E0) about 40 km (25 mi) to the southeast; at the PNL observatory (Well 6652-C); and near the Fast Flux Test Facility in the 400 Area (Well 699-S1-8J) about 32 km (20 mi) to the southeast. The nearest water supply wells located offsite are about 15 km (9.4 mi) to the northwest (upgradient). These wells obtain their water from the basalt and the basalt interbeds (the Berkshire Well and Chateau Ste. Michelle No. 1 and No. 2). The latter wells are reportedly used for irrigation although they may also be used to supply drinking water. Two wells for emergency cooling water supply are located near the B Plant and one well located near the 241-AY and 241-AZ Tank Farms in the 200 East Area.

3.7 HUMAN RESOURCES

The environmental conditions at the U Plant Aggregate Area must be evaluated in relationship to the surrounding population centers and other human resources. A very brief summary of demography, archaeology, historical resources, and community involvement is given below.

3.7.1 Demography

There are no residences on the Hanford Site. The nearest inhabited residences are farm homes on land located 21 km (13 mi) north of the U Plant Aggregate Area. There are approximately 411,000 people living within a 80 km (50 mi) radius of the 200 Areas Plateau. The primary population centers are the cities of Richland, Kennewick, and Pasco, located southeast of the Hanford Site, Prosser to the south, Sunnyside to the southwest, and Benton City to the southeast.

3.7.2 Archaeology

An archaeological survey has been conducted of undeveloped portions of the 200 West Area by the Hanford Cultural Resources Laboratory. Isolated artifacts and sites of interest were identified in the 200 West Area but not within the U Plant Aggregate Area. The closest site of interest is the remains of the White Bluffs Road, located approximately 1.6 km (1 mi) northwest of the aggregate area, which was previously an Indian trail.

3.7.3 Historical Resources

The only historic site in 200 West Area is the old White Bluffs freight road which crosses diagonally through the 200 West Area. This site is not considered to be eligible for the National Register.

3.7.4 Community Involvement

A Community Relations Plan (Ecology et al. 1989) has been developed for the Hanford Site Environmental Restoration Program which includes any potentially affected community with respect to the U Plant AAMSR. The Community Relations Plan includes a discussion on analysis of key community concerns and perceptions regarding the project, along with a list of all interested parties.

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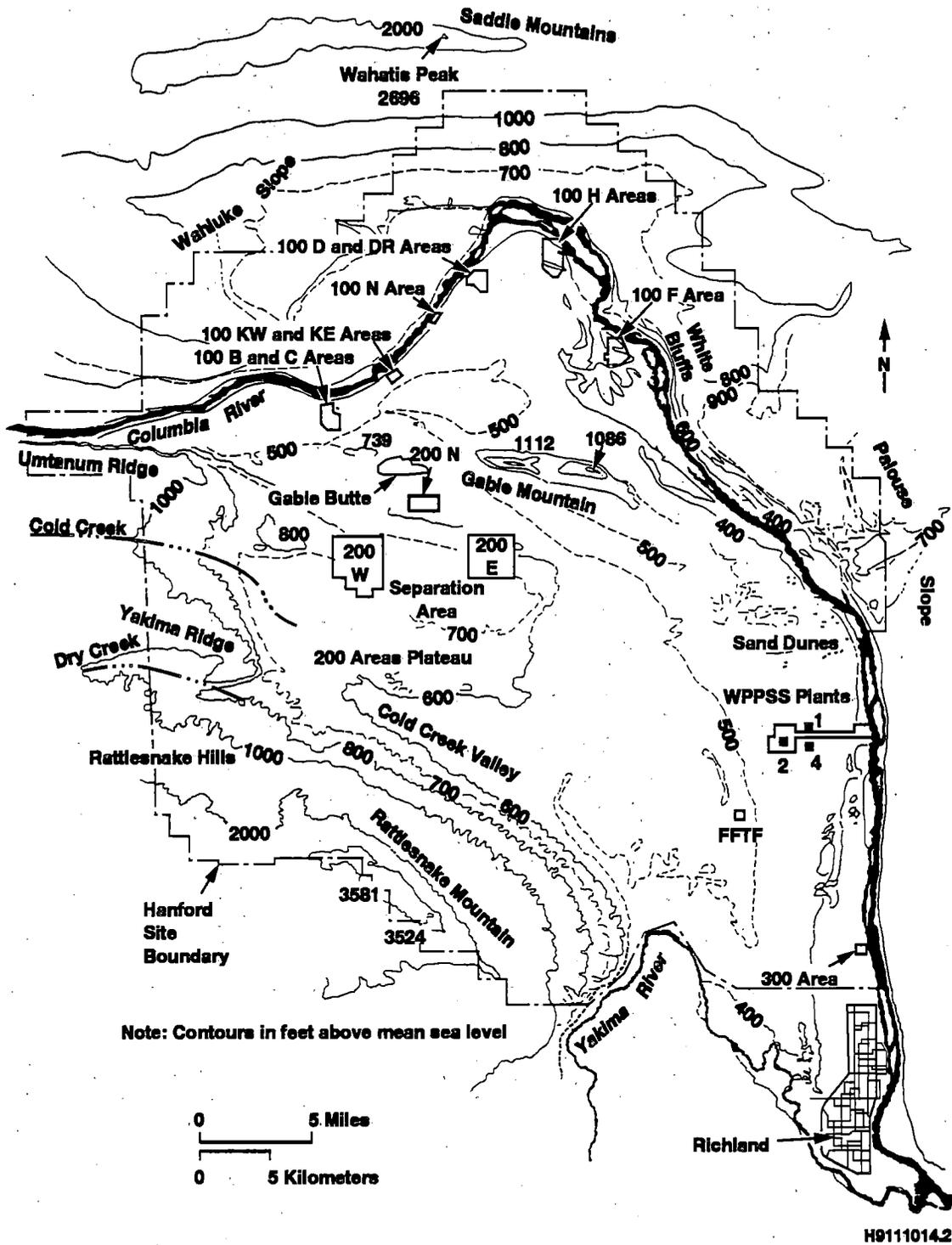


Figure 3-1. Topography and Location Map for the Hanford Site.

3F-2

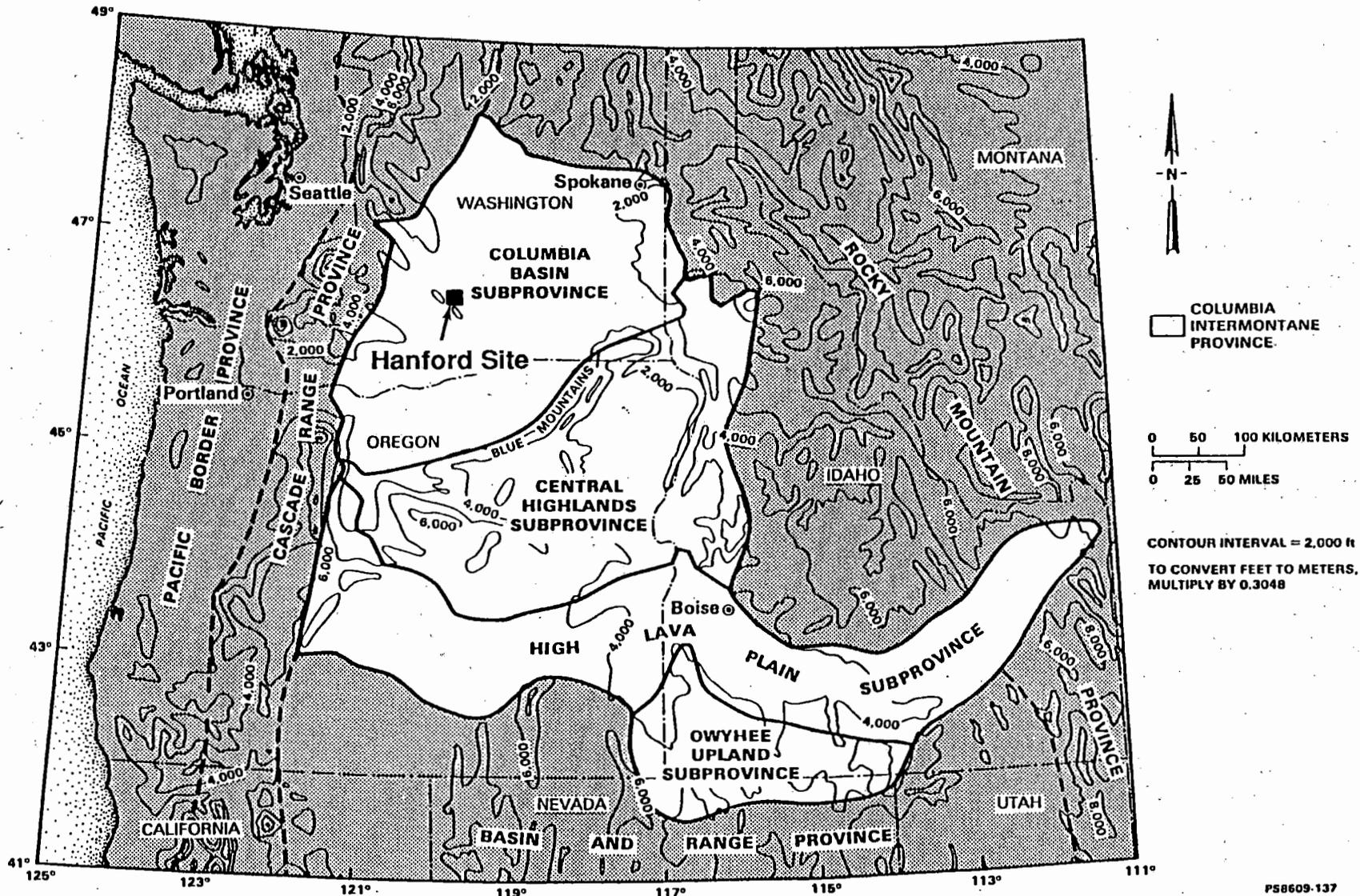


Figure 3-2. Divisions of the Columbia Intermontane Province and Adjacent Snake River Plains Province.

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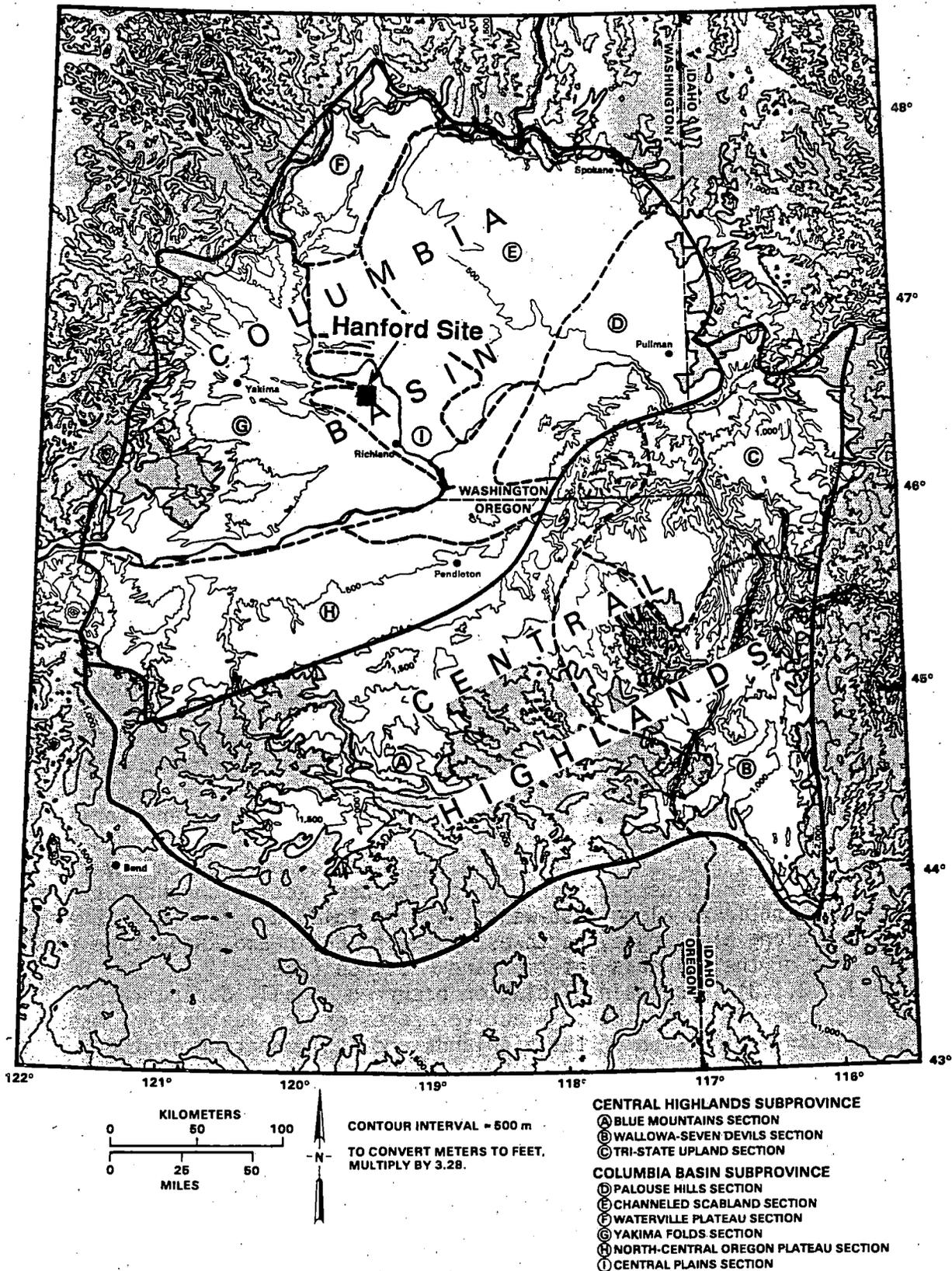


Figure 3-3. Geomorphic Units within the Central Highlands and Columbia Basin Subprovinces that Contain the Columbia River Basalt Group (unshaded area) (after Thornbury 1965) (Last et al. 1989).

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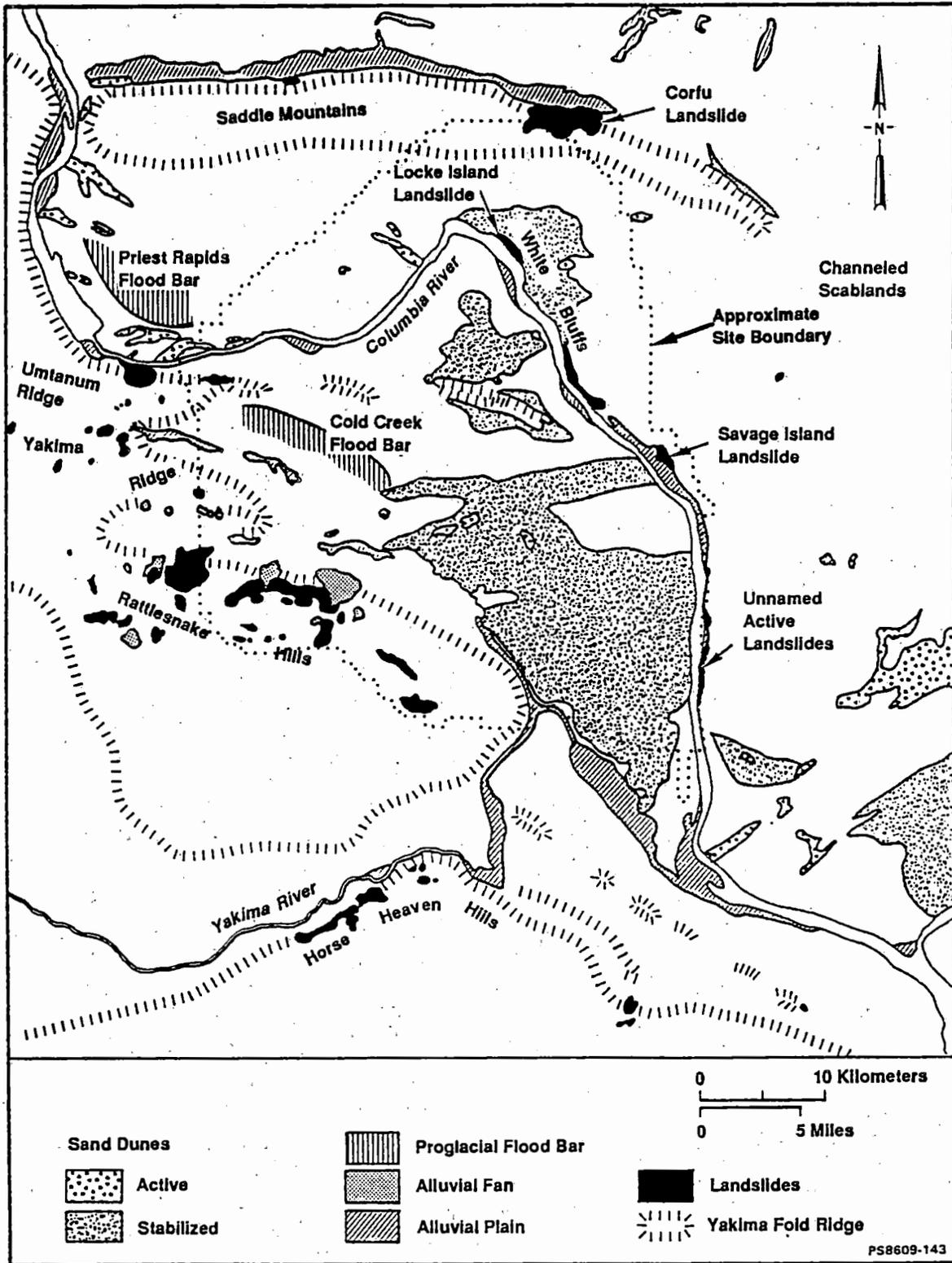
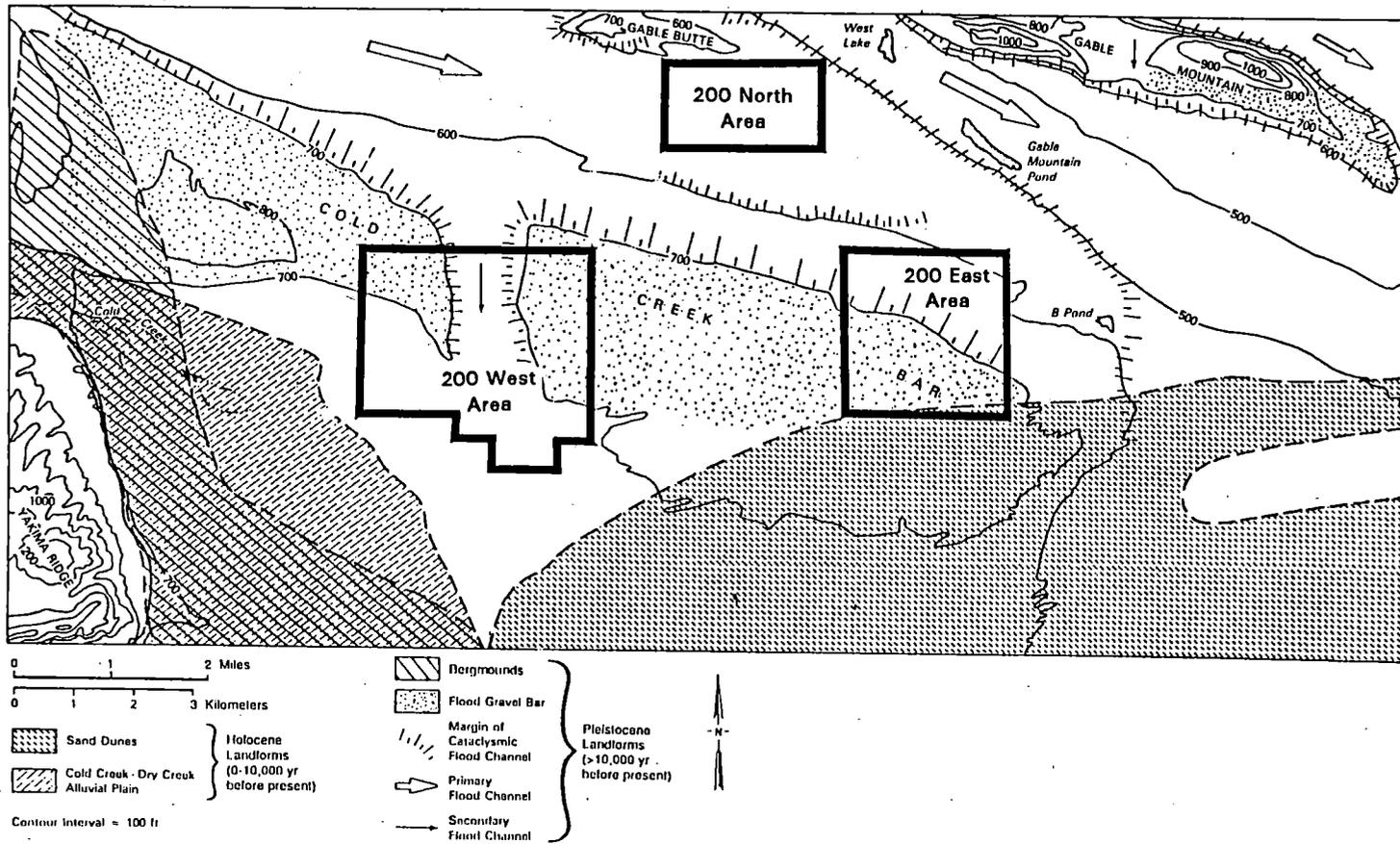
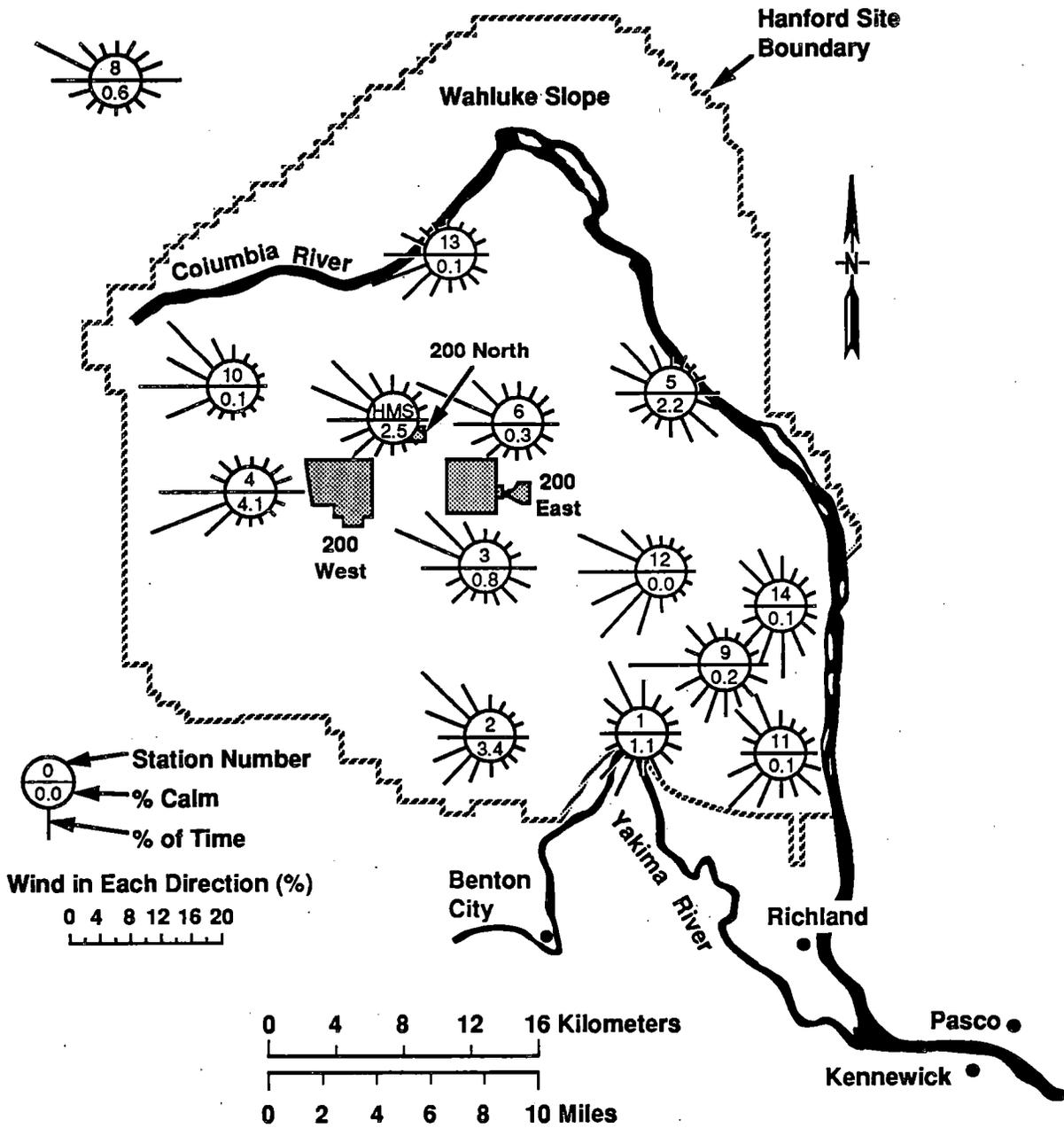


Figure 3-4. Landforms of the Pasco Basin and the Hanford Site.

Figure 3-5. Geomorphic Features Surrounding the 200 Areas (Last et al. 1989).



* Keyed features are specifically selected and do not encompass all features.

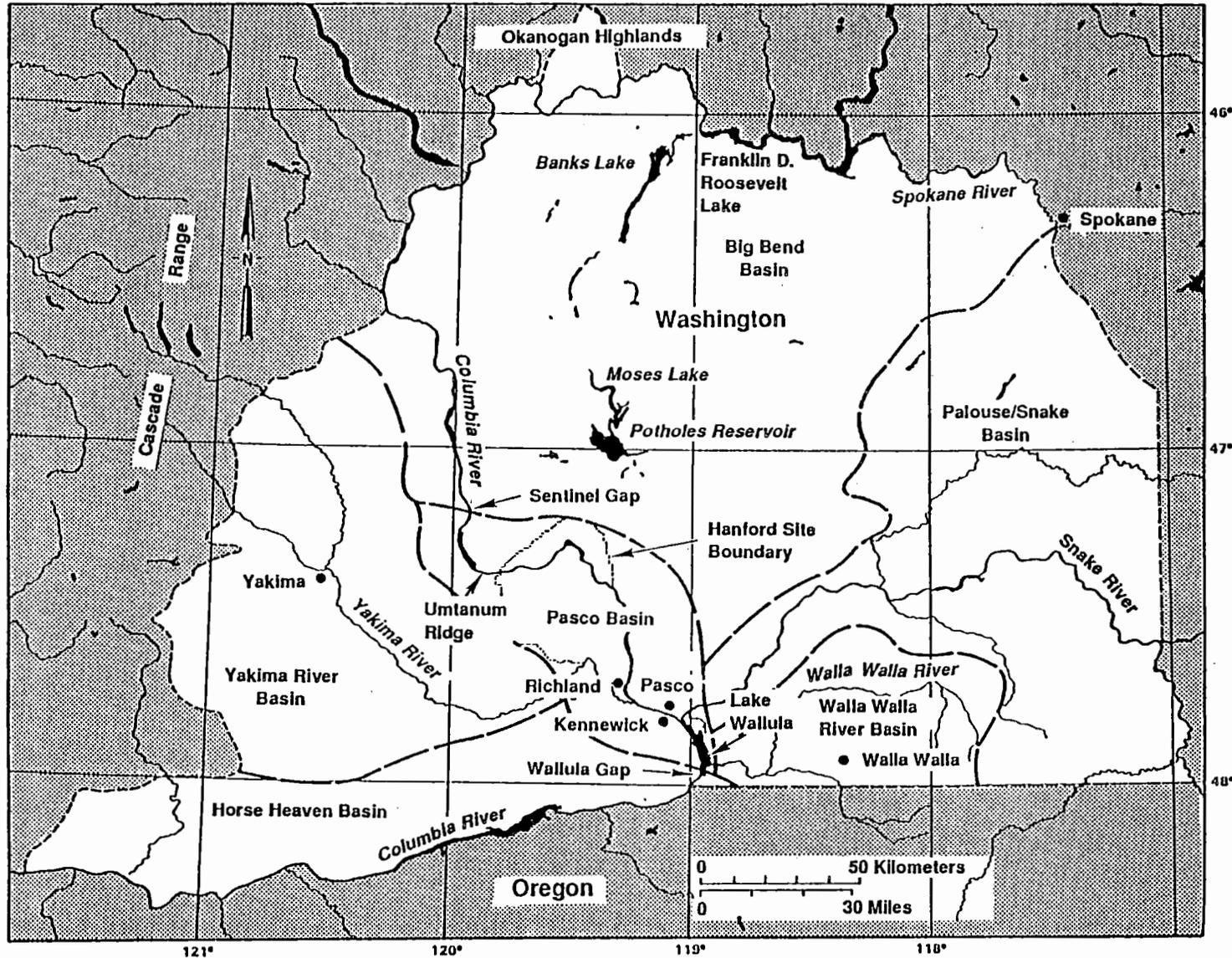


HMS = Hanford Meteorological Station

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Figure 3-6. Hanford Site Wind Roses, 1979 through 1982 (Stone et al. 1983).

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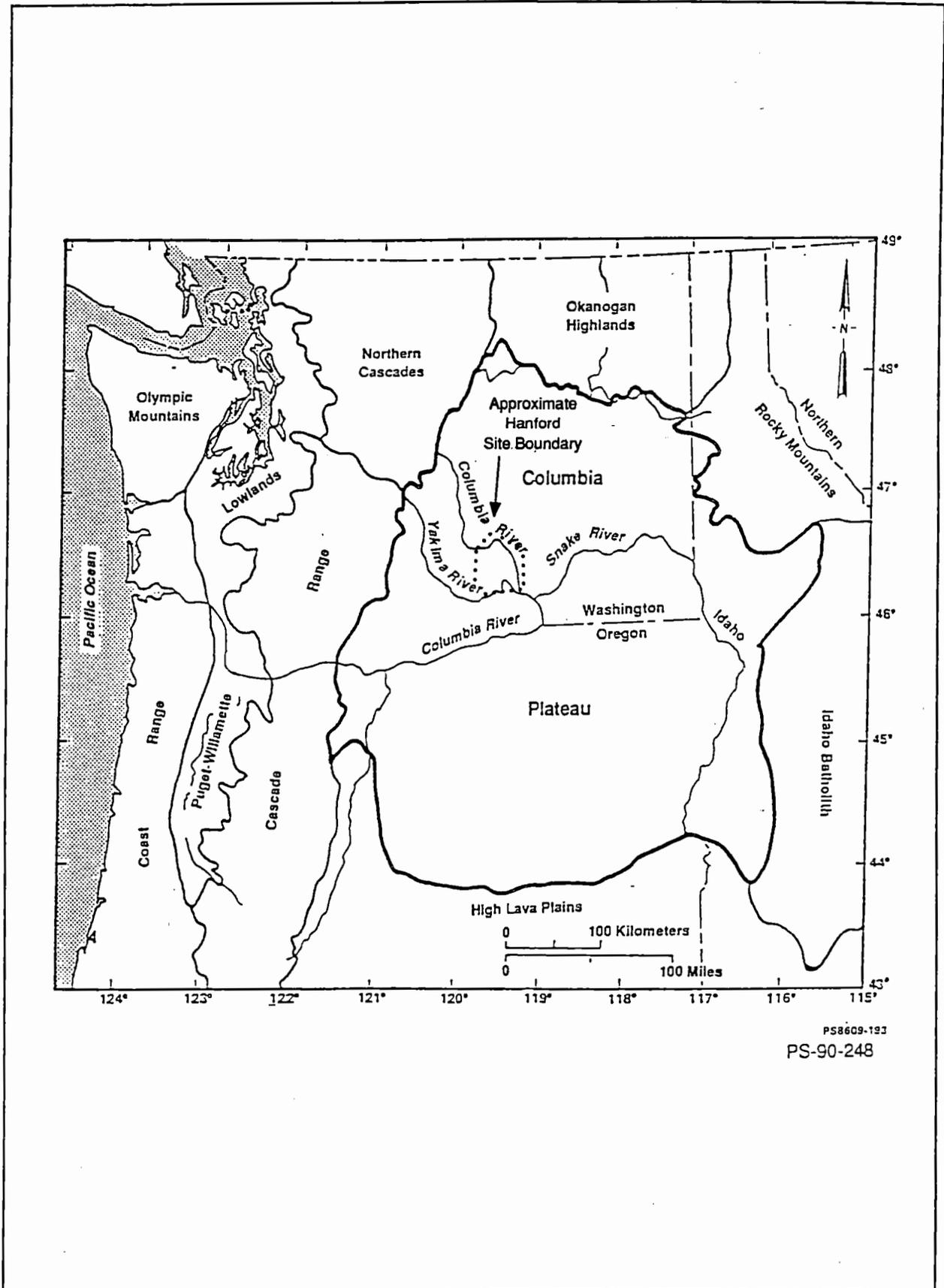
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Figure 3-7. Hydrologic Basins Designated for the Washington State Portion of the Columbia Plateau (DOE 1988b).

3F-7

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PS8609-193
PS-90-248

Figure 3-8. Columbia Plateau and Surrounding Structural Provinces.

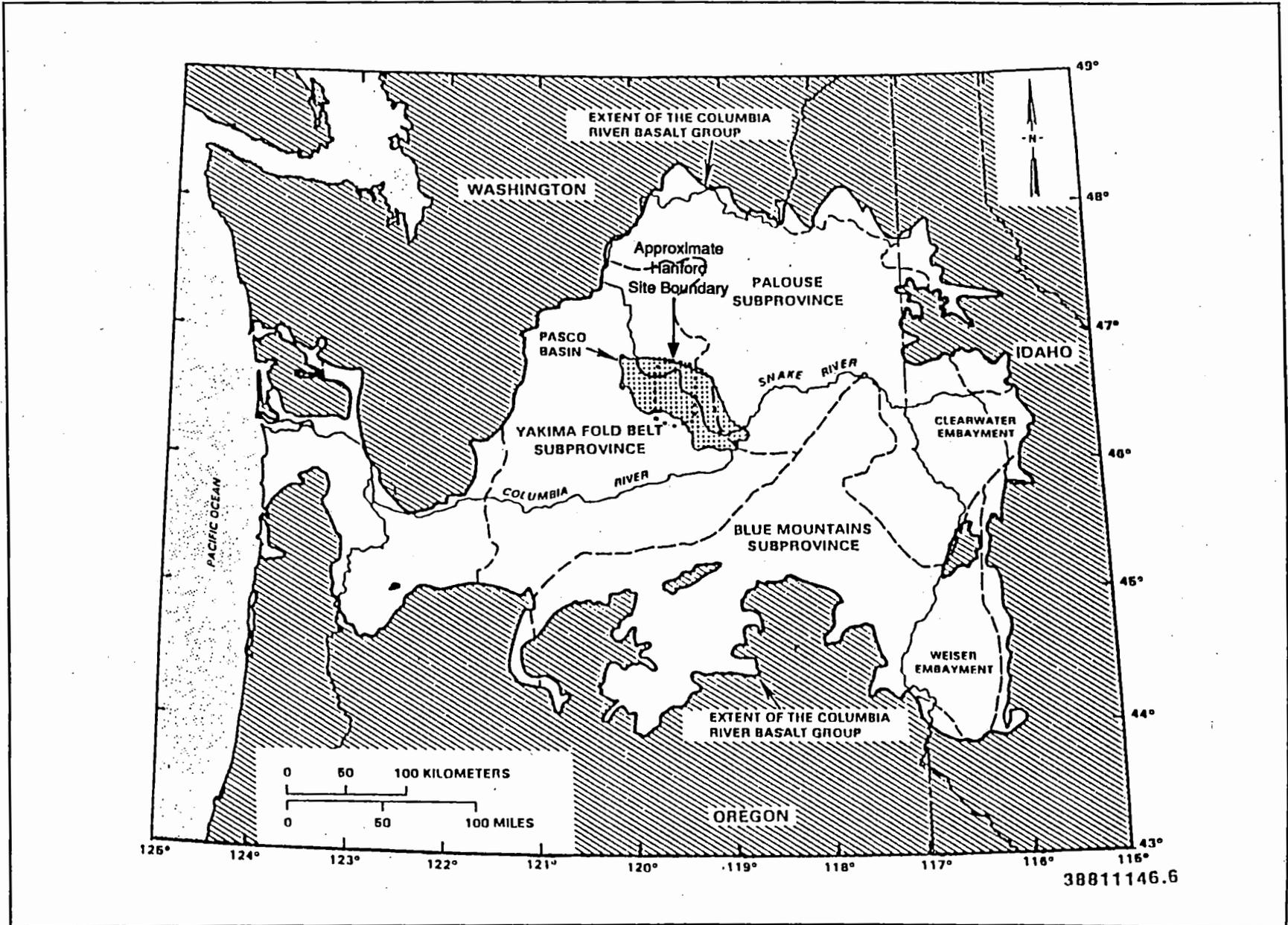
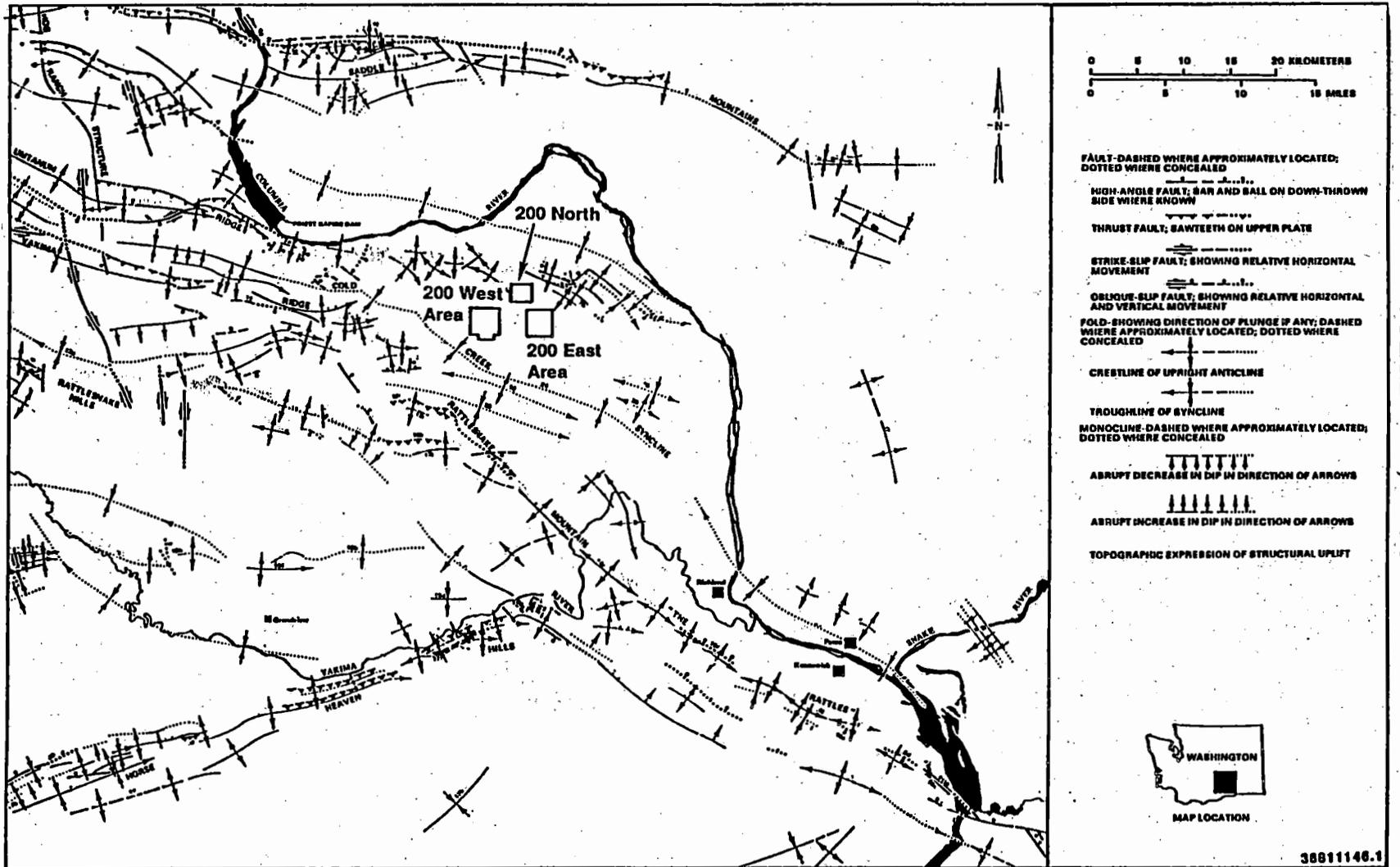


Figure 3-9. Structural Subprovinces of the Columbia Plateau (DOE 1988b)

3F-9

Figure 3-10. Structural Elements of the Yakima Fold Belt Subprovince (Last et. al 1989).



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3F-10

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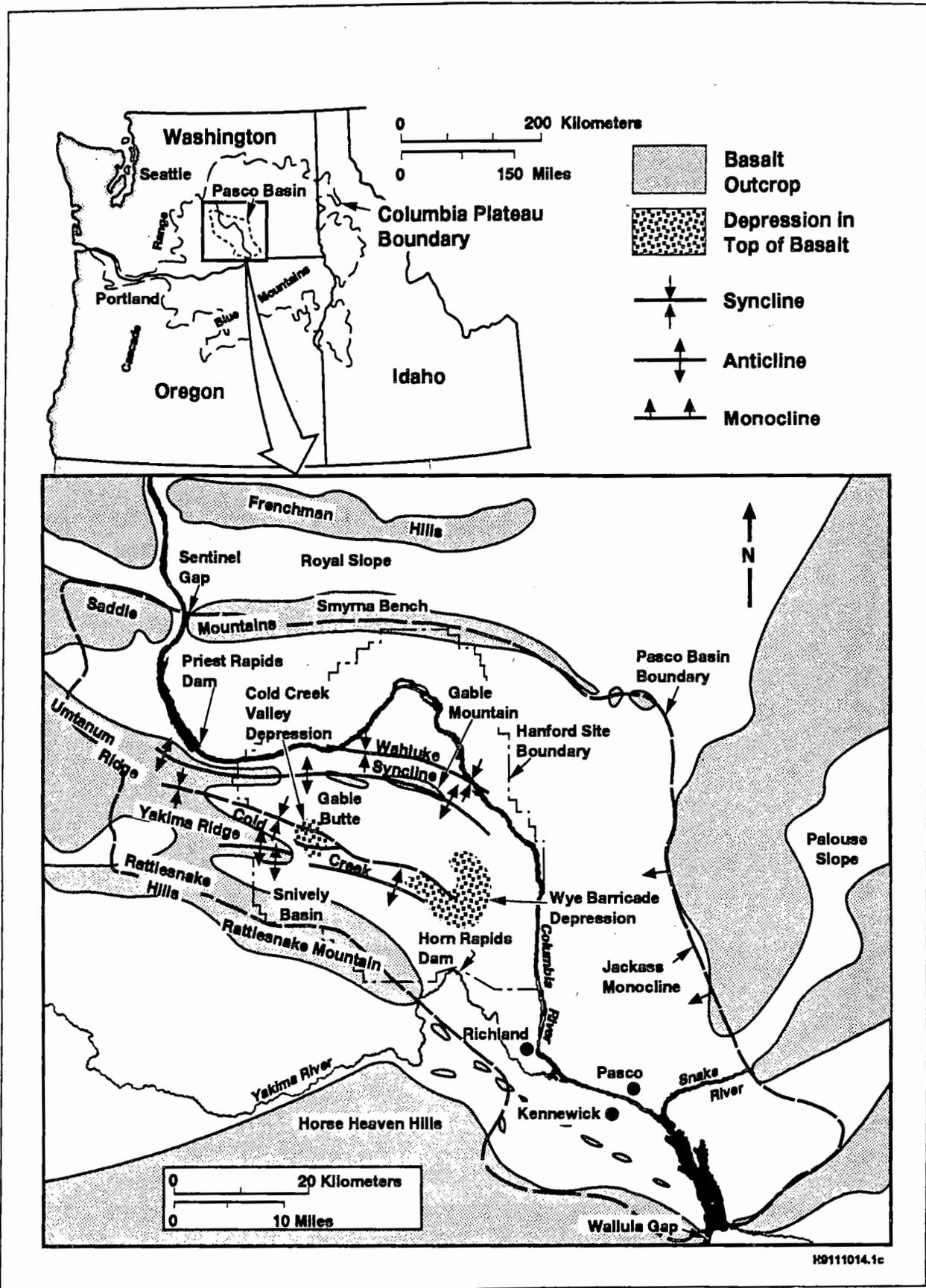


Figure 3-11. Geologic Structures of the Pasco Basin and the Hanford Site.

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Period	Epoch	Group	Formation	Isotopic Age Dates Years x 10 ⁴	Member (Formal and Informal)	Sediment Stratigraphy or Basalt Flows				
							QUATERNARY	Pleistocene	Holocene	
TERTIARY	Miocene	Columbia River Basalt Group	Hanford		Surficial Units	Loose Sand Dunes Alluvium and Alluvial Fans Landslides Talus Colluvium				
					Touchet beds					
					Pasco gravels					
					Pilo-Pleistocene unit					
					Ringold Formation					
							Saddle Mountains Basalt	8.5	Ice Harbor Member	basalt of Goose Island basalt of Martindale basalt of Basin City Levey interbed
								10.5	Elephant Mountain Member	basalt of Ward Gap basalt of Elephant Mountain Rattlesnake Ridge interbed
								12.0	Pomona Member	basalt of Pomona Selah interbed
									Esquatzel Member	basalt of Gable Mountain Cold Creek interbed
								13.5	Asotin Member	basalt of Huntzinger
									Wilbur Creek Member	basalt of Lapwai basalt of Wahluke basalt of Sillusi
									Umatilla Member	basalt of Umatilla
							Wanapum Basalt	14.5	Priest Rapids Member	Mabton interbed basalt of Lolo basalt of Rosalia Quincy interbed
									Roza Member	basalt of Roza Squaw Creek interbed
							Frenchman Springs Member			basalt of Lyons Ferry basalt of Sentinel Gap basalt of Sand Hollow basalt of Silver Falls basalt of Ginkgo basalt of Palouse Falls
		Grande Ronde Basalt	15.6	Sentinel Bluffs Unit	Vantage interbed basalt of Museum basalt of Rocky Coulee basalt of Levering basalt of Cohasset basalt of Birkett basalt of McCoy Canyon basalt of Umtanum					
			16.5		Umtanum Unit					
					Slack Canyon Unit					
					Ortley Unit	basalt of Benson Ranch				
					Grouse Creek Unit					
					Wapshilla Ridge Unit					
					Mt. Horrible Unit					
				China Creek Unit						
				Teepee Butte Unit						
				Buckhorn Springs Unit						
		Imnaha	17.5	Rock Creek Unit						
				American Bar Unit						

*The Grande Ronde Basalt consists of at least 120 major basalt flows. Only a few flows have been named. N₂, R₂, N₁ and R₁ are magnetostratigraphic units.

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Figure 3-12. Generalized Stratigraphy of the Hanford Site.

9 3 1 2 7 8 0 5 5 1

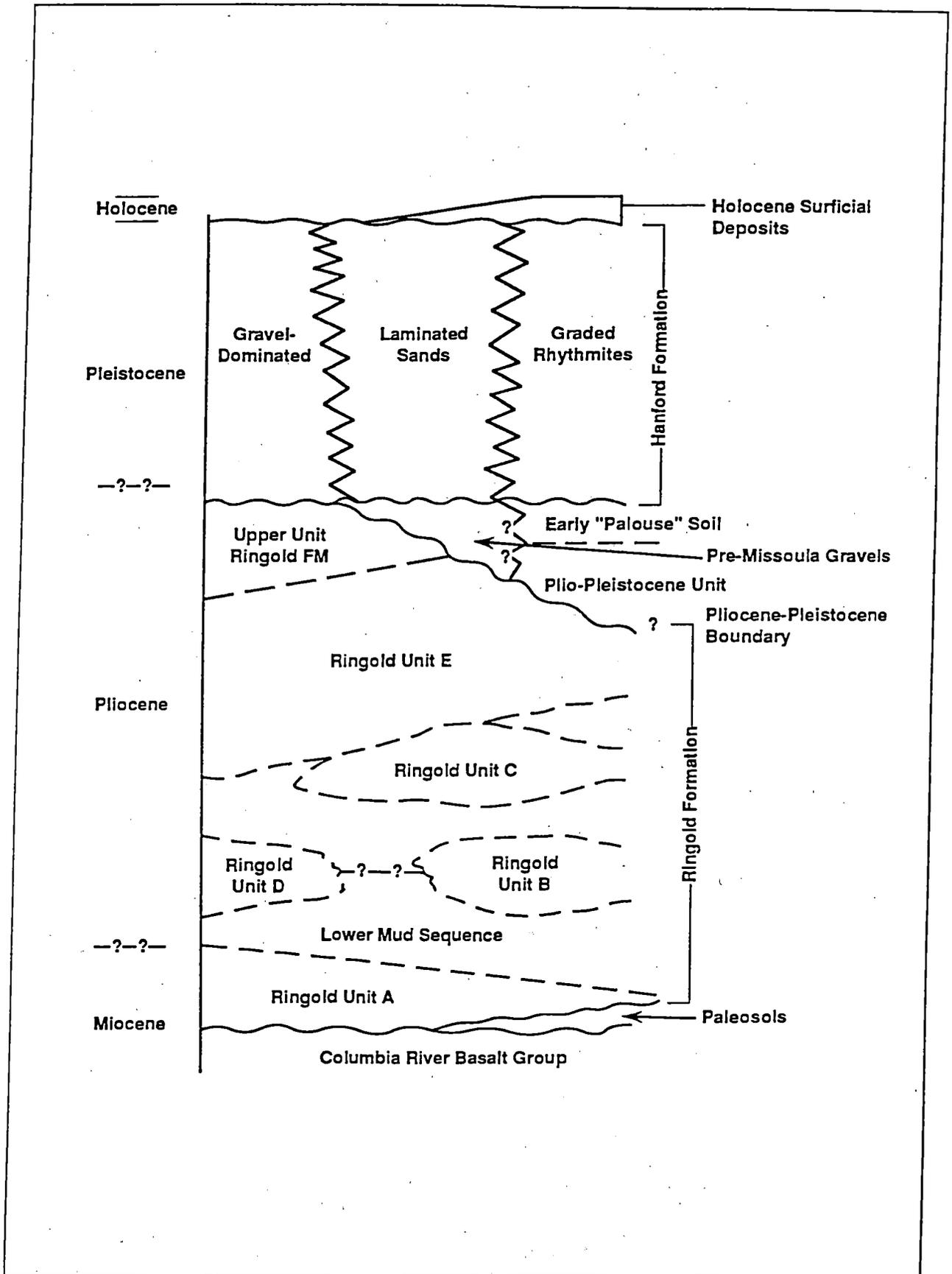


Figure 3-13. Generalized Stratigraphy of the Suprabasalt Sediments Beneath the Hanford Site.

3F-14

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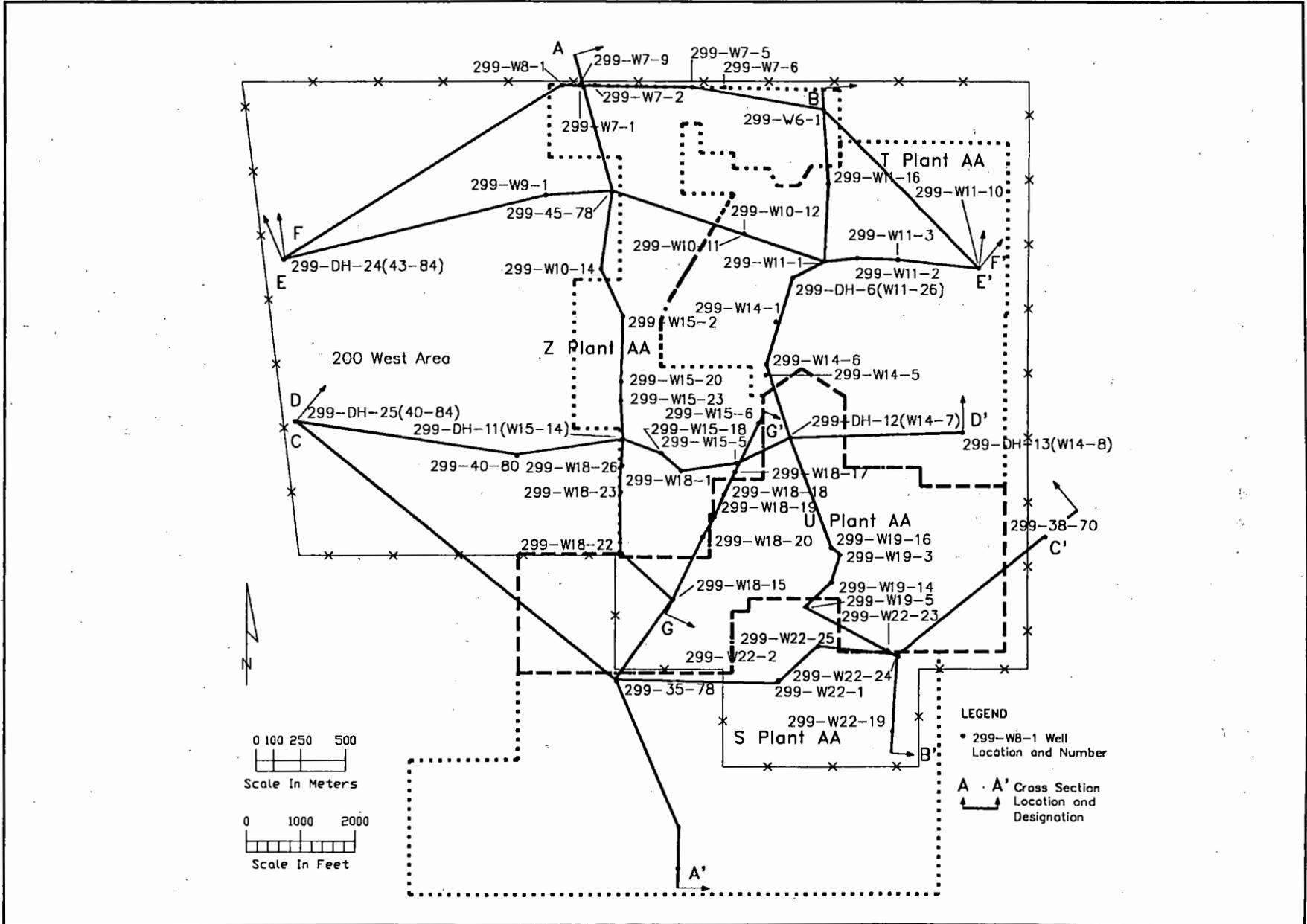


Figure 3-14. Location of 200 West Area Geologic Cross-Sections.

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Unit Abbreviations

Hc - Upper Coarse Unit, Hanford formation
 Hf - Lower Fine Unit, Hanford formation
 EP - Early "Palouse" Soil
 PP - Plio-Pleistocene Unit
 UR - Upper Unit, Ringold Formation
 E - Gravel Unit E, Ringold Formation
 LM - Lower Mud Sequence, Ringold Formation
 A - Gravel Unit A, Ringold Formation

Other Symbols

— ? — Formational contact, ? where inferred
 — - - - ? - - - Unit contact, ? where inferred
 - - - - - Major Facies Contact

 Pedogenic Calcium Carbonate
 Paleosols
 Ringold Clast Supported Gravels
 Open Framework Hanford Gravels
 Laminated Muds
 Basalt

NOTES:

1. Refer to Figure 3-14 for cross section locations and designation. Cross section presented on Figures 3-16 through 3-19.
2. Figures based on Lindsey et al. 1991 and Airhart et al. 1990.
3. Units predominantly consisting of Sand are indicated by blank spaces.

Figure 3-15. Legend for Cross-sections.

uplant/legend

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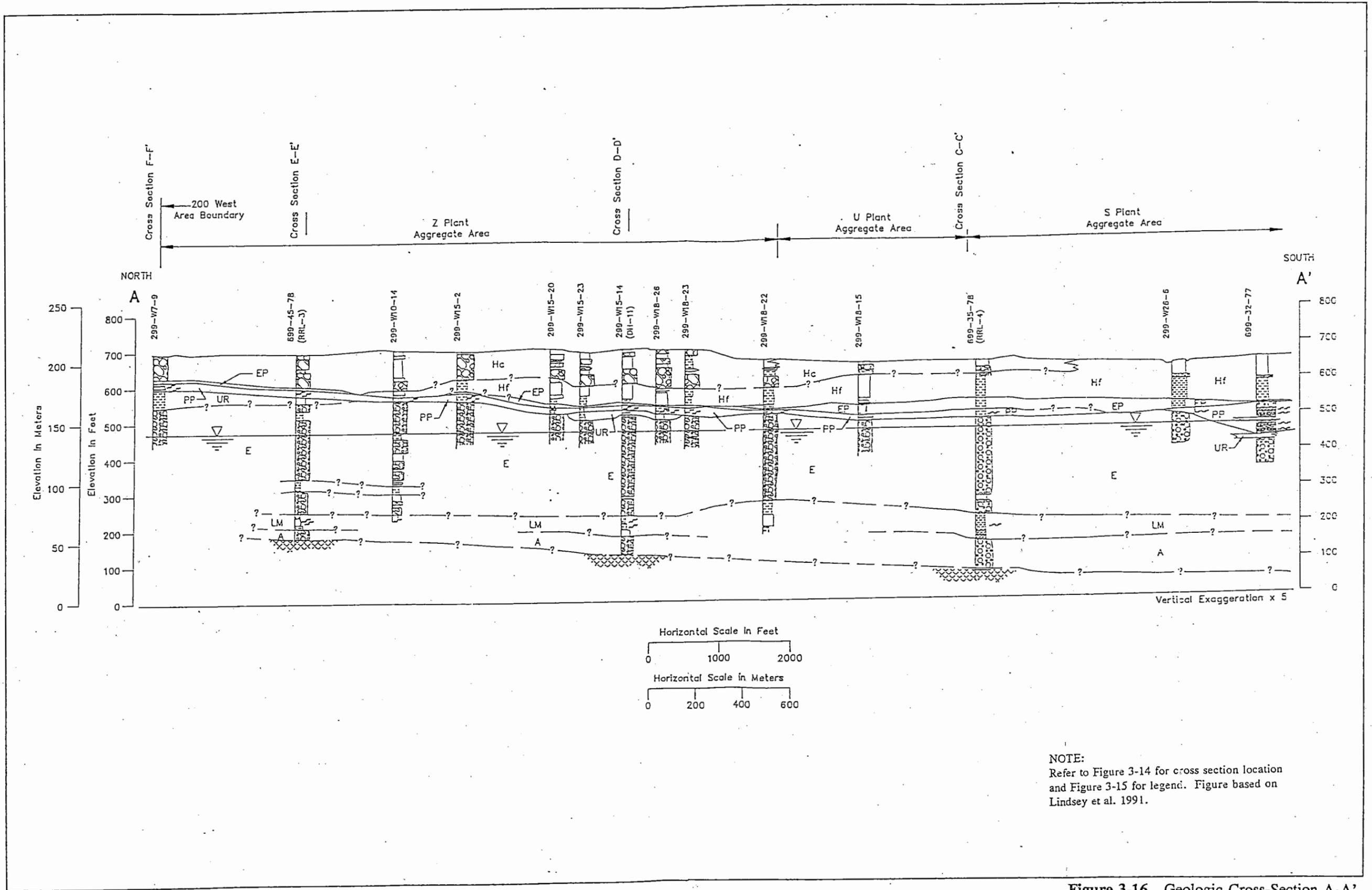
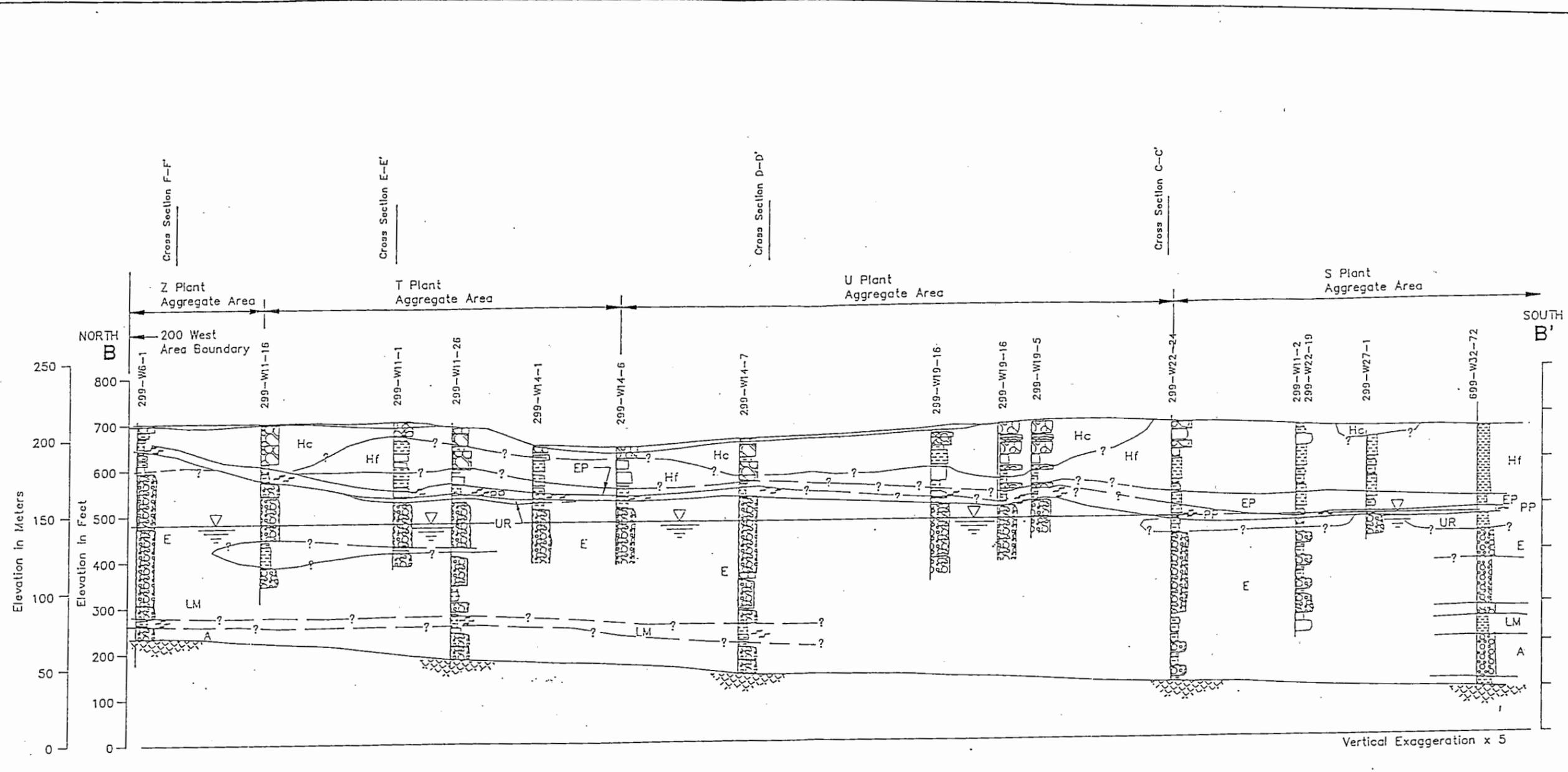


Figure 3-16. Geologic Cross-Section A-A'.

9 3 1 2 7 8 0 5 5 5



NOTE:
 Refer to Figure 3-14 for cross section location
 and Figure 3-15 for legend. Figure based on
 Lindsey et al. 1991.

Figure 3-17. Geologic Cross-Section B-B'.

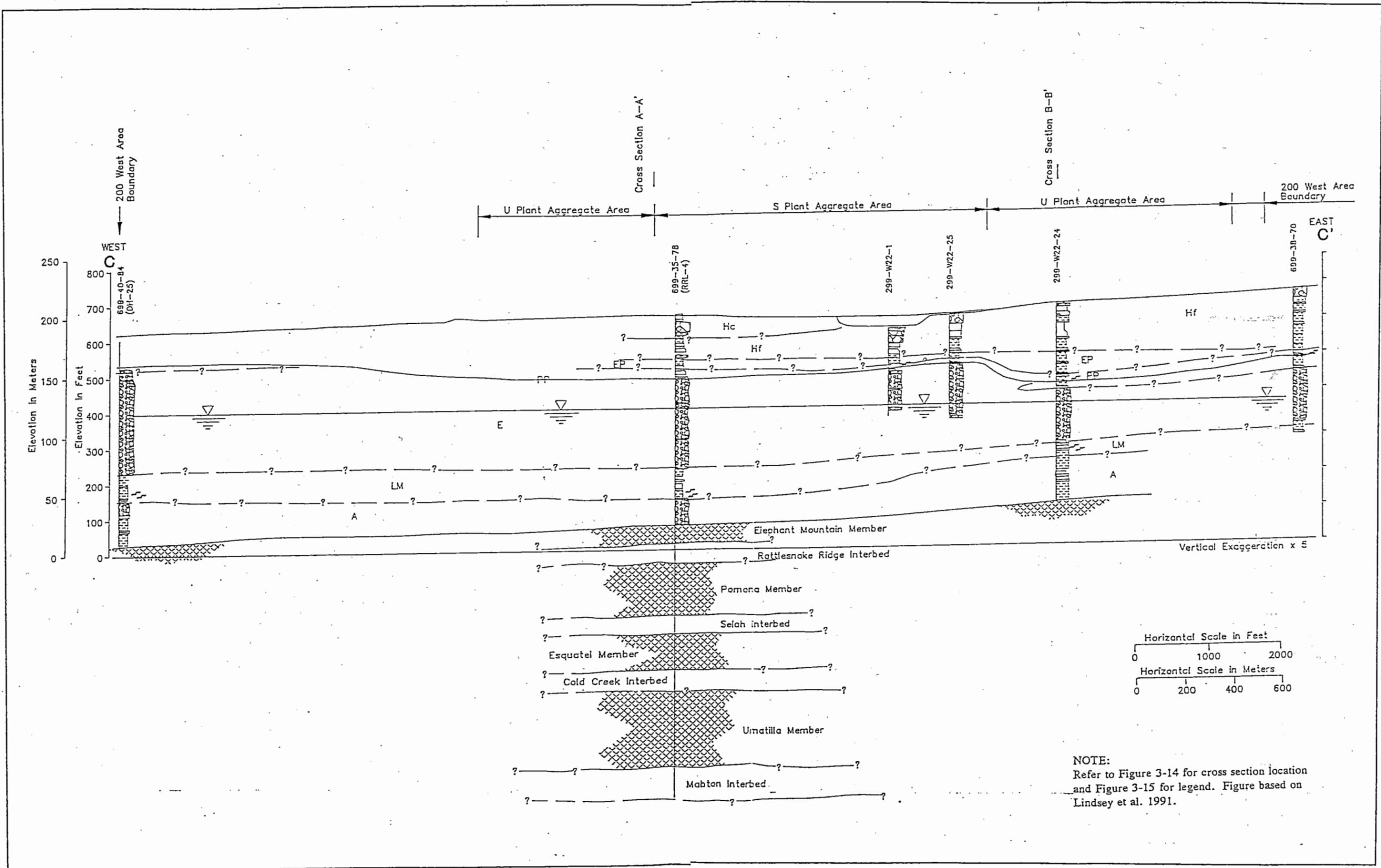


Figure 3-18. Geologic Cross-Section C-C'.

9 3 1 2 7 8 0 5 5 6

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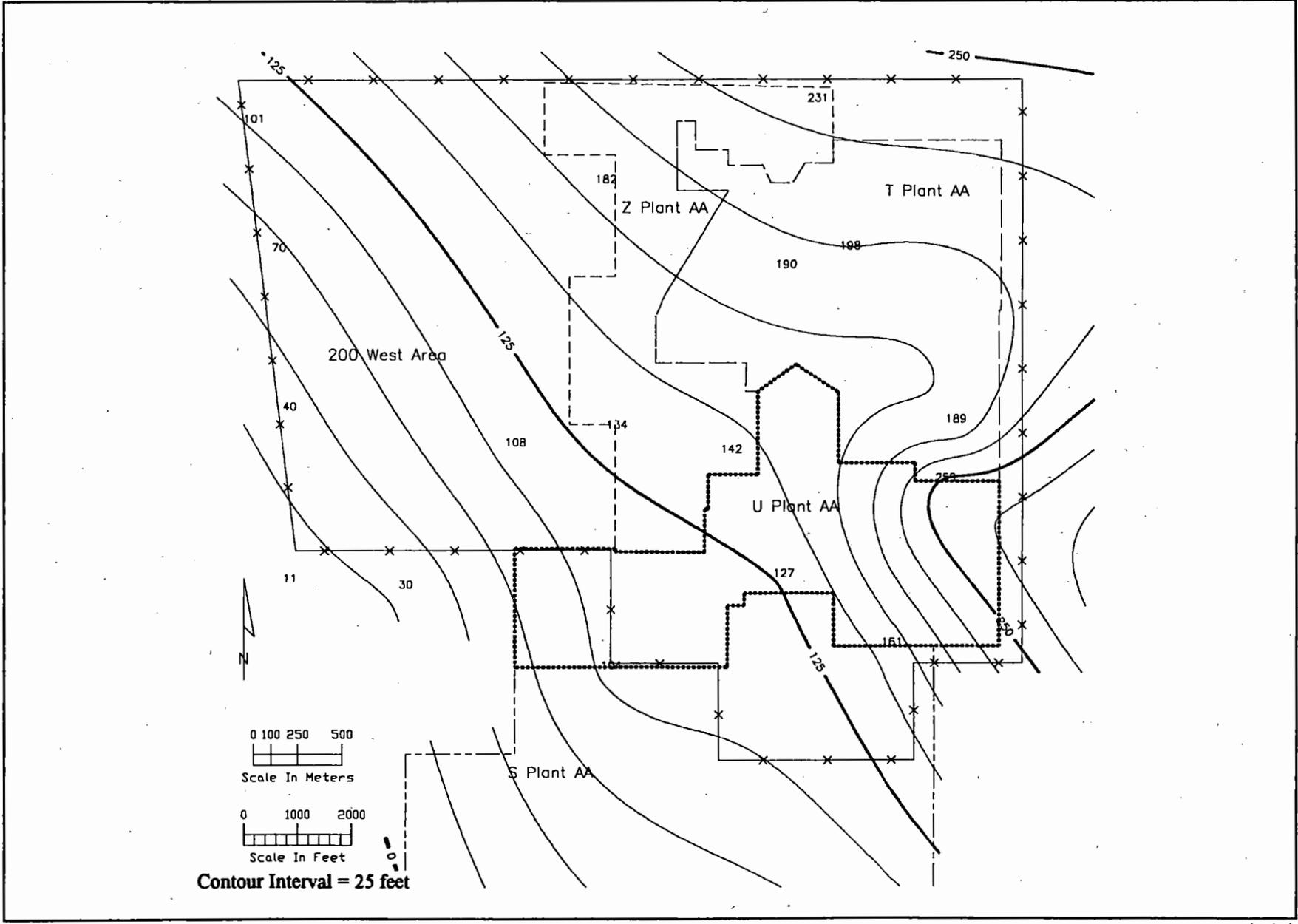


Figure 3-19. Top of the Elephant Mountain Basalt.

br_bot

3F-20

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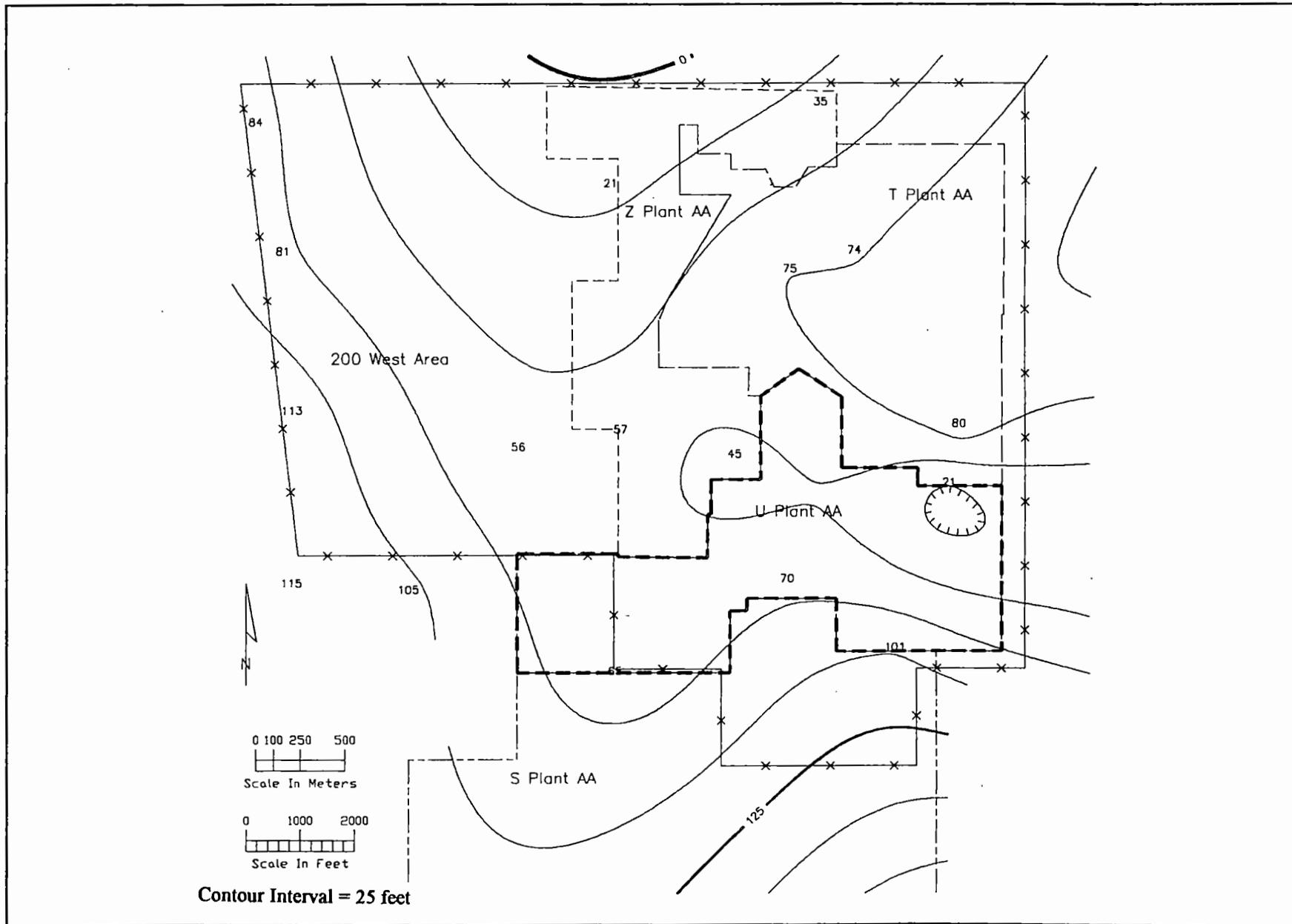


Figure 3-20. Isopach Map of the Ringold Gravel Unit A.

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3F-21

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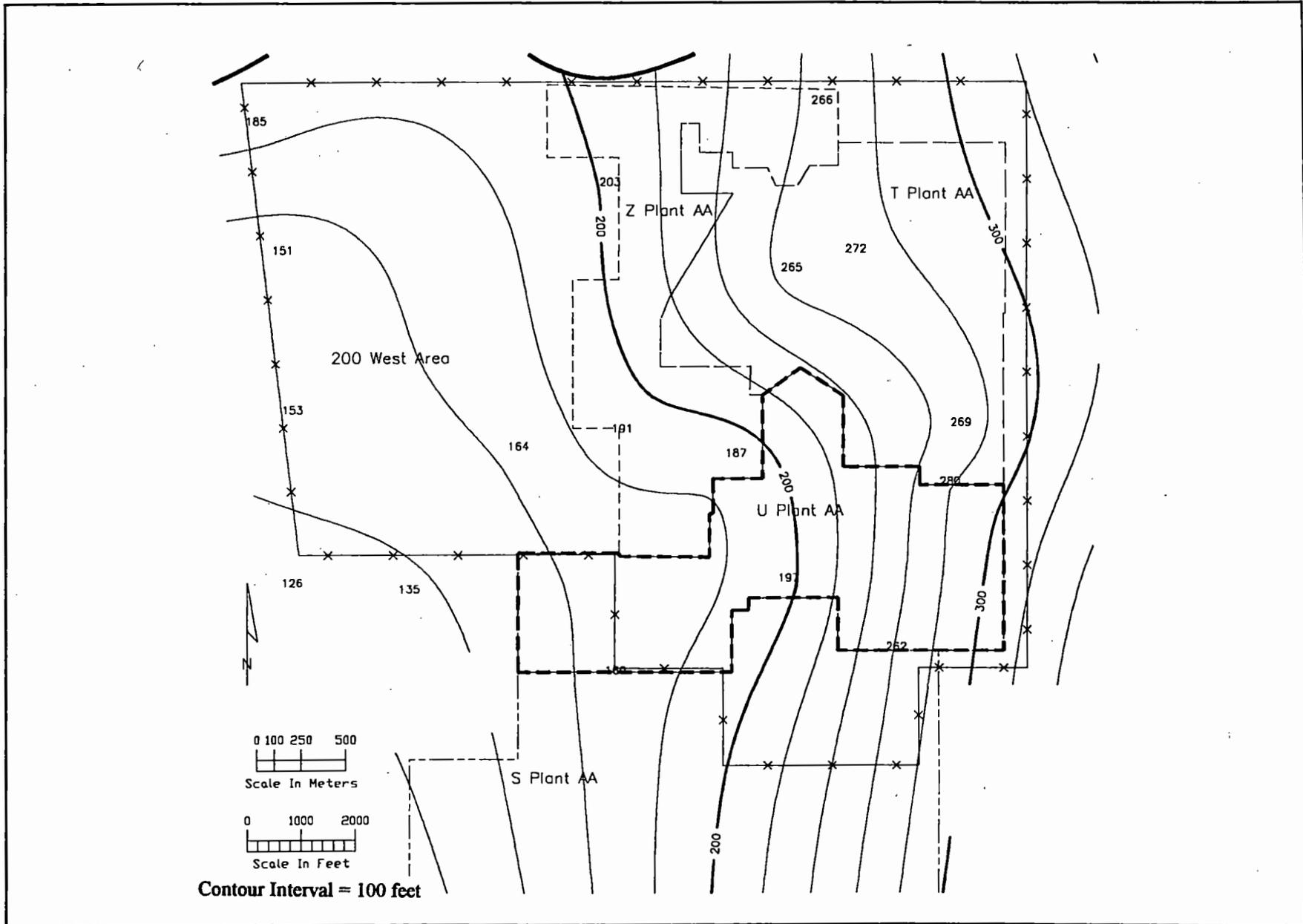
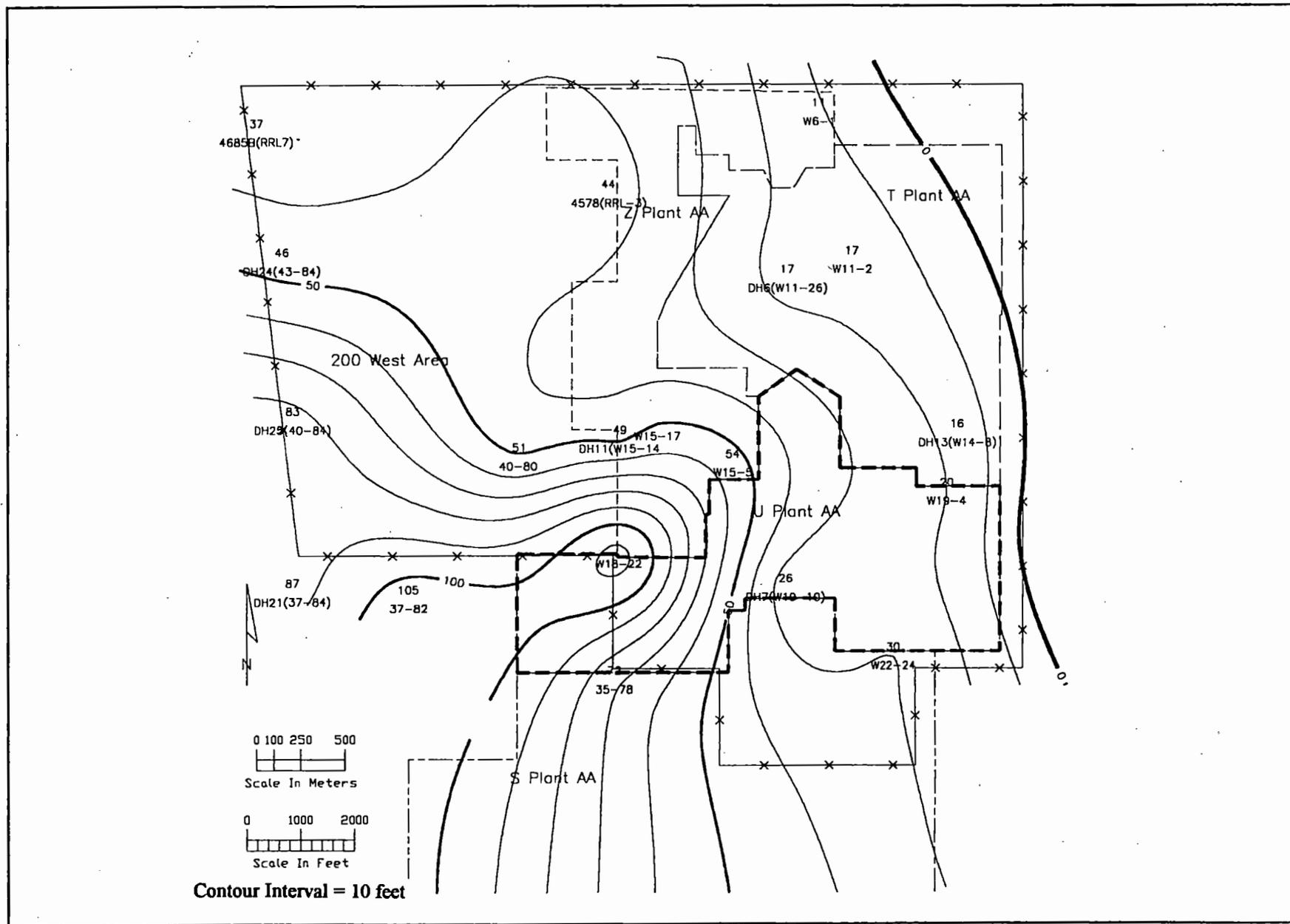


Figure 3-21. Structure Map of the Ringold Gravel Unit A.

br_top

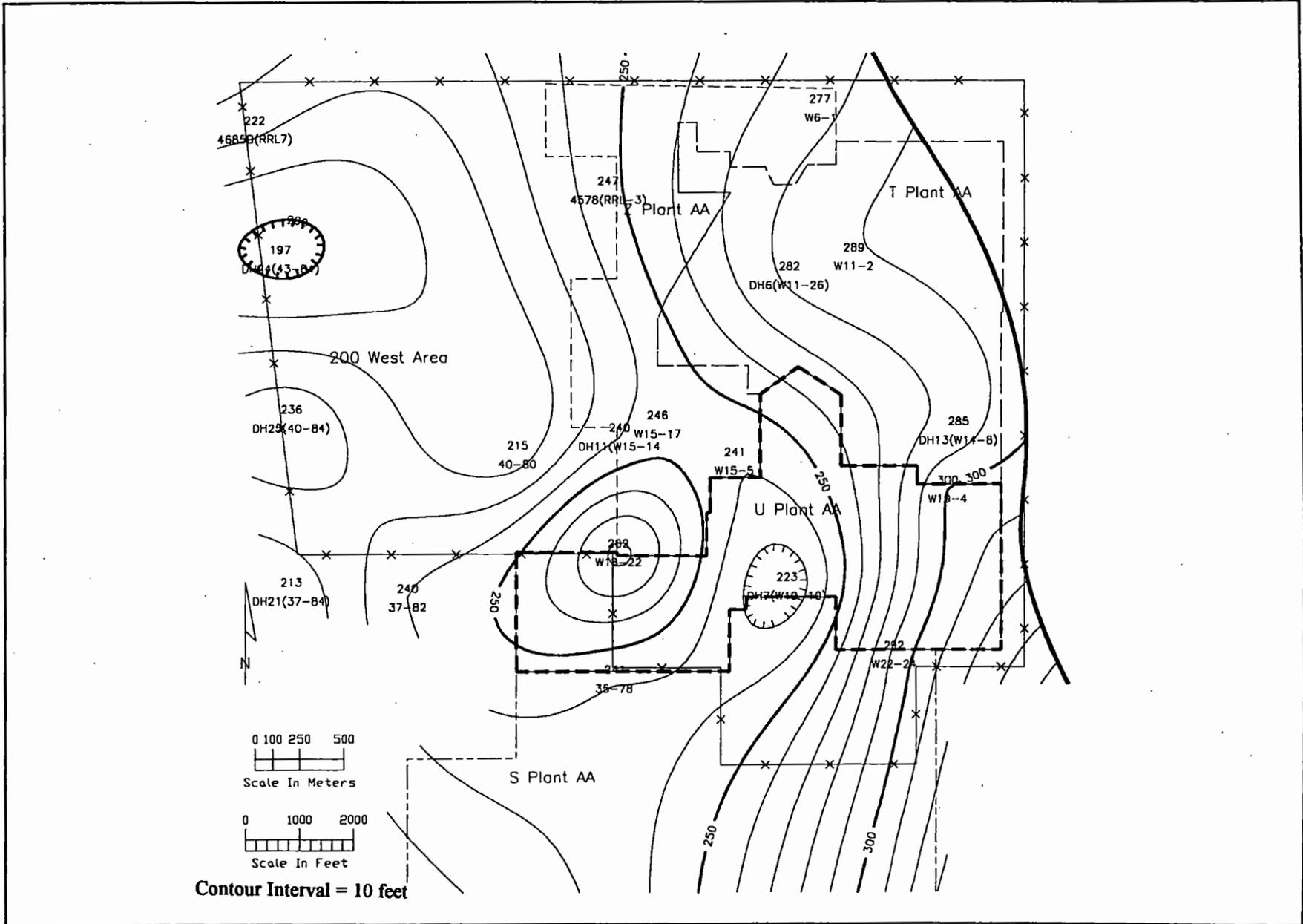
3F-22

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Contour Interval = 10 feet

Figure 3-22. Isopach Map of the Ringold Lower Mud Unit.

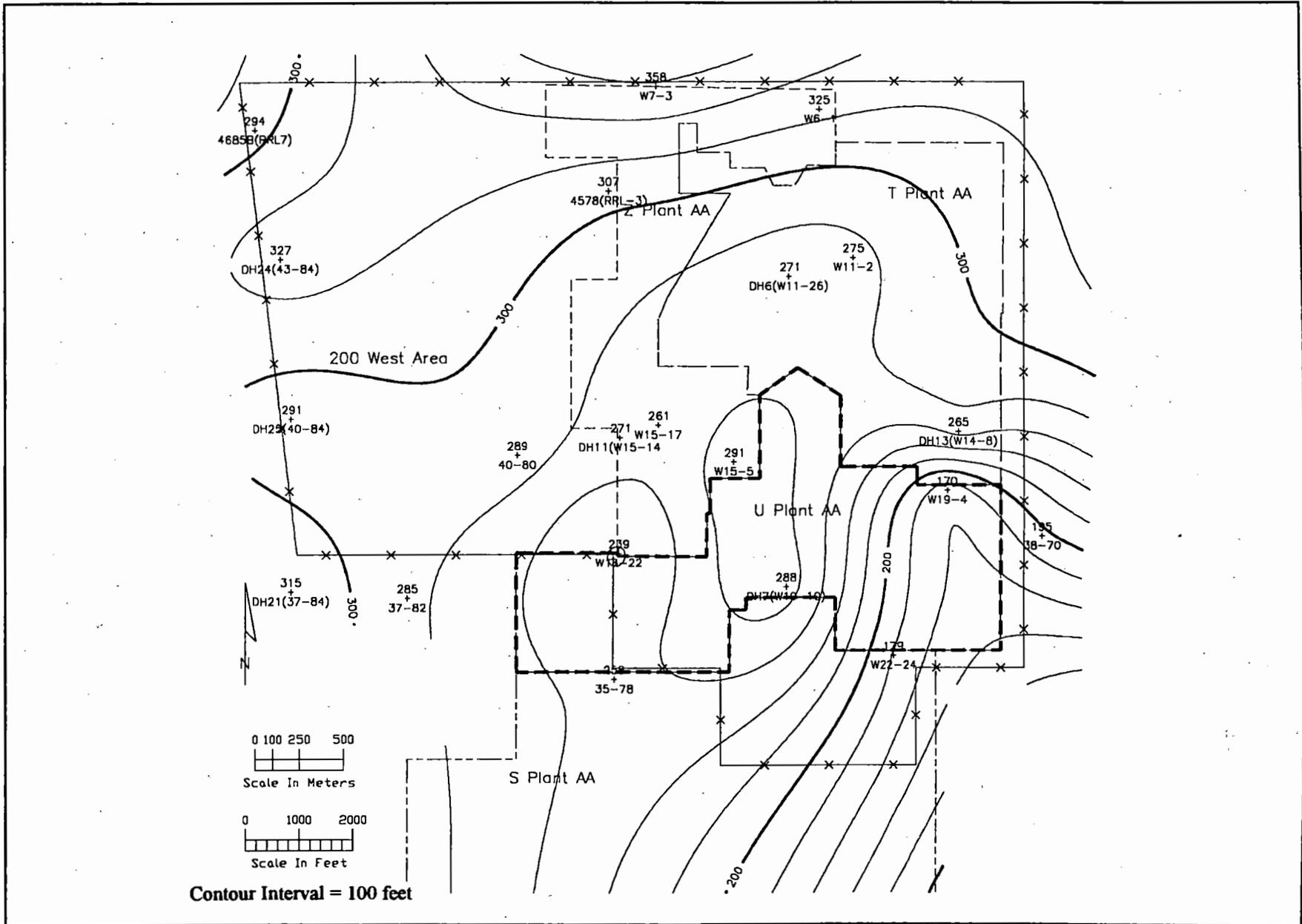


Contour Interval = 10 feet

Figure 3-23. Structure Map of the Ringold Lower Mud Unit.

3F-24

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Contour Interval = 100 feet

Figure 3-24. Isopach Map of the Ringold Gravel Unit E.

er_thk

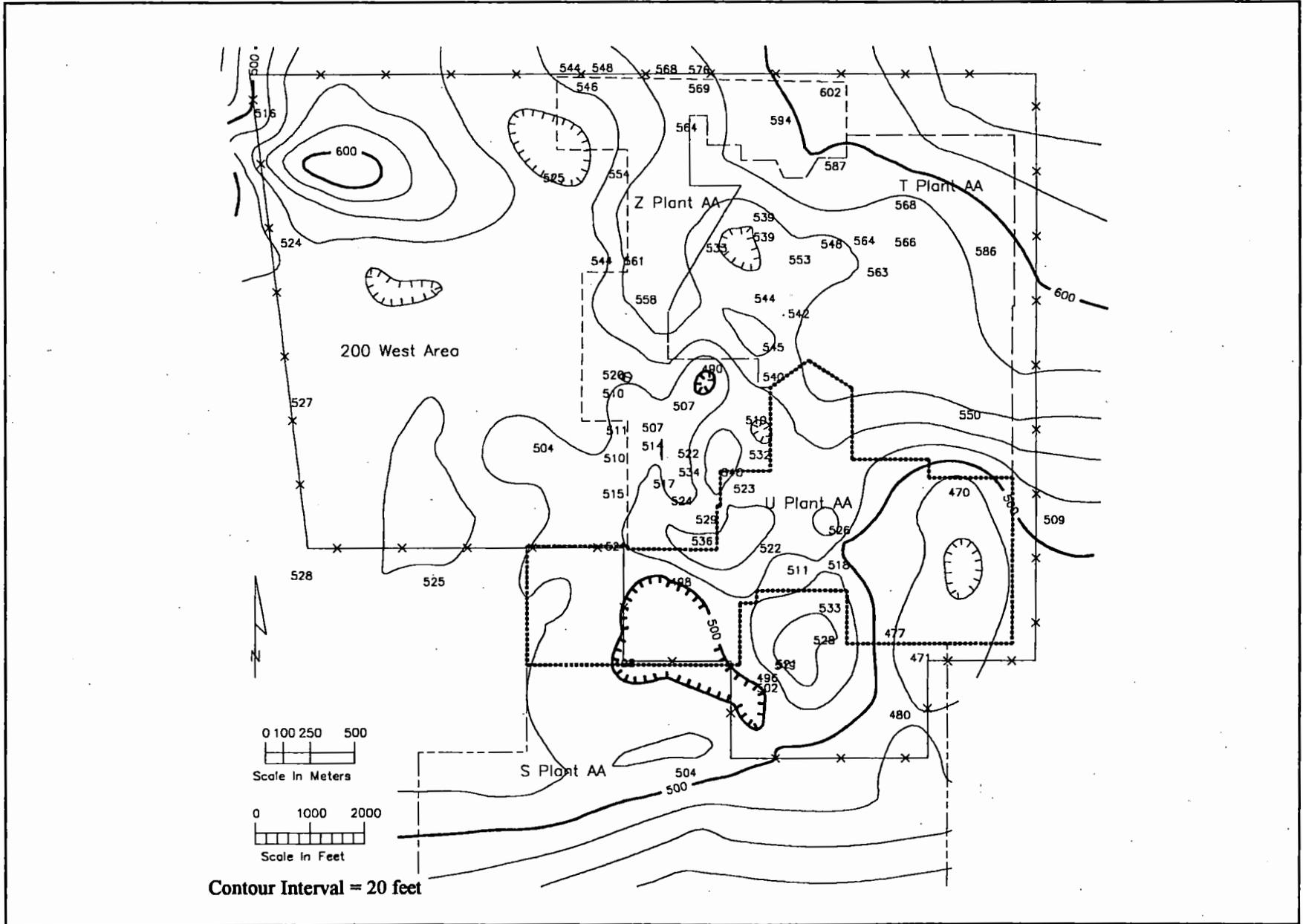


Figure 3-25. Structure Map of the Ringold Gravel Unit E.

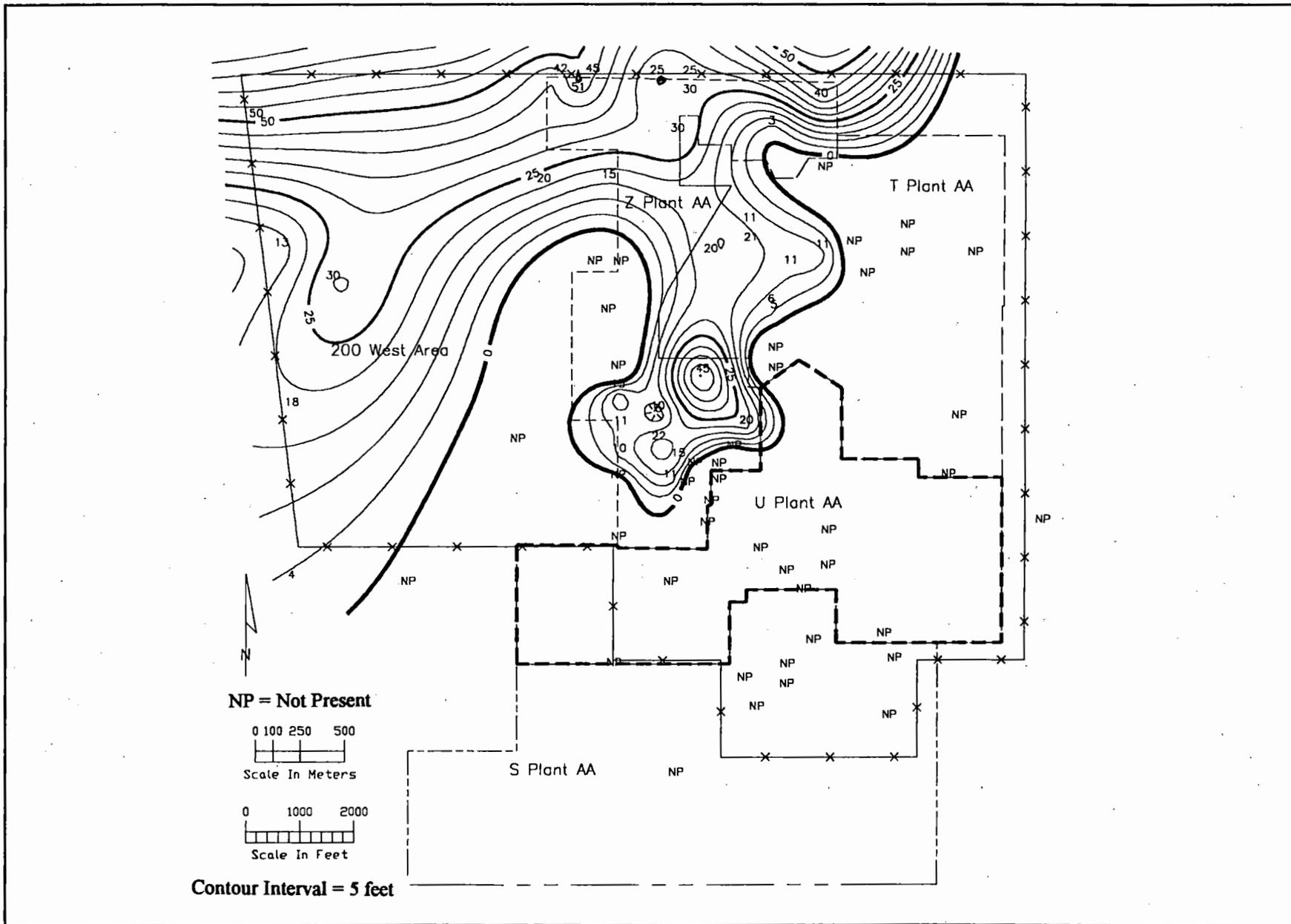
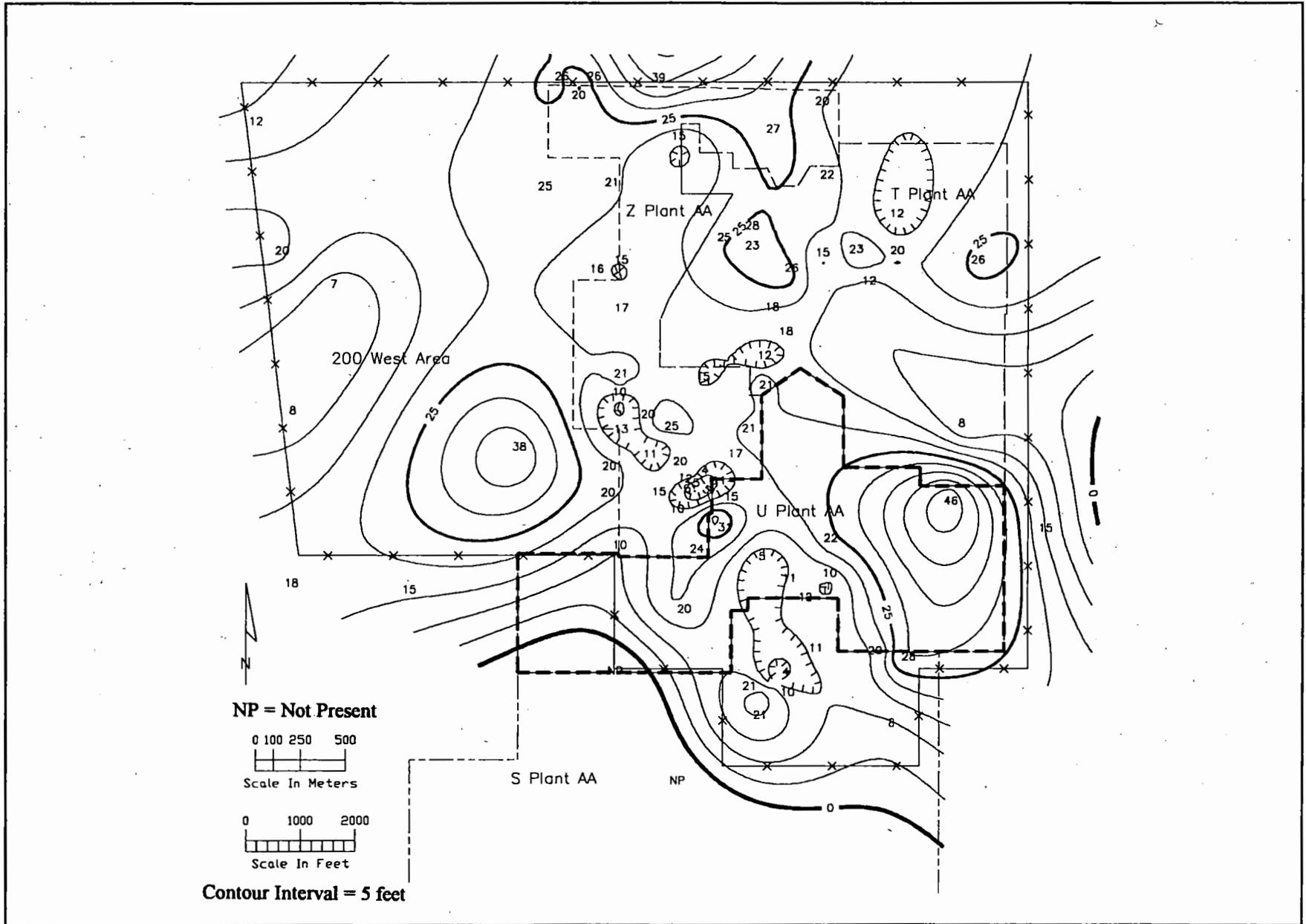


Figure 3-26. Isopach Map of the Upper Ringold.



NP = Not Present

0 100 250 500
Scale In Meters

0 1000 2000
Scale In Feet

Contour Interval = 5 feet

Figure 3-28. Isopach Map of the Plio-Pleistocene Unit.

3F-30

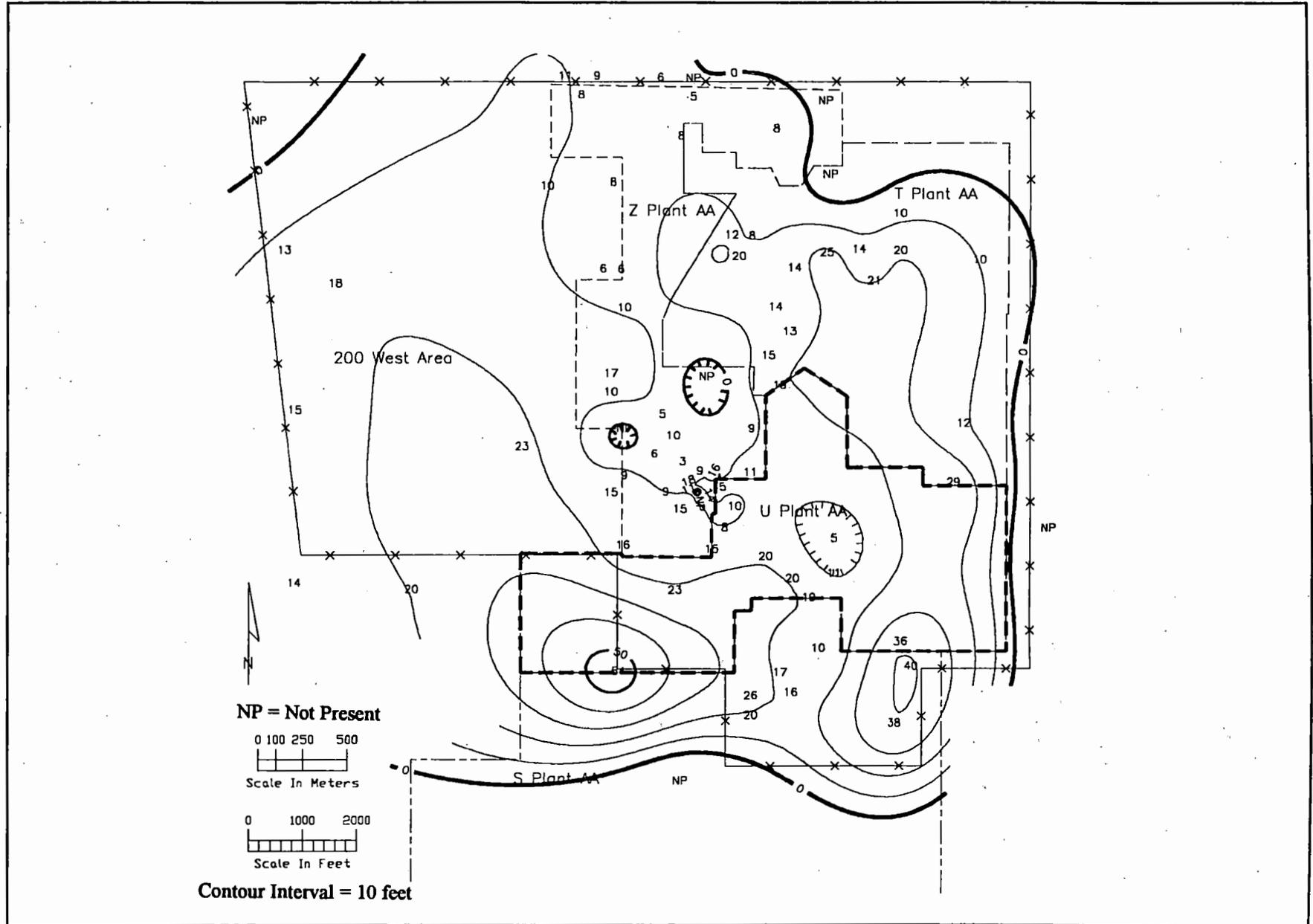


Figure 3-30. Isopach Map of the Early "Palouse" Soil.

3F-32

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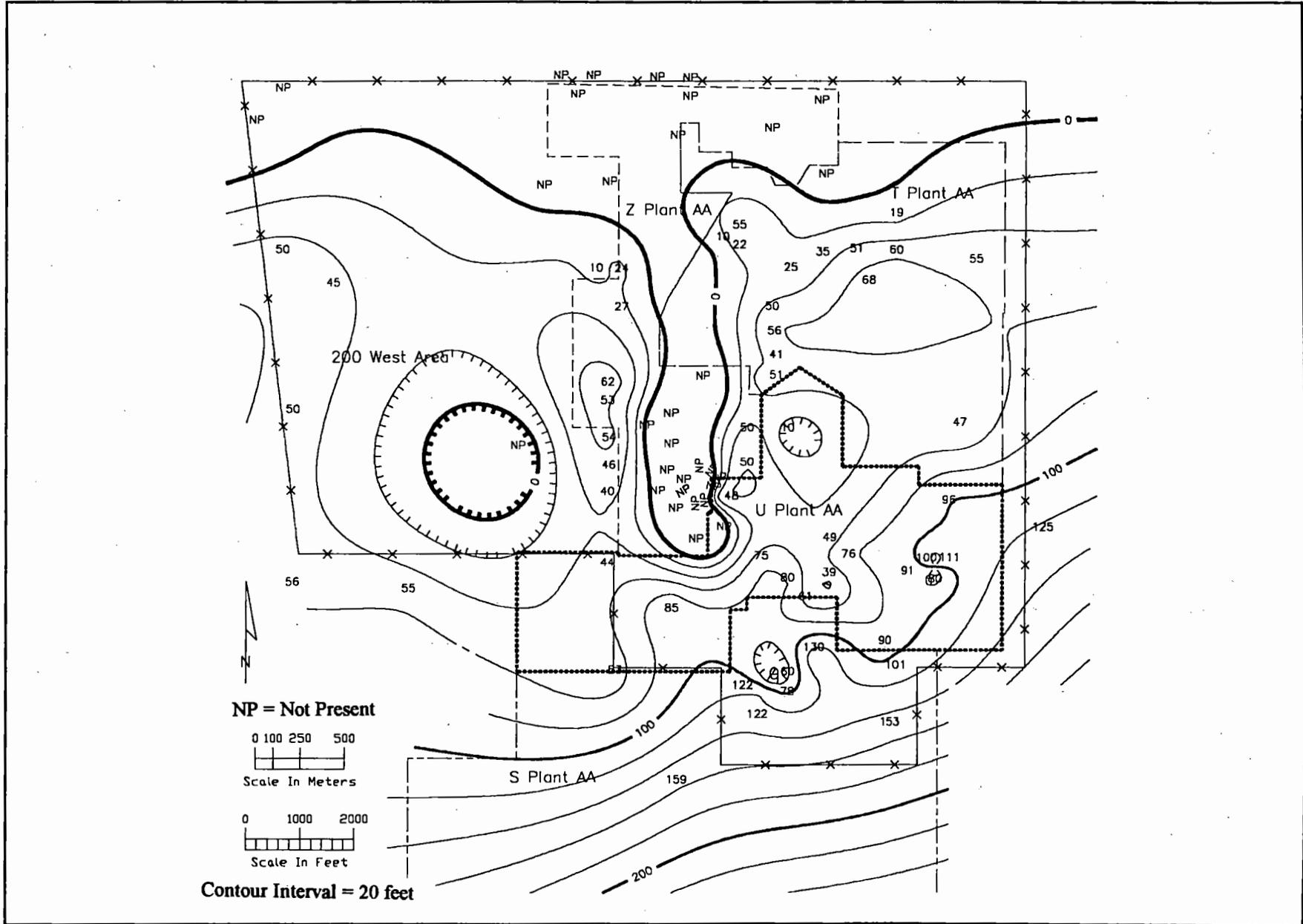


Figure 3-32. Isopach Map of the Lower Fine-Grained Unit of the Hanford Formation.

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3F-33

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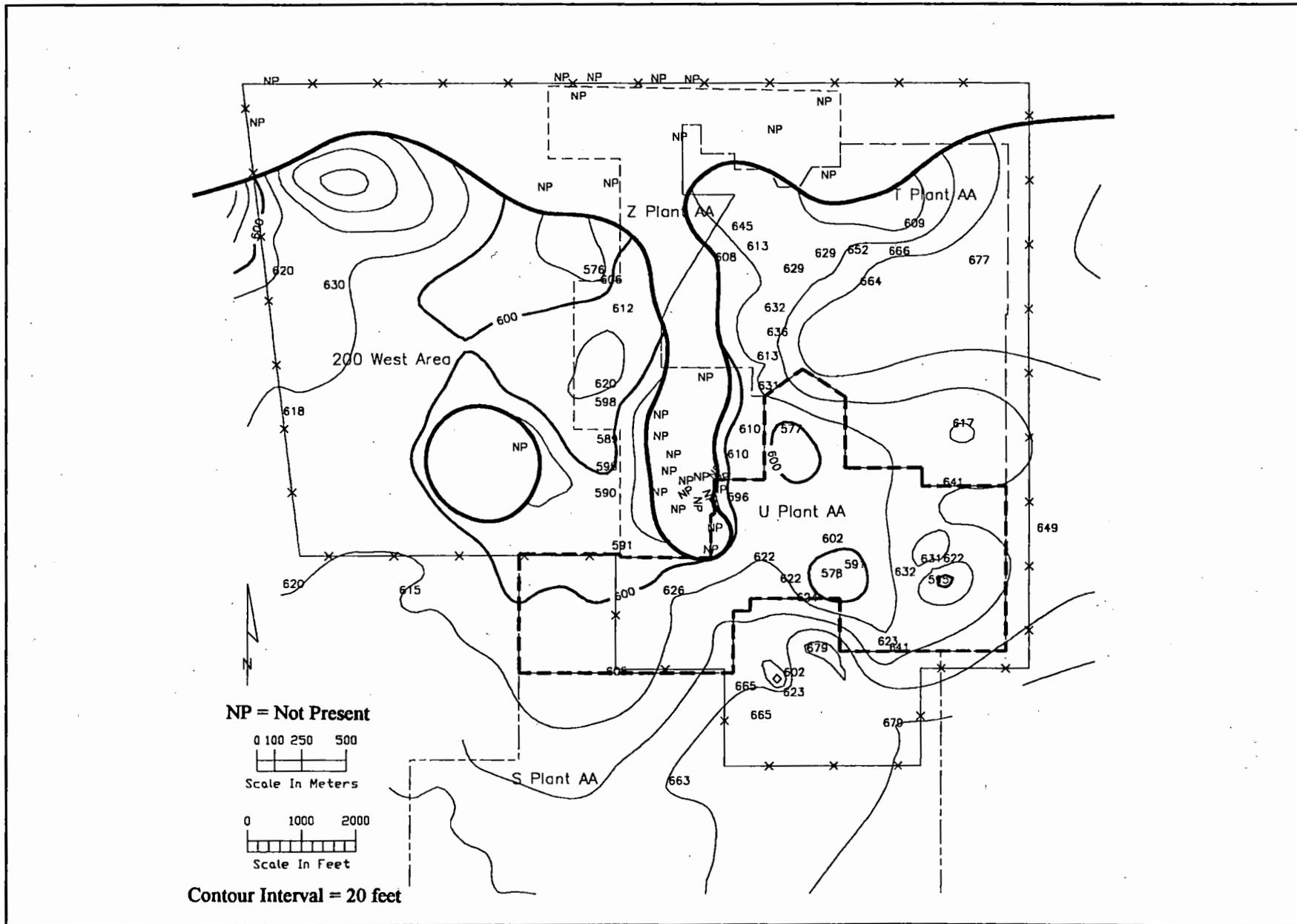


Figure 3-33. Structure Map of the Lower Fine-Grained Unit of the Hanford Formation.

hf2_top

3F-34

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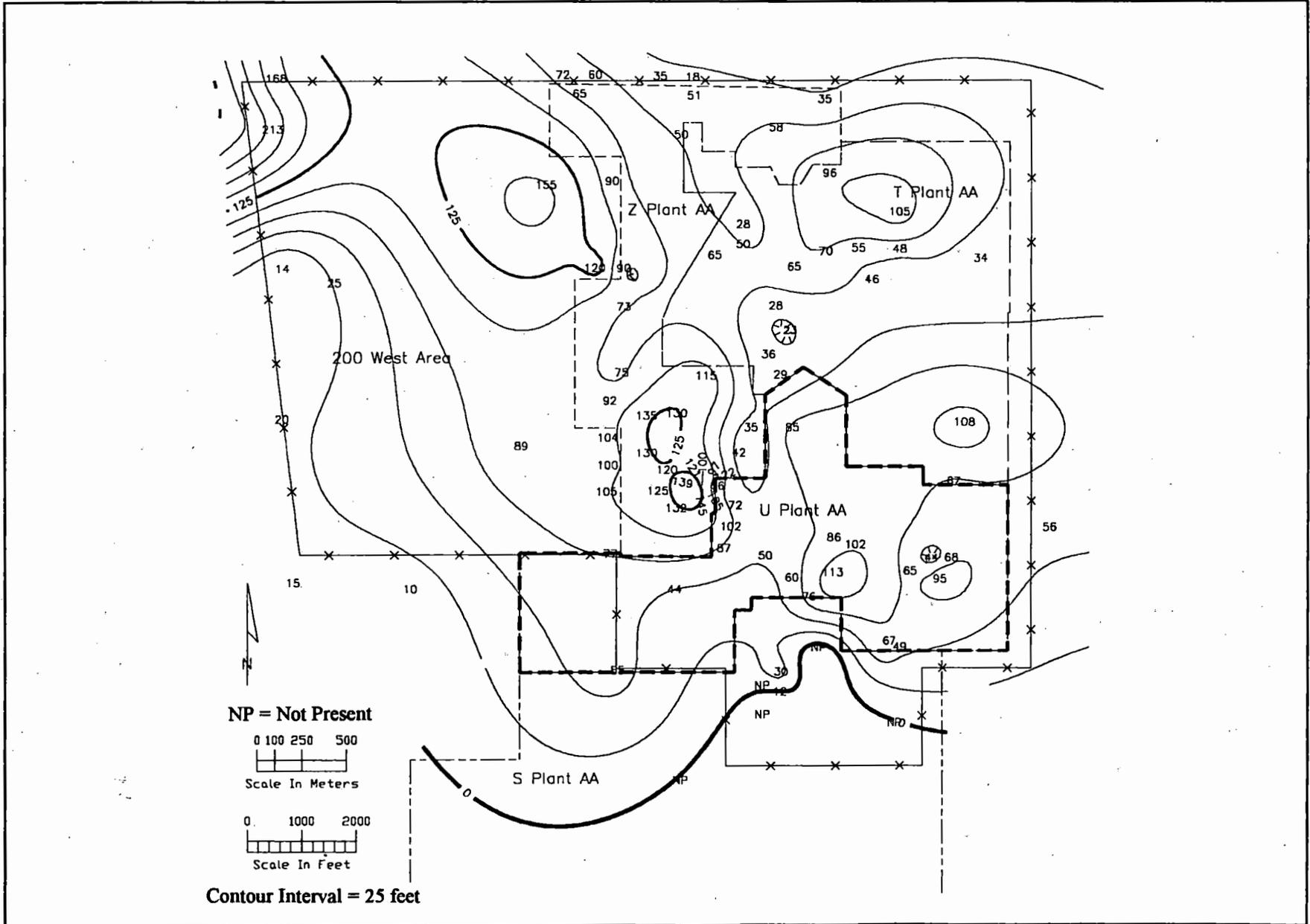


Figure 3-34. Isopach Map of the Upper Coarse-Grained Unit of the Hanford Formation.

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3F-36

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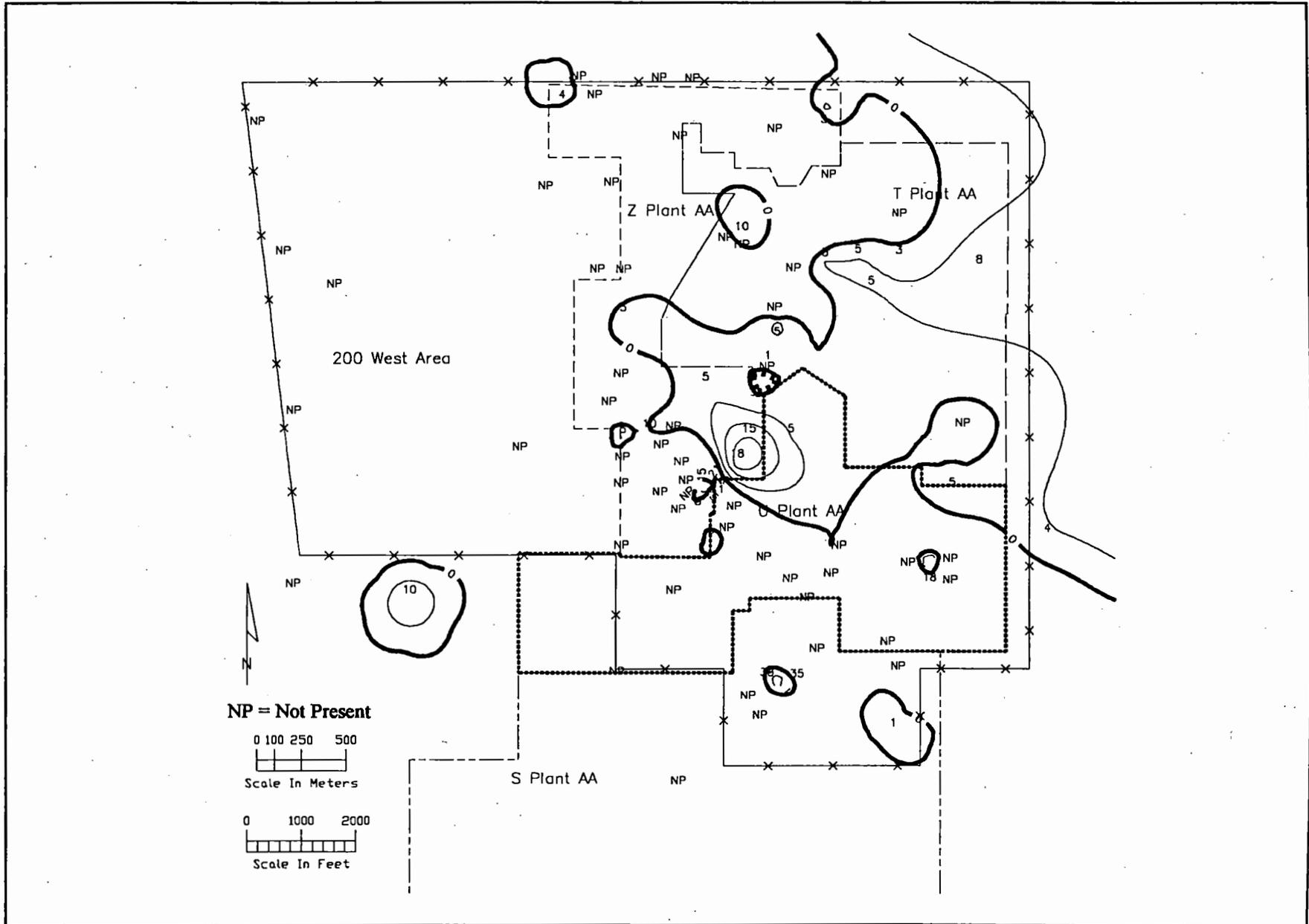
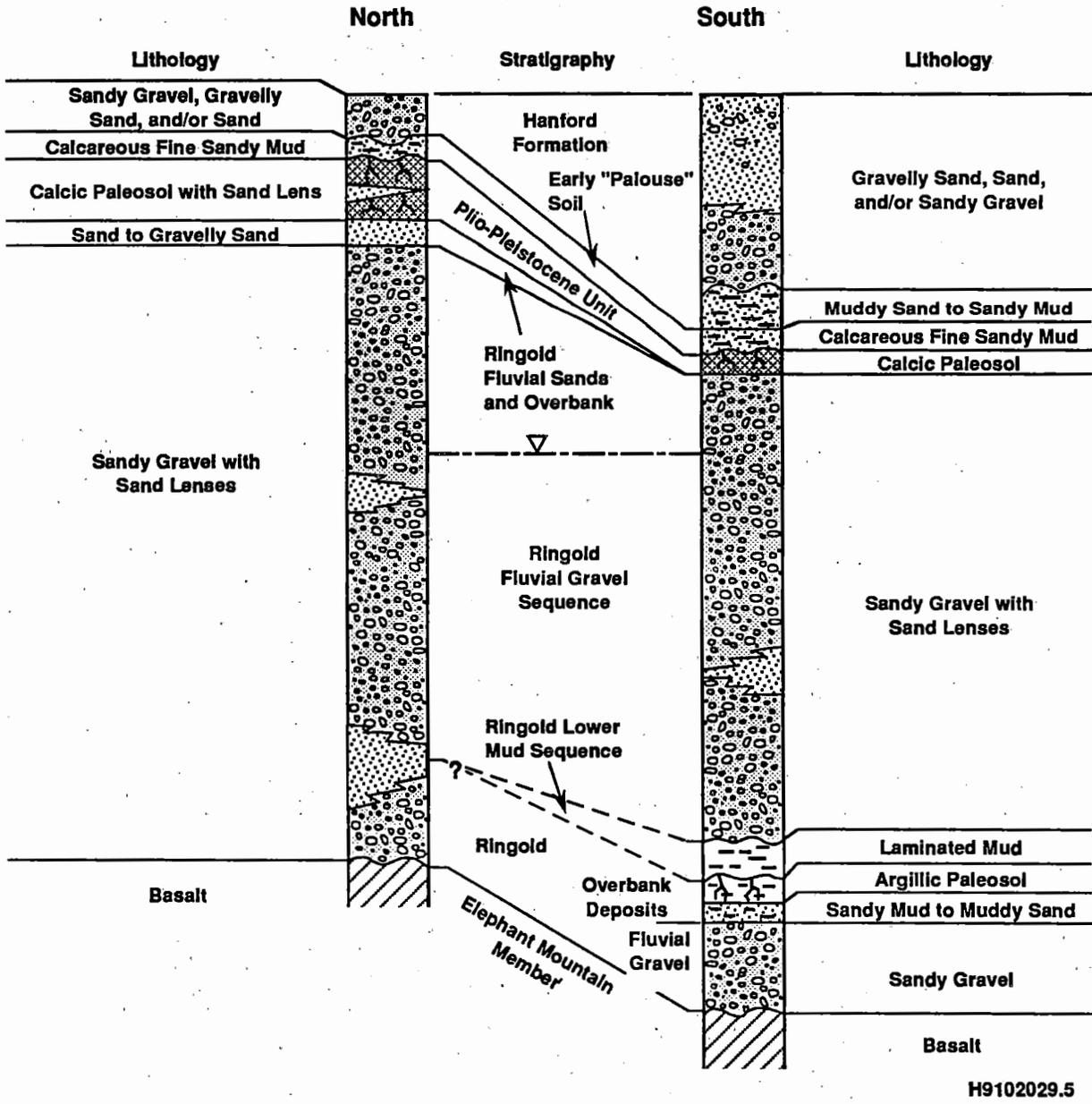


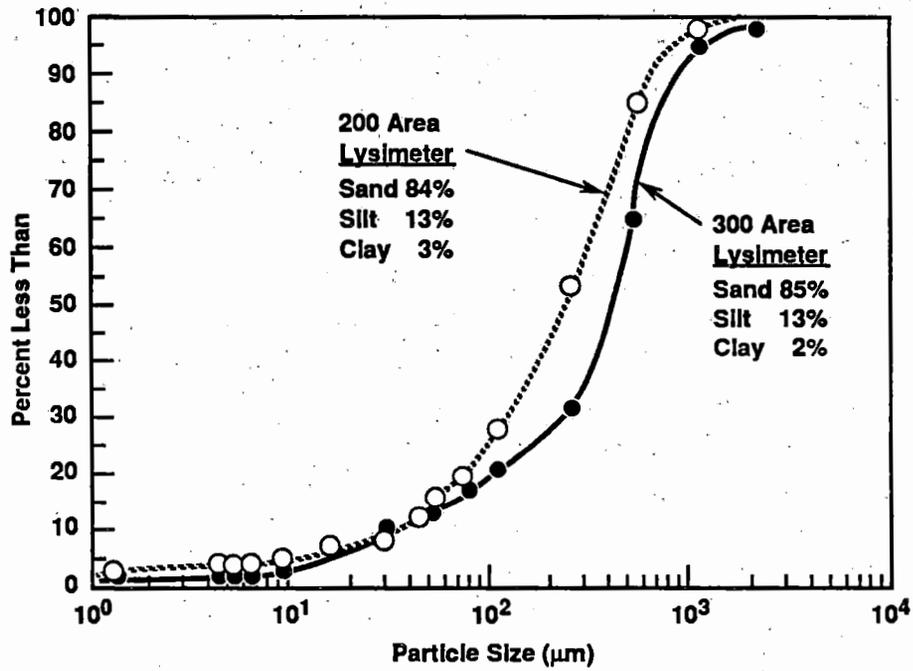
Figure 3-36. Isopach Map of the Backfilled Gravels and Eolian Sands.

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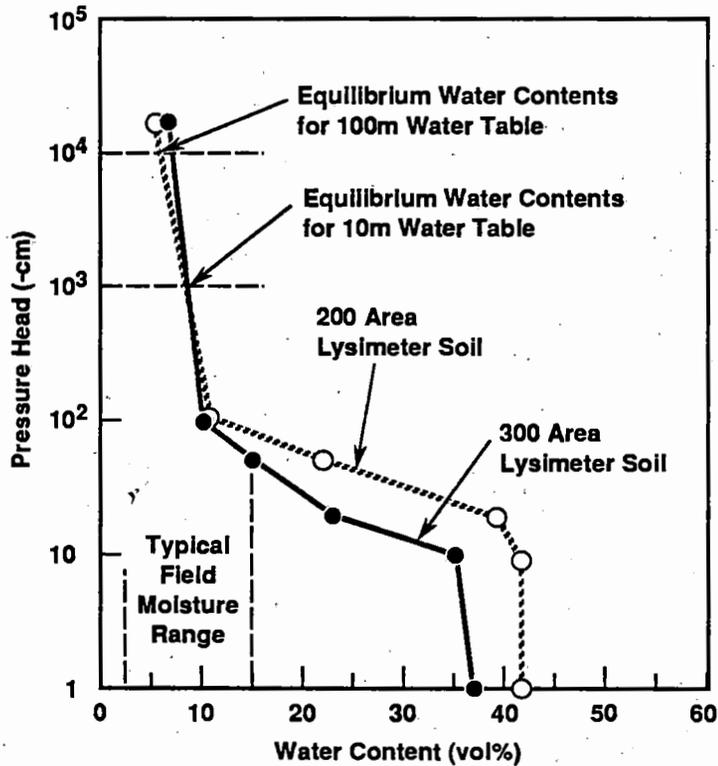


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Figure 3-37. Conceptual Geologic and Hydrogeological Column for the 200 West Area. (Last et al. 1989).



a. Particle Size Distribution



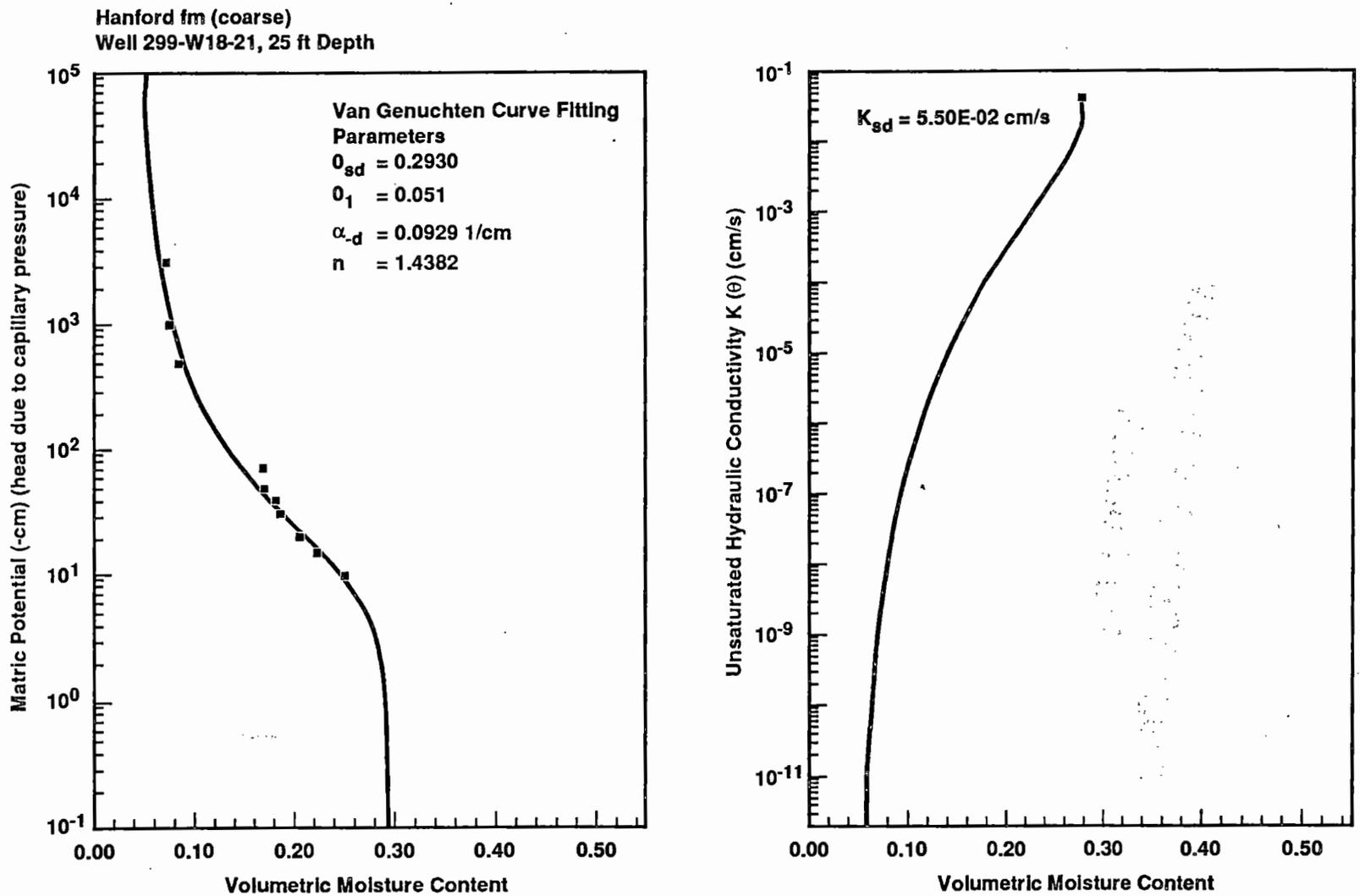
b. Water Retention Characteristics

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Figure 3-38. Wetting and Drying Curves for Well 299-W18-21

9 3 1 2 7 8 0 5 7 6

3F-39



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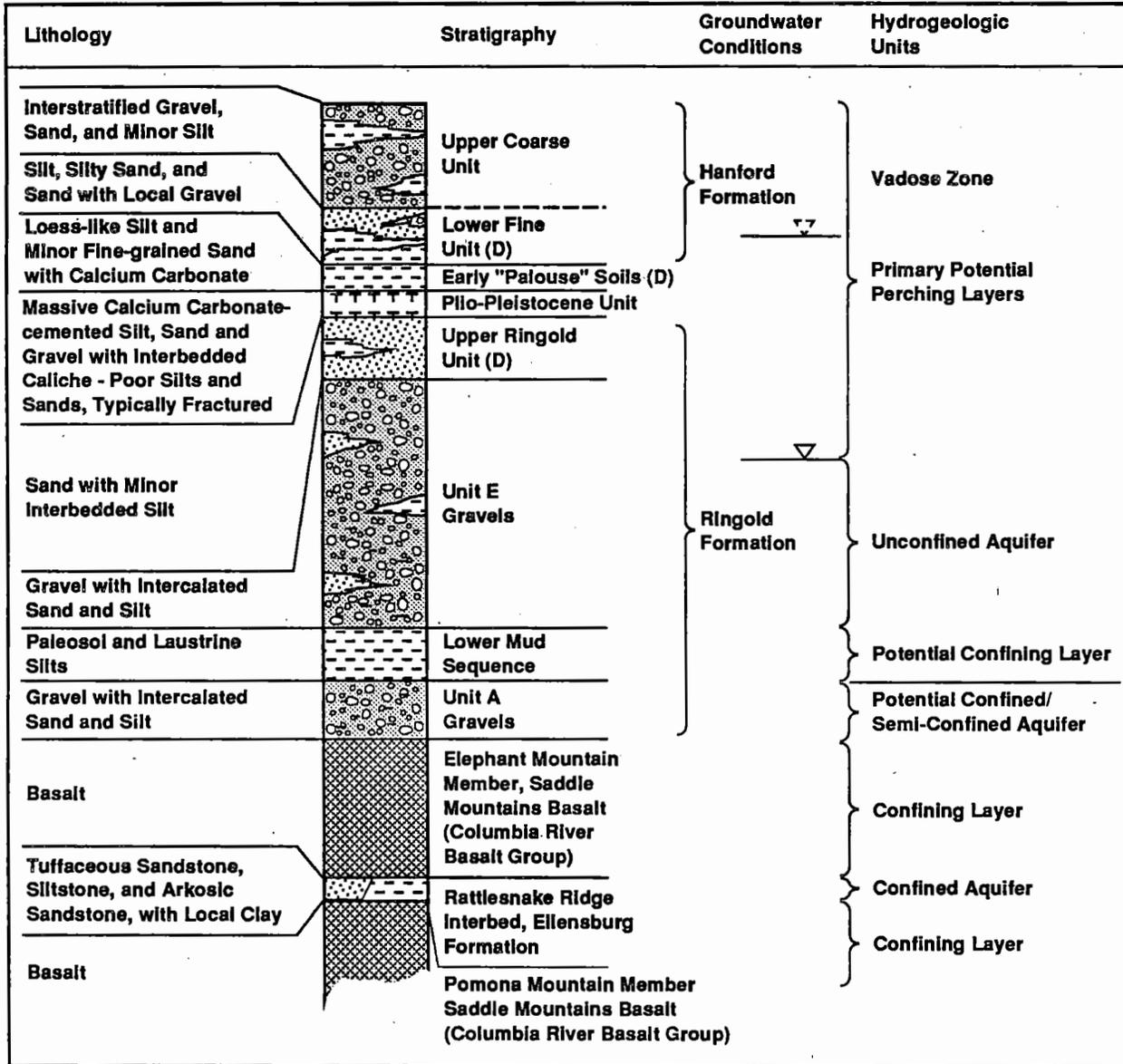
Figure 3-39. Particle Size Distribution and Water Retention Characteristics of Soils from Hanford Site Lysimeters.

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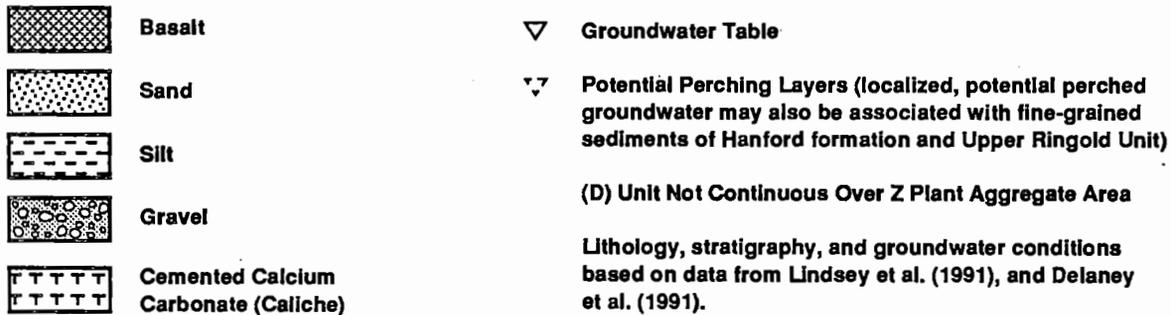


Figure 3-41. Conceptual Hydrogeologic Column for the U Plant Aggregate Area.

Table 3-1. Hydraulic Parameters for Various Areas and Geologic Units at the Hanford Site.

Location	Interval tested	Hydraulic conductivity (m/day)
Pasco Basin	Hanford formation	150 - 6,200
	Ringold Formation	6 - 180
	Unit E	
	Ringold Formation	0.03 - 3
Unit A		
100 Area	Ringold Formation Unit E	9 - 395
200 Areas	Hanford formation	610 - 3,050
	Ringold Formation	2.7 - 70
	Unit E	
	Ringold Formation	0.3 - 3.6
Unit A		
200 West Area	Ringold Formation	0.02 - 61
	Unit E	
	Ringold Formation	0.5 - 1.2
	Unit A	
	Lower Ringold laboratory	$9 \times 10^{-6} - 2.4 \times 10^{-5}$
Slug Tests at U-12 Crib	Upper Ringold	2.4 - 13
300 Area	Hanford Formation	3,350 - 15,250
300 Area	Ringold Formation	0.58 - 3,050
1100 Area	Ringold Formation	0.09 - 1.5
	Units C/B	
1100 Area	Ringold Formation	2.4×10^{-4}
	Overbank Deposits	0.03

9 3 1 2 7 8 0 5 0 0

Table 3-2. Summary of Reported Hydraulic Conductivity Values for
Hanford Site Vadose Zone Sediments.

Page 1 of 2

Reported Hydraulic Conductivity Value or Range of Values in cm/s	Water Content Volume Percent	Reported Geologic Unit or Sediment Type	Test Area or Sampling Location	Measurement Method or Basis for Reported Value
6.7 x 10 ⁻⁷	10	Sand	200 Area	Lysimeter Soil Experiments
1.7 x 10 ⁻⁸	7			
1.7 x 10 ⁻⁹	5.5			
1.7 x 10 ⁻¹⁰	5			
1.3 x 10 ⁻¹¹	4.3			
2.6 x 10 ⁻³	31	Sandy soil reported as "typical or many surface materials at the Hanford Site."		Unsaturated column studies.
5.7 x 10 ⁻⁴ (sat)	56			
6.3 x 10 ⁻¹¹	2.9	Near-surface soils	2-km south of 200 East Area	K estimates using water retention curve data.
2.2 x 10 ⁻¹¹	2.8			
5.40 x 10 ⁻⁸	8.3	Sandy fill excavated from near-surface soil (Hanford formation) with 1.27-cm particle size fraction screened out.	Buried Waste Test Facility (BWTF): 300 North Area Burial Grounds	Laboratory steady-state flux measurements.
9.78 x 10 ⁻³ (sat)	42.2			
8.4 x 10 ⁻³ (sat, arithmetic mean of four measurements)	na			
8 x 10 ⁻⁸	11	na	BWTF: Southeast Caisson, and North Caisson	Unsteady drainage-flux field measurements.
4 x 10 ⁻³ (Southeast Caisson)	26	na		
1 x 10 ⁻⁸	10	na		
1 x 10 ⁻² (North Caisson)	29	na		
4.5 x 10 ⁻³ (arithmetic mean of 15 measurements)	Field Saturation	na	BWTF North Caisson and area north of caisson	Guelph permeameter field measurements

Table 3-2. Summary of Reported Hydraulic Conductivity Values for
Hanford Site Vadose Zone Sediments.

Page 2 of 2

Reported Hydraulic Conductivity Value or Range of Values in cm/s	Water Content Volume Percent	Reported Geologic Unit or Sediment Type	Test Area or Sampling Location	Measurement Method or Basis for Reported Value
1×10^{-3} (Upper Soil, arithmetic mean of 7 measurements)	Field Saturation	Loam sand over sand	Grass Site; 3 km of BWTF	Guelph permeameter field measurements
9.2×10^{-3} (Lower Soil, arithmetic mean of 4 measurements)	Field Saturation	na		
8×10^{-7}	16	Loam to sandy loam	McGee Ranch: NW of 200 West Area on State Rt. 240	Unsteady drainage-flux field measurements.
9×10^{-4}	40			
9×10^{-4} (arithmetic mean of 9 measurements)	Field Saturation	na		Guelph permeameter field measurements.
5×10^{-3} (sat)	50	Sand, Gravel	Sediment types are idealized to represent stratigraphic layers commonly encountered below 200 Areas liquid disposal sites.	K_{sat} values derived from idealized moisture content curves.
1×10^{-3} (sat)	50	Coarse Sand		
5×10^{-4} (sat)	40	Fine Sand		
1×10^{-4} (sat)	40	Sand, Silt		
5×10^{-5} (sat)	40	Caliche		
1.2×10^{-5} (sat)	19.6 to 18.9	Hanford formation	Well 299-W7-9, 218-W-5 Burial Ground	van Genuchten equation fitted to moisture characteristic curves for Well 299-W7-9 soil samples
6.7×10^{-6} to 2.8×10^{-1} (sat)	37.6 to 41.4	Early "Palouse" Soils		
1.10×10^{-3} (sat)	18.3 to 21	Upper Ringold		
1.80×10^{-4} to 3.00×10^{-4} (sat)	24 to 25	Middle Ringold		

Notes:

na - Not identified in source.

sat - Value for saturated soil.

field saturation - Equilibrium water content after several days of gravity drainage.

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Table 3-3. Endangered, Threatened, and Sensitive Plant Species Reported On or Near the Hanford Site.

Scientific Name	Common Name	Family	Washington State Status
<i>Rorippa columbiae</i> ^{a/} Suksd. ex Howell	Persistent-sepal Yellowcress	Brassicaceae	Endangered
<i>Artemisia campestris</i> L ssp. <i>borealis</i> (Pall.) Hall & Clem. var. <i>wormskioldii</i> ^{a/} (Bess.) Cronq.	Northern Wormwood	Asteraceae	Endangered
<i>Astragalus columbianus</i> ^{a/} Barneby	Columbia Milk Vetch	Fabaceae	Threatened
<i>Lomatium tuberosum</i> ^{a/} Hoover	Hoover's Desert-Parsley	Apiaceae	Threatened
<i>Astragalus arrectus</i> Gray	Palouse Milk Vetch	Fabaceae	Sensitive
<i>Collinsia sparsiflora</i> Fisch. & Mey. var. <i>bruciae</i> (Jones) Newsom	Few-Flowered Collinsia	Scrophulariaceae	Sensitive
<i>Cryptantha interrupta</i> (Greene) Pays.	Bristly Cryptantha	Boraginaceae	Sensitive
<i>Cryptantha leucophaea</i> Dougl. Pays	Gray Cryptantha	Boraginaceae	Sensitive
<i>Erigeron piperianus</i> Cronq.	Piper's Daisy	Asteraceae	Sensitive
<i>Carex densa</i> L.H. Bailey	Dense Sedge	Cyperaceae	Sensitive
<i>Cyperus rivularis</i> Kunth	Shining Flatsedge	Cyperaceae	Sensitive
<i>Limosella acaulis</i> Ses. & Moc.	Southern Mudwort	Scrophulariaceae	Sensitive
<i>Lindernia anagallidea</i> (Michx.) Pennell	False-pimpernel	Scrophulariaceae	Sensitive
<i>Nicotiana attenuata</i> Torr.	Coyote Tobacco	Solanaceae	Sensitive
<i>Oenothera pygmaea</i> Dougl.	Dwarf Evening-Primrose	Onagraceae	Sensitive

a/ Indicates candidates on the 1991 Federal Register, Notice of Review.

Table 3-4. Federal and State Classifications of Animals that Could Occur on the 200 Areas Plateau.

Common Name	Status Federal	State
Peregrine Falcon (<i>Falco peregrinus</i>)	FE	SE
Sandhill Crane (<i>Grus canadensis</i>)	--	SE
Bald Eagle (<i>Haliaeetus leucocephalus</i>)	FT	ST
Ferruginous Hawk (<i>Buteo regalis</i>)	FC2	ST
Swainson's Hawk (<i>Buteo swainsoni</i>)	FC2	SC
Golden Eagle (<i>Aquila chrysaetos</i>)	--	SC
Burrowing Owl (<i>Athene cunicularia</i>)	--	SC
Loggerhead Shrike (<i>Lanius lucovicianus</i>)	--	SC
Sage Sparrow (<i>Amphispiza belli</i>)	--	SC
Great Blue Heron (<i>Casmerodius albus</i>)	--	SM
Merlin (<i>Falco columbarius</i>)	--	SM
Prairie Falcon (<i>Falco mexicanus</i>)	--	SM
Long-billed Curlew (<i>Numenius americanus</i>)	--	SM
Striped Whipsnake (<i>Masticophis taeniatus</i>)	--	SC

FE - Federal Endangered
 FT - Federal Threatened
 FC2 - Federal Candidate
 SE - State Endangered
 ST - State Threatened
 SC - State Candidate
 SM - State Monitor

Above information taken from Washington Department of Wildlife June 1991. Species of Concern in Washington.

4.0 PRELIMINARY CONCEPTUAL MODEL

Section 4.1 presents the chemical and radiological data available for each waste management unit. These chemical data, along with physical descriptions of the waste management units (Section 2.0) and descriptions of the surrounding environment (Section 3.0) are evaluated in Sections 4.2 and 5.0 in order to qualitatively assess the potential impacts of the contamination to human health and to the environment. The quality and sufficiency of the existing data are assessed in Section 8.0. This information is also used to identify potential applicable or relevant and appropriate requirements (ARARs) (Section 6.0). Contaminant information is assessed in Section 7.0 to provide a basis for selecting technologies which can be implemented at the sites.

Contaminants released into the environment at a waste management unit or unplanned release site may migrate from the point of release into other types of media. The potentially affected media in the U Plant Aggregate Area include surface soil, surface water, vadose zone soil and perched groundwater, air, and biota. The media affected at a specific site will depend upon the quantities, chemical and physical properties of the material released, and the subsequent site history. The potentially affected media at each waste management unit or unplanned release site are listed in Table 4-1 for radionuclide contamination and Table 4-2 for chemical contamination.

4.1 KNOWN AND SUSPECTED CONTAMINATION

There are two major categories of chemical and radiological data available for the U Plant Aggregate Area: site-specific data applicable to individual waste management units and unplanned releases; and area-wide environmental data that are useful in characterizing regional contamination trends.

Some waste management units and unplanned releases have been the subject of chemical and radiological studies in the past. However, most of these studies were limited in scope and did not provide a comprehensive analysis of the character and distribution of the contamination at each site. The types of unit-specific data that are available for some sites include inventory information, surface radiological surveys, external radiation dose rate monitoring, soil and sediment sampling, biota sampling, borehole geophysics, and groundwater sampling.

Table 4-3 summarizes the types of site-specific data available for each of the waste management units. It should be emphasized that the table only summarizes what types of data are available; it does not indicate the sufficiency of the data, either in terms of quality or quantity. These concerns are addressed in Section 8.0. The unit-specific information is presented for each waste management unit in Section 4.1.2.

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Although groundwater issues are considered outside the scope of this study, some groundwater data have been included. Groundwater contaminant plumes known to have originated from specific waste management units are described because they offer insight into the distribution of contaminants within the overlying vadose zone. A limited amount of groundwater data are presented separately for some of the sites in Section 4.1.2.

In addition to these site-specific data, there are area-wide data not directly applicable to any waste management unit within the U Plant Aggregate Area. The most important sources of this general environmental data are quarterly and annual environmental surveillance reports published by Westinghouse Hanford. There are also area-wide geophysical data available that include gravity, magnetic, magnetotelluric, seismic refraction and seismic reflection surveys (DOE 1988b). However, these studies are not useful for characterizing the extent of chemical and radionuclide contamination and so are not presented in Section 4.0. These data are discussed in more detail in Section 8.1.2.

The most recent environmental monitoring of the Hanford Site was conducted by the Pacific Northwest Laboratory (PNL) (Eberhardt et al. 1989) and Westinghouse Hanford. However, most of the data applicable to the U Plant Aggregate Area have been published by Westinghouse Hanford. The latest Quarterly Environmental Radiological Survey Summary Reports (Huckfeldt 1991a, 1991b) were reviewed during the current study, as well as the last six annually published environmental surveillance reports (Elder et al. 1986, 1987, 1988, 1989; and Schmidt et al. 1990, 1992). The quarterly reports only contain surface radiological survey results. The annual reports describe several different sampling and survey programs including surface soil sampling, external radiation measurements, biota sampling, air sampling, surface water sampling, groundwater sampling, and radiological surveys.

Air, soil, surface water, and biota samples were collected each year at the same locations within the 200 West Area. External radiation measurements were also taken annually at several locations. Until 1990, few of the sample locations were directly associated with any of the identified waste management units and so most of this information is only useful in characterizing area-wide trends. In 1990, however, new sampling locations were established near areas of known surface contamination. Currently, only external radiation data are available for these new sample locations. Both the new and old sampling locations are shown on Plate 3.

Section 4.1 describes available data regarding known and suspected contamination in the U Plant Aggregate Area on a media-specific basis (air, surface soil and biota, and vadose zone soil). The text summarizes sources of chemical and radiological sampling information. Section 4.1.1 presents data on a media-specific basis. Section 4.1.1.1 presents results of air quality sampling data. Surface soil data are described in Section 4.1.1.2. Results of surface water sampling are presented in Section 4.1.1.3. Results of vegetation and other biota sample analyses are presented in Section 4.1.1.4. Available vadose zone sampling data are

presented in Section 4.1.1.5. Section 4.1.1.5 also discusses evidence for contamination migration within the vadose zone to the unconfined aquifer underlying the site. Additional assessment of the nature and extent of groundwater contamination is presented in the 200 West Groundwater Aggregate Area Management Study Report (AAMSR).

To supplement available radiological and chemical analytical data, historical waste inventory information for the U Plant Aggregate Area waste management units were also included in the evaluation of known and suspected contaminants. Historical waste inventory data are detailed in Section 2.0 of this report (Tables 2-2 and 2-3). As discussed in Section 2.0, the compilation is based on supporting data from the Waste Inventory Data System (WIDS) (WHC 1991a) and the Hanford Inactive Site Survey (HISS) Database (DOE 1986a).

4.1.1 Affected Media

4.1.1.1 Air. Six high volume air samplers are stationed within or adjacent to the U Plant Aggregate Area (Plate 3). The samplers contain 3 μm filters which collect particles entrained in the air.

The air samples are collected by drawing samples through a 47-mm diameter, open-face filter (3 μm) at about 1 m (3 ft) above the ground (0.2 m³/min [2 ft³/min flowrate]). Throughout the 200 Areas, air samplers are operated on a continuous basis. Sample filters are exchanged weekly, held one week to allow for decay of short-lived natural radioactivity, and sent for initial laboratory analyses of gross alpha and beta activity. After the initial analysis, the filters are stored until the end of the calendar quarter, at which time they are composited by sample location (or as deemed appropriate according to the annual reports) and sent for laboratory analyses of specific radionuclides. Compositing of the filters by sample location provides a larger sample size, and thus a more accurate measurement of the concentration of airborne radionuclides resulting from operations in the 200 Areas.

The filters are analyzed quarterly for ⁹⁰Sr, ¹³⁷Cs, ²³⁹Pu, and total U. The results have shown a steady decline in the concentration of these radionuclides since 1979 throughout the 200 West Area because of improvements in operational environmental controls and curtailed operations (Schmidt et al. 1990). The last five years of data for the U Plant Aggregate Area have been averaged and the values are summarized in Table 4-4. The complete data set since 1985 is summarized in Appendix A.2.

4.1.1.2 Surface Soil. There are several sources of data available for characterizing surface soil contamination. These include: aerial and ground radiological surveys, external radiation measurements and surface soil sampling. These data will be presented in the following sections. In addition, there is a limited amount of site-specific radiological and soil sampling data that will be presented in the appropriate subsections of Section 4.1.2.

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4.1.1.2.1 Radiological Surveys. Radiological survey results may be influenced by buried or airborne radionuclide contamination but are generally indicative of surface and shallow soil contamination. Depending upon the instrumentation and survey techniques used, results may be reported in ct/min, dis/min, mr/h or mrem/yr. Typical natural background levels for these measurements are approximately: 50 ct/min, 2,000 dis/min (for an NaI detector), .05 mR/h and 90 mrem/yr. An aerial gamma-ray radiation survey was performed over the 200 West Area in July and August 1988 (Reiman and Dahlstrom 1988). The survey lines were flown with a 122 m (400 ft) spacing at an altitude of 61 m (200 ft). The data were normalized to a height of 1 m (3 ft) above the ground surface. Figure 4-1 presents the gross count data (counts per second) on an isoradiation contour map that covers the entire 200 West Area. In this figure background activity has been subtracted from the data. Background was determined onsite by suppressing specie-specific, naturally occurring activity and confirming with additional background measurements south and east of the Hanford Site.

The entire area has gross gamma counts that are above background. However, several high gamma count anomalies can be identified within the aggregate area. The highest gross count results in the U Plant Aggregate Area were between 70,000 and 220,000 ct/sec measured over the 241-U Tank Farm (site number 3 on Figure 4-1). The second highest results were between 22,000 and 70,000 ct/sec as measured over the active portion of the 216-U-14 Ditch to the south of the 241-U Tank Farm. The only other elevated radiation area in the aggregate area had counts of between 7,000 and 22,000 ct/sec and was centered over the southwest half of the 221-U Building and the 216-U-1 and 216-U-2 Cribs (site number 2 on Figure 4-1). The Z Ditch Complex and 216-U-10 Pond areas had lower counts than surrounding areas.

It is impossible to accurately convert these gross gamma counts to a meaningful exposure rate because of the complex distribution of radionuclides on the site. Many of the spectra do not have readily identifiable photo peaks but rather occur on a smear or continuum. Also, aerial systems integrate radiation levels over an area whose diameter may be ten times the height of the platform above the ground. Because of the large-area integration of the airborne system, localized anomalies will appear to be spread over a larger area with lower activities than actually exist on the ground (Reiman and Dahlstrom 1988). Spectra logs were only generated for two sites within the U Plant Aggregate Area and these had few identifiable photopeaks. A photopeak is a specific energy or wavelength that can be associated with the emissions from a specific radionuclide. Cesium-137 was the only radionuclide that could be identified from spectra information collected over the 241-U Tank Farm during the 1988 survey. Only ^{137}Cs and $^{234\text{m}}\text{Pa}$ were identified in the aggregate area. As such, the aerial radiation survey data should only be used as a qualitative tool for identifying more highly contaminated areas within the survey boundaries. In addition, the gamma counts noted in the survey probably result from both surface and shallow buried radionuclides, and are thus not entirely indicative of surface contamination.

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Elevated radiation zones identified by the aerial survey generally correspond to areas where surface contamination has been noted by surface radiation surveys. Figure 4-2 shows areas of known surface contamination, underground contamination and migration identified from surface surveys (Huckfeldt 1991b). The primary areas of surface contamination noted in the U Plant Aggregate Area include the following:

- The 241-U Tank Farm
- The 207-U Retention Basin
- The active part of the 216-U-14 Ditch
- An area surrounding the 216-U-1 and 216-U-2 Cribs
- The northeast side of the 221-U Building in the vicinity of the railroad spur
- The 216-U-8 and 216-U-12 Cribs.

Most of these areas fall within the anomalously high zones noted in the radiation survey. Areas of active surface contaminant migration include the following:

- The north side of the 241-U Tank Farm in the vicinity of the UPR-200-W-104 unplanned release site
- The north side of the 207-U Retention Basin
- The area surrounding the 216-U-1 and 216-U-2 Cribs
- An area on the northeast side of the 221-U Building in the vicinity of the 241-WR Vault
- An area along the southeast side of the 221-U Building in the vicinity of the 222-U Lab and Office Building and the 224-U Building
- An area immediately north of the 216-U-8 Crib.

Table 4-5 summarizes the radiological survey results for each waste management unit and unplanned release. The areas of surface contamination and contaminant migration will be discussed in more detail in the section dealing with the individual waste management units and unplanned releases (Section 4.1.2). Surface radiological surveys are done quarterly, semiannually, or annually at the waste management units. The surface contamination posting may change often because of resurveying and because of cleanups affected under the Radiation Reduction Program. These surveys yield data on gross contaminant levels (ct/min

and dis/min) which are useful in identifying the presence of contamination at a waste management unit and in making available comparisons between waste management units.

4.1.1.2.2 External Radiation Dose Rate Measurements. Dose rates from penetrating radiation were measured annually at 13 locations within or adjacent to the U Plant Aggregate Area between 1985 and 1989. The sample locations are shown on Plate 3, and the survey results are listed on Table 4-6. The measurements were taken with thermoluminescent dosimeters (TLDs) and are reported in mrem/yr. The TLDs measure dose rates resulting from all types of external radiation sources including cosmic radiation, naturally occurring radioactivity, fallout from nuclear weapons testing and contributions from other Hanford Site activities. Most of the results averaged less than 100 mrem/yr except for the 216-U-10 Pond and the 2W23 locations. The 1985 results from the 216-U-10 Pond were very high (572 mrem/yr), but readings were much lower in subsequent years (Schmidt et al. 1992). This change probably reflects the decommissioning and interim stabilization of the 216-U-10 Pond in 1985. Site 2W23, near the 241-U Tank Farm, had consistently high readings throughout the 5-year period. These results may indicate shine from waste contained within the tanks.

In 1990, new sampling locations were established giving the U Plant Aggregate Area seven dosimeter sites. The new sites were generally located on or near areas of known contamination and the results appear to be slightly elevated over the previous sampling rounds. Measurements were generally a little above 100 mrem/yr. The highest average reading was 135 mrem/yr from site 208, again adjacent to the 241-U Tank Farm. These results are summarized in Table 4-7.

4.1.1.2.3 Surface Soil Sampling. Between 1978 and 1989, surface soil samples were collected annually from a regular rectangular grid that covers the 200 West Area with 35 sampling points. Ten of these sampling sites are located within or adjacent to the U Plant Aggregate Area. The sample points have never been exactly surveyed, but are generally located close to the intersections of Hanford Site coordinate lines at 305 m (1,000 ft) spacings. In addition, between 1985 and 1989, soils have also been sampled along fences enclosing the three tank farms in the 200 West Area. There are three soil samples associated with the 241-U Tank Farm. None of the soil sampling locations were at waste management units or unplanned release sites, so these data cannot be applied directly to any site.

The results of the two soil sampling programs since 1985 are summarized in Tables 4-8 and 4-9. Tables that present all of the data collected since 1985 are contained in Appendix A.2. Counting errors are included with each analytical result and those entries that are greater than the accompanying counting errors are denoted with a plus (+) sign.

The most commonly detected radionuclides were ^{90}Sr , ^{137}Cs , ^{214}Pb , U(total), ^{238}Pu , ^{239}Pu , and ^{152}Eu . However, only ^{137}Cs , ^{90}Sr , and ^{239}Pu were found consistently at concentrations above counting errors (Schmidt et al. 1990).

0
5
0
8
7
1
3
6

The highest radionuclide concentrations were generally noted in the vicinity of the 241-U Tank Farm. The highest concentrations of ^{137}Cs were consistently found at site 2W23 and fence line sample location U-TF-NE. Both locations are adjacent to the 241-U Tank Farm. However, the trend at these locations has been generally downward since 1978 indicating that the elevated ^{137}Cs levels are not because of current operations at the tank farm (Schmidt et al. 1990). The highest ^{90}Sr and ^{239}Pu concentrations in the 200 West Area were also consistently found at site 2W23.

In 1990, new soil sampling locations were established that are located close to areas of known surface contamination. The locations of these new sites are shown on Plate 3. There are 18 new sample locations within or adjacent to the U Plant Aggregate Area. Currently, no analytical data are available for these new sample locations.

4.1.1.3 Surface Water. No natural surface water bodies exist within the U Plant Aggregate Area. However, the man-made 216-U-14 Ditch formerly received a variety of wastes, and surface water and sediment within the remaining open sections of the ditch are suspected to be contaminated. This part of the ditch was, until March 1992, kept filled with water from a nearby fire hydrant in order to reduce the exposure of contaminated sediments at the bottom of the ditch. The 207-U Retention Basin has also received a variety of aqueous wastes; thus, sediments and water within the basins may also be contaminated. No recent data from these two areas are available.

There are data for water quality in the Powerhouse Pond, an excavated portion of the previous 216-U-14 Ditch at the north end of the aggregate area that is used for disposal of wastewater from the 200 West Area Powerplant. The samples are taken weekly, composited, and analyzed monthly for total beta, total alpha, ^{137}Cs , ^{90}Sr , pH, and nitrate, even though the wastewater should be nonradioactive. The results are presented in Table 4-10, in the form of maximum and minimum recorded levels. Judging from the maximum concentrations (as the minimum levels were generally below detection) the radioactivities appear to be trending downward.

4.1.1.4 Biota. Westinghouse Hanford and PNL have conducted various biota sampling activities beginning in 1971 through 1988 inside as well as outside the Hanford Site. No upward trends in radionuclide concentrations were detected for any of the wildlife species examined (Eberhardt et al. 1989). A significant downward trend was exhibited in many analytes, particularly ^{137}Cs .

Three factors are believed to have contributed to the decline in concentration of these radionuclides: the cessation of atmospheric testing, the 1971 shutdown of the last Hanford reactor that discharged once-through cooling water to the river, and the reduction of environmental radionuclide contamination associated with some Hanford facilities and operations.

Biota samples have been collected since 1978 from ten sites within or adjacent to the U Plant Aggregate Area. Vegetation samples were collected from the same locations as the grid soil samples described in Section 4.1.1.2 (Plate 3). Average analytical results from 1985 through 1989 are compiled on Table 4-11. The complete data set from this sampling is presented in Appendix A.2.

Vegetation samples have generally had radionuclide concentrations that are slightly elevated above regional background (Schmidt et al. 1990). The most commonly detected radionuclides include ^{137}Cs , ^{90}Sr , ^{60}Co , ^{238}Pu , and ^{239}Pu . Grid site 2W23, adjacent to the 241-U Tank Farm, has usually had the highest ^{137}Cs concentrations in the area. There have been no statistically significant trends in vegetation radionuclide concentration since 1979 (Schmidt et al. 1990).

4.1.1.5 Vadose Zone. The extent of contamination in the vadose zone has been most extensively studied by geophysical well logging. Geophysical well logging has been conducted in the U Plant Aggregate Area since the late 1950's. Gross gamma-ray logs have been used since that time to evaluate radionuclide migration in the vadose zone beneath selected waste management units. However, very little gross gamma data have been published. Table 4-12 lists all of the logs that were reviewed as part of this study. The log interpretation generally consisted of identifying zones with anomalously high gamma-ray counts that could be indicative of radionuclide contamination. The depths, thicknesses and intensities of these zones were then compared for logs from the same holes. Any significant changes may be indicative of contaminant migration in the vadose zone. Interpretations were complicated by the fact that logging equipment and procedures have evolved over time. Consequently, a standardized, comparative baseline for interpreting gamma log results is not available. Attempts made to normalize data collected at different times met with limited success, and quantitative interpretations were not possible. The log interpretations are discussed in detail in Appendix A.1. The results of the log interpretations are also summarized with the appropriate waste management units in Section 4.1.2.

Waste management units that have received large volumes of liquid are more likely to have caused subsurface contaminant migration. The potential for liquid wastes to have migrated through the vadose zone to the groundwater was estimated by comparing the volume of waste discharged at each waste management unit to the estimated pore volume in the vadose zone soil column below the waste management unit. If the volume of liquid discharged to the ground is larger than the total soil column pore volume, then it is likely that wastewater may have reached the groundwater. These calculations are summarized on Table 4-13. They are based upon several conservative assumptions: (1) the discharged water does not spread out laterally from the point of discharge (i.e., the volume of affected vadose zone is equal to the depth to groundwater times the plan view cross-sectional area of the base of the waste management unit); (2) there is no significant change in liquid volume being introduced to the soil column due to evapotranspiration; and (3) the average porosity of the soil column is between 0.10 and 0.30 (the upper and lower porosity estimates shown on

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Table 4-13). If the amount of waste received was greater than the porosity (0.1) then the waste management unit was considered to have the potential to migrate to the groundwater. According to these calculations, fifteen waste management units have the potential for the migration of liquid discharges to the unconfined aquifer from past operations. This analysis does not take into account long term drainage which may be occurring at all sites which received liquid waste. Information was not available for three of the ditches so their past migration potential is not known.

As was discussed in Section 3.0, perched water zones may form locally under waste management units with large liquid discharges. However, the occurrence of contaminated perched water has only been documented beneath the 216-U-16 Crib (Baker et al. 1988).

4.1.2 Site-Specific Data

This section presents the site-specific data that are available for each waste management unit and unplanned release. The units are discussed in the same groups as were presented in Section 2.0. These groupings are useful because like units tend to have the similar types of available data.

4.1.2.1 Plants, Buildings, and Storage Areas. No site-specific data were compiled for any of the U Plant Aggregate Area plants, buildings, and structures.

4.1.2.2 Tanks and Vaults. The data available for the single-shell waste storage tanks generally include: inventory information, limited waste sampling, surface radiological surveys, vadose zone well geophysics, and internal tank monitoring of chemical and physical parameters. In the past, there has been much less emphasis in characterizing the catch tanks, settling tanks and vaults, and little information is available regarding these units. The following section is subdivided between single-shell tanks and other tanks to reflect this difference.

4.1.2.2.1 Single-Shell Tanks. All of the single-shell tanks in the U Plant Aggregate Area are located within the boundaries of the 241-U Tank Farm. The entire tank farm is characterized as an area of surface contamination and there is an area of active surface contamination migration on the northern end of the tank farm property (Huckfeldt 1991b).

A TLD stationed on the eastern margin of the tank farm averaged 197 mrem/yr between 1985 and 1989 (Table 4-6). A new monitoring location was established on the east side of the tank farm in 1990 and the result for the year was 135 mrem/yr (Table 4-7). These results are higher than any other monitoring location in the U Plant Aggregate Area. The high annual dose rate is probably indicative of a combination of surface contamination in the tank farm area and some emissions from the tanks themselves. The upper surfaces of tanks 241-U-101 through 241-U-112 are all 3 m (9 ft) below grade, and the upper surfaces of

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tanks 241-U-201 through 241-U-204 are 4 m (12 ft) below grade, so the waste contained within the tanks is largely, but not entirely shielded from the ground surface.

Surface radiation dose rate surveys are also performed regularly over the tank farm area. The highest dose rates observed in soils in the last two years have been 13 mrad/h beta and 1 mR/h gamma during a November 1990 survey. These high values were noted over a small patch of soil near the 241-U-106 Tank. The highest dose rates observed on structures in the tank farm were 220 mrad/h beta and 50 mR/h gamma on an observation port for the 241-U-110 Tank. This dose rate was also noted during a November 1990 survey. It is not known if these areas have been decontaminated. During the past two years, contamination has been most commonly noted in the vicinity of the 241-U-101 and 241-U-110 Tanks. These data were compiled directly from the Supplemental Scheduled Radiation Survey Reports kept at the Tank Farm Health Physics Department for the 200 West Area.

Several studies have been conducted in order to estimate the tank contents and the probability of their release to the environment. The primary potential release mechanisms are tank failure and leaking, and the potential buildup and ignition of flammable material in the tanks. Four of the sixteen tanks in the 241-U Tank Farm have failed in the past, so it seems likely that some of the remaining tanks will fail in the future. Tank leaks are identified by monitoring liquid levels in the tanks and by running gamma logs in the monitoring wells surrounding each tank.

Inventory Studies. Chemical inventories for the single-shell tanks have been modeled with the Tracks Radioactive Components (TRAC) computer code developed by Westinghouse Hanford. This program calculated tank inventories for 68 radioactive constituents and 30 chemical constituents. The estimates were based on the historical records of the quantities of material initially placed in the tanks from nuclear fuel production and later modified by tank transfers and radioactive decay. The TRAC inventories, though recognized as having serious limitations, represent the best current information on the contents of the tanks. TRAC predictions for ^{14}C , ^{137}Cs , ^{137}Ba and uranium isotopes show the least agreement with other data sources.

The TRAC inventory data are presented in Table 4-14. These data are for the total tank inventories and do not differentiate between drainable liquid and solids within the tanks. As shown in Table 2-4, some of the unstabilized tanks still contain large volumes of liquid, drainable waste. It is the radionuclides that are partitioned to this liquid phase which are of primary concern should a tank begin to leak. From a comparison of solid and liquid phase data presented in an earlier TRAC report, it appears that ^{241}Am , ^{14}C , ^{135}Cs , ^{137}Cs , ^{93}Nb , ^{99}Tc , ^{79}Se and ^{90}Sr are most strongly partitioned to the liquid phase in the tanks and would be the most likely radionuclides, present at high concentrations, to migrate in the event of a leak (Jungfleisch 1984).

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Tank Waste Sampling. Chemical sampling has been performed on some of the tanks. The usefulness of these samples is very limited because: (1) very few radionuclides or organic chemicals were analyzed; (2) much of the sampling was done in the 1970's and material has been moved into and out of the tanks since that time; and (3) no attempt was made to collect samples that were representative of the tank as a whole. Much of the sampling was done in order to characterize the chemical composition of liquid that was to be sent through an evaporator.

The available chemical data for each tank are summarized in Table 4-15. The information on the table was compiled from analytical data sheets from the MO-037 Library. The table includes any radionuclide data that are available for each sample, as well as pH and total organic carbon (TOC) data. Solutions with low pHs and high TOC (organic solvents) would tend to enhance radionuclide migration through the soil column.

Chemical Explosion Potential. There are three possible mechanisms recognized as having chemical explosion potential for Hanford single-shell tanks. The three are ferrocyanide in excess of 1,000 gram moles, hydrogen gas generation, and TOC greater than 3 wt%. None of the 241-U Tank Farm tanks is suspected of having a ferrocyanide problem, but several have the potential to generate significant quantities of hydrogen gas (Hanlon 1992). A watch list has been generated by the DOE that ranks tanks according to their potential for explosion. The factors in this ranking include: surface level fluctuation, temperature, total curies of waste, organic content, volume of solids, waste type, pressurization, crust formation and past flammable gas detections. Four 241-U tanks are on the hydrogen gas watch list (241-U-103, 241-U-105, 241-U-108 and 241-U-109). There are a total of 23 tanks on this list.

Tanks 241-U-106 and 241-U-107 are on the watch list for tanks containing concentrations of organic salts greater than 3 wt% TOCs. These tanks have organic chemicals which are potentially flammable and mixtures of organic materials mixed with nitrate and nitrate salts can deflagrate. These tanks are two of eight on the TOC watch list.

Vadose Zone Well Geophysical Logging. Most of the single-shell tanks are surrounded by an array of vadose zone wells. Gamma logging is performed on these wells on a regular basis in order to identify new tank leaks and to monitor the migration of existing contaminant releases to the soil. Table 4-16 summarizes the borehole geophysical data available for each tank. Three of the four assumed leaking tanks in the 241-U Tank Farm exhibit elevated gamma radiation levels in their associated monitoring wells.

Single-Shell Tanks Unplanned Releases. There are five unplanned releases associated with the single-shell tanks in the 241-U Tank Farm. Four of these unplanned releases resulted from tank leaks (UPR-200-W-154 through -157) and one release occurred when a waste line ruptured (UPR-200-W-128). Most of the available information on these releases

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is summarized on Table 2-6. Cesium inventory data for each of the four tank leaks are summarized in Table 4-17.

The vertical and lateral distribution of each of the tank leaks can be estimated from the borehole geophysics data (Table 4-16). Unplanned Release UPR-200-W-155 from the 241-U-104 Tank is probably related to the gamma peak noted from 15 to 18 m (52 to 60 ft) in the 60-04-08 Well. Similarly, radionuclides from Unplanned Releases UPR-200-W-156 (241-U-110 Tank) and UPR-200-W-157 (241-U-112 Tank) have probably caused the gamma peaks noted in wells 60-10-07 and 60-12-01 respectively. Unplanned Release UPR-200-W-154 from the 241-U-101 Tank has not caused an elevated gamma count in any of the surrounding wells. These releases do not appear to have migrated laterally very much because so few wells are affected. However, some do appear to have migrated vertically to depths of up to 30 m (100 ft).

4.1.2.2.2 Catch Tanks and Vaults. Very little data are available for the catch tanks and vaults. For most units the total volume of waste is known but there is no chemical or radiological information available.

241-WR Vault. This vault does not contain any waste liquids, but it is reported to contain equipment and structures with an estimated 60 Ci of beta contamination. All access to the vault has been closed, and it has been sealed with plasticized foam. The vault has held nitric acid, tributyl phosphate wastes, uranyl nitrate hexahydrate and thorium at various times. Radon gas may be present in the vault because of residual thorium contamination in the structure.

241-U-301 Catch Tank. This is an active waste management unit. It is currently reported to contain 18,500 L (4,900 gal) of waste.

241-U-302 (241-UX-302A) Catch Tank. This is an active waste management unit. It is currently reported to contain 26,500 L (7,000 gal) of waste.

241-U-361 Settling Tank. This unit has been interim stabilized. It is currently reported to contain 104,000 L (27,500 gal) of sludge with an estimated 2,125 Ci of beta/gamma activity. The tank is within an area of known surface contamination.

244-U Receiver Tank. This is an active waste management unit. Waste volumes are variable depending upon the specific plant operations, but the tank has a maximum capacity of 117,000 L (31,000 gal).

244-UR Vault. This vault may be flooded due to intrusion of water from the ground surface. The structure is estimated to contain approximately 50 Ci of beta activity. Unplanned Release UPR-200-W-24 is related to the vault. Although the contaminated soil was backfilled and stabilized after the unplanned release, the area around the vault is still

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classified as an area of migrating surface contamination. The information available for this site is summarized in Section 2.3.2.5.

4.1.2.3 Cribs and Drains. The types of information available for the cribs, drains, and drain fields include inventory data, radiological survey results, and borehole geophysical data. Soil, vegetation, and air monitoring data are generally unavailable for these sites. Inventory and radiological information have largely been compiled from the WIDS sheets (WHC 1991a) and the HISS database entries.

4.1.2.3.1 216-U-1 and 216-U-2 Cribs. The 216-U-1 and 216-U-2 Cribs are within an area of both underground and surface contamination. The surface contamination is migrating in the vicinity of the cribs. The tops of the wooden crib structures are reported to be 6 m (20 ft) below the ground surface.

There is some collapse potential over this unit, so only the crib perimeters have undergone radiation surveys. During a September 1991 radiological survey, beta contamination of up to 25,000 dis/min was detected near the cribs and in the zone extension. No alpha contamination was detected.

The inventory data for this unit are summarized on Tables 2-2 and 2-3. Approximately 4,000 kg (8,900 lb) of uranium was discharged to the cribs. As detailed in Section 2.3.3.1, this uranium was subsequently flushed through the vadose zone into the groundwater beneath the site (DeFord 1991). About 685 kg (1,510 lb) of uranium were subsequently removed during remedial groundwater treatments. There are still large amounts of uranium dispersed through the vadose zone beneath the unit.

4.1.2.3.2 216-U-3 French Drain. This drain is 3.6 m (12 ft) deep and is posted as containing underground radioactive material. No surface contamination was detected over the french drain during an August 1990 survey. Inventory data for this unit are summarized in Tables 2-2 and 2-3.

No high gamma activity was observed in an adjacent vadose zone well (299-W19-1) during the four times it was gamma logged between 1958 and 1987.

4.1.2.3.3 216-U-4A French Drain. The top of the french drain is buried approximately 1.5 m (5 ft) below grade and the pipe is at least 1.2 m (4 ft) long. No surface contamination was detected during a March 1985 radiology survey. Inventory data for this unit are summarized in Tables 2-2 and 2-3.

4.1.2.3.4 216-U-4B French Drain. This french drain extends 3 m (10 ft) below the surface. During a 1985 radiological survey the highest reading noted near the drain was 3000 ct/min with average values of 600 to 900 ct/min. No alpha radiation was detected. Inventory data for this unit are summarized in Tables 2-2 and 2-3.

4.1.2.3.5 216-U-7 French Drain. This french drain extends 5.2 m (17 ft) below the surface. No surface contamination was detected over the drain during an August 1982 radiological survey. However, the site is within an area with levels between 250 ct/min and 35,000 ct/min as determined during a second quarter, 1991 survey. Inventory data for this unit are summarized in Tables 2-2 and 2-3. An additional 140 kg (300 lb) of uranium may have been discharged to the ground through this drain in an incident covered under Unplanned Release UPR-200-W-138.

4.1.2.3.6 216-U-8 Crib. The 216-U-8 Crib has been posted as an area of surface contamination. The top of the crib is located about 9.4 m (31 ft) below grade. The site was deactivated in 1960 because of ground subsidence, but no settling has been observed over the crib since 1975. Radiological surveys are restricted to the perimeter of the site because of cave-in potential. No surface contamination was detected during the last perimeter survey in August 1990. Inventory data for this site are summarized in Tables 2-2 and 2-3. The 216-U-8 Crib reportedly holds the largest uranium inventory of any crib in the U Plant Aggregate Area.

Gross gamma logs are available from three monitoring wells located near the 216-U-8 Crib. Two wells in the crib showed elevated gamma levels between 9 and 15 m (30 and 48 ft) when they were logged in 1976. The 299-W19-2 Well, located east of the crib, was logged seven times between 1958 and 1976. Moderately sized peaks were observed at depths of 12 to 13 m (39 to 43 ft) and 26 to 31 m (85 to 102 ft) in this well. Since the water table is 68 m (223 ft) below grade at this site, this indicates that although there had been some radionuclide migration in the vadose zone, breakthrough of gamma radionuclides to the underlying groundwater had not occurred. Evaluation of this data is presented in Appendix A.

4.1.2.3.7 216-U-12 Crib. This site was recently downposted to an Underground Radioactive Material Zone. The top of the porous crib fill material is 1.8 m (6 ft) below grade and the feeder pipes are 3 m (10 ft) below grade. No surface contamination was detected over the crib during the August 1990 radiological survey. In 1990, two TLDs were placed on the north and south ends of the crib. The annual exposures noted at these sites were 102 and 106 mrem/yr, respectively (Table 4-7).

Inventory data for this unit are summarized in Tables 2-2 and 2-3. Contamination was detected in logs from two vadose zone wells immediately next to the crib in 1989 (299-W22-73 and W22-75). At these wells elevated gamma levels were observed from depths of 20 to 86 ft beneath the crib, with the most intense zone at 7.6 m (25 ft). A third well (299-W22-73) located just east of the crib had elevated gamma levels from 6 to 16 m (20 to 53 ft) with peaks at 7.6 to 10 m (25 to 33 ft) in 1989. The gamma-ray log profiles in these three wells did not appear to have changed between 1982 and 1989. In the 299-W22-22 Well which is located further away from the crib, a major gamma peak developed just above the groundwater surface between 1965 and 1968. The intensity of this peak diminished

substantially by 1976 and was nearly absent in the 1982 log. All other vadose zone wells associated with the crib have shown only background radiation levels.

4.1.2.3.8 216-U-16 Crib. The 216-U-16 Crib is posted as an area of underground radioactive material. The top of the crib fill gravel is 3 to 3.7 m (10 to 12 ft) below grade and the feeder pipes are 3.7 to 4.3 m (12 to 14 ft) below grade. No surface contamination was detected over the crib during an August 1990 radiological survey.

Inventory data for this crib are summarized in Tables 2-2 and 2-3. Gross gamma logs acquired in 1985 from two wells in the vicinity of the 216-U-16 Crib (W19-13 and W19-14) exhibit minor gamma ray peaks between depths of 7 and 46 m (23 and 150 ft). It is not clear, however, if these peaks result from radionuclide contamination or natural variability in the stratigraphic section.

4.1.2.3.9 216-U-17 Crib. The 216-U-17 Crib is posted as an area of underground radioactive material and is an active waste disposal site. The crib is located 6 m (18 ft) below the surface. No surface contamination was detected over the crib during a September 1990 radiological survey.

Inventory data for this crib are summarized in Tables 2-2 and 2-3. Elevated gamma activity was noted in four vadose zone wells surrounding the crib during a 1987 survey. The survey also showed that gamma emitting radionuclides had recently migrated and that some migration to groundwater had occurred.

According to the *Liquid Effluent Study Final Project Report* (WHC 1990b), key effluent constituents are not expected to reach groundwater during the interim use of this crib. Past sampling of the effluent stream to this crib indicates that tritium, nitrate and uranium commonly have exceeded concentration guidelines. Organic compounds have been detected at very low concentrations in the waste stream. However, subsequent process changes may have significantly reduced these contaminants in the waste stream. It is estimated that with continued operation, nitrate, tritium, fluoride and chromium would eventually reach groundwater.

4.1.2.3.10 216-Z-20 Crib. The 216-Z-20 Crib is posted as an area of underground radioactive material and is an active waste disposal site. The structure varies from 4 to 5 m (12 to 15 ft) in depth. No surface contamination was detected over the crib during a December 1990 radiological survey. In 1990, a TLD was set up over the 216-Z-20 Crib. The measured total dose rate at this location was 102 mrem/yr (Table 4-7).

Inventory data for this crib are summarized in Tables 2-2 and 2-3. In addition to the inventory, the site is known to have received about 3,400 kg (7,500 lb) of nitric acid and discharge that averaged 1.07 $\mu\text{Ci/L}$ of ^{239}Pu over an 8-hour period in 1984.

According to the *Liquid Effluent Study Final Project Report* (WHC 1990b), no significant additional impacts to soil and groundwater are likely due to interim use of this crib. Past effluent sampling data indicates that acetone, aluminum, and several radionuclides commonly have exceeded concentrations guidelines. However, new sampling of current process effluents show only traces of acetone and radionuclides, all below concentration guidelines.

4.1.2.3.11 216-S-4 French Drain. The 216-S-4 French Drain is posted as an area of surface contamination. The site is made up of two 6 m (20 ft) deep drains. No surface contamination was noted during an August 1990 radiological survey. Inventory data for the 216-S-4 French Drain are summarized in Tables 2-2 and 2-3.

4.1.2.3.12 216-S-21 Crib. The 216-S-21 Crib is posted as an area of surface contamination. It is a wood structure located 2.5 m (8.3 ft) below grade. Only the perimeters of the crib are surveyed because of collapse potential. No surface contamination was detected during the August 1990 radiological survey.

Inventory data for the crib are summarized in Tables 2-2 and 2-3. Monitoring Well 299-W23-4, adjacent to the 216-S-21 Crib, was gamma logged six times between 1958 and 1976. Radioactive contamination was detected from 9.8 to 48.8 m (32 to 160 ft) below the ground surface. The maximum radiation intensity was located 5.5 m (18 ft) below the crib (11.6 m [38 ft] below ground surface). As of 1976, the maximum radiation intensity beneath the crib had been increasing since the crib's closure in 1969. This may have been due to an influx of water from the nearby 216-U-10 Pond which remobilized some radionuclides.

4.1.2.4 Reverse Wells. The 216-U-4 Reverse Well is the only reverse well in the U Plant Aggregate Area. This reverse well is 23 m (75 ft) deep and the lower 7.6 m (25 ft) of the well are perforated. The well is identified with an underground radioactive material sign. No surface contamination was detected during a March 1985 radiological survey. The site contains less than 1 Ci of beta activity. Additional inventory data are summarized in Tables 2-2 and 2-3.

4.1.2.5 Ponds, Ditches, and Trenches. The 216-U-10 Pond System and its associated trenches were the subject of several field studies when they were active waste disposal units. In 1974, Emery et al. published data on plutonium and americium concentrations in sediments underlying the 216-U-10 Pond. A series of sediment and vegetation samples have been analyzed from the 216-Z-19 Ditch for ^{241}Am , ^{239}Pu , $^{89,90}\text{Sr}$, ^{137}Cs , ^{226}Ra , ^{40}K , ^{139}Ce and ^{154}Eu . Maxfield (1979) documented analytical results for soil samples collected from the leach trenches and the flood plain south of the U Pond.

In 1980, a comprehensive study was conducted on the U Pond and its associated trenches in preparation for their eventual closure (Last and Duncan 1980). Pre-existing data were incorporated into the 1980 study and new samples were collected to fill in any data

gaps that were identified. Soil samples were analyzed for ^{241}Am , ^{137}Cs , $^{239,240}\text{Pu}$, ^{90}Sr , and U. Several additional trenches and ditches that are unrelated to the 216-U-10 Pond System are also discussed in the latter part of this section.

4.1.2.5.1 216-U-10 Pond. The decommissioned and interim stabilized 216-U-10 Pond is currently classified as an area of underground contamination. When the 216-U-10 Pond was closed in 1985, the contaminated sediments of the pond were buried under a minimum of 1.2 m (4 ft) of clean fill. Some contaminated soil from areas adjacent to the pond was also moved into the central pond area before the burial began. These areas include the leach trenches (UPR-200-W-104, UPR-200-W-105, UPR-200-W-106) and the flood plain to the south of the main pond (UPR-200-W-107). Wastewater from the U Pond overflowed into these adjacent areas and they were closed as part of the U Pond, so they are included in the following discussions. Another surface contamination zone was noted on the southeast margin of the U Pond in 1990. This area was covered with 0.6 m (2 ft) of clean fill in 1991 (Schmidt et al. 1992). Several types of contaminant-specific and noncontaminant-specific measurements have been made in and around the 216-U-10 Pond. These have included total penetrating radiation dose rates from all sources (mrem/yr), gross nonradionuclide-specific contamination levels (ct/min), radionuclide-specific activity concentrations in soil (pCi/g), and, in the case of uranium, its mass concentration in soil (ppm [mg/kg]).

Radiation dose rates from penetrating radiation have been measured from one TLD location on the U Pond (see Section 4.1.1.2). In 1985, the annual dose rate was measured at 572 mrem/yr. Since 1985 the rate has never exceeded 112 mrem/yr and has averaged 94 mrem/yr. During a December 1990 semiannual surface radiological survey, surface contamination of up to 500 ct/min was noted. This is an increase from the previous survey.

Inventory data for the 216-U-10 Pond System are summarized in Tables 2-2 and 2-3. It should be noted that these numbers are for the total discharge to the pond and all of its associated trenches. The actual radionuclide content within the U Pond area itself is probably much less. The following radionuclides were detected in the U Pond sediment samples before the pond was closed and covered:

^{125}Sb	^{144}Ce	$^{134,137}\text{Cs}$
^{60}Co	$^{154,155}\text{Eu}$	^{106}Ru
^{22}Na	$^{85,90}\text{Sr}$	$^{238,239,240}\text{Pu}$
^{241}Am	$^{234,235,238}\text{U}$	^{226}Ra
^{139}Ce	^{40}K	

Of these radionuclides, only Cs, Sr, Am, Pu, and U exceeded releasable concentrations as of 1983. Contamination was localized in the upper 10 cm (4 in.) of the sediments and dropped off rapidly with depth. Radionuclides in the pond sediments were concentrated in the low points at the center of the pond and in the delta area on the northeast side of the old pond. The delta is where the 216-U-14 and 216-Z-1D, 216-Z-11 and 216-Z-19 Ditches

emptied into the pond. The contaminant distributions are illustrated in a series of contour maps that accompany the 1980 report by Last and Duncan. These data are confirmed by an aerial gamma survey that indicated that the delta area was the most contaminated part of the U Pond (Bruns 1974).

Table 4-18 summarizes the U Pond soil sampling data for the five most significant radionuclide contaminants. Section 4.1.2.5.6 discusses some additional data about radionuclides that were detected in samples from the lower end of the 216-Z-19 Ditch. The lower part of this ditch was low enough to receive floodwaters from the pond during periods of high water.

High plutonium values were localized in the delta region of the pond and in the lowermost reaches of the 216-Z-19 Ditch. The maximum $^{239,240}\text{Pu}$ concentration observed in U Pond sediments was 12,500,000 pCi/g in a sample from this area (Last and Duncan 1980). The total Pu concentration may have been higher because ^{238}Pu is not included with this value. The highest ^{238}Pu concentration noted in sediment samples from an earlier study was 1144 pCi/g (Emery et al. 1974). Most of the high concentrations in the delta area were associated with a thin (2.5 cm, 1 in.) organic rich layer below which the activity decreased rapidly. The average $^{238,239,240}\text{Pu}$ concentration for 60 soil samples collected in the basin by Emery et al. (1974) was 390 pCi/g. According to isoconcentration contours drawn by Last and Duncan (1980), the majority of the U Pond area is underlain by sediments containing between 100 and 1,000 pCi/g, and less than 10% of the basin was underlain by sediments containing above 1,000 pCi/g. According to estimates derived from the sediment samples, the first 10 cm (4 in.) of pond sediments are estimated to contain a total of 0.022 kg (0.05 lb) of plutonium.

The distribution of ^{241}Am in the U Pond sediments tends to mimic the plutonium distribution, but americium concentrations are generally an order of magnitude lower. The highest ^{241}Am concentration was 28,000 pCi/g, noted in a samples from the delta region. The majority of the basin appears to be underlain by sediments with less than 100 pCi/g of ^{241}Am and less than 5% of the basin is underlain by sediments containing more than 1,000 pCi/g (Last and Duncan 1980). The average concentration of americium for 32 samples collected by Emery et al. (1974) was 53.9 pCi/g.

The highest concentration of total uranium observed in the pond sediments was 1,238 ppm. However, according to isoconcentration contours drawn by Last and Duncan (1980), most of the pond area is underlain by sediments containing between 100 and 1,000 ppm uranium. Elevated uranium concentrations have been noted in groundwater monitoring wells beneath the U Pond for several years (Schmidt et al. 1990). It seems probable that this uranium originated from the U Pond area because there are no known upgradient uranium sources. This indicates that some uranium has migrated to groundwater below the U Pond and that much of the vadose zone beneath the pond is potentially uranium contaminated.

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The highest ^{90}Sr concentration noted in the pond sediments was 724 pCi/g, but the majority of the basin is underlain by sediments with less than 200 pCi/g of ^{90}Sr (Last and Duncan 1980).

The highest concentration of ^{137}Cs noted in any of the soil samples from the pond was 19,600 pCi/g and the majority of the basin is underlain by sediments between 1,000 and 10,000 pCi/g (Last and Duncan 1980).

A gross gamma log was run on Well 299-W18-15, located on the northeast side of the U Pond, in 1986. High gamma levels were noted at the surface and at depths of between 5.8 and 7.9 m (19 and 26 ft) in this log.

4.1.2.5.1.1 UPR-200-W-104, UPR-200-W-105 and UPR-200-W-106 Leach Trenches. The three leach trenches that correspond to unplanned releases UPR-200-W-104, UPR-200-W-105 and UPR-200-W-106 were closed along with the U Pond. Some contaminated material was removed from the trenches at the time of closure and moved to the center of the pond, but it is not known how much material was left in place. The trenches were then filled and covered with a minimum of 0.6 m (2 ft) of clean soil. The original depths of the three trenches were 3, 4.6, and 2.4 m (10, 15, and 8 ft) respectively.

The leach trenches received overflow wastewater from the 216-U-10 Pond and so would be expected to contain the same mix of radionuclides. However, as Table 4-19 shows, samples from the leach trenches typically have much lower radionuclide concentrations than those observed in U Pond sediments.

4.1.2.5.1.2 UPR-200-W-107 Flood Plain Area. The flood plain area on the south side of the main U Pond Basin was intermittently flooded during times of high water in the pond. When the pond was closed, some contaminated soil was removed from this area and placed in the center of the basin, but it is not known how much contaminated material was left in place. The outer margins of the U Pond were covered with a minimum of 0.6 m (2 ft) of clean soil during the closure.

A survey in January 1978 found beta/gamma activity on the surface of the ground to a maximum of 8,000 ct/min. According to isoconcentration contour maps by Last and Duncan (1980), this area was less contaminated than the main part of the U Pond. Surface sediment concentrations in this area varied as follows:

$^{238,239}\text{Pu}$	below 100 pCi/g
^{241}Am	no detections
Total U	no detections
^{90}Sr	below 100 pCi/g
^{137}Cs	10 to 2,600 pCi/g

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4.1.2.5.2 216-U-11 Trench. The 216-U-11 Trench also received overflow wastewater from the 216-U-10 Pond and so the pond inventory should also be applicable to the trench (Tables 2-2 and 2-3). When the facility was retired, the original 1.5 m (5 ft) deep trench was filled to grade. An additional 0.6 m (2 ft) of clean soil was added over the filled trench and the contaminated overflow areas.

The covered area undergoes a semiannual surface radiological survey. No radiation was detected during the survey performed in August 1990. This is a decrease from the August 1989 survey results.

The following radionuclides were detected in sediment samples collected from the U Pond and the 216-U-11 Trench before they were closed:

¹²⁵ Sb	¹⁴⁴ Ce	^{134,137} Cs
⁶⁰ Co	^{154,155} Eu	¹⁰⁶ Ru
²² Na	^{85,90} Sr	^{238,239,240} Pu
²⁴¹ Am	^{234,235,238} U	

Of these radionuclides, only Co, Am, Cs, Sr, U, and Pu exceeded releasable concentrations as of 1983. Table 4-20 summarizes the available data for most of these radionuclides. Maximum observed concentrations in the 216-U-11 Trench area are generally one to two orders of magnitude less than in the U Pond area. Concentrations tend to be higher in the trench than in the surrounding overflow areas.

4.1.2.5.3 216-U-14 Ditch. Approximately 75% of the 216-U-14 Ditch has been backfilled and is classified as an area of subsurface contamination. The remaining quarter of the ditch is still open and is classified as an area of surface contamination. The depth of burial of the inactive segments of the ditch is not known. The active part of the ditch varies between 1.5 and 3 m (5 and 10 ft) in depth. If the inactive portion of the ditch was also this deep, and was filled with clean soil to grade, then a conservative estimate of the depth to contamination would be 1.5 m (5 ft). In March 1992, a 230 m (750 ft) segment of the ditch was stabilized by burying contaminated vegetation and soil under coarse river gravel (see Section 2.3.5.1.2).

Radiation dose rates have been monitored from two TLD locations over the 216-U-14 Ditch (Section 4.1.1.2.2). Exposure rates at the site located on the northern end of the buried ditch have averaged 80 mrem/yr. The location of the second site on the ditch is unknown, but it averages approximately 79 mrem/yr. The highest yearly value measured at either site was 117 mrem/yr measured in 1990. Overall, the values have shown a gradual increase since 1985. No contamination has been detected over the backfilled portion of the ditch since the September 1988 surface radiological survey. The open part of the ditch was last surveyed in June 1990 and had readings from 2,000 dis/min to 13 mrem/h. This was an increase from the previous survey.

There are no separate radionuclide inventory data available for the 216-U-14 Ditch because it is grouped with the 216-U-10 Pond. Maxfield (1979) estimated the total beta content of the ditch to be less than 1 Ci. The most significant single contaminant release to the ditch occurred in 1986 when approximately 101,250 kg (225,000 lb) of corrosive solution (pH less than 2) and 45 kg (100 lb) of uranium flowed into the trench. Uranium concentrations in the groundwater below the ditch were slightly elevated in 1986 and 1987 indicating that some uranium had migrated through the vadose zone.

The following radionuclides have been detected in 216-U-14 Ditch soil samples:

^{141,144} Ce	¹³⁷ Cs	^{57,60} Co
^{152,154,155} Eu	⁵⁹ Fe	⁵⁴ Mn
⁹⁵ Nb	¹⁰⁶ Ru	²² Na
⁹⁰ Sr	⁶⁵ Zn	⁹⁵ Zr
^{234,235,238} U	^{239,240} Pu	

Last and Duncan, 1980, report that the only radionuclides that exceeded releasable concentrations as of 1983 from this list are: ¹³⁷Cs, ^{57,60}Co, ⁹⁰Sr and ^{239,240}Pu. However, analytical data are only provided in Last and Duncan, 1980, for ¹³⁷Cs, ⁶⁰Co, ⁵⁴Mn, and ^{154,155}Eu. Concentrations were highest in the bottom of the ditch and in the dredge spoils piles located to the west of the ditch. It is assumed that the spoils pile material was added to the bottom of the trench when it was decommissioned. The spoils piles are still in existence adjacent to the active part of the ditch.

Cesium concentrations north of 16th Street and upgradient from the 207-U Retention Basin outfall are much lower than concentrations south of 16th Street and downgradient of the outfall (Last and Duncan 1980). The highest concentrations were from ditch soil samples collected just upstream from the 216-U-10 Pond. The highest cesium concentration in the northerly, now buried, part of the ditch was 81.8 pCi/g and most values were between 10 and 50 pCi/g. The samples collected from the southerly, open, part of the ditch averaged 240 pCi/g ¹³⁷Cs and had a maximum value of 1,522 pCi/g. The backfilled part of the ditch adjacent to the U Pond had a high value of 5,430 pCi/g ¹³⁷Cs (Last and Duncan 1980).

Unlike cesium, the concentrations of manganese and europium are highest at the northern head of the 216-U-14 Ditch and decrease systematically to the south. Table 4-21 summarizes the available data for these radionuclides.

Gross gamma logs were acquired in 1986 and 1987 from six wells in the 216-U-14 Ditch area. Radionuclide contamination may be present in the upper 12 m (40 ft) of these wells. The log from Well W19-93 has an especially distinct series of peaks between depths of 4.3 and 11.9 m (14 and 39 ft).

According to the *Liquid Effluent Study Final Project Report* (WHC 1990b) no significant additional impact on soil and groundwater quality should occur due to routine, interim operation of this disposal facility.

4.1.2.5.4 216-Z-1D Ditch. This site is classified as an area of subsurface contamination. When the 216-Z-1D Ditch was closed, it was backfilled with 0.6 m (2 ft) of clean fill to grade. An additional 0.3 m (1 ft) of clean fill was added during the closure of the 216-Z-19 Ditch.

This site is surveyed annually along with the 216-Z-19 and 216-Z-20 Ditches. No surface contamination was noted in the December 1990 survey.

Sampling data indicate that plutonium and americium are the dominant radionuclides in the 216-Z-1D Ditch. However, very little inventory data are available from the WIDS sheets (WHC 1991a) or the HISS database, and the plutonium inventories listed in these sources appeared to be shared between the 216-Z-11 and 216-Z-1D Ditches (Tables 2-2 and 2-3). An estimate of the total plutonium discharged to the 216-Z-1D Ditch was 0.14 kg (0.31 lb). The majority of plutonium discharged to the ditch was retained by ditch sediments and did not reach the U Pond.

Plutonium-239,240 concentrations of up to 100,000 pCi/g were detected in core soil samples collected in 1980 from the buried 216-Z-1D Ditch. Plutonium was concentrated in the first 50 cm (20 in.) of soil below the old ditch bottom. No detectable plutonium was found at depths greater than 14 m (46 ft) below the old ditch (Last 1983).

4.1.2.5.5 216-Z-11 Ditch. The 216-Z-11 Ditch is classified as an area of subsurface contamination. It was backfilled to grade with 0.6 m (2 ft) of clean soil when it was closed. An additional 0.3 m (1 ft) of clean fill was added later when the 216-Z-19 Ditch was closed.

Sampling data indicate that plutonium and americium are the dominant radionuclides in the ditch. Inventory data from the WIDS sheets (WHC 1991a) and the HISS database appear to be shared between the 216-Z-11 and 216-Z-1D Ditches. It is estimated that the 216-Z-11 Ditch received 8.07 kg (17.8 lb) of total plutonium during its operational history and that the majority of the plutonium discharged to the ditch was retained by its sediments and did not reach the U Pond.

Plutonium-239,240 concentrations of up to 10,000 pCi/g were detected in soil samples from the ditch. Plutonium was concentrated in the first 50 cm (20 in.) of soil below the ditch bottom. No detectable plutonium was found more than 14 m (46 ft) below the old ditch.

4.1.2.5.6 216-Z-19 Ditch. The 216-Z-19 Ditch is classified as an area of subsurface contamination. It was backfilled to grade with 1.2 m (4 ft) of clean soil and then covered

with an additional 0.6 to 0.9 m (2 to 3 ft) of fill when closed. There is some cave-in potential at the north end of the ditch.

No surface contamination was detected during the December 1990 radiological survey. Between 1985 and 1989, the annual dose rate measured by a TLD at this site averaged 85 mrem/yr. The rate rose consistently since 1985 and the highest measurement was 118 mrem/yr in 1989.

No inventory data are available for the 216-Z-19 Ditch from either WIDS or the HISS database. A total of 0.14 kg (0.31 lb) of plutonium was discharged to the ditch. Last (1983) also states that the majority of plutonium discharged to the ditch was retained by its sediments and did not reach the U Pond.

The following radionuclides were detected in soil and vegetation samples collected from the 216-Z-19 Ditch in 1976:

^{241}Am
 ^{137}Cs
 ^{139}Ce

^{239}Pu
 ^{226}Ra
 ^{154}Eu

$^{89,90}\text{Sr}$
 ^{40}K

However, during a 1980 survey of the ditch, only cesium, americium, and plutonium were detected (Last and Duncan 1980). High plutonium and americium values were found over the entire length of the ditch. The other radionuclides were concentrated at the ditch entrance to the 216-U-10 Pond. These radionuclides were probably deposited by flood waters from the pond which filled the lower part of the 216-Z-19 Ditch occasionally.

Table 4-22 summarizes the analytical results for each of the detected radionuclides. Where available, data from the later survey by Last and Duncan were incorporated into the table. The following sections discuss contaminant distributions in the upper part of the ditch which extends north of 16th Street. The lowermost reaches of the ditch are discussed in conjunction with the 216-U-10 Pond.

Plutonium concentrations average approximately 8,850 pCi/g in samples from the upstream part of the ditch. The highest $^{239,240}\text{Pu}$ value in any of these samples was 97,800 pCi/g. Plutonium concentrations drop off rapidly with depth. Samples collected in the upper 30 cm (12 in.) of soil beneath the ditch bottom contained average plutonium concentrations of 17,650 pCi/g. Samples collected between 40 and 100 cm (16 and 39 in.) below the ditch bottom averaged only 57 pCi/g. No detectable plutonium was noted at depths greater than 14 m (46 ft) below the old ditch bottom.

Americium concentrations averaged approximately 770 pCi/g in samples from the upper part of the ditch. The highest concentration noted in any sample was 6,550 pCi/g. Americium concentrations drop off rapidly with depth. Samples collected in the upper 30 cm

(12 in.) of soil beneath the ditch floor averaged 1,529 pCi/g. Samples collected between 40 and 100 cm (16 and 39 in.) below the ditch bottom averaged only 11 pCi/g. No plutonium was detected in samples more than 14 m (46 ft) below the old ditch bottom. The other radionuclides listed in Table 4-22 were detected at very low concentrations in the upper part of the 216-Z-19 Ditch.

4.1.2.5.6.1 UPR-200-W-110. This unplanned release is a trench that contains soil mistakenly excavated from the 216-Z-1D Ditch. The abandoned ditch was accidentally reexcavated during the construction of the 216-Z-19 Ditch. Two meters (7 ft) of contaminated soil were placed in the bottom of the UPR-200-W-110 Trench and covered with 2.4 m (8 ft) of clean fill.

No inventory data are available for this unplanned release, but the most important contaminants are thought to be plutonium and americium. If concentrations of plutonium are comparable to those noted in the 216-Z-1D Ditch, then concentrations of up to 100,000 pCi/g may be buried in this trench. Before it was covered, readings of up to 100,000 dis/min were noted in the bottom of the trench.

4.1.2.5.7 216-U-13 Trench. Both of the 8 m (25 ft) deep trenches were backfilled to grade when this facility was closed. Contaminated soil from the bottom of each trench was removed and buried in the 200 West Burial Ground before the backfilling began. Inventory data for this waste management unit are listed in Tables 2-2 and 2-3.

A surface radiation survey conducted in 1981 over the backfilled trenches showed that all of the surface was uncontaminated except for two small spots. The area is no longer classified as a radiation zone.

4.1.2.5.8 216-U-5 and 216-U-6 Trenches. Both of these trenches were backfilled to grade with 3 m (10 ft) of clean soil immediately after receiving the waste. Each trench is reported to have received 360 kg (800 lb) of unirradiated uranium (WHC 1991a). Another reference states that 3,628 kg (8,000 lb) of uranium were disposed of in each trench (Baldrige 1959). Inventory data for other radionuclides are listed on Tables 2-2 and 2-3. No surface contamination was detected over the trenches during the annual radiological survey in 1990.

4.1.2.5.9 216-U-15 Trench. The 4.6 m (15 ft) deep trench was backfilled to grade immediately after receiving the waste. The waste consisted of approximately 26,495 L (7,000 gal) of interface crud, activated charcoal, and diatomaceous earth, containing about 1 Ci of fission products. No surface contamination was detected in an area over the filled trench during an August 1981 radiological survey. Inventory data are included on Tables 2-2 and 2-3. No other data are available for this site. Unplanned Release UN-200-W-125 also describes the 216-U-15 Trench.

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4.1.2.6 Septic Tanks and Associated Drain Fields. None of the septic tanks and associated drain fields are thought to have received any hazardous waste so there is no significant sampling information available.

4.1.2.6.1 2607-W-5 Septic Tank and Drain Field. This unit reportedly receives approximately 12,100 L (3,200 gal) of sanitary wastewater and sewage per day. It is not thought to have received any hazardous waste but no chemical or radiological data are available. However, the drain field is located directly over an area of high groundwater contamination (refer to 200 West Groundwater AAMSR). Groundwater contamination is a result of uranium disposed of in nearby 216-U-1 and 216-U-2 Cribs (Section 4.1.2.3.1). Artificial recharge in the area of the cribs, with the exception of 2607-W-5 Drain Field, has ceased yet contamination of the groundwater appears to continue. One possible explanation is that the liquid discharge to the drain field may be flushing contamination from the vadose zone into the groundwater. The maximum total isotopic uranium concentration in the groundwater is 3,425 pCi/L, well above the uranium groundwater limits (4% of the DCG) of 24 pCi/L.

4.1.2.6.2 2607-W-7 Septic Tank and Drain Field. This unit receives approximately 1,000 L (264 gal) of sanitary wastewater and sewage per day. It is not thought to have received any hazardous waste but no chemical or radiological data are available.

4.1.2.6.3 2607-W-9 Septic Tank and Drain Field. This unit receives approximately 1,000 L (264 gal) of sanitary waste and sewage per day. It is not thought to have received any hazardous waste but no chemical or radiological data are available.

4.1.2.6.4 2607-WUT Septic Tank and Drain Field. This unit receives approximately 1,020 L (270 gal) of sanitary waste and sewage per day. It is not thought to have received any hazardous waste but no chemical or radiological data are available.

4.1.2.7 Transfer Facilities, Diversion Boxes, and Pipelines. No chemical or radiological data are available for any of the diversion boxes in the U Plant Aggregate Area. Some of the process sewer lines are thought to have leaked, particularly the line to the 216-U-12 Crib. However, no inventory or sampling data are available to estimate the magnitude of these leaks.

4.1.2.8 Basins. The 207-U Retention Basin is the only basin in the U Plant Aggregate Area. Most of the data available for the basin and its associated unplanned releases are summarized from the WIDS sheets (WHC 1991a). The retention basin is posted as an area of surface contamination. Several contaminated areas, with counts of up to 70,000 dis/min were identified during the July 1990 surface radiological survey of the site. Similar conditions were reported on the previous survey.

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No inventory data are available for this unit. In the past it has generally received only low-level waste such as steam condensate and cooling water. In 1986 the unit is known to have received approximately 3,0000 L (800 gal) of nitric acid and 45 kg (100 lb) of uranium.

Two samples were collected from an area adjacent to the 207-U Retention Basin in 1991 (Schmidt et al. 1992). The sample results are summarized in Table 4-23. Uranium was the most significant contaminant in both of the samples.

In the 1960's, sludge was scraped from the bottom of the basin and placed in two trenches immediately to the north and south of the site. These disposal trenches have been designated UPR-200-W-111 and UPR-200-W-112 and will be considered in conjunction with the retention basin.

4.1.2.8.1 UN-200-W-111 Unplanned Release. Approximately 21 m³ (27 yd³) of sludge from the southern half of the 207-U Retention Basin was placed into a trench and covered with 1.2 m (4 ft) of clean fill. This area is currently designated as an area of surface contamination. Areas of contamination of up to 2 mR/h were noted in the vicinity of UPR-200-W-111 during the September 1989 radiological survey. Similar conditions were reported during the previous survey.

4.1.2.8.2 UN-200-W-112 Unplanned Release. Approximately 21 m³ (27 yd³) of sludge from the northern half of the 207-U Retention Basin was placed into a trench and covered with 1.2 m (4 ft) of clean fill. This area is currently designated as an area of surface contamination, but no contamination has been detected during the September 1988 and 1989 radiological surveys.

4.1.2.9 Burial Sites. There are two solid waste burial sites in the U Plant Aggregate Area. The Construction Surface Laydown Area is not thought to contain any hazardous waste and no chemical or radiological data are available for it. The Burial Ground/Burning Pit received radionuclide contaminated coveralls and soil. These materials were probably removed to another dump site, and no chemical or radiological data are available for the site.

4.1.2.10 Unplanned Releases. There is very little chemical or radiological data available for any of the other unplanned releases. Any information which was found is summarized in Table 2-5.

4.2 POTENTIAL IMPACTS TO HUMAN HEALTH AND THE ENVIRONMENT

This preliminary assessment is intended to provide a qualitative evaluation of potential human health and environmental hazards associated with the known and suspected contaminants at the U Plant Aggregate Area. The assessment includes a discussion of release mechanisms, potential transport pathways, develops a conceptual model of human and

environmental exposure based on these pathways, and presents the physical, radiological, and toxicological characteristics of the known or suspected contaminants.

In developing the conceptual model, potential exposures to groundwater have not been addressed in detail. Since migration to groundwater is the primary route for potential future exposures to many of the chemicals disposed of at the site, this pathway (i.e., travel time, receptors) will be addressed in the 200 West Groundwater AAMS.

It is important to note that these evaluations do not attempt to quantify potential human health or environmental risks associated with exposure to U Plant Aggregate Area waste management unit contaminants. Such risk assessments cannot be performed until additional waste unit characterization data are acquired. Risk assessment activities will be performed in accordance with the *Hanford Site Baseline Risk Assessment Methodology* document (DOE/RL 1992b) being prepared in response to the Tri-Party Agreement M-29 milestone. This methodology incorporates the requirements established in the *Risk Assessment Guidance for Superfund* (EPA 1989a) and the *EPA Region 10 Supplemental Risk Assessment Guidance for Superfund* (EPA 1991a).

The ability of this qualitative assessment to address potential environmental and ecological risks is severely constrained by the relative lack of data regarding potentially exposed biotic populations and exposure pathways. As discussed in Section 3.6, past studies of biota have been mostly conducted on a site-wide basis and do not provide useful data to evaluate the potential impacts of the U Plant Aggregate Area. The extent of U Plant Aggregate Area biota sampling has been limited to vegetation sampling (Section 4.1.1.4). The role of biota in transporting contaminants through the environment is discussed in the sections that follow, and biota are included as receptors in the conceptual model. However, the assessment of potential ecological risks associated with biota exposure to U Plant Aggregate Area contaminants is currently constrained by the lack of data. This data gap is addressed in Section 5.0, and is discussed further in Section 8.2.3.

4.2.1. Release Mechanisms

The U Plant Aggregate Area waste management units can be divided into two general categories based on the nature of the waste release: (1) units where waste was discharged directly to the environment; and (2) units where waste was disposed of inside a containment structure and bypassed an engineered barrier to reach the environment.

In the first group are those waste management units where release of wastes to the soil column was an integral part of the waste disposal strategy. Included in this group are tile fields, septic system drain fields, ditches, french drains, seepage basins, cribs without liners, reverse wells, and some disposal trenches. Also in this group are unplanned releases that involved waste material released to the soil. For this group of waste management units, if

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discharges to the unit contained contaminants of concern, it can be assumed that soils underlying the waste management unit are contaminated. The first task in developing a conceptual model for these units is to determine whether contaminants of concern are retained in soil near the waste management unit, or are likely to migrate to the underlying aquifer and then to receptor points such as drinking water wells or surface water bodies. Factors affecting migration of chemicals away from the point of release will be discussed in the following section.

In the second group are waste management units that were intended to act as a barrier to environmental releases. Included in this group are burial grounds containing drums or other containers, cribs with membrane liners, vaults, tanks, waste transfer facilities, and unplanned releases that occurred within containment structures. Waste management units that received only dry waste could also be included in this category, since the potential for wastes to migrate to soils outside of the unit is low due to the negligible natural recharge rate in the 200 Areas at the Hanford Site. For these waste management units, the first consideration to be addressed in developing a conceptual model is the integrity of the containment structure.

The ability of this report to evaluate the efficacy of engineered barriers is limited by the lack of vadose zone soil sampling data and air sampling data for many waste management units. Available sampling information for the waste management units and unplanned releases has been summarized in Section 4.1. The data indicate that membrane liner systems used in waste management units with significant liquid inputs (e.g., 216-Z-20 Crib) were ineffective in preventing releases to the subsurface.

The efficacy and integrity of concrete liners (207-U Retention Basin) and concrete and steel tanks (vaults) have not been determined. For those units that received only dry wastes, such as gloves, pumps, contaminated dirt, and process equipment, the potential for release is expected to be low. However, small amounts of liquid wastes (tritium, lab wastes) are known to have been disposed of in these waste management units, and early disposal records (prior to about 1968) are incomplete. Thus, releases from these structures to the surrounding soil are possible.

In addition to evaluating releases to the subsurface, the conceptual model must address the potential for releases to air and, for radionuclides, the potential for direct irradiation. All units have some type of barrier to releases to the surface; however, barriers can fail over time or may not be designed to prevent migration by certain transport pathways (e.g., volatilization).

Some of the cribs in the U Plant Aggregate Area have experienced cave-ins in recent years due to decomposition of the wooden framework. Such collapse can lead to high levels of direct radiation at the surface and the potential for spread of contaminated materials by wind erosion. Westinghouse Hanford has an ongoing program (RARA Program) to detect

and remediate cave-ins by covering the cribs with additional soil, and any exposures from these incidents are generally short-term.

4.2.2 Transport Pathways

Transport pathways expected within the U Plant Aggregate Area are summarized in this section, including:

- Drainage and leaching from soil to groundwater
- Volatilization from wastes, surface water, and shallow soils
- Wind erosion of contaminated surface soils
- Deposition of fugitive dust on soils, plants, and surface water
- Uptake from soils and surface water by vegetation
- Uptake by animals via direct contact with soils or surface water or ingestion of soils, surface water, vegetation, and other animals
- Direct radiation.

In addition, transport within the saturated zone and subsequent release to groundwater wells or to off-site surface water (i.e., the Columbia River) is of potential concern, but will not be addressed in this document, since this topic will be the focus of the 200 West Groundwater AAMS.

Following transport, exposure may occur through the following pathways:

- Inhalation of volatilized contaminants or suspended particulates
- Ingestion of contaminants in soils, vegetation, or animals
- Direct dermal contact with contaminants in soils
- Direct exposure to radiation.

4.2.2.1 Transport from Soils to Groundwater. Soil is the initial receiving medium for waste discharges in the U Plant Aggregate Area, whether the release is directly to soil or through failure of a containment system. Several factors determine whether chemicals that are introduced into the vadose zone will reach the unconfined aquifer, which lies at a depth

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of approximately 60 m (200 ft) below ground surface. These factors are discussed in the following sections.

4.2.2.1.1 Depth of Release. As a general rule, for a given volume, waste management units that released wastes at a greater depth below the surface have a higher potential to contaminate groundwater than waste management units where the release was shallow. Other factors, however, such as rate of discharge, underlying geology, and many others will all significantly impact contaminant movement. The 216-U-4 Reverse Well is a primary example of a deep release at the U Plant Aggregate Area. This unit discharged wastes to the vadose zone approximately 23 m (75 ft) below the surface.

4.2.2.1.2 Liquid Volume or Recharge Rate. For waste constituents to migrate to the underlying water table, some source of recharge must be present. In the U Plant Aggregate Area, the primary source of moisture for mobilizing contaminants are waste management units that discharge liquid waste to the soil column and precipitation recharge. As discussed in Section 3.5.2, a number of studies have estimated natural precipitation recharge in a range from 0 to 10 cm/yr (0 to 4 in./yr), primarily depending on surface soil type, vegetation, and topography. The upper value in the range was a computer model generated estimation rather than actual measurement. The actual natural precipitation recharge for U Plant is likely to fall at the lower end of this range. Gravelly surface soils with no or minor shallow rooted vegetation appear to facilitate precipitation recharge. One modelling study (Smoot et al. 1989) indicated that some radionuclide (^{137}Cs and ^{106}Ru) transport could occur with as little as 5 cm/yr (2 in./yr) of natural recharge. However, other researchers (Routson and Johnson 1990) have concluded that no net precipitation recharge occurs in the 200 Areas, particularly at waste management units that are capped with fine-grained soils or impermeable covers.

With respect to artificial recharge, some waste management units (e.g., the 216-U-16 Crib) were identified in which the known volume of liquid waste discharged substantially exceeded the total estimated soil pore volume present below the footprint of the facility. In this case, the moisture content of soil below the waste management units likely approached saturation during the periods of use of these facilities. Because vadose zone hydraulic conductivities are maximized at water contents near saturation, the volume of liquid wastewater historically discharged to the waste management units probably enhanced fluid migration in the vadose zone beneath these units.

Long term gravity drainage is also a potential mechanism of contaminant migration. It is unknown how long after shutdown the soil under such a unit will continue to drain and to transport contamination down to the groundwater.

Contaminants that are not initially transported to the water table by drainage may be mobilized at a later date if a large volume of liquid is added to the unit. In addition, liquids discharged to one unit could mobilize wastes discharged to an adjacent unit if lateral migration takes place within the vadose zone. An example of this process occurred at the

216-U-16 Crib, where lateral migration of acidic waste above a caliche layer mobilized radionuclides below the 216-U-1 and 216-U-2 Cribs (Baker et al. 1988).

4.2.2.1.3 Soil Moisture Transport Properties. The moisture flux in the vadose zone is dependent on hydraulic conductivity as well as gradients of moisture content or matrix suction. Higher unsaturated hydraulic conductivities are associated with higher moisture contents. However, higher unsaturated hydraulic conductivities may be associated with fine-grained soils compared to coarse-grained soils at low moisture contents. Due to the stratified nature of the Hanford Site vadose zone soils and the moisture content dependence of unsaturated hydraulic conductivity, vertical anisotropy is expected, i.e., vadose zone soils are likely to be more permeable in the horizontal direction than in the vertical. This vertical anisotropy may reduce the potential for contaminant migration to the unconfined aquifer.

4.2.2.1.4 Retardation. The rate at which contaminants will migrate out of a complex waste mixture and be transported through unsaturated soils depends on a number of characteristics of the chemical, the waste, and the soil matrix. In general, chemicals that have low solubilities in the leaching fluid or are strongly adsorbed to soils will be retarded in their migration velocity compared to the movement of soil pore water. Studies have been conducted of soil parameters affecting waste migration at the Hanford Site to attempt to identify the factors that control migration of radionuclides and other chemicals. Recent studies of soil sorption are summarized in Serne and Wood (1990). Some of the processes that have been shown to control the rate of transport are as follows:

- **Adsorption to Soils.** Most contaminants are chemically attracted to some degree to the solid components of the soil matrix. For organic compounds, the adsorption is generally to the organic fraction of the soil, although in extremely low-organic soils, adsorption to inorganic components may be of greater importance. Soil components contributing to adsorption of inorganic compounds include clays, organic matter, and iron and aluminum oxyhydroxides. In general, Hanford surface soils are characterized as sandy or gravelly with very low organic content (<0.1%) and low clay content (<12%) (Tallman et al. 1981). Thus, site-specific adsorption factors are likely to be lower, and rate of transport higher, than the average for soils nationwide.
- **Filtration.** Filtration of suspended particulates by fine-grained sediments has been suggested as a mechanism for concentration of radionuclides in certain sedimentary layers. This finding suggests that migration of suspended particulates may be an important mechanism of transport for poorly soluble contaminants.
- **Solubility.** The rate of release of some chemicals is controlled by the rate of dissolution of the chemical from a solid form. The concentration of these chemicals in the pore water will be extremely low, even if they are poorly

sorbed. An example cited by Serne and Wood (1990) is the solubility of plutonium oxide, which appears to be the limiting factor controlling the release of plutonium from waste materials at neutral and basic pH.

- **Ionic Strength of Waste.** For some inorganics, the dominant mechanism leading to desorption from the soil matrix is ion exchange. Leachate having high ionic strength (high salt content) can bias the sorption equilibrium toward desorption, leading to higher concentrations of the contaminant in the soil pore water. Wastes within the U Plant Aggregate Area that can be considered high ionic strength include any releases from tanks and wastes disposed of at the 216-U-5 and 216-U-6 Trenches.
- **Waste pH.** The pH of a leachant has a strong effect on inorganic contaminant transport. Acidic leachates tend to increase migration both by increasing the solubility of precipitates and by changing the distribution of charged species in solution. The exact impact of acidic or basic wastes will depend on whether the chemical is normally in cationic, anionic, or neutral form, and the form that it takes at the new pH. Cationic species tend to be more strongly adsorbed to soils than neutral or anionic species. The extent to which addition of acidic leachate will cause a contaminant to migrate will also depend on the buffering or neutralizing capacity of the soil, which is correlated with the calcium carbonate (CaCO_3) content of the soil. The soils in the Hanford formation beneath the U Plant Aggregate Area generally have carbonate contents in the range of 0.1 to 5%. Higher carbonate contents (20 to 30%) are observed within the Plio-Pleistocene caliche layer.

Once the leaching solution has been neutralized, the dissolved constituents may re-precipitate or become reabsorbed to the soil. Observations of pH impacts on waste transport at the Hanford Site include:

- The remobilization of uranium beneath the 216-U-1 and 216-U-2 Cribs is believed to have occurred in part because of this introduction of low pH solutions.
- Leaching of americium from the Z Plant Aggregate Area 216-Z-9 Trench sediments was found to be solubility controlled and correlated to solution pH.

4.2.2.1.5 Complexation by Organics. Certain organic materials disposed of at the U Plant Aggregate Area are known to form complexes with inorganic ions, which can enhance their solubility and mobility. Tributyl phosphate is the primary organic complexing agent disposed of at the U Plant Aggregate Area.

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4.2.2.1.6 Contaminant Loss Mechanisms. Processes that can lead to loss of chemicals from soils, and thus decrease the amount of chemical available for leaching to groundwater, include:

- **Radioactive Decay.** Radioactivity decays over time, generally decreasing the quantities and concentrations of radioactive isotopes.
- **Biotransformation.** Microorganisms in the soil may degrade organic contaminants such as kerosene and inorganic chemicals such as nitrate.
- **Chemical Transformation.** Hydrolysis, oxidation, reduction, radiolytic degradation and other chemical reactions are possible degradation mechanisms for contaminants.
- **Vegetative Uptake.** Vegetation may remove chemicals from the soil, bring them to the surface, and introduce them to the food web.
- **Volatilization.** Organic chemicals and volatile radionuclides can be transported in the vapor phase through open pores in soil either to adjacent soil or to the atmosphere. These volatilized compounds could include acetone, radon (a decay product of uranium), and tritium (HTO in tritiated water). Some elements (mainly fission products such as iodine, ruthenium, cerium, and antimony) are referred to as "semivolatiles" because they have a lesser tendency to volatilize.

4.2.2.2 Transport from Soils and Surface Water to Air. Transport of contaminants from waste management units to the atmosphere can occur by means of vapor transport or by fugitive dust emissions.

Vapor transport may occur from waste management units where volatile organics (e.g., CCl_4) or volatile radionuclides (^{14}C , $^{14}\text{CO}_2$, ^{129}I , or ^3H) have been released. Transport mechanisms include evaporation/volatilization, diffusion down a concentration gradient, and gas-driven flow. Situations where the latter process may occur include production of methane gas from degradation of organic compounds in soil, or production of hydrogen and oxygen gases by radiolytic hydrolysis of water.

In order for fugitive dust emissions to occur, contaminants must be exposed at the surface of the waste management unit. A number of mechanisms could lead to exposure of contaminants in soil-covered waste management units. These mechanisms include uptake by vegetation, transport by animals, disruption of the waste management unit (e.g., cave-ins at cribs), and wind erosion. Wind erosion can strip off surface soil and uncover waste materials. This mechanism has been identified as an ongoing problem in some of the waste management unit areas. The processes by which biota may expose contaminated soils are discussed in Section 4.2.2.4.

The contribution of the U Plant Aggregate Area to the overall fugitive dust emissions at the Hanford Site boundary is expected to be relatively minor, based on results of air monitoring downwind of the U Plant Aggregate Area waste management units (Schmidt et al. 1992).

4.2.2.3 Transport from Soils to Surface Water. The only surface water available in the U Plant Aggregate Area is at the 216-U-14 Ditch, the associated Powerhouse Pond, and the 207-U Retention Basin. The 216-U-14 Ditch has been active since 1944 and has received waste liquids from a variety of sources (Section 4.1.2.5.3). Three-quarters of the 216-U-14 Ditch is backfilled with 0.5 to 1 m (1.5 to 3 ft) of soil at this time. The unfilled portion of the ditch is classified as an area of surface contamination.

Transport of contaminants to surface water bodies outside of the U Plant Aggregate Area via groundwater discharge and deposition of fugitive dust on water bodies are the primary pathways of potential concern for surface water effects. Groundwater discharge will be addressed in the 200 West Groundwater AAMSR.

4.2.2.4 Transport from Soils and Surface Water to Biota. Biota, plants and animals, have the potential for taking up (bio-uptake), concentrating (bioaccumulating), transporting, and depositing contamination beyond its original extent. Transfer from one species to another in the food chain is also possible because of predation. The possibility of these processes contributing significantly to the transport of contamination from U Plant Aggregate Area waste management units, or resulting in damage to affected ecosystems, is unclear. The currently available data, as described in Sections 3.6 and 4.1, are too general and do not adequately evaluate biotic transport or ecological risk. This data gap is discussed further in Sections 5.0 and 8.0. The future acquisition of additional data will be guided by the requirements for human health and ecological risk assessments in the *Hanford Baseline Risk Assessment Methodology* (DOE/RL 1992b) being prepared in response to the M-29 milestone.

4.2.2.4.1 Uptake by Vegetation. Release of radioactivity to the surface by growth of vegetation is an ongoing problem at U Plant Aggregate Area waste management units. Roots of sagebrush and other native species can take up radionuclides from soils below the surface and transport these chemicals to the foliage. Wind dispersal of portions of the contaminated vegetation, or entire plants (tumbleweeds) can lead to transport of contaminants outside of the unit. Westinghouse Hanford has an ongoing vegetation control (herbicide application, reseeding with shallow-rooted vegetation, and mechanical removal) and radiological survey program to prevent radioactivity from being transported by this mechanism. However, the program does not ensure complete removal of vegetation, and incidents of detection of contaminated vegetation are reported occasionally in the radiological surveys.

4.2.2.4.2 Transport by Animals. Disturbance of waste management unit barriers by animals occasionally leads to release of contaminants to the surface. Subsurface soils can be

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transported to the surface by burrowing animals, thus exposing contaminants for release to the air. Additionally, animals that become contaminated by direct contact with subsurface waste or through ingestion of subsurface contaminants (e.g., chemical salts) and contaminated vegetation, water, or other animals can spread contamination in their feces on the surface and outside of the waste management unit. An example of transport through this mechanism is the UN-200-W-86 Unplanned Release, in which pigeon feces containing ^{134}Cs , ^{137}Cs , ^{90}Sr , and ^{106}Ru were detected around the U Plant and 204-S Retention Basin.

4.2.3 Conceptual Model

Figure 4-3 presents a graphical summary of the physical characteristics and mechanisms at the site which could potentially affect the generation, transport, and impact of contamination in the U Plant Aggregate Area on humans and biota (conceptual model).

The sources of contamination include process wastes (condensates, cooling water, sewage) from U Plant and the Plutonium Finishing Plant (Z Plant); unirradiated uranium wastes from the cold startup of U Plant ("interface crud"); condensate from 241-U Tank Farm; laboratory wastes; drainage from diversion boxes; sanitary wastes; process feed materials; materials from outside the aggregate area (e.g., laundry water and powerhouse wastewater); and contaminated equipment or waste material that was spilled during transit or disposed of in the Burial Ground/Burning Pit, or Construction Surface Laydown Area.

Contaminants from these sources have been disposed of at the waste management units that are under investigation. These include the 216-U-10 Pond, ditches, retention basins, settling tanks, trenches, cribs, french drains, reverse wells, catch tanks, septic tanks and drain fields, single-shell tanks, vaults, and the various unplanned releases that have occurred on the site. These releases and disposal activities are described in Sections 2.0 and 4.1. Some of the unplanned releases are associated with specific waste sites, and are shown on Figure 4-3 as dashed lines with "U" designations.

From these waste management units, various release mechanisms may have transported contamination to the potentially affected media. Volatilization could release chemicals from surface waters into the atmosphere. Materials in the ditches flowing toward U Pond may have seeped into the vadose zone, or deposited into the sediments in the ditch. The 207-U Retention Basin may have released contaminants in a similar fashion, with the exception of offsite flow. Biota may have taken up contaminants from the surface water and near-surface contaminated soils (via deep roots or burrowing animals).

Many waste management units discharge their waste effluents directly to the near surface (vadose zone) soils. The trenches are potential release points via leaching or drainage of the liquid portion of the disposed materials. The cribs provide seepage discharge and similarly the french drains, reverse wells, and septic system drain fields directly inject

their effluents into the subsurface sediments. The unplanned releases have mainly impacted surface soils although some contamination may have also taken place on building surfaces. Fugitive dust from sediment and surface soils has also been released or resuspended due to wind effects or surface disturbances, and some surface soils have been buried or removed to offsite disposal.

The primary mechanism of vertical contaminant migration is the downward movement of water from the surface through the vadose zone to the unconfined aquifer. The contaminants generally move as a dissolved phase in the water and their rate of migration is controlled both by groundwater movement rates and by adsorption and desorption reactions involving the surrounding sediments. Some contaminants are strongly sorbed on sediments and their downward movement through the stratigraphic column is greatly retarded. Significant lateral migration of contaminants is restricted to perched water zones and to the unconfined aquifer, where water is moving laterally. Again adsorption and desorption reactions may greatly retard lateral contaminant migration. Contaminants that were introduced to the soil column outside of the aggregate area may migrate into the area along with perched or aquifer water.

Figure 4-4 is a schematic diagram illustrating these processes and describing probable contaminant distributions in the vadose zone. For liquid waste management units, the point of release shown on this figure may be in the subsurface, such as at cribs, drains, and reverse wells, or it may be exposed to the surface, such as at ponds, ditches, trenches, or at most unplanned releases. Small-scale contaminant releases are much less likely to impact the lower vadose zone or groundwater than large scale releases. Liquid disposal units in the U Plant Aggregate Area are dominated by cribs and the U Pond and associated ditches. Table 4-13 identifies those units that had liquid discharges large enough to reach the unconfined aquifer.

Contaminant distributions near the burial ground type units in the U Plant Aggregate Area are likely significantly different from those associated with the liquid waste management units. Because burial grounds received only dry waste, the burial grounds are unlikely to release contaminants to the vadose zone. As a result, only surface contaminant releases have been identified at burial grounds. In this case, wind and near surface biological activity are the dominant processes for transporting and redistributing contaminants.

Contaminant distribution at most unplanned releases is expected to be at or just below the surface. These sites generally received little, if any, liquid, therefore, migration into the lower vadose zone is not expected. The primary process for transporting and redistributing contaminants in this case is wind and near surface biological activity.

The schematic diagram is based on the stratigraphy underlying the U Plant Aggregate Area, the chemical characteristics of the primary suspected contaminants in the area, and

known vadose zone contaminant distributions identified from previous studies. The subsurface geology of the aggregate area is presented in Sections 3.4 and 3.5, and the chemical characteristics of various contaminants are detailed in Section 4.2.4.

In the past, drilling and sampling programs have been conducted at the 216-Z-1A Tile Field (Price et al. 1979), the 216-Z-9 Trench (Smith 1973), the 216-Z-12 Crib (Kasper 1981), the 200-BP-1 Operable Unit cribs (the BY Cribs) (Buckmaster and Kaczor 1992), the 216-U-10 Pond (Last and Duncan 1980), and the 216-Z-19 Ditch (Last and Duncan 1980). These studies, in conjunction with geophysical well logging data, have been used to estimate the expected contaminant distributions beneath comparable waste management units in the U Plant Aggregate Area.

Some of the general conclusions that may be drawn from these previous studies are:

- (1) Maximum radionuclide contaminant concentrations should be expected directly beneath the main discharge points of the units with the exception of highly mobile contaminants such as tritium.
- (2) Radionuclide contamination is not expected to spread laterally more than 15 to 30 m (50 to 100 ft) beyond the point of discharge and should be at much lower concentrations than those noted beneath the center of the discharge point; a possible exception being areas of perched water.
- (3) Radionuclide contamination decreases rapidly with depth. The highest concentrations should occur within 2 or 3 m (6 to 10 ft) of the bottom of the discharge point and concentrations should be near background levels at 20 m (65 ft) depth.
- (4) The maximum lateral radionuclide contaminant movement tends to occur along relatively impermeable horizons.
- (5) Radionuclide contaminants should be concentrated in fine-grained horizons compared to surrounding coarse-grained horizons and when found in coarse-grained horizons they are associated with the fine-grained particles.
- (6) Perched water zones are most likely to occur immediately above the caliche layer. With rapid loading, perch water may extend from the caliche layer up into the lower Hanford formation. Significant lateral water and contaminant movement may occur in such a situation.
- (7) The caliche layer is an important physical and chemical barrier to vertical contaminant migration.

- (8) Most chemical contaminants of concern have distributions that tend to mimic radionuclide contaminant distributions in the vadose zone.

There are four exposure routes by which humans (offsite and onsite) and other biota (plants and animals) can be exposed to these possible contaminants:

- Inhalation of airborne volatiles or fugitive dusts with adsorbed contamination
- Ingestion of surface water, fugitive dust, surface soils, biota (either directly or through the food chain), or groundwater
- Direct contact with the waste materials (such as those exhumed by burrowing animals), contaminated surface soils, buildings, or plants, and
- Direct radiation from waste materials, surface soils, building surfaces, or fugitive dusts.

4.2.4 Characteristics of Contaminants

Table 4-24 is a list of radioactive and nonradioactive chemical substances that represent candidate contaminants of potential concern for this study based on their known presence in wastes, usage, disposal in waste management units, historical association, or detection in environmental media at the U Plant Aggregate Area. Table 4-25 summarizes the types of known or suspected contamination thought to exist at the individual waste sites. Known contaminants have been proven to exist from sampling and inventory data (Tables 2-2 and 2-3). Suspected contaminants are those which could occur at a site based upon historical practices or chemical associations. Given the large number of chemicals known or suspected to be present, it is appropriate to focus this assessment on those contaminants that have been detected through sampling efforts and which pose the greatest risk to human health or the environment.

The EPA Region 10 guidance on risk-based contaminant screening (EPA 1991a), as summarized in the *Hanford Baseline Risk Assessment Methodology* (DOE/RL 1992b), was consulted to establish the U Plant Aggregate Area contaminants of potential concern. The risk-based contaminant screening mostly involves comparing maximum contaminant concentrations to risk-based benchmark concentrations. However, contaminant concentrations in environmental media are not available for the U Plant Aggregate Area, and direct risk-based screening could not be performed. To ensure that the intent of the EPA Region 10 approach could be achieved an alternative and more conservative approach was employed. This requires U Plant Aggregate Area contaminants with potential risks to be included in the list of contaminants of potential concern. The alternative approach retains

any contaminant that is known or suspected of being carcinogenic or toxic, regardless of quantity or concentration.

Table 4-26 lists the contaminants of potential concern for the U Plant Aggregate Area. This list was developed from Table 4-24 and includes only those contaminants which meet the following criteria:

- Radionuclides that have a half-life of greater than one year. Radionuclides with half-lives less than one year will not persist in the environment at concentrations sufficient to contribute to overall risks.
- Radionuclides with a half-life of less than one year and are part of long-lived decay chains that result in the buildup of the short-lived radionuclide activity to a level of 1% or greater of the parent radionuclide's activity within the time period of interest. Although daughter radionuclides are adequately identified during normal parent radionuclide investigations, they are also identified as contaminants of concern through this criterion. This provides an additional level of assurance that all primary contaminants will be addressed.
- Contaminants that are known or suspected carcinogens or have a U.S. Environmental Protection Agency (EPA) noncarcinogenic toxicity factor. In addition, chemicals with known toxic effects but no toxicity factors are included. In some instances the criteria have been withdrawn by EPA pending review of the toxicological data and will be reissued at a future date. Chemicals with known toxicity for which toxicity factors are presently not available include lead, selenium, kerosene and tributyl phosphate.

The following characteristics will be discussed for the contaminants listed in Table 4-26:

- Detection of contaminants in environmental media
- Historical association with plant activities
- Mobility
- Persistence
- Toxicity
- Bioaccumulation.

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4.2.4.1 Detection of Contaminants in Environmental Media. The nature and extent of surface and subsurface soils, surface water, groundwater, air, and biota contamination have not yet been adequately characterized for the U Plant Aggregate Area. All recent environmental monitoring data were reviewed and summarized for each media in Section 4.1.

The most extensive monitoring data available has been for groundwater. Because groundwater will be evaluated in the 200 West Groundwater AAMSR, it will not be discussed further here. Surface soil and biota samples have been collected from locations on a regular rectangular grid. These sampling locations do not correspond to any of the waste management units, but are intended to characterize the U Plant Aggregate Area as a whole. Air and external radiation samples have been collected at several locations within or adjacent to the U Plant Aggregate Area. These sampling stations are also not located directly on any of the waste management units and therefore the sampling results cannot be attributed to any particular unit. The only routine sampling data that correspond directly to waste management units are the external radiation surveys, which are performed on a regular basis. There is little soil or vegetation sampling data available for any of the units.

4.2.4.2 Historical Association with U Plant Aggregate Area Activities. Radionuclides that are known components of U Plant Aggregate Area waste streams are listed in Table 2-10. This list includes chemicals in the process wastes as well as chemicals that were detected at elevated levels in wastewater. Since these waste streams are known to have been disposed of directly to the soil column in some waste management units, it is probable that the chemicals on this list have affected environmental media.

Based on the WIDS data (WHC 1991a), radionuclides that are known to have been disposed of to U Plant Aggregate Area waste management units in the greatest quantities are as follows:

- ^{239}Pu
- ^{240}Pu
- ^{137}Cs
- ^{90}Sr
- ^3H
- ^{238}U

Note that a complete radionuclide analysis of the U Plant waste streams is not available. Thus, it is possible that additional radionuclides were disposed of to U Plant Aggregate Area waste management units that are not included in the waste inventories.

Nonradioactive chemicals reportedly released into U Plant Aggregate Area waste management units in large quantities include nitric acid, nitrates, sodium, phosphate, sulfate, tributyl phosphate, ammonium nitrate, and hexone.

4.2.4.3 Mobility. Since most wastes at the U Plant Aggregate Area were released directly to subsurface soils via injection, infiltration, or burial, the mobility of the wastes in the subsurface will determine the potential for future exposures. The mobility of the contaminants listed in Table 4-26 varies widely and depends on site-specific factors as well as the intrinsic properties of the contaminant. These site-specific factors include site stratigraphy, hydraulic conductivity, porosity, and other factors. Much of the site-specific information needed to characterize mobility is not available and will need to be obtained during future field investigations. However, it is possible to make general statements about the relative mobility of the candidate contaminants of concern.

4.2.4.3.1 Transport to the Subsurface. The mobility of radionuclides and other inorganic elements in groundwater depends on the chemical form and charge of the element or molecule, which in turn depends on site-related factors such as the pH, redox state, and ionic composition of the groundwater. Cationic species (e.g., Cd^{2+} , Pu^{4+}) generally are retarded in their migration relative to groundwater to a greater extent than anionic species such as nitrate (NO_3^-). The presence in groundwater of complexing or chelating agents can increase the mobility of metals by forming neutral or negatively charged compounds.

The chemical properties of radionuclides are essentially identical to the nonradioactive form of the element; thus, discussions of the chemical properties affecting the transport of contaminants can apply to both radionuclides and nonradioactive chemicals.

A soil-water distribution coefficient (K_d) can be used to predict mobility of inorganic chemicals in the subsurface. Table 4-27 presents a summary of K_d values that have been developed for many of the inorganic chemicals of concern at the U Plant Aggregate Area. As discussed above, the pH and ionic strength of the leaching medium has an impact on the absorption of inorganics to soil; thus, the listed K_d values are valid only for a limited range of pH and waste composition. In addition, soil sorption of inorganics is highly dependent on the mineral composition of the soil, the ionic composition of the soil pore water, and other site-specific factors. Thus, a high degree of uncertainty is involved with use of K_d values that have not been verified by experimentation with site soils.

Serne and Wood (1990) recommended K_d values for use with Hanford waste assessments for a limited number of important radionuclides (americium, cesium, cobalt, copper, iodine, plutonium, ruthenium, strontium, and tritium) based on soil column or batch desorption studies, and have proposed conservative average values for a more extensive list of elements based on a review of the literature. An assumed K_d values of < 1 is recommended for americium, cesium, plutonium, and strontium under acidic conditions.

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Streng and Peterson (1989) developed default K_d values for a large number of elements for use in the Multimedia Environmental Pollution Assessment System (MEPAS), a computerized waste management unit evaluation system. The K_d values were based on findings in the scientific literature, and include non-site-specific as well as Hanford Site values. Values are provided for nine sets of environmental conditions: three ranges of waste pH and three ranges of soil adsorbent material (sum of percent clay, organic material, and metal hydrous oxides). The values presented in Table 4-27 are for conditions of neutral waste pH and less than 10% adsorbent material, which is likely to be most representative of Hanford Site soils.

The mobility of inorganic species in soil can be divided roughly into three classes using site-specific values (Serne and Wood 1990) where available and generic values otherwise: highly mobile ($K_d < 5$), moderately mobile ($5 < K_d < 100$), and low mobility ($K_d > 100$). Table 4-28 lists the class ranking for each of the inorganic contaminants of concern. The ranking presented in this table indicates general mobility characteristics. Actual mobility of specific contaminants will be influenced by their valence state and ligands. Specific mobilities will be determined in future site investigations and will address these potential influences.

The tendency of organic compounds to adsorb to the organic fraction of soils is indicated by the soil organic matter partition coefficient, K_{oc} . Partition coefficients for the organic chemicals of concern at the U Plant Aggregate Area are listed in Table 4-29. Chemicals with low K_{oc} values are weakly absorbed by soils and will tend to migrate in the subsurface, although their rate of travel will be retarded somewhat relative to the pore water or groundwater flow. Soils at the Hanford Site have very little organic carbon content and thus sorption to the inorganic fraction of soils may dominate over sorption to soil organic matter.

4.2.4.3.2 Transport to Air. Transport of contaminants from waste management units to the atmosphere can occur by means of vapor transport or by fugitive dust emissions. Chemicals subject to transport via airborne dust dispersion are those that are non-volatile and persistent on the soil surface, including most radionuclides and inorganics, and some organics such as creosote and coal tar.

Chemicals subject to volatilization are mostly organic compounds; however, some of the radionuclides detected at the site are subject to evaporation and could be lost from shallow soils to the ambient air. The most important species in this category are ^{14}C , ^3H , and ^{129}I .

The tendency of an organic compound to volatilize can be predicted from its Henry's Law Constant, K_h , a measured or calculated parameter with units of atmospheres per cubic meter per mole of chemical. Henry's Law Constants of the organic candidate contaminants of concern are presented in Table 4-29. Compounds with a K_h greater than about 10^{-3} will

be lost rapidly to the atmosphere from surface water and shallow soils. Organic contaminants of concern that fall into this class include:

- Carbon tetrachloride
- Chloroform
- Methylene chloride
- Toluene
- Tributyl phosphate.

4.2.4.4 Persistence. Once released to environmental media, the concentration of a contaminant may decrease because of biological or chemical transformation, radioactive decay, or the intermediate transfer processes discussed above that remove the chemical from the medium (e.g., volatilization to air). Radiological, chemical, and biological decay processes affecting the persistence of the U Plant Aggregate Area contaminants of concern are discussed below.

The persistence of radionuclides depends primarily on their half-lives. A comparison of the half-lives and specific activities for most radionuclide contaminants of concern for U Plant is presented in Table 4-30. The specific activity is the decay rate per unit mass, and is inversely proportional to the half-life of the radionuclide. Half-lives for the radionuclides listed in Table 4-30 range from seconds to over one billion years. Also listed are the decay mechanisms of primary concern for the radionuclide. Note that radionuclides often undergo several decay steps in quick succession, (e.g., an alpha decay followed by release of one or more gamma rays). The daughter products of these decays are themselves often radioactive.

Decay will occur during transport (e.g., through the vadose zone to the aquifer, through the aquifer) and may lead to significant reductions in levels discharging to the Columbia River. For direct exposures (e.g., to surface soils or air), the half-life of the radionuclide is of less importance, unless the half-life is so short that the radionuclide undergoes substantial decay between the time of disposal and release to the environment.

Nonradioactive inorganic chemicals detected at the site are generally persistent in the environment, although they may decline in concentration due to transport processes or change their chemical form due to chemical or biological reactions. Nitrate undergoes chemical and biological transformations that may lead to its loss to the atmosphere (as N_2) or incorporation into living organisms, depending on the redox environment and microbiological communities present in the medium.

Biotransformation rates for organics vary widely and are highly dependent on site-specific factors such as soil moisture, redox conditions, and the presence of nutrients and of organisms capable of degrading the compound. Ketones, such as acetone and methyl isobutyl ketone (MIBK), are easily degraded by microorganisms in soil and thus would tend not to persist. Chlorinated solvents (e.g., carbon tetrachloride) may undergo slow biotransformation in the subsurface under anoxic conditions. Volatile aromatics such as toluene are generally intermediate in their biodegradability.

4.2.4.5 Toxicity. Contaminants may be of potential concern for impacts to human health if they are known or suspected to have carcinogenic properties, or if they have adverse noncarcinogenic human health effects. The toxicity characteristics of the chemicals detected at the aggregate area are summarized below.

4.2.4.5.1 Radionuclides. All radionuclides are classified by EPA as known human carcinogens based on their property of emitting ionizing radiation and on the evidence provided by epidemiological studies of radiation-induced cancers in humans. Non-carcinogenic health effects associated with radiation exposure include genetic and teratogenic effects; however, these effects generally occur at higher exposure levels than those required to induce cancer. Thus, the carcinogenic effect of radionuclides is the primary identified health concern for these chemicals (EPA 1989b).

Risks associated with radionuclides differ for various routes of exposure depending on the type of ionizing radiation emitted. Nuclides that emit alpha or beta particles are hazardous primarily if the materials are inhaled or ingested, since these particles expend their energy within a short distance after penetrating body tissues. Gamma-emitting radioisotopes, which deposit energy over much larger distances, are of concern as both external and internal hazards. A fourth mode of radioactive decay, neutron emission, is generally not of major health concern, since this mode of decay is much less frequent than other decay processes. In addition to the mode of radioactive decay, the degree of hazard from a particular radionuclide depends on the rate at which particles or gamma radiation are released from the material.

Excess cancer risks for exposure to the primary radionuclide contaminants of concern by inhaling air, drinking water, ingesting soil, and by external irradiation are shown in Table 4-31. These values represent the increase in probability of cancer to an individual exposed for a lifetime to a radionuclide at a level of 1 pCi/m³ in air, 1 pCi/L in drinking water, 1 pCi/g in ingested soil, or to external radiation from soil having a radionuclide content of 1 pCi/g (EPA 1991b). These values are computed as the slope factor (risk per unit intake or exposure) multiplied by the inhalation or ingestion rate and the number of days in a 70 year lifetime (EPA 1991b).

For those radionuclides without EPA slope factors, the *Hanford Baseline Risk Assessment Methodology* (DOE/RL 1992b) will be consulted. This document proposes to

consult the EPA Office of Radiation Programs to request the development of a slope factor or to use the dose conversion factors developed by the International Commission on Radiological Protection to calculate a risk value. Any Hanford site risk assessments will be performed in accordance with the *Hanford Baseline Risk Assessment Methodology* document (DOE-RL 1992b) which includes the guidance established in the *Risk Assessment Guidance for Superfund* (EPA 1989a) and the *EPA Region 10 Supplement Risk Assessment Guidance for Superfund* (EPA 1991a).

The unit risk factors for different radionuclides are roughly proportional to their specific activities, but also incorporate factors to account for distribution of each radionuclide within various body organs, the type of radiation emitted, and the length of time that the nuclide is retained in the organ of interest.

Based on the factors listed in Table 4-31, the highest risk for exposure to 1 pCi/m³ in air is from plutonium, americium and uranium isotopes, which are alpha emitters. Among the radionuclides contaminants of concern for the U Plant Aggregate Area, the highest risks from ingestion of soil at 1 pCi/g are for ²²⁷Ac, ²⁴¹Am, ²⁴³Am, ²³⁸Pu, ²⁴⁴Cm, ¹³⁴Cs, ¹²⁹I, ²³⁷Np, ²³¹Pa, ²²⁶Ra, ²²⁸Ra, ²²⁹Th, and the uranium isotopes. The primary gamma-emitters are ²¹⁴Bi, ⁶⁰Co, ¹³⁴Cs, ¹³⁷Cs (because of its metastable decay product, ^{137m}Ba), ¹⁵²Eu, ¹⁵⁴Eu, ²³⁹Np, and ²¹⁴Pb. It is important to note that this table only presents unit risk factors for the listed radionuclides and does not include potential contributions from daughter products.

The standard EPA risk assessment methodology assumes that the probability of a carcinogenic effect increases linearly with dose at low dose levels, i.e., there is no threshold for carcinogenic response. The EPA methodology also assumes that the combined effect of exposure to multiple carcinogens is additive without regard to target organ or cancer mechanism. However, the additive risk resulting for radionuclides and carcinogenic chemicals should be computed separately (EPA 1989a).

4.2.4.5.2 Hazardous Chemicals. Carcinogenic and non-carcinogenic health effects associated with chemicals anticipated at the aggregate area are summarized in Table 4-32. The basis for these potential health effects are described in the respective reference documents and may be associated with either human or animal data. Health effects were developed according to the hierarchy established in the *Risk Assessment Guidance for Superfund* (EPA 1989a). References were consulted in the following order: IRIS (Integrated Risk Information System) (EPA 1991b), HEAST (Health Effects Assessment Summary Tables) (EPA 1991c), and other toxicity articles and documents.

Several of the chemicals have known toxic effects but no toxicity criterion is presently available. In some instances the criteria have been withdrawn by EPA pending review of the toxicological data and will be reissued at a future date. Chemicals with known toxicity for which toxicity factors are presently not available include lead, selenium, kerosene and tributyl phosphate.

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4.2.4.6 Bioaccumulation potential. Contaminants may be of concern for exposure if they have a tendency to accumulate in plant or animal tissues at levels higher than those in the surrounding medium (bioaccumulation) or if their levels increase at higher trophic levels in the food chain (biomagnification). Contaminants may be bioaccumulated because of element-specific uptake mechanisms (e.g., incorporation of strontium into bone) or by passive partitioning into body tissues (e.g., concentration of organic chemicals in fatty tissues).

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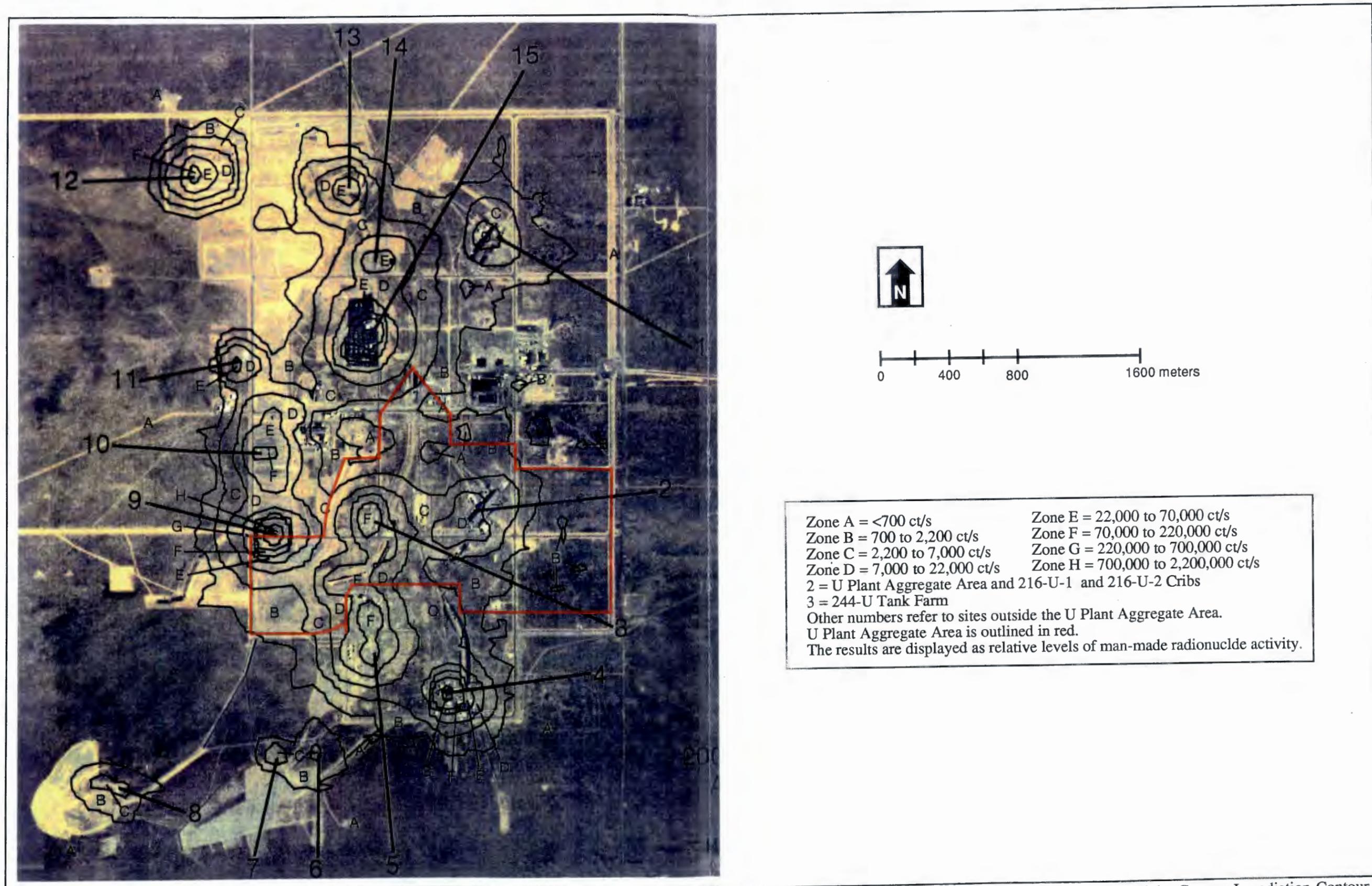


Figure 4-1. Gamma Isoradiation Contour
 Map of the 200 West Area.

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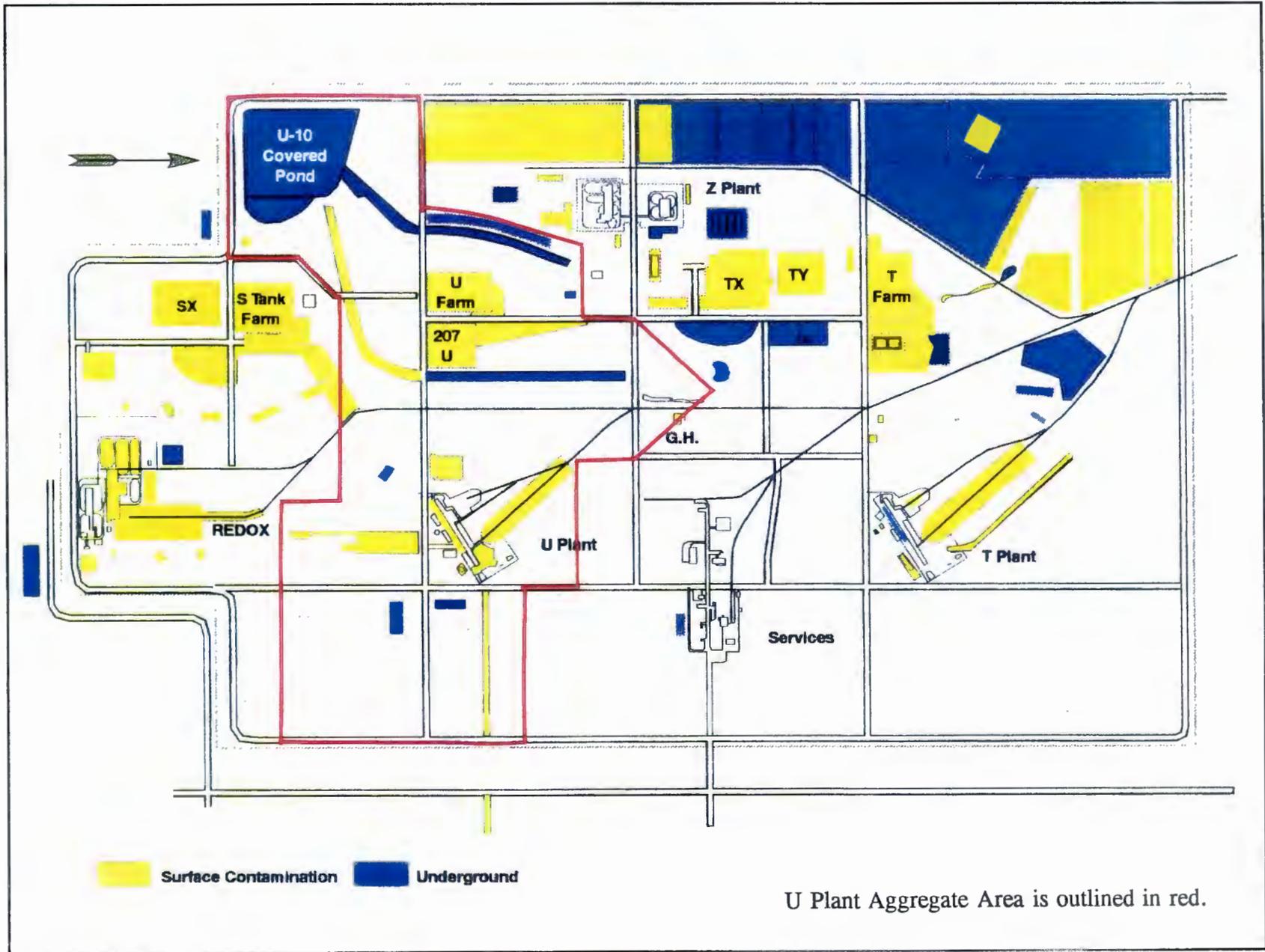


Figure 4-2. Surface, Underground, and Migrating Map of the 200 West Area. (Huckfeldt 1991b)

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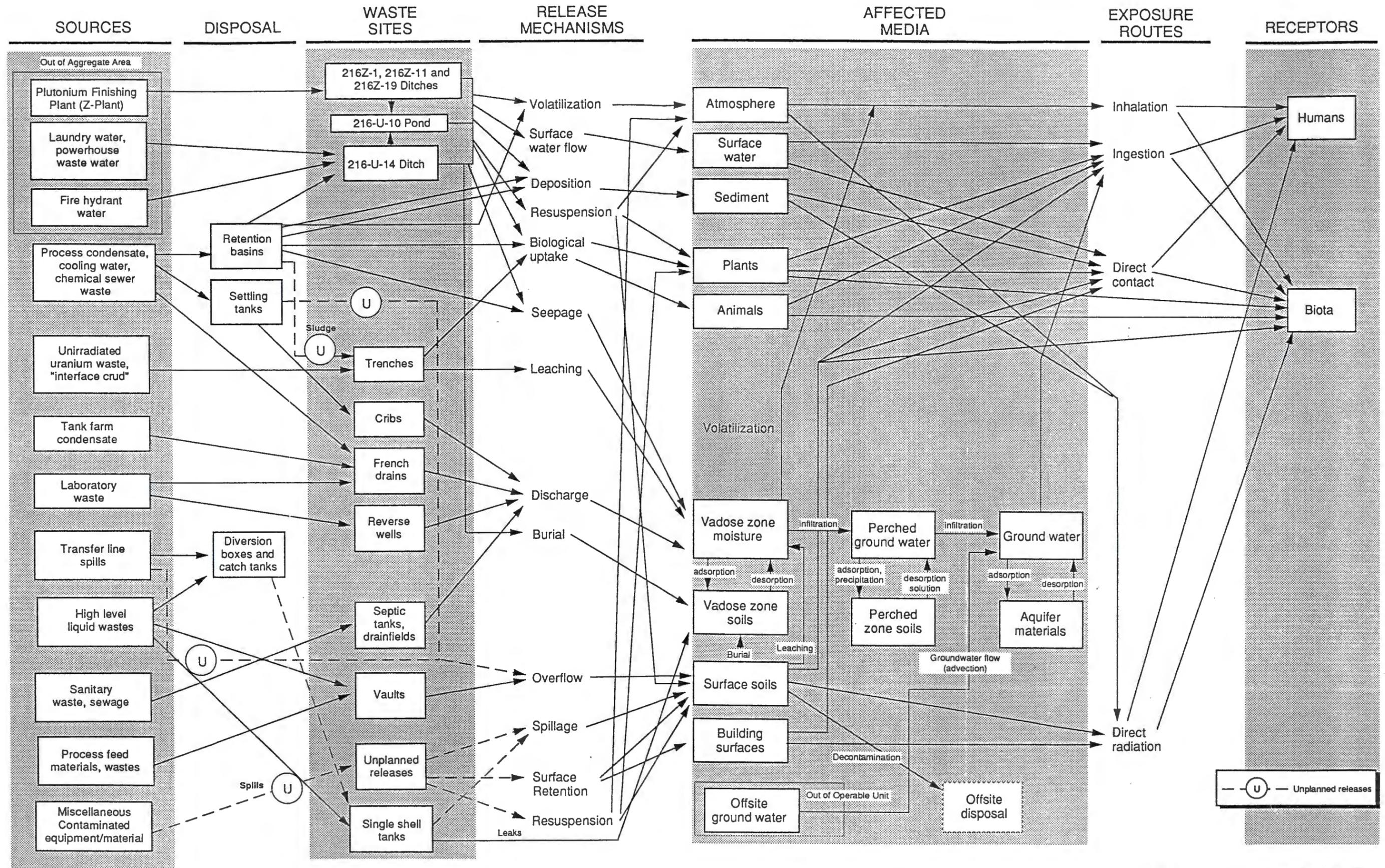
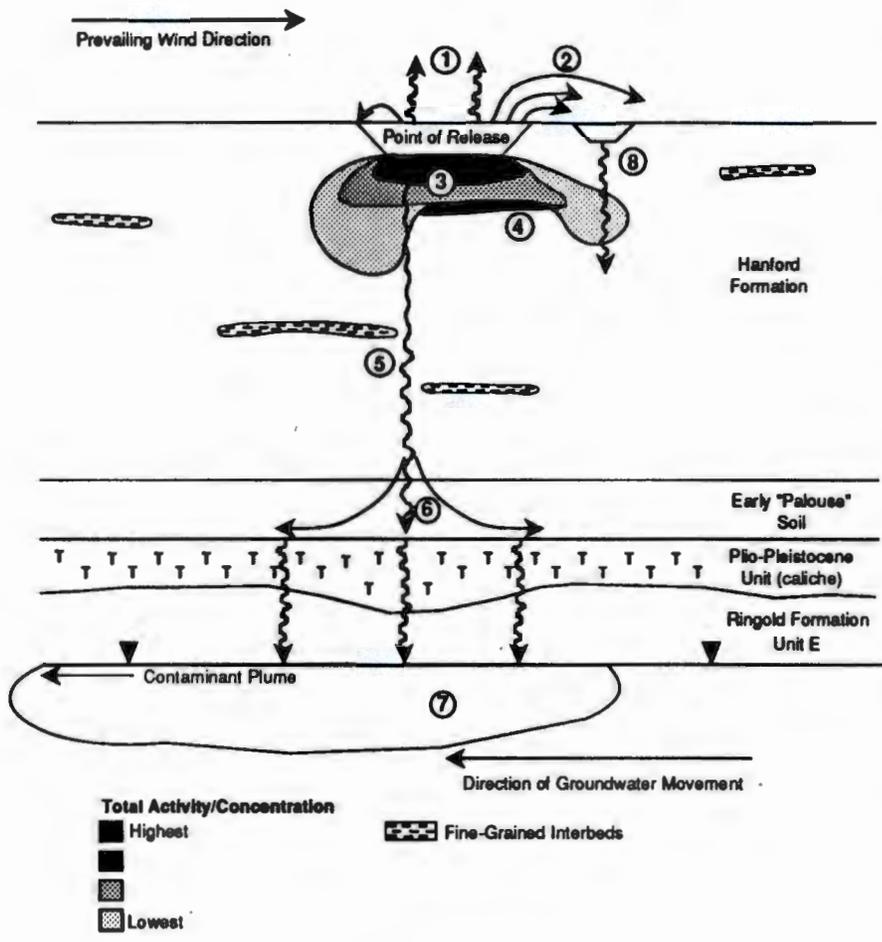


Figure 4-3. Conceptual Model of the U Plant Aggregate Area.

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- ① Some contaminants may volatilize and enter the atmosphere after release.
- ② Wind may move contaminants laterally at the surface. For a surface release, this may occur immediately. For subsurface releases, contaminants must first be moved to the surface by biological activity.
- ③ The majority of contaminants are held in the vadose zone soils immediately beneath the point of release. The highest total activities will be immediately beneath the point of release and less mobile contaminants such as TRUs should be restricted to this area.
- ④ Thin discontinuous aquitards may cause small perched water zones. Some lateral migration of contaminants may occur above such a zone, particularly if it occurs close to the point of release.
- ⑤ The majority of liquid travels downward through the vadose zone carrying some more mobile contaminants such as fission products. Contaminants may be locally concentrated in fine-grained horizons, though at much lower concentrations than occur immediately beneath the point of release.
- ⑥ Some of the most mobile contaminants (tritium, cyanide, iodine, nitrates, nitrites, fluoride) reach the groundwater and may form contaminant plumes.
- ⑦ Perched water eventually percolates through the caliche layer or passes through gaps in the caliche and reaches the groundwater. Some of the most mobile contaminants (tritium, cyanide, iodine, nitrates, nitrites, fluoride) reach the groundwater and may form contaminant plumes.
- ⑧ Waste water from adjacent active waste management units may remobilize contaminants in the underlying vadose zone.

Figure 4-4. Physical Conceptual Model of Contamination Distribution.

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Table 4-1. Summary of Known and Suspected Radionuclide Contamination.

Source Waste Management Unit	Air	Surface Soil (0-1 m)	Surface Water	Biota	Vadose Zone	Remarks
Tanks and Vaults						
241-U-101 Single-Shell Tank	--	--	--	--	S	Also described by UPR-200-W-154
241-U-102 Single-Shell Tank	--	--	--	--	S	No reported release
241-U-103 Single-Shell Tank	--	--	--	--	S	As described by UPR-200-W-128
241-U-104 Single-Shell Tank	--	--	--	--	S	Also described by UPR-200-W-155
241-U-105 Single-Shell Tank	--	--	--	--	--	No reported release
241-U-106 Single-Shell Tank	--	--	--	--	--	No reported release
241-U-107 Single-Shell Tank	--	--	--	--	--	No reported release
241-U-108 Single-Shell Tank	--	--	--	--	--	No reported release
241-U-109 Single-Shell Tank	--	--	--	--	--	No reported release
241-U-110 Single-Shell Tank	--	--	--	--	S	Also described by UPR-200-W-156
241-U-111 Single-Shell Tank	--	--	--	--	--	No reported release
241-U-112 Single-Shell Tank	--	--	--	--	S	Also described by UPR-200-W-157
241-U-201 Single-Shell Tank	--	--	--	--	--	No reported release
241-U-202 Single-Shell Tank	--	--	--	--	--	No reported release
241-U-203 Single-Shell Tank	--	--	--	--	--	No reported release
241-U-204 Single-Shell Tank	--	--	--	--	--	No reported release
241-U-301 Catch Tank	--	--	--	--	--	No reported release
241-U-361 Settling Tank	--	--	--	--	--	No reported release (See Unplanned Release UN-200-W-19)

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Table 4-1. Summary of Known and Suspected Radionuclide Contamination.

Source Waste Management Unit	Air	Surface Soil (0-1 m)	Surface Water	Biota	Vadose Zone	Remarks
241-U-302 Catch Tank	--	--	--	--	--	No reported release (See Unplanned Release UN-200-W-6)
244-U Receiver Tank	--	--	--	--	--	No reported release
244-UR-Vault	--	--	--	--	S	Also described by UPR-200-W-24
241-WR Vault	--	--	--	--	--	No reported release
Cribs and Drains						
216-S-21 Crib	S	S	--	S	--	
216-U-1 and 216-U-2 Cribs	S	K	--	--	K	Uranium contamination identified in perched water zones
216-U-8 Crib	S	S	--	S	S	
216-U-12 Crib	--	--	--	--	S	
216-U-16 Crib	--	--	--	--	S	
216-U-17 Crib	--	--	--	--	S	
216-Z-20 Crib	--	--	--	--	S	
216-S-4 French Drain	S	S	--	S	S	
216-U-3 French Drain	--	--	--	--	S	
216-U-4A French Drain	--	--	--	--	S	Began to plug--possibility of overflow to surface soil
216-U-4B French Drain	--	--	--	--	S	Received overflow from 216-U-4 Reverse Well to possibly cause some surface or near-surface contamination
216-U-7 French Drain	--	--	--	--	S	

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Table 4-1. Summary of Known and Suspected Radionuclide Contamination.

Source Waste Management Unit	Air	Surface Soil (0-1 m)	Surface Water	Biota	Vadose Zone	Remarks
Reverse Wells						
216-U-4 Reverse Well	--	--	--	--	S	
Ponds, Ditches, and Trenches						
216-U-10 Pond	--	R?	--	--	K	
216-U-14 Ditch	S	K,R? (banks of ditch)	S	S	K	
216-Z-1D Ditch	--	K,R?	--	--	K	
216-Z-11 Ditch	--	K,R?	--	--	K	
216-Z-19 Ditch	--	K,R?	--	--	K	
216-U-5 and 216-U-6 Trenches	--	--	--	--	S	
216-U-11 Trench	--	--	--	--	K	
216-U-13 Trench	--	--	--	--	S	
216-U-15 Trench	--	--	--	--	--	
Septic Tanks and Associated Drain Fields						
2607-W-5 Septic Tank/Drain Field	--	--	--	--	--	No reported contaminants Discharged to 216-U-1 and 216-U-2 Cribs
2607-W-7 Septic Tank/Drain Field	--	--	--	--	--	No reported release
2607-W-9 Septic Tank	--	--	--	--	--	No reported contaminants
2607-WUT Septic Tank	--	--	--	--	--	No reported contaminants

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Table 4-1. Summary of Known and Suspected Radionuclide Contamination.

Source Waste Management Unit	Air	Surface Soil (0-1 m)	Surface Water	Biota	Vadose Zone	Remarks
Transfer Facilities, Diversion Boxes, and Pipelines						
241-U-151 Diversion Box	--	--	--	--	--	No reported release (See Unplanned Release UN-200-W-6)
241-U-152 Diversion Box	--	--	--	--	--	No reported release (See Unplanned Release UN-200-W-6)
241-U-153 Diversion Box	--	--	--	--	--	No reported release
241-U-252 Diversion Box	--	--	--	--	--	No reported release
241-UR-151 Diversion Box	--	--	--	--	--	No reported release
241-UR-152 Diversion Box	--	--	--	--	--	No reported release
241-UR-153 Diversion Box	--	--	--	--	--	No reported release
241-UR-154 Diversion Box	--	--	--	--	--	No reported release
241-UX-154 Diversion Box	--	--	--	--	--	No reported release (See Unplanned Release UN-200-W-6)
241-U-A Valve Pit	--	--	--	--	--	No reported release
241-U-B Valve Pit	--	--	--	--	--	No reported release
241-U-C Valve Pit	--	--	--	--	--	No reported release
241-U-D Valve Pit	--	--	--	--	--	No reported release
Retention Basins						
207-U Retention Basin	S	S	S	S	S	

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Table 4-1. Summary of Known and Suspected Radionuclide Contamination.

Source Waste Management Unit	Air	Surface Soil (0-1 m)	Surface Water	Biota	Vadose Zone	Remarks
Burial Sites						
Burial Ground/Burning Pit	--	--	--	--	--	
Construction Surface Laydown Area	--	--	--	--	--	No reported contaminants
Unplanned Releases						
UN-200-W-6	--	S	--	--	--	
UN-200-W-19	--	S,R?	--	--	S,R?	
UN-200-W-33	--	S,R?	--	--	S,R?	
UN-200-W-39	--	S	--	--	S	Site is now under the 224-UA Addition
UN-200-W-46	--	--	--	--	--	In 1958, contamination was reported on all outside horizontal surfaces.
UN-200-W-48	--	S	--	--	--	
UN-200-W-55	--	S,R?	--	--	--	
UN-200-W-60	--	S,R?	--	--	--	
UN-200-W-68	--	S	--	--	S	
UN-200-W-71	--	S,R	--	--	--	
UN-200-W-78	--	K,R?	--	--	--	
UN-200-W-86	--	K,R	--	--	--	
UN-200-W-101	S	K	--	S	S	
UN-200-W-111	--	S	--	S	S	
UN-200-W-112	--	S	--	S	S	

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Table 4-1. Summary of Known and Suspected Radionuclide Contamination.

Source Waste Management Unit	Air	Surface Soil (0-1 m)	Surface Water	Biota	Vadose Zone	Remarks
UN-200-W-117	--	S	--	S	S	
UN-200-W-118	S	S	--	S	S	Windborne particulate
UN-200-W-125	--	S	--	S	S	Same as 216-U-15 Trench
UN-200-W-138	--	S	--	S	S	
UN-200-W-161	S	K	--	S	S	
UPR-200-W-24	S	K	--	S	S	
UPR-200-W-104	--	K,R?	--	S	S	
UPR-200-W-105	--	K,R?	--	S	S	
UPR-200-2-106	--	K,R?	--	S	S	
UPR-200-W-107	--	K,R?	--	S	S	
UPR-200-W-110	--	K	--	S	S	
UPR-200-W-128	--	S	--	S	S	
UPR-200-W-154	--	--	--	--	S	
UPR-200-W-155	--	--	--	--	S	
UPR-200-W-156	--	--	--	--	S	
UPR-200-W-157	--	--	--	--	S	
Uranium Contamination Leak	--	S	--	S	S	

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Table 4-1. Summary of Known and Suspected Radionuclide Contamination.

Source Waste Management Unit	Air	Surface Soil (0-1 m)	Surface Water	Biota	Vadose Zone	Remarks
Paint Waste Spill	--	--	--	--	--	

Notes:

- S Suspected contamination, primarily based on WIDS (WHC 1991a) and other waste inventory data.
- K Known contamination based on chemical analytical data, WIDS (WHC 1991a), or other sources.
- R Complete remediation reported.
- R? Remediation attempted, effectiveness not documented.
- NC No contamination indicated.

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Table 4-2. Summary of Chemical Contamination in Various Affected Media for
U Plant Aggregate Area.

Source Waste Management Unit	Air	Surface Soil (0-1 m)	Surface Water	Biota	Vadose Zone	Remarks
Tanks and Vaults						
241-U-101 Single-Shell Tank	--	--	--	--	S	Also described by UPR-200-W-154
241-U-102 Single-Shell Tank	--	--	--	--	--	No reported release
241-U-103 Single-Shell Tank	--	--	--	--	S	As described by UPR-200-W-128
241-U-104 Single-Shell Tank	--	--	--	--	S	Also described by UPR-200-W-155
241-U-105 Single-Shell Tank	--	--	--	--	--	No reported release
241-U-106 Single-Shell Tank	--	--	--	--	--	No reported release
241-U-107 Single-Shell Tank	--	--	--	--	--	No reported release
241-U-108 Single-Shell Tank	--	--	--	--	--	No reported release
241-U-109 Single-Shell Tank	--	--	--	--	--	No reported release
241-U-110 Single-Shell Tank	--	--	--	--	S	Also described by UPR-200-W-156
241-U-111 Single-Shell Tank	--	--	--	--	--	No reported release
241-U-112 Single-Shell Tank	--	--	--	--	S	Also described by UPR-200-W-157
241-U-201 Single-Shell Tank	--	--	--	--	--	No reported release
241-U-202 Single-Shell Tank	--	--	--	--	--	No reported release
241-U-203 Single-Shell Tank	--	--	--	--	--	No reported release
241-U-204 Single-Shell Tank	--	--	--	--	--	No reported release
241-U-301 Catch Tank	--	--	--	--	--	No reported release
241-U-361 Settling Tank	--	--	--	--	S	No reported release (See Unplanned Release UN-200-W-19)

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**Table 4-2. Summary of Chemical Contamination in Various Affected Media for
U Plant Aggregate Area.**

Source Waste Management Unit	Air	Surface Soil (0-1 m)	Surface Water	Biota	Vadose Zone	Remarks
241-U-302 Catch Tank	--	--	--	--	S	No reported release (See Unplanned Release UN-200-W-6)
244-U Receiver Tank	--	--	--	--	--	No reported release
244-UR-Vault	--	--	--	--	S	Also described by UPR-200-W-24
241-WR Vault	--	--	--	--	--	No reported release
Cribs and Drains						
216-S-21 Crib	--	--	--	--	S	
216-U-1 and 216-U-2 Cribs	S	S	--	S	S	
216-U-8 Crib	--	--	--	--	S	
216-U-12 Crib	--	--	--	--	S	
216-U-16 Crib	--	--	--	--	S	
216-U-17 Crib	--	--	--	--	S	
216-Z-20 Crib	S	S	--	S	S	
216-S-4 French Drain	--	--	--	S	--	
216-U-3 French Drain	--	--	--	--	S	
216-U-4A French Drain	--	--	--	--	S	Began to plug--possibility of overflow to surface soil
216-U-4B French Drain	--	--	--	--	S	Received overflow from 216-U-4 to possibly cause some surface or near-surface contamination
216-U-7 French Drain	--	--	--	--	S	

Table 4-2. Summary of Chemical Contamination in Various Affected Media for U Plant Aggregate Area.

Source Waste Management Unit	Air	Surface Soil (0-1 m)	Surface Water	Biota	Vadose Zone	Remarks
Reverse Wells						
216-U-4 Reverse Well	--	--	--	--	S	
Ponds, Ditches and Trenches						
216-U-10 Pond	--	--	--	--	S	
216-U-14 Ditch	--	--	--	--	S	
216-Z-1D Ditch	--	--	--	--	S	
216-Z-11 Ditch	--	--	--	--	S	
216-Z-19 Ditch	--	--	--	--	S	
216-U-5 and 216-U-6 Trenches	--	--	--	--	S	
216-U-11 Trench	--	--	--	--	S	
216-U-13 Trench	--	--	--	--	S	
216-U-15 Trench	S	S	--	S	S	
Septic Tanks and Associated Drain Fields						
2607-W-5 Septic Tank/Drain Field	--	--	--	--	--	No reported contaminants Discharged to 216-U-1 and 216-U-2 Cribs
2607-W-7 Septic Tank/Drain Field	--	--	--	--	--	No reported release
2607-W-9 Septic Tank	--	--	--	--	--	No reported contaminants
2607-WUT Septic Tank/Drain Field	--	--	--	--	--	No reported contaminants

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**Table 4-2. Summary of Chemical Contamination in Various Affected Media for
U Plant Aggregate Area.**

Source Waste Management Unit	Air	Surface Soil (0-1 m)	Surface Water	Biota	Vadose Zone	Remarks
Transfer Facilities, Diversion Boxes, and Pipelines						
241-U-151 Diversion Box	--	--	--	--	S	No reported release (See Unplanned Release UN-200-W-6)
241-U-152 Diversion Box	--	--	--	--	S	No reported release (See Unplanned Release UN-200-W-6)
241-U-153 Diversion Box	--	--	--	--	--	No reported release
241-U-252 Diversion Box	--	--	--	--	--	No reported release
241-UR-151 Diversion Box	--	--	--	--	--	No reported release
241-UR-152 Diversion Box	--	--	--	--	--	No reported release
241-UR-153 Diversion Box	--	--	--	--	--	No reported release
241-UR-154 Diversion Box	--	--	--	--	--	No reported release
241-UX-154 Diversion Box	--	--	--	--	--	No reported release (See Unplanned Release UN-200-W-6)
241-U-A Valve Pit	--	--	--	--	--	No reported release
241-U-B Valve Pit	--	--	--	--	--	No reported release
241-U-C Valve Pit	--	--	--	--	--	No reported release
241-U-D Valve Pit	--	--	--	--	--	No reported release
Basins						
207-U Retention Basin	S	--	K	S	--	

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**Table 4-2. Summary of Chemical Contamination in Various Affected Media for
U Plant Aggregate Area.**

Source Waste Management Unit	Air	Surface Soil (0-1 m)	Surface Water	Biota	Vadose Zone	Remarks
Burial Sites						
Burial Ground/Burning Pit	--	--	--	--	--	
Construction Surface Laydown Area	--	--	--	--	--	No reported contaminants
Unplanned Releases						
UN-200-W-6	--	--	--	--	--	
UN-200-W-19	S	--	--	S	--	
UN-200-W-33	--	--	--	--	--	
UN-200-W-39	--	--	--	--	--	Site is now under the 224-UA Addition
UN-200-W-46	--	--	--	--	--	In 1958, contamination was reported on all outside horizontal surfaces.
UN-200-W-48	--	--	--	--	--	
UN-200-W-55	--	--	--	--	--	
UN-200-W-60	--	--	--	--	--	
UN-200-W-68	--	--	--	--	--	
UN-200-W-71	--	--	--	--	--	
UN-200-W-78	--	--	--	--	--	
UN-200-W-86	--	--	--	--	--	
UN-200-W-101	--	--	--	--	--	
UN-200-W-111	S	S	--	S	S	
UN-200-W-112	S	S	--	S	S	

**Table 4-2. Summary of Chemical Contamination in Various Affected Media for
U Plant Aggregate Area.**

Source Waste Management Unit	Air	Surface Soil (0-1 m)	Surface Water	Biota	Vadose Zone	Remarks
UN-200-W-117	--	--	--	--	--	
UN-200-W-118	S	S	--	S	S	Windborne particulate
UN-200-W-125	S	S	--	S	S	Same as 216-U-15 Trench
UN-200-W-138	S	S	--	S	S	
UN-200-W-161	--	--	--	--	--	
UPR-200-W-18	--	--	--	--	--	
UPR-200-W-24	--	--	--	--	S	
UPR-200-W-104	--	--	--	--	--	
UPR-200-W-105	--	--	--	--	--	
UPR-200-2-106	--	--	--	--	--	
UPR-200-W-107	--	--	--	--	--	
UPR-200-W-110	--	--	--	--	--	
UPR-200-W-128	--	--	--	--	--	
UPR-200-W-154	--	--	--	--	--	
UPR-200-W-155	--	--	--	--	--	
UPR-200-W-156	--	--	--	--	--	
UPR-200-W-157	--	--	--	--	--	
Uranium Contamination Leak	--	--	--	S	S	

**Table 4-2. Summary of Chemical Contamination in Various Affected Media for
U Plant Aggregate Area.**

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Source Waste Management Unit	Air	Surface Soil (0-1 m)	Surface Water	Biota	Vadose Zone	Remarks
Paint Waste Spill	S	S	--	S	S	

Notes:

- S Suspected contamination, based on WIDS (WHC 1991a), *200-UP-2 Operable Unit Technical Baseline Report* (DeFord 1991), other waste inventory data, and available sampling and analysis information.
- K Known contamination based on WIDS (WHC 1991a), *200-UP-2 Operable Unit Technical Baseline Report* (DeFord 1991), or other sources.
- R Complete remediation reported.
- R? Remediation attempted, effectiveness not documented.
- NC No contamination indicated by the available data.

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Table 4-3. Types of Data Available for Each Waste Management Unit.

Waste Management Unit or Unplanned Release	Inventory	Surface Radiological Survey	External Radiation Monitoring	Waste, Soil, or Sediment Sampling	Biota Sampling	Borehole Geophysics
Tanks and Vaults						
241-U-101 Single-Shell Tank	R,C	--	--	--	--	R
241-U-102 Single-Shell Tank	R,C	--	--	R	--	R
241-U-103 Single-Shell Tank	R,C	--	--	R	--	R
241-U-104 Single-Shell Tank	R,C	--	--	--	--	R
241-U-105 Single-Shell Tank	R,C	--	--	R	--	R
241-U-106 Single-Shell Tank	R,C	--	--	R	--	R
241-U-107 Single-Shell Tank	R,C	--	--	R	--	R
241-U-108 Single-Shell Tank	R,C	--	--	R	--	R
241-U-109 Single-Shell Tank	R,C	--	--	R	--	R
241-U-110 Single-Shell Tank	R,C	--	--	R	--	R
241-U-111 Single-Shell Tank	R,C	--	--	R	--	R
241-U-112 Single-Shell Tank	R,C	--	--	--	--	R
241-U-201 Single-Shell Tank	R,C	--	--	R	--	R
241-U-202 Single-Shell Tank	R,C	--	--	R	--	R
241-U-203 Single-Shell Tank	R,C	--	--	R	--	R
241-U-204 Single-Shell Tank	R,C	--	--	R	--	R
241-U-301 Catch Tank	--	--	--	--	--	--
241-U-361 Settling Tank	--	--	--	--	--	--

Table 4-3. Types of Data Available for Each Waste Management Unit.

Waste Management Unit or Unplanned Release	Inventory	Surface Radiological Survey	External Radiation Monitoring	Waste, Soil, or Sediment Sampling	Biota Sampling	Borehole Geophysics
241-U-302 Catch Tank	--	--	--	--	--	--
244-U Receiver Tank	--	--	--	--	--	--
241-WR Vault	--	--	--	--	--	--
244-UR Vault	--	--	--	--	--	--
Cribs and Drains						
216-S-21 Crib	R,C	R	--	--	--	R
216-U-1 and 216-U-2 Cribs	R,C	R	--	--	--	R
216-U-8 Crib	R,C	R	--	--	--	R
216-U-12 Crib	R	R	R	--	--	R
216-U-16 Crib	R	R	--	--	--	R
216-U-17 Crib	R	R	--	--	--	R
216-Z-20 Crib	R,C	R	R	--	--	--
216-S-4 French Drain	R	R	--	--	--	--
216-U-3 French Drain	R	R	--	--	--	R
216-U-4A French Drain	R	R	--	--	--	--
216-U-4B French Drain	R	R	--	--	--	--
216-U-7 French Drain	R	R	--	--	--	--

Table 4-3. Types of Data Available for Each Waste Management Unit.

Waste Management Unit or Unplanned Release	Inventory	Surface Radiological Survey	External Radiation Monitoring	Waste, Soil, or Sediment Sampling	Biota Sampling	Borehole Geophysics
Reverse Wells						
216-U-4 Reverse Well	C	R	--	--	--	--
Ponds, Ditches, and Trenches						
216-U-10 Pond	R	R	R	R	--	--
216-U-14 Ditch	--	R	R	R	--	R
216-Z-1D Ditch	R	--	--	R	--	--
216-Z-11 Ditch	R	--	--	R	--	--
216-Z-19 Ditch	R	R	--	R	--	--
216-U-5 Trench	R,C	R	--	--	--	--
216-U-6 Trench	R	R	--	--	--	--
216-U-11 Trench	--	R	--	R	--	--
216-U-13 Trench	R	R	--	--	--	--
216-U-15 Trench	R,C	R	--	--	--	--
Septic Tanks and Associated Drain Fields						
2607-W-5 Septic Tank/Drain Field	--	--	--	--	--	--
2607-W-7 Septic Tank/Drain Field	--	--	--	--	--	--
2607-W-9 Septic Tank/Drain Field	--	--	--	--	--	--
2607-WUT Septic Tank/Drain Field	--	--	--	--	--	--

Table 4-3. Types of Data Available for Each Waste Management Unit.

Waste Management Unit or Unplanned Release	Inventory	Surface Radiological Survey	External Radiation Monitoring	Waste, Soil, or Sediment Sampling	Biota Sampling	Borehole Geophysics
Transfer Facilities, Diversion Boxes, and Pipelines						
241-U-A,B,C,D Valve Pits	--	--	--	--	--	--
241-U-151 Diversion Box	--	--	--	--	--	--
241-U-152 Diversion Box	--	--	--	--	--	--
241-U-153 Diversion Box	--	--	--	--	--	--
241-U-252 Diversion Box	--	--	--	--	--	--
241-UR-151 Diversion Box	--	--	--	--	--	--
241-UR-152 Diversion Box	--	--	--	--	--	--
241-UR-153 Diversion Box	--	--	--	--	--	--
241-UR-154 Diversion Box	--	--	--	--	--	--
241-UX-154 Diversion Box	--	--	--	--	--	--
Basins						
207-U Retention Basin	--	R	--	R	R	--
Burial Sites						
Burial Ground/Burning Pit	--	--	--	--	--	--
Construction Surface Laydown Area	--	--	--	--	--	--
Unplanned Releases						
UN-200-W-6	--	--	--	--	--	--
UN-200-W-19	--	--	--	--	--	--

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Table 4-3. Types of Data Available for Each Waste Management Unit.

Waste Management Unit or Unplanned Release	Inventory	Surface Radiological Survey	External Radiation Monitoring	Waste, Soil, or Sediment Sampling	Biota Sampling	Borehole Geophysics
UN-200-W-33	--	--	--	--	--	--
UN-200-W-39	--	--	--	--	--	--
UN-200-W-46	--	--	--	--	--	--
UN-200-W-48	--	--	--	--	--	--
UN-200-W-55	--	--	--	--	--	--
UN-200-W-60	--	--	--	--	--	--
UN-200-W-68	--	--	--	--	--	--
UN-200-W-71	--	--	--	--	--	--
UN-200-W-78	--	--	--	--	--	--
UN-200-W-86	--	--	--	--	--	--
UN-200-W-101	--	R	--	--	--	--
UN-200-W-111	--	R	--	--	--	--
UN-200-W-112	--	R	--	--	--	--
UN-200-W-117	--	R	--	--	--	--
UN-200-W-118	--	R	--	--	--	--
UN-200-W-125	R,C	R	--	--	--	--
UN-200-W-138	R	R	--	--	--	--
UN-200-W-161	--	R	--	R	--	--
UPR-200-W-18	--	--	--	--	--	--

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Table 4-3. Types of Data Available for Each Waste Management Unit.

Waste Management Unit or Unplanned Release	Inventory	Surface Radiological Survey	External Radiation Monitoring	Waste, Soil, or Sediment Sampling	Biota Sampling	Borehole Geophysics
UPR-200-W-24	--	--	--	--	--	--
UPR-200-W-104	R	--	--	R	--	R
UPR-200-W-105	R	--	--	R	--	--
UPR-200-W-106	R	--	--	R	--	--
UPR-200-W-107	R	--	--	R	--	--
UPR-200-W-110	--	R	--	--	--	--
UPR-200-W-128	--	--	--	--	--	--
UPR-200-W-154	R	--	--	--	--	R
UPR-200-W-155	R	--	--	--	--	R
UPR-200-W-156	R	--	--	--	--	R
UPR-200-W-157	R	--	--	--	--	R
Uranium Contamination Leak	R	--	--	--	--	--
Paint Waste Spill	--	--	--	--	--	--

Notes:

C = Chemical-related data

R = Radionuclide-related data

Table 4-4. Summary of Air Monitoring Results (pCi/m³).

Radionuclide	Site					
	N155 ^{a/}	N165 ^{a/}	N168 ^{a/}	N960 ^{a/}	N975 ^{a/}	N995 ^{a/}
Sr-90	5.85E-04	6.55E-04	7.61E-04	5.44E-04	4.02E-04	2.71E-04
Cs-137	1.24E-03	1.37E-04	6.36E-04	4.97E-04	1.60E-04	1.37E-03
Pu-239	2.29E-05	2.37E-04	3.77E-05	2.52E-05	2.28E-05	4.33E-05
U (total)	4.56E-05	4.45E-05	2.92E-04	5.04E-05	4.67E-05	5.33E-04

a/ These values are averages for each year with a detection since 1985.

See Appendix A for complete data set.

See Plate 2 for sampling locations.

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**Table 4-5. Radiation and Dose Rate Surveys at the U Plant Aggregate Area
Waste Management Units.**

Waste Management Unit	Radiation Surveys			Survey Date	Radiation Type
	ct/min	dis/min	mrem/h		
Tanks and Vaults					
241-U-361 Settling Tank	NA	NA	NA	--	--
241-UX-302A Catch Tank	NA	NA	NA	--	--
241-WR Vault	NA	NA	NA	--	--
Cribs and Drains					
261-S-21 Crib	NC	NC	NC	Aug-90	--
216-U-1 & U-2 Cribs	--	25,000	--	Sep-91	β
216-U-8 Crib	NC	NC	NC	Aug-90	--
216-U-12 Crib	NC	NC	0.01	1990	--
216-U-16 Crib	NC	NC	NC	Aug-90	--
216-U-17 Crib	NC	NC	NC	Sep-90	--
216-Z-20 Crib	NC	NC	0.01	1990	Unknown
216-S-4 French Drain	NC	NC	NC	Aug-90	--
216-U-3 French Drain	NC	NC	NC	Aug-90	--
216-U-4A French Drain	--	--	<1	Mar-85	Unknown
216-U-4B French Drain	3,000	--	--	Mar-85	Unknown
216-U-7 French Drain	35,000	--	--	1991	Unknown
Reverse Wells					
216-U-4 Reverse Well	--	--	<1	Mar-85	β
Ponds, Ditches, and Trenches					
216-U-10 Pond	500	--	--	Dec-90	--
216-U-11 Trench	NC	NC	NC	Aug-90	--

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Table 4-5. Radiation and Dose Rate Surveys at the U Plant Aggregate Area Waste Management Units.

Waste Management Unit	Radiation Surveys			Survey Date	Radiation Type
	ct/min	dis/min	mrem/h		
216-U-14 Ditch	--	2,000	13	Jun-90	Unknown
216-Z-1D Ditch	NC	NC	NC	Dec-90	--
216-Z-11 Ditch	NA	NA	NA	--	--
216-Z-19 Ditch	NC	NC	0.01	Dec-90	Unknown
216-U-5 Trench	NC	NC	NC	1990	--
216-U-6 Trench	NC	NC	NC	1990	--
216-U-13 Trench	NC	NC	NC	1981	--
216-U-15 Trench	NC	NC	NC	Aug-81	--
Septic Tanks and Associated Drain Fields					
2607-W5 Septic Tank/Drain Field	NA	NA	NA	--	--
2607-W7 Septic Tank/Drain Field	NA	NA	NA	--	--
2607-W9 Septic Tank/Drain Field	NA	NA	NA	--	--
Diversion Boxes					
241-U-151 Diversion Box	NA	NA	NA	--	--
241-U-152 Diversion Box	NA	NA	NA	--	--
241-UX-154 Diversion Box	NA	NA	NA	--	--
Basins					
207-U Retention Basin	--	70,000	--	Jul-90	Unknown
Burial Sites					
Burial Ground/Burning Pit	NA	NA	NA	--	--
200-W Burial Ground	NA	NA	NA	--	--

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Table 4-5. Radiation and Dose Rate Surveys at the U Plant Aggregate Area Waste Management Units.

Waste Management Unit	ct/min	Radiation Surveys		Survey Date	Radiation Type
		dis/min	mrem/h		
Unplanned Releases					
UN-200-W-6 Unplanned Release	NA	NA	NA	--	--
UN-200-W-19 Unplanned Release	NA	NA	NA	--	--
UN-200-W-33 Unplanned Release	NC	NC	NC	Dec-70	--
UN-200-W-39 Unplanned Release	NC	NC	NC	July-72	--
UN-200-W-46 Unplanned Release	NA	NA	NA	--	--
UN-200-W-48 Unplanned Release	NA	NA	NA	--	--
UN-200-W-55 Unplanned Release	NA	NA	NA	--	--
UN-200-W-60 Unplanned Release	NA	NA	NA	--	--
UN-200-W-68 Unplanned Release	NA	NA	NA	--	--
UN-200-W-78 Unplanned Release	NA	NA	NA	--	--
UN-200-W-86 Unplanned Release	NA	NA	NA	--	--
UN-200-W-101 Unplanned Release	35,000	--	--	1991	Unknown
UN-200-W-117 Unplanned Release	NC	NC	NC	--	--
UN-200-2-118 Unplanned Release	NC	NC	NC	--	--
UN-200-W-161 Unplanned Release	500	--	--	Oct-90	Unknown

NA = No data available
 NC = No contamination detected

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Table 4-6. Results of External Radiation Monitoring, 1985 through 1989: TLDs (mrem/yr).

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Location	1985	1986	1987	1988	1989	Average Total
2W18: 216-U-14 Ditch W						
Max	74	88	108	104		
Min	57	58	74	88		
Total	66	69	90	94		80
2W21: 200 W W						
Max	76	98	100	110		
Min	62	62	75	85		
Total	68	76	85	96		81
2W22: Z-Plant-S						
Max	82	96	110	124		
Min	66	62	68	93		
Total	73	75	83	105		84
2W23: 241-U E						
Max	205	227	247	249	232	
Min	148	162	175	208	124	
Total	175	190	204	220	194	197
2W24: U-Plant SE						
Max	78	101	107	111	128	
Min	64	74	77	93	68	
Total	73	85	88	103	100	90

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Table 4-6. Results of External Radiation Monitoring, 1985 through 1989: TLDs (mrem/yr).

Location	1985	1986	1987	1988	1989	Average Total
2W25: 200 West Area E						
Max	72	96	106	117		
Min	61	66	72	87		
Total	68	76	88	96		82
2W26: 200 W W						
Max	77	94	119	113		
Min	64	66	77	89		
Total	70	75	93	100		85
2W27: SE U-10 Covered Pond						
Max		106	128	124		
Min		80	79	101		
Total		93	100	109		101
2W29: U-Plant S						
Max	81	95	120	123		
Min	64	70	79	94		
Total	73	79	100	104		89
2W30: 200 West Area SE						
Max	78	100	112	114		
Min	59	66	78	90		
Total	68	78	95	98		85

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Table 4-6. Results of External Radiation Monitoring, 1985 through 1989: TLDs (mrem/yr).

Location	1985	1986	1987	1988	1989	Average Total
U-10 Pond						
Max	572	95	95	193	112	
Min	572	70	72	61	72	
Total	572	78	83	112	99	189
U-14 Ditch: 216-U-14						
Max		80	78	129	108	
Min		60	61	63	15	
Total		67	69	90	90	79
Z-19 Ditch: 216-Z-19						
Max	75	81	91	110	152	
Min	58	68	68	67	96	
Total	68	72	81	87	118	85

Source: Schmidt et al. 1990; Elder et al. 1986, 1987, 1988, 1989.

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Table 4-7. Results of External Radiation Monitoring for 1990 (mrem/yr).

Location	Maximum	Minimum	Average
205: 216-Z-20	116	88	102
206: 216-U-14	136	92	117
207: 216-U-10	108	88	97
208: 241-U-East	208	52	135
209: 221-U-Southeast	116	92	105
211: 216-U-12 South	116	100	106
212: 216-U-12 North	116	96	102

Source: Schmidt et al. 1992.

9 3 1 2 7 8 0 6 4 2

Table 4-8. Summary of Grid Soil Sampling Results (pCi/g).

Radionuclide	Site									
	2W18 ^{a/}	2W21 ^{a/}	2W22 ^{a/}	2W23 ^{a/}	2W24 ^{a/}	2W25 ^{a/}	2W26 ^{a/}	2W27 ^{a/}	2W29 ^{a/}	2W30 ^{a/}
Ce-141		2.5E-02		-7.70E-02	-4.30E-02	-2.20E-02		-7.60E-03	-1.80E-02	-3.11E-02
Ce-144		1.1E-01		1.44E-01	-1.63E-02	-4.70E-02		-1.10E-02	9.70E-02	3.34E-03
Co-58		2.5E-02		2.51E-02	2.68E-02	1.90E-02		-3.80E-03	5.20E-03	5.29E-02
Co-60	2.60E-04	1.1E-02	9.5E-03	3.51E-02	4.96E-03	-5.50E-03	1.0E-02	-1.18E-02	1.64E-02	2.64E-03
Cs-134	6.00E-02	3.5E-02	3.0E-02	1.35E-02	1.36E-02	2.70E-02		5.45E-02	2.80E-02	5.22E-02
Cs-137	1.68E+00	8.1E-01	1.1E+00	5.99E+01	2.01E+00	7.40E-01	3.1E-01	2.79E+00	1.62E+00	1.18E+00
Eu-152	9.90E-02	4.1E-02	1.4E-01	3.92E-02	6.46E-02	1.03E-01	1.1E-01	9.45E-02	1.05E-01	9.39E-02
Eu-154	1.70E-02	-5.1E-02	1.8E-02	6.39E-02	5.43E-02	6.52E-02	-6.8E-03	-1.03E-02	3.30E-02	1.70E-03
Eu-155	1.30E-02	5.5E-02	4.5E-02	-2.09E-02	2.38E-02	3.54E-02	5.4E-02	4.20E-02	4.00E-02	3.41E-02
I-129				1.81E-01	1.03E-01			3.30E-01		-2.53E-01
K-40				1.44E+01	1.36E+01					1.52E+01
Mn-54	1.12E-02	2.4E-02	-2.4E-03	6.30E-03	3.61E-02	2.33E-02	5.6E-03	1.85E-03	2.50E-03	8.16E-03
Nb-95	-8.80E-03	-2.7E-02	-1.7E-02	-3.61E-02	4.50E-02	-1.10E-02	1.6E-02	-2.40E-03	-1.30E-02	-1.16E-02
Pb-212				6.38E-01	6.98E-01					7.92E-01
Pb-214	5.70E-01	5.6E-01	6.5E-01	6.16E-01	6.25E-01	5.70E-01	6.0E-01	5.50E-01	6.50E-01	6.56E-01
Pu-238	1.25E-02	2.4E-03	2.6E-03	2.21E-02	1.33E-03	7.93E-04	8.6E-04	1.86E-03	5.53E-03	4.50E-03
Pu-239	6.62E-01	4.4E-02	5.7E-02	1.27E+00	5.22E-02	2.67E-02	2.4E-02	4.60E-02	7.00E-02	1.05E-01
Ru-106	1.03E-01	-1.0E-01	2.3E-01	-1.74E-01	6.37E-02	8.50E-03	-4.6E-02	9.05E-02	3.00E-01	8.13E-03
Sr-90	2.70E-01	3.3E-01	6.3E-01	1.48E+00	3.85E-01	3.40E-01	1.9E-01	6.47E-01	7.35E-01	4.09E-01
Tc-99				2.35E-01	3.00E-01			4.10E-01		1.64E-01
U	3.33E-01	2.6E-01	3.5E-01	4.41E-01	8.77E-01	7.07E-01	2.4E-01	3.33E-01	3.93E-01	1.07E+00
Zn-65		3.4E-02		-5.22E-02	-9.10E-02	-3.10E-02		7.50E-04	-6.80E-03	-4.94E-02
Zr-95	-1.70E-03	2.2E-02	3.4E-02	7.17E-02	-1.16E-02	1.70E-02	1.8E-02	7.81E-03	0.00E+00	-3.90E-03

a/ These values are averages for each year with a detection since 1985.
See Plate 3 for sampling locations.

Table 4-9. Summary of Fenceline Soil Sampling Results (pCi/g).

Radionuclide	Site		
	U-TF-SE ^{a/}	U-TF-W ^{a/}	U-TF-NE ^{a/}
Ce-141	1.03E-03	2.77E-02	-5.20E-02
Ce-144	-1.57E-02	1.99E-02	8.14E-02
Co-58	2.13E-02	4.40E-03	-2.19E-02
Co-60	1.33E-02	-8.25E-04	2.12E-02
Cs-134	1.72E-02	1.15E-02	8.75E-03
Cs-137	7.89E+00	1.16E+00	2.56E+02
Eu-152	6.19E-02	1.07E-01	1.65E-02
Eu-154	2.96E-02	1.00E-02	-3.95E-02
Eu-155	9.60E-03	5.01E-02	6.63E-02
K-40	1.45E+01	-1.44E+01	1.39E+01
Mn-54	1.66E-02	1.15E-02	1.10E-02
Nb-95	-2.71E-02	-3.74E-02	-2.65E-02
Pb-212	6.47E-01	7.52E-01	5.10E-01
Pb-214	6.12E-01	5.87E-01	4.31E-01
Pu-238	1.65E-03	1.04E-02	
Pu-239	7.73E-02	5.37E-01	3.00E+00
Ru-106	8.33E-03	1.39E-02	-2.92E-01
Sr-90	1.27E+00	1.85E+00	7.00E+01
U	3.81E-01	2.84E-01	
Zn-65	-2.48E-02	7.35E-02	-1.17E-01
Zr-95	2.11E-02	3.30E-02	4.57E-02

a/ These values are averages for each year with a detection since 1985.

RM27: (West) Powerhouse Pond Table 4-10. Results of Surface Water Sampling (pCi/L).

Radionuclide	1985		1986		1987		1988		1989	
	Result	Error	Result	Error	Result	Error	Result	Error	Result	Error
beta (t)	max	4.96E+02	1.39E+02		6.40E+01		2.30E+01		7.00E+00	
	min	7E+00	<1.0E+02		<1.00E+02		<1.00E+02		<1.00E+02	
	avg	5.7E+01	2.77E+02							
alpha (t)	max	2.1E+01	1.3E+01		3.10E+01		<4.00E+01		<4.00E+01	
	min	1E+00	<4.0E+01		<4.0E+01		<4.0E+01		<4.0E+01	
	avg	4E+00	1.1E+01							
Ca-137	max	9.1E+01	7.0E+01		<5.70E+01		<2.00E+02		<6.30E+01	
	min	4.0E+01	<2.00E+0		<2.00E+02		<2.00E+02		<2.00E+02	
	avg	5.3E+01	3.2E+01	2						
Sr-90	max	6.3E+01	3.6E+01		1.19E+02		<1.00E+02		2.30+01	
	min	1.4E+01	<1.00E+0		<1.00E+02		<1.00E+02		<1.00E+02	
	avg	2.8E+01	2.8E+01	2						
pH	max		10.5		10.0		10.4		10.6	
	min		7.2		7.2		6.9		7.9	
	avg		9.2		9.0		9.4		9.3	
NO3 (ppm)	max		<1.2		<1.2		<1.2		<1.2	
	min		<1.2		<1.2		<1.2		<1.2	
	avg		<1.2		<1.2		<1.2		<1.2	

+ Indicates Positive Detection (Result Greater Than Error)

Source: Schmidt et al. 1990, 1992; Elder et al. 1986, 1987, 1988, 1989.

Table 4-11. Summary of Vegetation Sampling Results (pCi/g).

Radionuclide	Site									
	2W18 ^{a/}	2W21 ^{a/}	2W22 ^{a/}	2W23 ^{a/}	2W24 ^{a/}	2W25 ^{a/}	2W26 ^{a/}	2W27 ^{a/}	2W29 ^{a/}	2W30 ^{a/}
Be-7				1.75E+00	2.20E+00					3.14E+00
Ce-141				9.33E-03	-7.38E-03					-4.83E-03
Co-58									9.70E-02	
Co-60	2.70E-03	2.3E-02	6.4E-03	1.58E-02	3.79E-03	2.83E-02	1.4E-02	-4.5E-03	5.00E-02	1.78E-02
Cs-134	1.50E-01	7.2E-02	1.8E-01		1.14E-01			7.5E-02	9.00E-02	
Cs-137	2.26E-01	1.4E-01	1.4E-01	2.40E+00	3.96E-01	3.42E-01	1.5E-01	2.5E-01	6.53E-01	2.32E-01
Eu-152	5.40E-02	8.0E-01	-2.7E-02	4.32E-02	1.58E-02	3.70E-02	4.9E-02	-1.0E-02	1.14E-01	3.43E-02
Eu-154	1.90E-02	1.5E-01	7.1E-03	9.63E-03	2.33E-03	7.30E-03	-3.8E-02	-1.5E-02	6.60E-02	-3.77E-02
Eu-155	1.20E-02	2.1E-02	3.7E-02	1.45E-02	8.75E-03	1.90E-02	-2.5E-02	9.6E-03	3.70E-03	-1.05E-02
I-129				8.27E-02	3.03E-02					-2.86E-01
K-40				1.54E+01	1.11E+01					1.22E+01
Nb-95	-8.00E-03	1.7E-02	5.5E-02	3.13E-02	2.30E-02	-2.70E-04	-3.8E-03	2.0E-01	-1.30E-02	-2.07E-02
Pb-212				1.37E-02	3.27E-02					5.07E-02
Pb-214				6.46E-02	2.16E-02					3.85E-02
Pu-238				1.39E-03	4.73E-04					5.35E-04
Pu-239				5.86E-02	1.38E-02					9.39E-03
Ru-103	1.70E-01	7.7E-02	1.7E-01	6.60E-02	8.90E-02			9.5E-02	8.10E-02	
Ru-106	2.93E-01				2.42E-01			1.3E-01		
Sr-90	4.80E-02		1.9E-02	3.01E-01	1.44E-01				4.20E-01	7.59E-01
Tc-99				7.69E-01	9.97E+00					1.48E+00
Zr-95		2.4E-02		7.01E-02	-1.35E-02			8.3E-02		2.42E-02

a/ These values are averages for each year with a detection since 1985.

Table 4-12. Summary of Gamma-Ray Logs
that were Reviewed.

Waste Management Unit	Well Number	Number of Times Logged	Inclusive Dates	
Tanks				
241-U Tank Farm Perimeter	299-W18-25	2	10/90 to 11/90	
	299-W19-31	2	10/90 to 12/90	
	299-W19-32	2	10/90 to 11/90	
	299-W18-51 (60-00-06)	1	5/63	
	299-W18-52 (60-00-11)	1	5/63	
	299-W18-53 (60-00-10)	1	5/63	
	299-W18-55 (60-00-08)	1	5/63	
	299-W19-53A (60-00-05)	1	5/63	
	299-W19-54A (60-00-02)	1	5/63	
	241-U-101 Single-Shell Tank	299-W18-135 (60-01-08)		
		299-W18-36 (60-01-10)		
241-U-102 Single-Shell Tank	299-W18-137 ^{b/} (60-02-01)			
	299-W18-138 ^{b/} (60-02-05)			
	299-W18-139 ^{b/} (60-02-07)			
	299-W18-140 ^{b/} (60-02-08)			
	299-W18-141 ^{b/} (60-02-10)			
	299-W18-142 ^{b/} (60-02-11)			
241-U-103 Single-Shell Tank	299-W18-143 ^{b/} (60-03-01)			
	299-W18-144 ^{b/} (60-03-05)			
	299-W18-145 ^{b/} (60-03-08)			
	299-W18-146 ^{b/} (60-03-10)			
	299-W18-147 ^{b/} (60-03-11)			

Table 4-12. Summary of Gamma-Ray Logs
that were Reviewed.

Waste Management Unit	Well Number	Number of Times Logged	Inclusive Dates
241-U-104 Single-Shell Tank	299-W18-76 ^{b/} (60-04-03)		
	299-W18-124 ^{b/} (60-04-08)		
	299-W18-125 ^{b/} (60-04-10)		
	299-W18-126 ^{b/} (60-04-12)		
241-U-105 Single-Shell Tank	299-W18-127 ^{b/} (60-05-05)		
	299-W18-128 ^{b/} (60-05-07)		
	299-W18-129 ^{b/} (60-05-10)		
	299-W18-130 ^{b/} (60-05-04)		
	299-W18-176 ^{b/} (60-05-04)		
241-U-106 Single-Shell Tank	299-W18-131 ^{b/} (60-06-07)		
	299-W18-132 ^{b/} (60-06-08)		
	299-W18-133 ^{b/} (60-06-10)		
	299-W18-134 ^{b/} (60-06-11)		
241-U-107 Single-Shell Tank	299-W18-114 ^{b/} (60-07-01)		
	299-W18-116 ^{b/} (60-07-10)		
	299-W18-117 ^{b/} (60-07-11)		
	299-W19-74 ^{b/} (60-07-02)		
241-U-108 Single-Shell Tank	299-W18-54 ^{a/b/} (60-08-10)	1	5/63
	299-W18-115 ^{b/} (60-08-04)		
	299-W18-118 ^{b/} (60-08-08)		
	299-W18-119 ^{b/} (60-08-09)		

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Table 4-12. Summary of Gamma-Ray Logs
that were Reviewed.

Waste Management Unit	Well Number	Number of Times Logged	Inclusive Dates
241-U-109 Single-Shell Tank	299-W18-120 ^{b/}		(60-09-01)
	299-W18-121 ^{b/}		(60-09-07)
	299-W18-122 ^{b/}		(60-09-08)
	299-W18-123 ^{b/}		(60-09-10)
241-U-110 Single-Shell Tank	299-W18-100 ^{b/}		(60-10-01)
	299-W18-104 ^{b/}		(60-10-05)
	299-W18-107 ^{b/}		(60-10-11)
	299-W18-148 ^{b/}		(60-10-07)
	299-W19-75 ^{b/}		(60-10-02)
241-U-111 Single-Shell Tank	299-W18-101 ^{b/}		(60-11-06)
	299-W18-102 ^{b/}		(60-11-03)
	299-W18-105 ^{b/}		(60-11-12)
	299-W18-109 ^{b/}		(60-11-05)
	299-W18-110 ^{b/}		(60-11-07)
241-U-112 Single-Shell Tank	299-W18-90 ^{b/}		(60-12-07)
	299-W18-91 ^{b/}		(60-12-10)
	299-W18-92 ^{b/}		(60-12-05)
	299-W18-103 ^{b/}		(60-12-03)
	299-W18-113 ^{b/}		(60-12-01)

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Table 4-12. Summary of Gamma-Ray Logs
that were Reviewed.

Waste Management Unit	Well Number	Number of Times Logged	Inclusive Dates
Cribs and Drains			
216-S-21 Crib	299-W23-4	6	2/58 to 2/76
216-U-1 and U-2 Cribs	299-W19-3	10	2/58 to 4/85
	299-W19-9	2	3/85 to 5/85
	299-W19-11	2	3/85 to 4/85
	299-W19-15	2	4/85 to 5/85
	299-W19-16	4	4/85 to 6/85
	299-W19-17	1	12/85
	299-W19-18	1	11/85
216-U-8 Crib	299-W19-2	7	3/58 to 5/76
	299-W19-70	1	12/76
	299-W19-71	1	12/76
216-U-12 Crib	299-W22-22	7	5/63 to 9/82
	299-W22-23	5	5/63 to 8/82
	299-W22-28	3	3/64 to 2/68
	299-W22-40	3	3/90 to 5/90
	299-W22-41	2	3/90 to 5/90
	299-W22-42	3	2/90 to 4/90
	299-W22-43	3	3/90 to 5/90
	299-W22-60	2	7/65 to 2/68
	299-W22-73 ^{a/} (06-12-02)	1	8/82
	299-W22-75 ^{a/} (06-12-06)	1	8/82
216-U-16 Crib	299-W19-13	2	3/85 to 4/85
	299-W19-14	1	3/85
216-U-17 Crib	299-W19-19	1	1/87
	299-W19-20	2	6/86
	299-W19-23	2	3/87
	299-W19-24	2	3/87 to 4/87
	299-W19-25	1	4/87
	299-W19-26	2	4/87
	299-W19-89 ^{a/} (06-17-07)	3	2/87 to 3/89
	299-W19-90 ^{a/} (06-17-02)	4	2/87 to 3/89
	299-W19-91 ^{a/} (06-17-02)	4	2/87 to 3/89
216-U-3 French Drain	299-W18-177	2	6/86 to 9/87
	299-W19-1	4	2/58 to 5/87

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**Table 4-12. Summary of Gamma-Ray Logs
that were Reviewed.**

Waste Management Unit	Well Number	Number of Times Logged	Inclusive Dates
Ponds and Ditches			
216-U-10 Pond	299-W18-15	1	9/86
216-U-14 Ditch	299-W19-21	2	6/86 to 7/86
	299-W19-22	2	6/86
	299-W19-27	1	4/87
	299-W19-91	1	4/87
	299-W19-92	1	4/87
	299-W19-93	1	5/87

^{a/} Also logged by WHC Tank Surveillance Group.

^{b/} For each of these wells, logs from every one or two years have been collected.

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Table 4-13. Potential for Past Migration of Liquid Discharges to the Unconfined Aquifer. Page 1 of 2

Waste Management Unit	Range of Soil Column Pore Volumes (m ³) ^{a/}	Liquid Effluent Volume Received (m ³)	Past Migration to Unconfined Aquifer
Cribs and Drains			
216-S-21 Crib	1,200 to 3,500	87,100	Yes
216-U-1 and 216-U-2 Cribs	130 to 400	46,200	Yes
216-U-8 Crib	3,700 to 11,100	379,000	Yes
216-U-12 Crib	460 to 1,400	150,000	Yes
216-U-16 Crib	5,500 to 16,500	409,000	Yes
216-U-17 Crib	700 to 2,100	2,110	Yes
216-Z-20 Crib	7,400 to 22,000	3,800,000	Yes
216-S-4 French Drain	50 to 150	1,000	Yes
216-U-3 French Drain	13 to 39	791	Yes
216-U-4A French Drain	7 to 20	545	Yes
216-U-4B French Drain	3 to 11	33	Yes
216-U-7 French Drain	2 to 7	7	Yes
Reverse Wells			
216-U-4 Reverse Well	0.1 to 0.4	300	Yes
Ponds, Ditches, and Trenches			
216-U-10 Pond	600,000 to 1,800,000	165,000,000	Yes
216-Z-1D Ditch	8,000 to 24,000	1,000	No
216-Z-11 Ditch ^{b/}	NA	NA	NA
216-U-5 and 216-U-6 Trenches	1,100 to 3,300	4,500	Yes

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Table 4-13. Potential for Past Migration of Liquid Discharges to the Unconfined Aquifer. Page 2 of 2

Waste Management Unit	Range of Soil Column Pore Volumes (m ³) ^{a/}	Liquid Effluent Volume Received (m ³)	Past Migration to Unconfined Aquifer
216-U-13 Trench	3,300 to 10,000	11	No
216-U-14 Ditch ^{b/}	NA	NA	NA
216-U-15 Trench	180 to 560	68	No
216-Z-19 Ditch ^{b/}	NA	NA	NA

^{a/} Pore volume calculation: (waste unit section area) x (nominal depth to groundwater) x (porosity). Lower pore volume value reflects 0.10 porosity, higher pore volume reflects 0.3 porosity. Pore volume calculation does not account for the ability of the soil to retain the liquid discharged. Groundwater depth of 50 m was used.

^{b/} There were no waste volume data available for these units so no calculations were made. Liquid volume was included in 216-U-10 Pond effluent volume. The lack of calculations did not exclude these units from consideration for LFIs and IRMs.

Table 4-14. TRAC Inventory Data.

Total (1/1/90)	U-101 Curies	U-102 Curies	U-103 Curies	U-104 Curies	U-105 Curies	U-106 Curies	U-107 Curies	U-108 Curies
1. Ac225	2E-08	2E-08	6E-08	1E-16	4E-09	2E-08	3E-08	7E-09
2. Ac227	3E-05	2E-05	2E-08	9E-13	3E-08	7E-13	4E-05	7E-06
3. Am241	9E+00	5E+00	1E-04	1E-07	2E-01	8E-07	2E+-02	9E+00
4. Am242	3E-05	9E-03	3E-07	4E-12	6E-06	1E-09	2E-01	1E-02
5. Am242m	3E-05	9E-03	3E-07	4E-12	6E-06	1E-09	2E-01	1E-02
6. Am243	6E-03	2E-03	7E-08	5E-11	6E-05	4E-10	9E-02	3E-03
7. At217	2E-08	2E-08	6E-08	1E-16	4E-09	2E-08	3E-08	7E-09
8. Ba135m	0E+00							
9. Ba137m	6E+04	1E+05	2E+01	3E-04	4E+01	2E-04	8E+04	6E+01
10. Bi210	4E-11	5E-12	1E-13	2E-18	4E-13	1E-16	1E-11	9E-12
11. Bi211	3E-05	2E-05	2E-08	9E-13	4E-08	7E-13	4E-05	7E-06
12. Bi213	2E-08	2E-08	6E-08	1E-16	4E-09	2E-08	3E-08	7E-09
13. Bi214	2E-10	1E-11	8E-13	8E-18	2E-12	7E-16	6E-11	5E-11
14. C14	1E+01	3E+01	4E-03	2E-09	7E-03	6E-08	8E+00	1E-02
15. Cm242	3E-05	7E-03	2E-07	3E-12	5E-06	8E-10	2E-01	8E-03
16. Cm244	8E-03	2E-02	2E-06	2E-11	9E-06	2E-11	3E-01	6E-06
17. Cm245	3E-07	1E-06	6E-11	7E-16	6E-10	6E-16	2E-05	2E-10
18. Cs135	4E-01	1E+00	1E+04	3E-09	3E-04	1E-09	4E-01	4E-04
19. Cs137	6E+04	2E+05	2E+01	4E-04	5E+01	3E-04	9E+04	7E+01
20. Fr221	2E-08	2E-08	6E-08	1E-16	4E-09	2E-08	3E-08	7E-09
21. Fr223	4E-07	3E-07	3E-10	1E-14	6E-10	1E-14	6E-07	9E-08
22. I129	3E-02	7E-02	1E-05	2E-10	2E-05	9E-11	1E-01	3E-05
23. Nb93m	1E+00	4E-01	1E-04	9E-08	2E-02	2E-08	4E+00	4E-01

Table 4-14. TRAC Inventory Data.

Total (1/1/90)	U-101 Curies	U-102 Curies	U-103 Curies	U-104 Curies	U-105 Curies	U-106 Curies	U-107 Curies	U-108 Curies
24. Ni59	0E+00							
25. Ni63	2E+02	5E+01	7E-02	5E-08	1E-01	4E-07	6E+01	2E-01
26. Np237	8E-02	2E-01	3E-05	4E-10	4E-05	3E-10	2E-01	1E-04
27. Np239	6E-03	2E-03	7E-08	5E-11	6E-05	3E-10	9E-02	3E-03
28. Pa231	8E-05	3E-05	3E-08	2E-12	2E-07	3E-12	7E-05	2E-05
29. Pa233	8E-02	2E-01	3E-05	4E-10	4E-05	3E-10	2E-01	1E-04
30. Pa234m	2E+00	5E-09	5E-09	8E-08	1E-02	2E-07	5E-07	9E-01
31. Pb209	2E-08	2E-08	6E-08	1E-06	4E-09	2E-08	2E-08	7E-09
32. Pb210	4E-11	5E-12	1E-13	2E-18	3E-13	1E-16	1E-11	8E-12
33. Pb211	3E-05	2E-05	2E-08	9E-13	3E-08	7E-13	4E-05	7E-06
34. Pb214	2E-10	1E-11	8E-13	8E-18	2E-12	7E-16	6E-11	5E-11
35. Pd107	4E-02	1E-01	2E-05	2E-10	3E-05	1E-10	2E-01	5E-05
36. Po210	4E-11	5E-12	1E-13	2E-18	3E-13	1E-16	1E-11	8E-12
37. Po213	2E-08	2E-08	6E-08	1E-16	4E-09	2E-08	3E-08	6E-09
38. Po214	2E-10	1E-11	9E-13	1E-17	2E-12	9E-16	7E-11	6E-11
39. Po215	3E-05	2E-05	2E-08	9E-13	4E-08	7E-13	4E-05	7E-06
40. Po218	2E-10	1E-11	8E-13	8E-18	2E-12	7E-16	6E-11	5E-11
41. Pu238	2E-01	3E-03	1E-02	2E-08	9E-03	2E-05	3E-02	4E-01
42. Pu239	2E+00	1E-05	4E-09	1E-07	5E-02	2E-07	1E-04	1E+01
43. Pu240	4E-01	9E-05	2E-04	3E-08	1E-02	4E-05	4E-04	3E+00
44. Pu241	3E+00	2E-05	3E-07	1E-07	7E-02	5E-07	3E-04	4E+01
45. Ra223	3E-05	2E-05	2E-00	9E-13	3E-08	7E-13	4E-05	7E-06
46. Ra225	2E-08	2E-08	6E-08	1E-16	4E-09	2E-08	3E-08	7E-09
47. Ra226	2E-10	1E-11	8E-13	8E-18	2E-12	7E-16	6E-11	5E-11

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Table 4-14. TRAC Inventory Data.

Total (1/1/90)	U-101 Curies	U-102 Curies	U-103 Curies	U-104 Curies	U-105 Curies	U-106 Curies	U-107 Curies	U-108 Curies
48. Ru106	9E-06	5E-05	8E-09	9E-14	1E-10	9E-12	3E-05	1E-03
49. Sb126	3E-01	2E-01	8E-10	1E-08	6E-03	3E-08	3E+00	1E-01
50. Sb126m	3E-01	2E-01	8E-10	1E-08	6E-03	3E-08	3E+00	1E-01
51. Se79	5E-01	1E+00	2E-04	3E-09	4E-04	1E-09	3E+00	5E-04
52. Sm151	4E+02	2E+02	1E-05	6E-06	7E+00	3E-05	4E+03	1E+02
53. Sn126	3E-01	2E-01	8E-10	1E-08	6E-03	3E-08	3E+00	1E-01
54. Sr90	1E+04	5E+04	2E+00	4E-04	3E+00	2E-03	8E+04	5E+04
55. Tc99	2E+01	5E+01	7E-03	1E-07	1E-02	5E-08	9E+01	2E-02
56. Th227	3E-05	2E-05	2E-08	9E-13	3E-08	7E-13	4E-05	6E-06
57. Th229	2E-08	2E-08	6E-08	1E-16	4E-09	2E-08	3E-08	7E-09
58. Th230	4E-08	4E-10	2E-10	2E-15	4E-10	2E-13	6E-09	1E-08
59. Th231	1E-01	2E-10	2E-10	4E-09	5E-04	9E-09	2E-08	5E-02
60. Th233	0E+00	0E+00	0E+00	0E+00	0E+00	0E+00	0E+00	0E+00
61. Th234	2E+00	5E-09	5E-09	8E-08	1E-02	2E-07	5E-07	9E-01
62. Tl207	3E-05	2E-05	2E-08	9E-13	3E-08	7E-13	4E-05	7E-06
63. U233	1E-05	3E-05	3E-05	8E-14	1E-06	8E-06	1E-05	3E-06
64. U234	3E-04	2E-07	1E-06	1E-11	2E-06	1E-09	1E-06	1E-04
65. U235	1E-01	2E-10	2E-10	4E-09	5E-04	9E-09	2E-08	5E-02
66. U238	2E+00	5E-09	5E-09	8E-08	1E-02	2E-07	5E-07	9E-01
67. Y90	1E+04	5E+04	2E+00	4E-04	3E+00	2E-03	8E+04	5E+04
68. Zr93	2E+00	3E-09	7E-09	1E-07	4E-02	2E-09	2E-07	6E-01
TOTAL CURIE	E1.41E+05	4.00E+05	4.41E+01	1.51E-03	1.04E+02	4.60E-03	3.34E+05	1.00E+05

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Table 4-14. TRAC Inventory Data.

Total (1/1/90)	U-109 Curies	U-110 Curies	U-111 Curies	U-112 Curies	U-201 Curies	U-202 Curies	U-203 Curies	U-204 Curies	Total-U FA Curies
1. Ac225	5E-09	2E-08	4E-08	4E-08	4E-09	4E-09	4E-09	1E-09	2.861E-07
2. Ac227	2E-06	3E-04	1E-05	9E-06	1E-06	1E-06	1E-06	4E-07	4.258E-04
3. Am241	3E-01	1E+02	4E+01	5E-01	1E-04	1E-04	1E-04	4E-05	3.680E+02
4. Am242	5E-05	7E-02	6E-02	4E-04	4E-07	1E-07	1E-07	5E-08	3.535E-01
5. Am242m	5E-05	7E-02	6E-02	5E-04	4E-07	1E-07	1E-07	5E-08	3.536E-01
6. Am243	2E-04	2E-02	2E-02	1E-04	8E-08	8E-08	8E-08	2E-08	1.424E-01
7. At217	4E-09	2E-08	4E-08	4E-08	4E-09	4E-09	4E-09	1E-09	2.851E-07
8. Ba135m	0E+00	0.000E+00							
9. Ba137m	2E+04	1E+03	2E+04	9E+04	1E+04	2E+04	1E+04	4E+03	4.151E+05
10. Bi210	1E-12	1E-09	1E-11	4E-12	4E-14	6E-14	5E-14	2E-14	1.084E-09
11. Bi211	2E-06	3E-04	1E-05	9E-06	1E-06	2E-06	1E-06	4E-07	4.268E-04
12. Bi213	5E-09	2E-08	4E-08	4E-08	4E-09	5E-09	4E-09	1E-09	2.871E-07
13. Bi214	6E-12	6E-09	7E-11	2E-11	2E-13	3E-13	2E-13	7E-14	6.424E-09
14. C14	3E+00	2E-01	2E+00	2E+01	3E+00	3E+00	2E+00	6E-01	8.187E+01
15. Cm242	4E-05	6E-02	5E-02	4E-04	3E-07	1E-07	1E-07	4E-08	3.285E-01
16. Cm244	2E-03	9E-05	7E-02	4E-03	7E-04	9E-04	8E-04	3E-04	4.068E-01
17. Cm245	6E-08	3E-09	4E-06	9E-08	2E-08	3E-08	2E-08	8E-09	2.553E-05
18. Cs135	1E-01	6E-03	1E-01	1E+00	1E-01	1E-01	1E-01	3E-02	3.337E+00
19. Cs137	2E+04	1E+03	2E+04	1E+05	2E+04	2E+04	1E+04	4E+03	5.451E+05
20. Fr221	5E-09	2E-08	4E-08	4E-08	4E-09	4E-09	4E-09	1E-09	2.861E-07
21. Fr223	3E-08	4E-06	3E-07	1E-07	2E-08	2E-08	2E-08	5E-09	5.862E-06
22. I129	9E-03	5E-04	4E-02	5E-02	8E-03	8E-03	7E-03	2E-03	3.246E-01
23. Nb93m	7E-02	1E+01	2E+00	2E-01	4E-03	5E-03	4E-03	1E-03	1.811E+01
24. Ni59	0E+00	0.000E+00							

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Table 4-14. TRAC Inventory Data.

Total (1/1/90)	U-109 Curies	U-110 Curies	U-111 Curies	U-112 Curies	U-201 Curies	U-202 Curies	U-203 Curies	U-204 Curies	Total-U FA Curies
25. Ni63	2E+01	3E+00	1E+01	3E+02	5E+01	5E+01	4E+01	1E+01	7.934E+02
26. Np237	1E-02	2E-03	5E-02	1E-01	2E-02	2E-02	2E-02	5E-03	7.072E-01
27. Np239	2E-04	2E-02	2E-02	1E-04	8E-08	8E-08	7E-08	2E-08	1.424E-01
28. Pa231	3E-06	8E-04	3E-05	1E-05	2E-06	2E-06	2E-06	5E-07	1.053E-03
29. Pa233	1E-02	2E-03	5E-02	1E-01	2E-02	2E-02	2E-02	5E-03	7.072E-01
30. Pa234m	2E-02	3E+01	3E-01	7E-02	2E-09	3E-23	3E-23	1E-23	3.330E+01
31. Pb209	5E-09	2E-08	4E-08	4E-08	4E-09	4E-09	4E-09	1E-09	2.861E-07
32. Pb210	1E-12	1E-09	1E-11	4E-12	4E-14	6E-14	4E-14	2E-14	1.083E-09
33. Pb211	2E-06	3E-04	1E-05	9E-06	1E-06	1E-06	1E-06	4E-07	4.258E-04
34. Pb214	6E-12	6E-09	7E-11	2E-11	2E-13	3E-13	2E-13	8E-14	6.424E-09
35. Pd107	1E-02	8E-04	6E-02	7E-02	1E-02	1E-02	1E-02	3E-03	5.139E-01
36. Po210	1E-12	1E-09	1E-11	4E-12	4E-14	5E-14	4E-14	2E-14	1.083E-09
37. Po213	4E-09	2E-08	4E-08	4E-08	4E-09	4E-09	4E-09	1E-09	2.841E-07
38. Po214	8E-12	7E-09	8E-11	2E-11	2E-13	3E-13	3E-13	9E-14	7.458E-09
39. Po215	2E-06	3E-04	1E-05	9E-06	1E-06	2E-06	1E-06	4E-07	4.268E-04
40. Po218	6E-12	6E-09	7E-11	2E-11	2E-13	3E-13	2E-13	8E-14	6.42E-09
41. Pu238	4E-02	4E+01	1E-01	7E-02	2E-03	3E-03	3E-03	1E-03	4.087E+01
42. Pu239	6E-02	2E+02	2E+00	3E-01	1E-10	1E-10	1E-10	4E-11	2.144E+02
43. Pu240	1E-02	4E+01	5E-01	5E-02	5E-06	6E-06	6E-06	2E-06	4.397E+01
44. Pu241	7E-02	3E+02	3E+00	3E-01	2E-08	2E-08	2E-08	7E-09	3.464E+02
45. Ra223	2E-06	3E-04	1E-05	9E-06	1E-06	1E-06	1E-06	4E-07	4.258E-04
46. Ra225	5E-09	2E-08	4E-08	4E-08	4E-09	4E-09	4E-09	1E-09	2.861E-07
47. Ra226	6E-12	6E-09	7E-11	2E-11	2E-13	3E-13	2E-13	8E-14	6.424E-09
48. Ru106	1E-07	6E-05	9E-06	3E-07	1E-09	9E-10	8E-10	3E-10	1.159E-03

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Table 4-14. TRAC Inventory Data.

Total (1/1/90)	U-109 Curies	U-110 Curies	U-111 Curies	U-112 Curies	U-201 Curies	U-202 Curies	U-203 Curies	U-204 Curies	Total-U FA Curies
49. Sb126	1E-02	3E+00	1E+00	2E-02	1E-10	1E-14	5E-11	3E-11	7.736E+00
50. Sb126m	1E-02	3E+00	1E+00	2E-02	1E-10	1E-14	5E-11	3E-11	7.736E+00
51. Se79	2E-01	9E-03	7E-01	9E-01	1E-01	1E-01	1E-01	3E-02	6.640E+00
52. Sm151	2E+01	4E+03	1E+03	3E+01	3E-05	3E-05	3E-05	9E-06	1.006E+04
53. Sn126	1E-02	3E+00	1E+00	2E-02	1E-10	1E-14	5E-11	3E-11	7.736E+08
54. Sr90	9E+02	3E+05	4E+04	3E+03	2E+01	2E+01	1E+01	5E+00	5.347E+05
55. Tc99	6E+00	3E-01	2E+01	3E+01	5E+00	5E+00	4E+00	1E+00	2.313E+02
56. Th227	2E-06	3E-04	1E-05	9E-06	1E-06	1E-06	1E-06	4E-07	4.237E-04
57. Th229	5E-09	2E-08	4E-08	4E-08	4E-09	4E-09	4E-09	1E-09	2.861E-07
58. Th230	1E-09	1E-06	1E-08	3E-09	4E-11	5E-11	5E-11	2E-11	1.072E-06
59. Th231	9E-04	1E+00	1E-02	3E-03	1E-10	4E-18	3E-18	8E-19	1.164E+00
60. Th233	0E+00	0.000E+00							
61. Th234	2E-02	3E+01	3E-01	7E-02	2E-09	3E-23	2E-23	1E-23	3.330E+01
62. T1207	2E-06	3E-04	1E-05	9E-06	1E-06	1E-06	1E-06	4E-07	4.258E-04
63. U233	1E-06	7E-06	2E-05	2E-05	3E-06	3E-06	3E-06	7E-07	1.535E-04
64. U234	5E-06	7E-03	5E-05	2E-05	3E-07	3E-07	2E-07	1E-07	7.480E-03
65. U235	9E-04	1E+00	1E-02	3E-03	1E-10	4E-18	3E-18	9E-19	1.164E+00
66. U238	2E-02	3E+01	3E-01	7E-02	2E-09	3E-23	3E-23	1E-23	3.330E+01
67. Y90	9E+02	3E+05	4E+04	3E+03	2E+01	2E+01	2E+01	5E+00	5.348E+05
68. Zr93	8E-02	2E+01	1E+01	1E-01	0E+00	0E+00	0E+00	0E+00	2.382E+01
TOTAL CURIE	4.19E+04	6.08E+05	1.21E+05	1.96E+05	3.01E+04	4.01E+04	2.01E+04	8.02E+03	2.042E+06

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Table 4-14. TRAC Inventory Data.

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Total (1/1/90)	U-101 GRAMS	U-102 GRAMS	U-103 GRAMS	U-104 GRAMS	U-105 GRAMS	U-106 GRAMS	U-107 GRAMS	U-108 GRAMS
69. Ag	0.000321	0.000749	0.000000	2.1E-12	0.000000	1.1E-12	0.000642	0.000000
70. Al	9204600	23013800	18400	0	27600	4600.023	13846000	4646000
71. Ba	959	1781	2740.137	0.000005	411.274	685.0000	959	822.411
72. Bi	1.1E-10	7.3E-11	2.1E-10	9.6E-19	1.9E-11	6.3E-11	1.3E-10	4.2E-11
73. C2H3O3	0	3750	0	0	0	0.0006	375000	0
74. C6H5O7	0	756000	0	0	0	3.8E-11	11340000	0
75. CO3	23400000	3000000	30	0.24	480	0.06	3000000	60
76. C2O4	0	0	0	0	0	0	0	0
77. Ca	0	0.08	8.0E-12	0	0	2.0E-18	0.008	0
78. Cd	0	0	0	0	0	0	0	0
79. Ce	7.0E-18	28000	0.07	0	0	5.6E-14	5600	0.14
80. Cl	0	0.0007	3.5E-14	0	0	1.1E-18	0.0028	0
81. Cr	0.000312	1.04	1.0E-11	0	4.2E-15	3.6E-13	416	1.0E-15
82. EDTA	0	23040	0	0	0	0.002304	2016000	0
83. F	1.1E-15	380000	7.6	0	0	9.5E-12	380000	3800019
84. Fe	0	33611.2	3.9E-30	0	0	0.000207	560002.8	0
85. Fe(CN)	0	0.424	0	0	0	1.1E-10	0.212	0
86. HEDTA	0	57800	0	0	0	0.00578	2890000	0
87. Hg	0	0	0	0	0	0	0	0
88. K	0	390	0	0	0	0.000000	195000	0
89. La	0	0	0	0	0	0	2.8E-13	0
90. Mn	0	1100	0	0	0	0.000055	110000	0
91. NO2	2.8E-15	13800000	27600	0	41400	0.000023	18400000	92000
92. NO3	4.3E+08	3.7E+08	5.6E+08	0.03722	372000	1.86	68200000	6.2E+08

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Table 4-14. TRAC Inventory Data.

Total (1/1/90)	U-101 GRAMS	U-102 GRAMS	U-103 GRAMS	U-104 GRAMS	U-105 GRAMS	U-106 GRAMS	U-107 GRAMS	U-108 GRAMS
93. Na	1.4E+08	46000000	2.1E+08	46920000	92000	2070	11500000	2.3E+08
94. Ni	0	5.9	0	0	0	5.9E-13	11804.13	0
95. OH	13940	35700	6800	850.034	18700	10030	103700	11901700
96. PO4	8557600	285000	66.5	0.095	190	0.0095	665000	190
97. Pb	0.000000	0.207	0.000000	5.2E-15	0.000000	2.1E-10	0.207000	0.000000
98. SeO4	0	0	0	0	0	0	0	0
99. SiO3	7.6E-16	2280000	760	77520000	1520	0.000000	152000	2280
100. Sn	0	0	0	0	0	0	0	0
101. SO4	8640480	8640960	1977.6	0.096	768	480.048	960480	768
102. Sr	0	4.4	0	0	0	0.000000	176	0
103. WO4	0	0	0	0	0	0	0	0
104. ZrO	246.1	171.2	0.00856	0.000007	21.40462	107.0000	214	642.0107
TOTAL GRAMS	6.2E+08	4.7E+08	7.7E+08	1.2E+08	5550090.6	17974.00	1.3E+08	8.7E+08

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Table 4-15. Summary of Single-Shell Waste Tank Sampling Data.

241-U-102 Single-Shell Tank									
Description	Date	Pu (g/gal)	¹³⁷ Cs (uCi/gal)	¹³⁴ Cs (uCi/gal)	^{89,90} Sr (uCi/gal)	¹⁵⁴ Eu (uCi/gal)	⁶⁰ Co (uCi/gal)	pH	Total Organic Carbon (g/gal)
Liquid	8/5/78	2.02 X 10 ⁻⁵	6.59 X 10 ⁵		1.24 X 10 ⁴			12.6	19.3
Liquid	6/14/78	2.18 X 10 ⁻⁵	6.09 X 10 ⁵		3.50 X 10 ⁴			12.0	35.6
Suspended Solids	12/18/77	1.63 X 10 ⁻⁴	4.31 X 10 ⁵		1.16 X 10 ⁵			10.5	
Liquid	9/8/75	5.0 X 10 ⁻³	8.75 X 10 ⁵	5.42 X 10 ³	2.36 X 10 ⁵	4.66 X 10 ³		12.6	
Liquid	8/26/75	5.30 X 10 ⁻⁶	46.22	85.64	5.11 X 10 ²		1.33 X 10 ²	10.0	
Average		1.04 X 10 ⁻³	1.29 X 10 ⁶	27.52 X 10 ²	3.99 X 10 ⁵			11.5	27.45
241-U-103 Single-Shell Tank									
Description	Date	Pu (g/gal)	¹³⁷ Cs (uCi/gal)	¹³⁴ Cs (uCi/gal)	^{89,90} Sr (uCi/gal)	¹⁵⁴ Eu (uCi/gal)	⁶⁰ Co (uCi/gal)	pH	Total Organic Carbon (g/gal)
Liquid	9/8/75	1.74 X 10 ⁻³	1.04 X 10 ⁶	5.78 X 10 ³	1.44 X 10 ⁵	2.25 X 10 ³	2.09 X 10 ³	12.7	
Suspended Solids	12/16/77	1.09 X 10 ⁻⁴	1.28 X 10 ⁶		6.78 X 10 ⁴			10.5	
Liquid	12/10/77	8.82 X 10 ⁻⁵	3.18 X 10 ⁶		1.21 X 10 ⁵				
Liquid	12/4/78	4.02 X 10 ⁻⁹	157.0		3.86				
Average		4.84 X 10 ⁻⁴	1.37 X 10 ⁶		3.32 X 10 ⁵			11.6	
241-U-105 Single-Shell Tank									
Description	Date	Pu (g/gal)	¹³⁷ Cs (uCi/gal)	¹³⁴ Cs (uCi/gal)	^{89,90} Sr (uCi/gal)	¹⁵⁴ Eu (uCi/gal)	⁶⁰ Co (uCi/gal)	pH	Total Organic Carbon (g/gal)
Liquid	8/3/75	9.378 X 10 ⁻³	1.0 X 10 ⁶	9.91 X 10 ³	5.17 X 10 ⁵		2.74 X 10 ³	12.2	
Liquid	12/4/78	2.46 X 10 ⁻⁶	223.2		27.7				
Sludge	3/14/77	5.04 X 10 ⁻³	2.58 X 10 ⁵		1.89 X 10 ⁵				
Liquid	7/31/75	4.06 X 10 ⁻⁴	8.64 X 10 ⁵	3.85 X 10 ³	6.13 X 10 ⁴			12.9	
Average		3.70 X 10 ⁻³	5.30 X 10 ⁵	6.88 X 10 ³	1.92 X 10 ⁵			12.5	
241-U-106 Single-Shell Tank									
Description	Date	Pu (g/gal)	¹³⁷ Cs (uCi/gal)	¹³⁴ Cs (uCi/gal)	^{89,90} Sr (uCi/gal)	¹⁵⁴ Eu (uCi/gal)	⁶⁰ Co (uCi/gal)	pH	Total Organic Carbon (g/gal)
Liquid	8/7/75	<4.44 X 10 ⁻⁶	4.79 X 10 ⁵	1.04 X 10 ³	54.39			13.2	

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Table 4-15. Summary of Single-Shell Waste Tank Sampling Data.

241-U-107 Single-Shell Tank									
Description	Date	Pu (g/gal)	¹³⁷ Cs (uCi/gal)	¹³⁴ Cs (uCi/gal)	^{89,90} Sr (uCi/gal)	¹⁵⁴ Eu (uCi/gal)	⁶⁰ Co (uCi/gal)	pH	Total Organic Carbon (g/gal)
Liquid	5/27/80	6.83 X 10 ⁻⁶	5.74 X 10 ⁵		2.44 X 10 ³				21.9
Liquid	4/9/75	<7.11 X 10 ⁻⁶	2.23 X 10 ³		2.82			10.3	
Liquid	1/7/75	<6.21 X 10 ⁻⁶	1.62 X 10 ⁴		3.18 X 10 ²			12.28	
Liquid	10/14/74	3.24 X 10 ⁻⁵	4.96 X 10 ³	26.76	1.58 X 10 ³			11.4	
Liquid	11/20/74	2.71 X 10 ⁻⁵	3.46 X 10 ³					10.0	
Liquid	6/5/75		1.89 X 10 ³	21.01	8.85 X 10 ²	2.51 X 10 ²			
Liquid	5/23/75	4.44 X 10 ⁻⁶	1.62 X 10 ³		1.19 X 10 ²			11.4	
Liquid	2/13/80	6.81 X 10 ⁻⁵	5.48 X 10 ⁵		3.10 X 10 ³				
Liquid	8/17/78	2.40 X 10 ⁻⁶	1.61 X 10 ⁴		1.46 X 10 ²			10.3	1.86
Liquid	7/17/78	1.53 X 10 ⁻⁵	1.24 X 10 ⁶		1.456 X 10 ⁴			12.1	37.8
Liquid	6/30/78	8.13 X 10 ⁻⁷	7.87 X 10 ⁴		3.11 X 10 ²			10.9	4.5
Liquid	6/16/78	5.26 X 10 ⁻⁵	2.51 X 10 ⁶		2.36 X 10 ⁴			11.2	49.2
Liquid	6/11/78	1.37 X 10 ⁻⁵	1.59 X 10 ⁶		4.96 X 10 ³			13.5	35.6
Liquid	6/10/78	1.20 X 10 ⁻⁶	6.81 X 10 ⁴		1.02 X 10 ²			12.25	7.2
Liquid	4/9/78	5.56 X 10 ⁻⁶	2.46 X 10 ⁶		2.12 X 10 ³			11.1	18.1
Liquid	2/17/78	<2 X 10 ⁻⁶	1.94 X 10 ²		4.09			11.1	
Liquid	1/21/78	3.37 X 10 ⁻⁶	1.30 X 10 ³		24.3			10.5	
Liquid	12/23/75	8.88 X 10 ⁻⁶	1.07 X 10 ³	20.04	1.95 X 10 ²		23.35	12.1	
Liquid	1/27/76	1.60 X 10 ⁻⁵	1.59 X 10 ³	19.46	2.45 X 10 ³		32.36	12.5	
Liquid	5/18/78	5.24 X 10 ⁻⁶	3.13 X 10 ³		8.06 X 10 ²			12.0	13.2
Liquid	4/13/76	4.54 X 10 ⁻⁵	5.44 X 10 ³	84.38	9.29 X 10 ²			12.8	
Liquid	11/7/76	<4.44 X 10 ⁻⁶	3.35 X 10 ³		69.70			12.0	
Average		1.57 X 10 ⁻⁵	4.29 X 10 ⁵	34.33	2.96 X 10 ³		27.85	11.5	21.04

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Table 4-15. Summary of Single-Shell Waste Tank Sampling Data.

241-U-108 Single-Shell Tank									
Description	Date	Pu (g/gal)	¹³⁷ Cs (uCi/gal)	¹³⁴ Cs (uCi/gal)	^{89,90} Sr (uCi/gal)	¹⁵⁴ Eu (uCi/gal)	⁶⁰ Co (uCi/gal)	pH	Total Organic Carbon (g/gal)
Liquid	7/15/75	<5.33 X 10 ⁻⁶	4.11 X 10 ⁴	6.34 X 10 ²	2.17 X 10 ²	81.74	33.61	11.8	
Liquid	7/22/75	<4.44 X 10 ⁻⁶	4.66 X 10 ⁴	6.85 X 10 ²	1.30 X 10 ²			11.2	
Liquid	8/4/75	<4.44 X 10 ⁻⁶	2.02 X 10 ⁵		1.77 X 10 ²			12.7	
Liquid	8/12/75	<3 X 10 ⁻⁶	9.99 X 10 ³	2.59 X 10 ²	1.51 X 10 ²			10.7	
Liquid	9/8/75	1.21 X 10 ⁻⁴	2.91 X 10 ³	48.58	3.21 X 10 ³		1.93 X 10 ²	10.0	
Liquid	8/26/75	5.18 X 10 ⁻³	8.89 X 10 ⁵	4.72 X 10 ³	2.54 X 10 ⁵	6.63 X 10 ³	1.88 X 10 ³	12.9	
Suspended Solids	12/12/75		1.95 X 10 ⁶	1.17 X 10 ⁴	4.06 X 10 ⁴			13.8	
Average		8.86 X 10 ⁻⁴	4.48 X 10 ⁵	3.01 X 10 ³	4.26 X 10 ⁴	3.35 X 10 ³	7.02 X 10 ²	11.8	
241-U-109 Single-Shell Tank									
Description	Date	Pu (g/gal)	¹³⁷ Cs (uCi/gal)	¹³⁴ Cs (uCi/gal)	^{89,90} Sr (uCi/gal)	¹⁵⁴ Eu (uCi/gal)	⁶⁰ Co (uCi/gal)	pH	Total Organic Carbon (g/gal)
Liquid	11/5/75	<3.29 X 10 ⁻⁶	5.98 X 10 ⁵	6.07 X 10 ³	20.76			13.5	

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Table 4-15. Summary of Single-Shell Waste Tank Sampling Data.

241-U-110 Single-Shell Tank									
Description	Date	Pu (g/gal)	¹³⁷ Cs (uCi/gal)	¹³⁴ Cs (uCi/gal)	^{89,90} Sr (uCi/gal)	¹⁵⁴ Eu (uCi/gal)	⁶⁰ Co (uCi/gal)	pH	Total Organic Carbon (g/gal)
Sludge	7/3/74		5.7 X 10 ⁴	8.33 X 10 ²	0.93	8.38 X 10 ²	5.50 X 10 ²		
Liquid	7/8/75	1.23 X 10 ⁻⁵	8.25 X 10 ³	66.43	7.87 X 10 ²	11.09		12.5	
Average			3.26 X 10 ⁴	4.49 X 10 ²	3.94 X 10 ²	4.24 X 10 ²			
241-U-111 Single-Shell Tank									
Description	Date	Pu (g/gal)	¹³⁷ Cs (uCi/gal)	¹³⁴ Cs (uCi/gal)	^{89,90} Sr (uCi/gal)	¹⁵⁴ Eu (uCi/gal)	⁶⁰ Co (uCi/gal)	pH	Total Organic Carbon (g/gal)
Liquid	7/23/80	1.56 X 10 ⁻⁶	2.21 X 10 ⁵		1.50 X 10 ³			11.5	6.98
Liquid	7/23/80	6.39 X 10 ⁻⁵	4.72 X 10 ⁵		1.06 X 10 ⁴			10.8	20.06
Liquid	5/25/78	2.40 X 10 ⁻³	1.07 X 10 ⁶		1.75 X 10 ⁶			11.2	1.01 X 10 ²
Liquid	7/8/75	5.06 X 10 ⁻⁶	1.48 X 10 ⁵	61.70	2.40 X 10 ²			12.8	
Average		6.17 X 10 ⁻⁴	4.77 X 10 ⁵		4.40 X 10 ⁵			11.5	42.68

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Table 4-15. Summary of Single-Shell Waste Tank Sampling Data.

241-U-201 Single-Shell Tank									
Description	Date	Pu (g/gal)	¹³⁷ Cs (uCi/gal)	¹³⁴ Cs (uCi/gal)	^{89,90} Sr (uCi/gal)	¹⁵⁴ Eu (uCi/gal)	⁶⁰ Co (uCi/gal)	pH	Total Organic Carbon (g/gal)
Liquid	9/25/75	<3.78 X 10 ⁻⁶	2.11 X 10 ⁵		1.32			13.0	
241-U-202 Single-Shell Tank									
Description	Date	Pu (g/gal)	¹³⁷ Cs (uCi/gal)	¹³⁴ Cs (uCi/gal)	^{89,90} Sr (uCi/gal)	¹⁵⁴ Eu (uCi/gal)	⁶⁰ Co (uCi/gal)	pH	Total Organic Carbon (g/gal)
Liquid	9/25/75	<3.78 X 10 ⁻⁶	1.24 X 10 ⁵	1.66 X 10 ²	3.56			12.8	
241-U-203 Single-Shell Tank									
Description	Date	Pu (g/gal)	¹³⁷ Cs (uCi/gal)	¹³⁴ Cs (uCi/gal)	^{89,90} Sr (uCi/gal)	¹⁵⁴ Eu (uCi/gal)	⁶⁰ Co (uCi/gal)	pH	Total Organic Carbon (g/gal)
Liquid	9/25/75	5.68 X 10 ⁻⁶	2.33 X 10 ⁵		1.34			13.1	
241-U-204 Single-Shell Tank									
Description	Date	Pu (g/gal)	¹³⁷ Cs (uCi/gal)	¹³⁴ Cs (uCi/gal)	^{89,90} Sr (uCi/gal)	¹⁵⁴ Eu (uCi/gal)	⁶⁰ Co (uCi/gal)	pH	Total Organic Carbon (g/gal)
Liquid	9/25/75	<3.78 X 10 ⁻⁶	5.90 X 10 ⁴		8.83 X 10 ⁻²			12.6	

Table 4-16. Summary of Tank Farm Vadose Zone Well Geophysical Logging Results.

Tank	Number of Assoc. Dry Wells	Geophysical Evidence of Leaking?	Comments
241-U-101	3	no	Radiation levels in the vadose zone wells have remained stable.
241-U-102	7	no	Radiation levels in the vadose zone wells have remained stable, slightly elevated gamma levels in upper part of well 60-02-01.
241-U-103	5	no	Radiation levels in the vadose zone wells have remained stable. Slightly elevated gamma levels in upper part of well 60-03-08.
241-U-104	4	yes	Increasing activity noted in vadose zone well 60-04-08 in 1978. A moderate gross gamma-peak at 52 to 60 ft depth.
241-U-105	5	no	Radiation levels in the vadose zone wells have remained stable.
241-U-106	4	no	Radiation levels in the vadose zone wells have remained stable.
241-U-107	4	no	No associated vadose zone wells until 1974. Three of the dry wells have had low level activity at approximately 50 ft depth since first monitored.
241-U-108	4	no	Radiation levels in the vadose zone wells have remained stable.
241-U-109	4	no	radiation levels in the vadose zone wells have remained stable.
241-U-110	5	yes	Tank categorized as an assumed leaker because of increased radiation levels in well 60-10-07. High values noted at depths from 0 to 25 feet and 50 to 60 feet. Logs from adjacent wells are unaffected.
241-U-111	6	no	Radiation levels in vadose zone wells have remained stable. Slightly elevated gamma levels in vadose zone well 60-11-03.
241-U-112	5	yes	Elevated radiation levels noted in 60-12-01. Activity in well continues to diminish. High gamma ray responses noted at depths from 1 to 10 ft and 50 to 100 ft. Logs from adjacent wells are unaffected.
241-U-201	1	no	Radiation levels in vadose zone wells have remained stable.
241-U-202	none active	no	--
241-U-203	none active	no	--
241-U-204	none active	no	--

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Table 4-17. Cesium Inventories for Tank Leak Unplanned Releases.

Release Number	Tank	Liters Leaked	¹³⁷ Cs ^{a/}
UPR-200-W-154	241-U-101	113,550	14.44
UPR-200-W-155	241-U-104	208,200	0.06
UPR-200-W-156	241-U-110	30,700	--
UPR-200-W-157	241-U-112	1,900	8.9

^{a/} Cs values reported in kCi.

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Table 4-18. Summary of Soil Sampling Results for the 216-U-10 Pond.

Radionuclide	Maximum Concentration ^{a/}	Average Concentration ^{b/}	Comments ^{c/}
^{239,240} Pu	12,500,000 pCi/g	390 pCi/g(60)	Less than 10% of basin underlain by sediments containing more than 1,000 pCi/g; majority of basin contains sediments between 100 and 1,000 pCi/g.
²⁴¹ Am	28,000 pCi/g	53.9 pCi/g (32)	Less than 5% of basin underlain by sediments containing more than 1,000 pCi/g; majority of basin underlain by sediments with less than 100 pCi/g.
Total U	1,238 ppm	--	Most of pond underlain by sediments with between 100 and 1,000 p/m.
⁹⁰ Sr	724 pCi/g	--	The majority of the basin is underlain by sediments with less than 200 pCi/g.
¹³⁷ Cs	19,600 pCi/g	--	The majority of the basin is underlain by sediments with between 1,000 and 10,000 pCi/g.

^{a/} Data are from Last and Duncan 1980.

^{b/} Data are from Emery and Klopfer 1974. Number in parenthesis is the number of samples that were averaged.

^{c/} Areas are estimated from isoconcentration contour maps by Last and Duncan 1980.

Table 4-19. Summary of Survey and Sampling Results for the Leach Trenches.

	Ct/min ^{a/}	^{238,239} Pu b/	²⁴¹ Am	Total U	⁹⁰ Sr	¹³⁷ Cs	¹⁴⁴ Ce	⁴⁰ K	¹⁵⁵ Eu
UPR-200-W-104	2,000	14.6	28,000	5.91	5.2	1,870	6.5	19.1	4.6
		14.6 (1)	9,890 (3)	5.91 (1)	4.01 (4)	544 (5)	3.7 (3)	15.7 (3)	2.03 (3)
UPR-200-W-105	2,000 to 3,000	1.45	--	14.2	80.2	2,030	--	15.2	--
		1.45 (1)	--	5.5 (3)	53.1 (3)	781 (6)	--	14.3 (3)	--
UPR-200-W-106	2,000 to 3,000	--	--	9.31	58.5	1,350	--	14.4	--
		--	--	5.50 (2)	39 (3)	1,116 (3)	--	13.7 (3)	--

^{a/} G.M. readings taken in January 1978 from bottom of ditches for beta/gamma activity compiled from WIDS Sheets (WHC 1991a).

^{b/} Data are presented in pCi/g except for Total U which is in ppm. Upper value is maximum concentration, lower value is average with number of samples in parentheses; compiled from Last and Duncan 1980.

Table 4-20. Summary of 216-U-11 Trench Soil Sampling Results.

Radionuclide	Maximum Concentration ^{a/}	Comments
^{239,240} Pu	77 pCi/g 29.5 pCi/g	Less than 5 percent of the area underlain by sediments containing above 10 pCi/g.
²⁴¹ Am	48.6 pCi/g ND ^b	Detections in only 2 out of 18 samples. No detections outside of trench.
Total U	56.8 ppm 58.4 ppm	Positive detections in nearly all samples, with values relatively evenly distributed between below detection and the maximum.
⁹⁰ Sr	34.2 pCi/g 23.0 pCi/g	Most of area underlain by sediments with concentrations between 10 and 35 pCi/g.
¹³⁷ Cs	1,390 pCi/g 965 pCi/g	Less than 5 percent of area over 600 pCi/g. Most of area between 100 and 600 pCi/g.
⁴⁰ K	13 pCi/g ^c --	Only one sample collected in trench.

- a/ Data are from Last and Duncan 1980 unless otherwise noted.
Upper value is maximum concentration from samples in trench. Lower value is maximum from samples in overflow area in the southern part of the basin.
- b/ ND = no detections.
- c/ Data are from WIDS sheets (WHC 1991a).

Table 4-21. Summary of Soil Sampling Results for the 216-U-14 Ditch (pCi/g).

Radionuclide	Upper Ditch ^{a/}			Lower Ditch		
	Max	Min	Avg	Max	Min	Avg
¹³⁷ Cs	81.8	BD ^{b/}	--	1,522	BD	240
⁶⁰ Co	149	38.9	83	45.5	0.292	14
⁵⁴ Mn	26.8	1.17	--	0.70	BD	--
¹⁵⁴ Eu	36.9	9.8	--	9.11	BD	--
¹⁵⁵ Eu	22.2	4.14	--	5.55	BD	--

^{a/} Data are compiled from Last and Duncan 1980.

^{b/} BD = Below Detection.

Table 4-22. Summary of Sampling Results for the 216-Z-19 Ditch (pCi/g).

Radionuclide		Upper Trench ^{a/}		Lower Trench ^{b/}	
		Max	Average	Max	Average
²⁴¹ Am	Soil	6,550	770	9,170	3,590
²⁴¹ Am	Vegetation	1,800	930	--	--
^{239,240} Pu	Soil	97,800	8,850	12,500,000	1,797,000
^{239,240} Pu	Vegetation	153	62	--	--
^{89,90} Sr	Soil	402	193	--	--
¹³⁷ Cs	Soil	19.1	4	120,000	61,900
¹³⁷ Cs	Vegetation	2.6	1.9	--	--
²²⁶ Ra	Soil	0.53	0.46	5,200	5,100
²²⁶ Ra	Vegetation	1.3	0.89	--	--
⁴⁰ K	Soil	13	11.8	130,000	130,000
⁴⁰ K	Vegetation	12.4	11.2	--	--
¹³⁹ Ce	Soil	0.4	0.28	1,400	1,400
¹³⁹ Ce	Vegetation	0.42	0.24	--	--
¹⁵⁴ Eu	Soil	0.4	0.4	4,900	4,600

a/ This is the area from the head of the ditch to 16th Street.

b/ From 16th Street to the U Pond outlet.

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Table 4-23. Sampling Results for the 207-U Retention Basin.

Sample Type	¹³⁷ Cs	Total Pu	⁹⁰ Sr	Total U
Vegetation	1800 pCi/g	0.5 pCi/g	3.9 pCi/g	0.26 ppm
Soil and Vegetation	500 pCi/g	0.5 pCi/g	3.3 pCi/g	0.90 ppm

Source: Schmidt et al. 1992.

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Table 4-24. Candidate Contaminants of Potential Concern for the U Plant Aggregate Area.

RADIONUCLIDES	FISSION PRODUCTS (Cont.)	HEAVY METALS
Gross alpha	Francium-221	Aluminum
Gross beta	Francium-223 ^{d/}	Arsenic
	Iodine-129	Barium
	Iron-59 ^{c/d/}	Bismuth
TRANSURANICS	Lead-209	Cadmium
Americium-241 ^{a/}	Lead 210	Cerium
Americium-242	Lead 211	Chromium
Americium-242m	Lead-212 ^{d/}	Copper
Americium-243	Lead-214	Iron
Curium-242	Manganese-54 ^{d/}	Lanthanum
Curium-244	Nickel-59	Lead
Curium-245	Nickel 63	Manganese
Neptunium-237	Niobium-93m	Mercury
Neptunium-239	Niobium-95 ^{d/}	Nickel
Plutonium	Palladium-107 ^{d/}	Selenium
Plutonium-238	Polonium-210	Silver
Plutonium-239/240	Polonium-213 ^{d/}	Strontium
Plutonium-241	Polonium-214	Thorium ^{a/}
	Polonium-215	Tin
URANIUM	Polonium-218	Titanium
	Potassium-40	Uranium
Uranium	Protactinium-231	Vanadium
Uranium-233	Protactinium-233 ^{d/}	Zinc
Uranium-234	Protactinium-234m ^{d/}	
Uranium-235	Radium ^{b/}	OTHER INORGANICS
Uranium-238	Radium-223	Ammonium ion
	Radium-225	Ammonium fluoride
FISSION PRODUCTS	Radium-226	Ammonium nitrate
Actinium-225	Ruthenium-103 ^{d/}	Ammonium oxalate
Actinium-227	Ruthenium-106	Barium nitrate
Antimony-126	Samarium-151	Bismuth phosphate
Antimony-126m	Selenium-79	Boric acid
Astutine-217 ^{d/}	Silver-110m ^{d/}	Boron
Barium-135m ^{d/}	Sodium-22 ^{c/}	Calcium
Barium-137m	Strontium-85 ^{c/d/}	Carbonate
Bismuth-210	Strontium-90	Ceric Iodate
Bismuth-211	Technetium-99	Chloride
Bismuth-213	Thallium-207	Chloroplatinic acid
Bismuth-214	Thorium-227	Chromus sulfate
Carbon-14 ^{b/}	Thorium-229	Cyanide
Cerium-141 ^{d/}	Thorium-230	Ferric cyanide
Cerium-144 ^{d/}	Thorium-231	Fluoride
Cesium-134	Thorium-233 ^{d/}	Hydrobromic acid
Cesium-135	Thorium-234	Hydrochloric acid
Cesium-137	Tin-126 ^{d/}	Hydrofluoric acid
Cobalt-57 ^{c/d/}	Tritium	Hydroiodic acid
Cobalt-58 ^{d/}	Yttrium-90	Hydroxide
Cobalt-60	Zinc-65 ^{d/}	Lanthanum fluoride
Europium-152	Zirconium-93	Lithium
Europium-154	Zirconium-95 ^{d/}	Magnesium
Europium-155		Molybdate - Citrate reagent

**Table 4-24. Candidate Contaminants of Potential Concern for the
U Plant Aggregate Area.**

OTHER INORGANICS (Continued)	VOLATILE ORGANICS	SEMIVOLATILE ORGANICS
Nitrate	Acetone	Citrate
Nitric acid	Butyl Alcohol	Dibutyl phosphate
Nitrite	Carbon tetrachloride	Ethanol
Oxalic acid	Chloroform	Ethylene diamine tetraacetate (EDTA)
Phosphate	Decane	Gylcolate
Phosphoric acid	Ethyl ether	Kerosene ^{a/}
Phosphorous pentoxide	Methylene chloride	Monobutyl phosphate
Potassium	MIBK ("Hexone")	N-(2-hydroxyethyl) ethylenediaminetriacetate (HEDTA)
Potassium carbonate	Toluene	Oxalate
Potassium fluoride		Paraffin hydrocarbons
Potassium hydroxide		Tributyl phosphate ^{a/}
Potassium permanganate		1,1,1-Trichloroethane
Silica		
Silicon		
Sodium		
Sodium fluoride		
Sodium hydroxide		
Sodium nitrate		
Sulfamic acid		
Sulfate		
Sulfuric acid		
Uranium oxide		
Uranyl nitrate hexahydrate		
Zirconium oxide		

^{a/} Reported in waste inventory but not analyzed for or not detected.

^{b/} Detected in groundwater at or below the method detection limit.

^{c/} Detected in 1983 in the 216-U-14 Ditch, but not elsewhere on the site.

^{d/} The radionuclide has a half-life of <1 year and if it is a daughter product, the parent has a half-life of <1 year, or the buildup of the short-lived daughter would result in an activity of <1% of the parent radionuclide's initial activity.

Table 4-25. Summary of Known and Suspected Contamination at Each Waste Management Unit and Unplanned Release Types.

Waste Management Unit or Unplanned Release	TRU	Fission Products	Uranium	Heavy Metals	Other Inorganics	Volatiles	Semi-volatiles
Tanks and Vaults							
241-U-101 Single-Shell Tank	K	K	K	K	K	K	K
241-U-102 Single-Shell Tank	K	K	K	K	K	K	K
241-U-103 Single-Shell Tank	K	K	K	K	K	K	K
241-U-104 Single-Shell Tank	K	K	K	K	K	K	K
241-U-105 Single-Shell Tank	K	K	K	K	K	K	K
241-U-106 Single-Shell Tank	K	K	K	K	K	K	K
241-U-107 Single-Shell Tank	K	K	K	K	K	K	K
241-U-108 Single-Shell Tank	K	K	K	K	K	K	K
241-U-109 Single-Shell Tank	K	K	K	K	K	K	K
241-U-110 Single-Shell Tank	K	K	K	K	K	K	K
241-U-111 Single-Shell Tank	K	K	K	K	K	K	K
241-U-112 Single-Shell Tank	K	K	K	K	K	K	K
241-U-201 Single-Shell Tank	K	K	K	K	K	K	K
241-U-202 Single-Shell Tank	K	K	K	K	K	K	K
241-U-203 Single-Shell Tank	K	K	K	K	K	K	K
241-U-204 Single-Shell Tank	K	K	K	K	K	K	K
241-U-301 Catch Tank	S	S	S	S	S	S	S
241-U-361 Settling Tank	K	K	K	S	K	S	K
241-U-302 Catch Tank	S	S	S	S	S	S	S
244-U Receiver Tank	S	S	S	S	S	S	S
241-WR-Vault	S	S	S	S	S	S	S
244-UR Vault	S	S	S	S	S	S	S

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Table 4-25. Summary of Known and Suspected Contamination at Each Waste Management Unit and Unplanned Release Types.

Waste Management Unit or Unplanned Release	TRU	Fission Products	Uranium	Heavy Metals	Other Inorganics	Volatiles	Semi-volatiles
Cribs and Drains							
216-S-21 Crib	K	K	K	S	K	S	S
216-U-1 and 216-U-2 Cribs	K	K	K	S	K	S	K
216-U-8 Crib	K	K	K	S	K	S	S
216-U-12 Crib	K	K	K	S	K	S	S
216-U-16 Crib	K	K	K	S	S	S	S
216-U-17 Crib	K	S	K	S	S	S	S
216-Z-20 Crib	K	K		S	S	S	
216-S-4 French Drain	S	S	S	S	K	S	S
216-U-3 French Drain	K	K	K	S	K	S	S
216-U-4A French Drain	K	K	K	S	K	S	S
216-U-4B French Drain	K	K	S	S	K	S	S
216-U-7 French Drain	S	S	K	S	K	--	--
Reverse Wells							
216-U-4 Reverse Well	K	K	S	S	K	S	S
Ponds, Ditches, and Trenches							
216-U-10 Pond	K	K	K	S	S	S	S
216-U-14-Ditch	K	K	K	S	K	S	S
216-Z-1D Ditch	K	S	--	S	S	S	--
216-Z-11 Ditch	K	S	--	S	S	S	--
216-Z-19 Ditch	K	K	--	S	S	S	--

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Table 4-25. Summary of Known and Suspected Contamination at Each Waste Management Unit and Unplanned Release Types.

Waste Management Unit or Unplanned Release	TRU	Fission Products	Uranium	Heavy Metals	Other Inorganics	Volatiles	Semi-volatiles
216-U-5 and 216-U-6 Trenches	K	K	K	S	K	S	S
216-U-11 Trench	K	K	K	S	S	S	S
216-U-13 Trench	K	K	K	S	K	--	--
216-U-15 Trench	S	S	S	S	K	S	K
Septic Tanks and Associated Drain Fields							
2607-W-5 Septic Tank/Drain Field	--	--	--	S	S	S	--
2607-W-7-Septic Tank/Drain Field	--	--	--	S	S	S	--
2607-W-9 Septic Tank/Drain Field	--	--	--	S	S	S	--
2607-WUT Septic Tank/Drain Field	--	--	--	S	S	S	--
Transfer Facilities, Diversion Boxes, and Pipelines							
241-U-A,B,C,D Valve Pits	S	S	S	S	S	S	S
241-U-151 Diversion Box	S	S	S	S	S	S	S
241-U-152 Diversion Box	S	S	S	S	S	S	S
241-U-153 Diversion Box	S	S	S	S	S	S	S
241-U-252 Diversion Box	S	S	S	S	S	S	S
241-UR-151 Diversion Box	S	S	S	S	S	S	S
241-UR-152 Diversion Box	S	S	S	S	S	S	S
241-UR-153 Diversion Box	S	S	S	S	S	S	S
241-UR-154 Diversion Box	S	S	S	S	S	S	S
241-UX-154 Diversion Box	S	S	S	S	S	S	S

Table 4-25. Summary of Known and Suspected Contamination at Each Waste Management Unit and Unplanned Release Types.

Waste Management Unit or Unplanned Release	TRU	Fission Products	Uranium	Heavy Metals	Other Inorganics	Volatiles	Semi-volatiles
Basins							
207-U Retention Basin	K	K	K	S	K	S	S
Burial Sites							
Burial Ground/Burning Pit	--	S	--	--	--	--	--
Construction Surface Laydown Area	--	--	--	S	--	S	--
Unplanned Releases							
UN-200-W-6	S	S	S	S	S	--	S
UN-200-W-19	S	S	S	S	S	--	S
UN-200-W-33	S	S	S	S	S	--	S
UN-200-W-39	S	S	K	S	--	--	--
UN-200-W-46	--	--	--	--	--	--	--
UN-200-W-48	--	--	--	--	--	--	--
UN-200-W-55	S	S	K	S	--	--	--
UN-200-W-60	S	S	S	--	--	--	--
UN-200-W-68	--	S	S	--	--	--	--
UN-200-W-71	--	--	--	--	--	--	--
UN-200-W-78	S	S	K	S	--	--	--
UN-200-W-86	--	K	--	--	--	--	--
UN-200-W-101	S	K	S	S	K	--	S
UN-200-W-117	S	S	S	S	S	--	--

Table 4-25. Summary of Known and Suspected Contamination at Each Waste Management Unit and Unplanned Release Types.

Waste Management Unit or Unplanned Release	TRU	Fission Products	Uranium	Heavy Metals	Other Inorganics	Volatiles	Semi-volatiles
UN-200-W-118	S	S	S	S	S	--	--
UN-200-E-161	S	K	S	--	--	--	--

K = Known contamination (contaminants identified from inventory or sampling data).
 S = Suspected contamination (contaminants that could occur at a site). Evidence includes process data, historical records and chemical associations.

Table 4-26. Contaminants of Potential Concern for the U Plant Aggregate Area.

RADIONUCLIDES	FISSION PRODUCTS (continued)	HEAVY METALS (continued)
Gross alpha	Lead-209	Vanadium
Gross beta	Lead-211	Zinc
TRANSURANICS	Lead-212	OTHER INORGANICS
Americium-241	Lead-214	Boron
Americium-242	Nickel-59	Cyanide
Americium-242m	Niobium-93m	Fluoride
Americium-243	Polonium-214	Nitrate
Curium-244	Polonium-218	
Curium-245	Potassium-40	VOLATILE ORGANICS
Neptunium-237	Protactinium-231	Acetone
Neptunium-239	Protactinium-234m	Carbon tetrachloride
Plutonium-238	Ruthenium-106	Chloroform
Plutonium-239/240	Samarium-151	Methylene chloride
Plutonium-241	Selenium-79	MIBK ("hexone")
URANIUM	Sodium-22	Toluene
Uranium-233	Strontium-90	1,1,1-Trichloroethane
Uranium-234	Technetium-99	SEMIVOLATILE ORGANICS
Uranium-238	Thallium-207	Kerosene
FISSION PRODUCTS	Thorium-229	Tributyl phosphate
Antimony-126m	Thorium-230	
Barium-137m	Thorium-231	
Bismuth-210	Tritium	
Bismuth-211	Yttrium-90	
Bismuth-213	Zirconium-93	
Bismuth-214	HEAVY METALS	
Carbon-14	Arsenic	
Cesium-134	Barium	
Cesium-135	Cadmium	
Cesium-137	Chromium	
Cobalt-60	Copper	
Europium-152	Iron	
Europium-154	Lead	
Europium-155	Manganese	
Francium-221	Mercury	
Iodine-129	Nickel	
	Selenium	
	Silver	
	Titanium	

Table 4-27. Soil-Water Distribution Coefficient K_d for Radionuclides^{a/} and Inorganics of Concern at U Plant Aggregate Area Waste Management Units. Page 1 of 2

Element or Chemical	Recommended K_d for Hanford Site (Serne and Wood 1990) in mL/g	Conservative Default K_d ^{b/} (Serne and Wood 1990) in mL/g	MEPAS Default K_d pH 6-9 ^{c/} (Streng and Peterson 1989) in mL/g	Mobility Class
Actinium	—	—	228	low
Americium	2 100 - 1000 (<1 @ pH 1-3)	100	82	low
Antimony	—	—	2	high
Arsenic	—	0	5.86	moderate
Barium	—	50	530	moderate
Bismuth	—	20	—	moderate
Boron	—	—	0.19	high
Cadmium	—	15	14.9	moderate
Carbon (¹⁴ C)	—	—	0	high
Cesium	200 - 1,000 1 - 200 (acidic waste)	50	51	low
Chromium	—	0	16.8	moderate
Cobalt	500 - 2000	10	1.9	low
Copper	—	15	41.9	moderate
Curium	100 - $>2,000$	100	82	low
Cyanide	—	—	—	unknown
Europium	—	—	228	low
Fluoride	—	—	0	high
Francium	—	—	—	unknown
Iodine	<1	0	0	high
Iron	—	20	15	moderate
Lead	—	30	234	moderate
Manganese	—	20	16.5	moderate
Mercury	—	—	322	low
Neptunium	$<1-5$	3	3	high
Nickel	—	15	12.2	moderate
Niobium	—	—	50	moderate

Table 4-27. Soil-Water Distribution Coefficient K_d for Radionuclides^{a/} and Inorganics of Concern at U Plant Aggregate Area Waste Management Units. Page 2 of 2

Element or Chemical	Recommended K_d for Hanford Site (Serne and Wood 1990) in mL/g	Conservative Default K_d ^{b/} (Serne and Wood 1990) in mL/g	MEPAS Default K_d pH 6-9 ^{c/} (Streng and Peterson 1989) in mL/g	Mobility Class
Nitrate/nitric acid	—	—	0	high
Plutonium	100 - 1,000 < 1 at pH 1 - 3	100	10	low
Polonium	—	—	5.9	high
Protactinium	—	—	0	high
Radium	—	20	24.3	moderate
Ruthenium	20 - 700 (< 2 at > 1 M nitrate)	—	274	moderate
Samarium	—	—	228	low
Selenium	—	0	5.91	moderate
Silver	—	20	0.4	moderate
Sodium	—	3	0	high
Strontium	5 - 100 3 - 5 (acidic conditions) 200 - 500 (w/phosphate or oxalate)	10	24.3	moderate
Technetium	0 - 1	0	3	high
Thallium	—	—	0	high
Thorium	—	50	100	moderate
Titanium	—	—	—	unknown
Tritium	0	0	0	high
Uranium	—	0	0	high
Vanadium	—	—	50	moderate
Yttrium	—	—	278	low
Zinc	—	15	12.7	moderate
Zirconium	—	30	50	moderate

^{a/} Radionuclides with half-lives of greater than 3 months.

^{b/} Average K_{Ds} for low salt and organic solutions with neutral pH.

^{c/} Default values for pH 6-9 and soil content of [clay + organic matter + metal oxyhydroxides] < 10% (Streng and Peterson 1989).

MEPAS = Multimedia Environmental Pollution Assessment System, a computerized waste management unit evaluation system.

Table 4-28. Mobility of Inorganic Species in Soil.

Highly mobile ($K_d < 5$)	
Antimony	Protactinium
Boron	Selenium
Carbon (as $^{14}\text{CO}_2$)	Silver
Fluoride	Sodium
Iodine	Technetium
Neptunium	Thallium
Nitrate	Tritium
	Uranium
Moderately mobile ($5 < K_d < 100$)	
Arsenic	Nickel
Barium	Niobium
Bismuth	Polonium
Cadmium	Radium
Cesium	Strontium
Chromium	Thorium
Copper	Vanadium
Iron	Zinc
Lead	Zirconium
Manganese	
Low mobility ($K_d > 100$)	
Actinium	
Americium	
Cesium	
Cobalt	
Curium	
Europium	
Mercury	
Plutonium	
Ruthenium	
Samarium	
Yttrium	

9 3 1 2 7 8 0 7 0 5

Table 4-29. Physical/Chemical Properties of Organic Contaminants of Concern for U Plant Aggregate Area Waste Management Units.

Compound	Molecular Weight in g/mole	Water Solubility in mg/L	Vapor Pressure in mm Hg	Henry's Law Constant in atm-m ³ /mo	Soil/Organic Matter Partition Coef. K _{oc} in mL/g
Acetone	58.0	miscible	270	2.1 x 10 ⁻⁵	2.2
Carbon tetrachloride	154.0	758	90	2.4 x 10 ⁻²	110
Chloroform (trichloromethane)	119	8,200	150	2.9 x 10 ⁻³	31
Kerosene ^{a/}	142.2	32	0.045	2.9 x 10 ⁻⁴	4,500
Methylene chloride	84.9	20,000	360	2 x 10 ⁻³	8.8
Methyl isobutyl ketone (MIBK)	100.16	19,000	6	4.2 x 10 ⁻⁵	19
Tributyl phosphate	266.3	280	15	1.9 x 10 ⁻²	6,000
1,1,1 Trichloroethane	133.41	1,500	120	1.4 x 10 ⁻²	150

Source: Streng and Peterson (1989).

^{a/} Kerosene properties are represented by 2-methyl naphthalene.

Table 4-30. Radiological Properties of Potential Radionuclides of Concern in U Plant Aggregate Area Waste Management Units. Page 1 of 3

Radionuclide	Half-Life	Specific Activity ^{a/} in Ci/g	Principal Radiation of Concern ^{b/}
²²⁵ Ac	10 d	5.8×10^4	α
²²⁷ Ac	21.8 yr	7.2×10^1	β, α
²⁴¹ Am	432 yr	3.4×10^0	α
²⁴² Am	16 hr	8.1×10^5	β
^{242m} Am	152 yr	9.7×10^0	α
²⁴³ Am	7,380 yr	2.0×10^{-1}	α
^{137m} Ba	2.6 min	5.3×10^8	γ
²¹⁰ Bi	5.01 d	1.2×10^5	β
²¹¹ Bi	2.13 min	4.2×10^8	α, β
²¹³ Bi	45.6 min	1.9×10^7	β, α
²¹⁴ Bi	19.9 min	4.4×10^7	β, γ
¹⁴ C	5,730 yr	4.5×10^0	β
²⁴² Cm	163.2 d	3.3×10^3	α
²⁴⁴ Cm	18.1 yr	8.1×10^1	α
²⁴⁵ Cm	8,500 yr	1.7×10^{-1}	α, γ
⁶⁰ Co	5.3 yr	1.1×10^3	γ
¹³⁴ Cs	2.06 yr	1.3×10^3	γ
¹³⁵ Cs	3×10^6 yr	8.8×10^{-4}	β
¹³⁷ Cs	30 yr	8.7×10^1	γ
¹⁵² Eu	13.3 yr	7.7×10^2	β, γ^{cl}
¹⁵⁴ Eu	8.8 yr	2.7×10^2	β, γ^{cl}
¹⁵⁵ Eu	4.96 yr	4.6×10^2	β, γ
²²¹ Fr	4.8 min	1.8×10^8	α, γ
³ H	12.3 yr	9.7×10^3	β
¹²⁹ I	1.6×10^7 yr	1.7×10^{-4}	β
⁴⁰ K	1.3×10^9 yr	6.7×10^{-6}	β, γ^{cl}
⁵⁹ N	8×10^4 yr	7.6×10^{-2}	γ
⁶³ N	92 yr	6.2×10^2	β
²² Na	2.6 yr	6.3×10^3	β, γ
^{93m} Nb	14.6 yr	2.8×10^2	γ^{cl}

Table 4-30. Radiological Properties of Potential Radionuclides of Concern in U Plant Aggregate Area Waste Management Units. Page 2 of 3

Radionuclide	Half-Life	Specific Activity ^{a/} in Ci/g	Principal Radiation of Concern ^{b/}
⁹⁵ Nb	34.97 d	3.9×10^4	β, γ
²³⁷ Np	2.14×10^6 yr	7.0×10^4	α, γ
²³⁹ Np	2.35 d	2.3×10^5	β
²³¹ Pa	32,800 yr	4.7×10^{-2}	α
^{234m} Pa	1.2 min	6.7×10^8	β, γ
²⁰⁹ Pb	3.25 hr	4.5×10^6	β
²¹⁰ Pb	22.3 yr	7.6×10^1	β
²¹¹ Pb	36.1 min	2.5×10^7	β
²¹² Pb	10.6 hr	1.4×10^6	$\beta, \gamma^{c/}$
²¹⁴ Pb	26.8 min	3.3×10^7	$\beta, \gamma^{c/}$
²¹⁴ Po	6×10^{-5} sec	8.8×10^{14}	α
²¹⁵ Po	7.8×10^{-4} sec	2.9×10^{13}	α
²¹⁸ Po	3.05 min	2.8×10^8	α
²³⁸ Pu	87.7 yr	1.7×10^1	α
²³⁹ Pu	24,400 yr	6.2×10^{-2}	α
²⁴⁰ Pu	6,560 yr	2.3×10^{-1}	α
²⁴¹ Pu	14.4 yr	1.0×10^2	β
²²⁵ Ra	14.8 d	3.9×10^4	β
²²⁶ Ra	1,600 yr	9.9×10^{-1}	α
¹⁰⁶ Ru	1.0 yr	3.4×10^3	$\beta, \gamma^{c/}$
⁷⁹ Se	< 65,000 yr	7.0×10^{-2}	β
¹⁵¹ Sm	90 yr	2.6×10^1	β
⁹⁰ Sr	28.5 yr	1.4×10^2	β
⁹⁹ Tc	213,000 yr	1.7×10^{-2}	β
²²⁷ Th	18.7 d	3.1×10^4	α
²²⁹ Th	7,340 yr	2.1×10^{-1}	α
²³⁰ Th	77,000 yr	2.1×10^{-2}	α
²³¹ Th	25.5 hr	5.3×10^5	β
²⁰⁷ Tl	4.8 min	1.9×10^8	β, γ
²³³ U	159,000 yr	9.7×10^{-3}	α

Table 4-30. Radiological Properties of Potential Radionuclides of Concern in U Plant Aggregate Area Waste Management Units. Page 3 of 3

Radionuclide	Half-Life	Specific Activity ^{a/} in Ci/g	Principal Radiation of Concern ^{b/}
²³⁴ U	244,500 yr	6.2×10^{-3}	α
²³⁵ U	7.0×10^8 yr	2.2×10^{-6}	α, γ
²³⁸ U	4.5×10^9 yr	3.4×10^{-7}	α
⁹⁰ Y	6.41 hr	5.4×10^5	β
⁹³ Zr	1.5×10^6 yr	2.6×10^{-3}	β

^{a/} Calculated from half-life and atomic weight.

^{b/} α - alpha decay; β - negative beta decay; γ - release of gamma rays.

^{c/} Daughter radiation.

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Table 4-31. Comparison of Radionuclide Relative Risks for Radionuclides of Concern at the U Plant Aggregate Area.

Page 1 of 3

Radionuclide	Half-Life	Air Unit Risk ^{b/} in (pCi/m ³) ⁻¹	Drinking Water Unit Risk ^{c/} in (pCi/L) ⁻¹	Soil Ingestion Unit Risk ^{d/} in (pCi/g) ⁻¹	External Exposure Unit Risk ^{e/} in (pCi/g) ⁻¹
²²⁵ Ac	10 d	1.2 x 10 ⁻³	8.7 x 10 ⁻⁷	4.6 x 10 ⁻⁸	9.4 x 10 ⁻⁶
²²⁷ Ac	21.8 yr	4.2 x 10 ⁻²	1.8 x 10 ⁻⁵	9.5 x 10 ⁻⁷	1.3 x 10 ⁻⁷
²⁴¹ Am	433 yr	2.1 x 10 ⁻²	1.6 x 10 ⁻⁵	8.4 x 10 ⁻⁷	1.6 x 10 ⁻⁵
²⁴² Am	16 hr	na	na	na	na
^{242m} Am	152 yr	na	na	na	na
²⁴³ Am	7,380 yr	2.1 x 10 ⁻²	1.5 x 10 ⁻⁵	8.1 x 10 ⁻⁷	3.6 x 10 ⁻⁵
²¹⁰ Bi	5.01 d	4.1 x 10 ⁻⁵	9.7 x 10 ⁻⁸	5.1 x 10 ⁻⁹	0
²¹¹ Bi	2.13 min	9.7 x 10 ⁻⁸	6.1 x 10 ⁻¹⁰	3.2 x 10 ⁻¹¹	2.8 x 10 ⁻⁵
²¹³ Bi	45.6 min	1.6 x 10 ⁻⁷	1.2 x 10 ⁻⁸	6.2 x 10 ⁻¹⁰	8.1 x 10 ⁻⁵
²¹⁴ Bi	19.9 min	1.1 x 10 ⁻⁶	7.2 x 10 ⁻⁹	3.8 x 10 ⁻¹⁰	8.0 x 10 ⁻⁴
¹⁴ C	5,730 yr	3.2 x 10 ⁻⁹	4.7 x 10 ⁻⁸	2.5 x 10 ⁻⁹	0
²⁴² Cm	163.2 d	na	na	na	na
²⁴⁴ Cm	18.1 yr	1.4 x 10 ⁻²	1.0 x 10 ⁻⁵	5.4 x 10 ⁻⁷	5.9 x 10 ⁻⁷
²⁴⁵ Cm	8,500 yr	na	na	na	na
⁶⁰ Co	5.3 yr	8.1 x 10 ⁻⁵	7.8 x 10 ⁻⁷	4.1 x 10 ⁻⁸	1.3 x 10 ⁻³
¹³⁴ Cs	2.06 yr	1.4 x 10 ⁻⁵	2.1 x 10 ⁻⁶	1.1 x 10 ⁻⁷	8.9 x 10 ⁻⁴
¹³⁷ Cs	30 yr	9.6 x 10 ⁻⁶	1.4 x 10 ⁻⁶	7.6 x 10 ⁻⁸	0 (3.4 x 10 ⁻⁴) ^f
¹⁵² Eu	13.3 yr	6.1 x 10 ⁻³	1.1 x 10 ⁻⁷	5.7 x 10 ⁻⁹	6.3 x 10 ⁻⁴
¹⁵⁴ Eu	8.8 yr	7.2 x 10 ⁻⁵	1.5 x 10 ⁻⁷	8.1 x 10 ⁻⁹	6.8 x 10 ⁻⁴
¹⁵⁵ Eu	4.96 yr	na	na	na	na
³ H	12.3 yr	4.0 x 10 ⁻⁸	2.8 x 10 ⁻⁹	1.5 x 10 ⁻¹⁰	0
¹²⁹ I	1.6 x 10 ⁷ yr	6.1 x 10 ⁻⁵	9.6 x 10 ⁻⁶	5.1 x 10 ⁻⁷	1.5 x 10 ⁻⁵
⁴⁰ K	1.3 x 10 ⁹ yr	4.0 x 10 ⁻⁶	5.7 x 10 ⁻⁷	3.0 x 10 ⁻⁸	7.8 x 10 ⁻⁵
²² Na	2.6 yr	na	na	na	na
^{93m} Nb	14.6 yr	na	na	na	na
⁵⁹ Ni	75,000 yr	3.5 x 10 ⁻⁷	4.4 x 10 ⁻⁹	2.3 x 10 ⁻¹⁰	3.4 x 10 ⁻⁷
⁶³ Ni	100.1 yr	8.7 x 10 ⁻⁷	1.2 x 10 ⁻⁸	6.2 x 10 ⁻¹⁰	0

Table 4-31. Comparison of Radionuclide Relative Risks for Radionuclides of Concern at the U Plant Aggregate Area. Page 2 of 3

Radionuclide	Half-Life	Air Unit Risk ^{b/} in (pCi/m ³) ⁻¹	Drinking Water Unit Risk ^{c/} in (pCi/L) ⁻¹	Soil Ingestion Unit Risk ^{d/} in (pCi/g) ⁻¹	External Exposure Unit Risk ^{e/} in (pCi/g) ⁻¹
²³⁷ Np	2.14 x 10 ⁶ yr	1.8 x 10 ⁻²	1.4 x 10 ⁻⁵	7.3 x 10 ⁻⁷	1.8 x 10 ⁻⁵
²³⁹ Np	2.35 d	7.7 x 10 ⁻⁷	4.8 x 10 ⁻⁸	2.5 x 10 ⁻⁹	1.1 x 10 ⁻⁴
²³¹ Pa	32,800 yr	2.0 x 10 ⁻²	9.7 x 10 ⁻⁶	5.1 x 10 ⁻⁷	2.0 x 10 ⁻⁵
²⁰⁹ Pb	3.25 hr	3.6 x 10 ⁻⁸	4.3 x 10 ⁻⁹	2.3 x 10 ⁻¹⁰	0
²¹⁰ Pb	22.3 yr	8.7 x 10 ⁻⁴	3.4 x 10 ⁻⁵	1.8 x 10 ⁻⁶	1.8 x 10 ⁻⁶
²¹¹ Pb	36.1 min	1.5 x 10 ⁻⁶	9.2 x 10 ⁻⁹	4.9 x 10 ⁻¹⁰	2.9 x 10 ⁻⁵
²¹² Pb	10.6 hr	2.4 x 10 ⁻⁵	3.7 x 10 ⁻⁷	1.9 x 10 ⁻⁸	9.2 x 10 ⁻⁵
²¹⁴ Pb	26.8 min	1.5 x 10 ⁻⁶	9.2 x 10 ⁻⁹	4.9 x 10 ⁻¹⁰	1.5 x 10 ⁻⁴
²¹⁴ Po	6 x 10 ⁻⁵ sec	1.4 x 10 ⁻¹³	5.1 x 10 ⁻¹⁶	2.7 x 10 ⁻¹⁷	4.7 x 10 ⁻⁸
²¹⁵ Po	7.8 x 10 ⁻⁴ sec	2.9 x 10 ⁻¹²	1.4 x 10 ⁻¹⁴	7.6 x 10 ⁻¹⁶	8.7 x 10 ⁻⁸
²¹⁸ Po	3.05 min	3.0 x 10 ⁻⁷	1.4 x 10 ⁻⁹	7.6 x 10 ⁻¹¹	0
²³⁸ Pu	87.7 yr	2.1 x 10 ⁻²	1.4 x 10 ⁻⁵	7.6 x 10 ⁻⁷	5.9 x 10 ⁻⁷
²³⁹ Pu	24,400 yr	2.6 x 10 ⁻²	1.6 x 10 ⁻⁵	8.4 x 10 ⁻⁸	2.6 x 10 ⁻⁷
²³⁹ Pu oxide	24,400 yr	2.6 x 10 ⁻²	1.6 x 10 ⁻⁶	8.4 x 10 ⁻⁸	2.6 x 10 ⁻⁷
²⁴⁰ Pu	6,560 yr	2.1 x 10 ⁻²	1.6 x 10 ⁻⁵	8.4 x 10 ⁻⁸	5.9 x 10 ⁻⁷
²⁴⁰ Pu oxide	6,560 yr	2.1 x 10 ⁻²	1.6 x 10 ⁻⁶	8.4 x 10 ⁻⁸	5.9 x 10 ⁻⁷
²⁴¹ Pu	14.4 yr	1.5 x 10 ⁻⁴	2.5 x 10 ⁻⁷	1.3 x 10 ⁻⁸	0
²²⁵ Ra	14.8 d	8.2 x 10 ⁻⁴	3.4 x 10 ⁻⁶	1.8 x 10 ⁻⁷	8.0 x 10 ⁻⁶
²²⁶ Ra	1,600 yr	1.5 x 10 ⁻³	6.1 x 10 ⁻⁶	3.2 x 10 ⁻⁷	4.1 x 10 ⁻⁶
²²⁸ Ra	5.75 yr	3.4 x 10 ⁻⁴	5.1 x 10 ⁻⁶	2.7 x 10 ⁻⁷	5.6 x 10 ⁻¹³
¹⁰⁶ Ru	1.0 yr	2.3 x 10 ⁻⁴	4.9 x 10 ⁻⁷	2.6 x 10 ⁻⁸	0
⁷⁹ Se	< 65,000 yr	na	na	na	na
¹⁵¹ Sm	90 yr	na	na	na	na
⁹⁰ Sr	28.5 yr	2.8 x 10 ⁻⁵	1.7 x 10 ⁻⁶	8.9 x 10 ⁻⁸	0
⁹⁹ Tc	213,000 yr	4.2 x 10 ⁻⁶	6.6 x 10 ⁻⁸	3.5 x 10 ⁻⁹	0
²²⁷ Th	18.72 d	2.5 x 10 ⁻³	2.5 x 10 ⁻⁷	1.3 x 10 ⁻⁸	6.6 x 10 ⁻⁶
²²⁹ Th	7,340 yr	3.9 x 10 ⁻²	2.0 x 10 ⁻⁶	1.1 x 10 ⁻⁷	5.8 x 10 ⁻⁵
²³⁰ Th	77,000 yr	1.6 x 10 ⁻²	1.2 x 10 ⁻⁶	6.5 x 10 ⁻⁸	5.9 x 10 ⁻⁷

Table 4-31. Comparison of Radionuclide Relative Risks for Radionuclides of Concern at the U Plant Aggregate Area. Page 3 of 3

Radionuclide	Half-Life	Air Unit Risk ^{b/} in (pCi/m ³) ⁻¹	Drinking Water Unit Risk ^{c/} in (pCi/L) ⁻¹	Soil Ingestion Unit Risk ^{d/} in (pCi/g) ⁻¹	External Exposure Unit Risk ^{e/} in (pCi/g) ⁻¹
²³¹ Th	25.5 h	2.5×10^{-7}	2.0×10^{-8}	1.1×10^{-9}	1.1×10^{-5}
²³³ U	159,000 yr	1.4×10^{-2}	7.2×10^{-6}	3.8×10^{-7}	3.2×10^{-7}
²³⁴ U	244,500 yr	1.4×10^{-2}	7.2×10^{-6}	3.8×10^{-7}	5.6×10^{-7}
²³⁵ U	7.0×10^8 yr	1.3×10^{-2}	6.6×10^{-6}	3.5×10^{-7}	9.7×10^{-5}
²³⁸ U	4.5×10^9 yr	1.2×10^{-2}	6.6×10^{-6}	3.5×10^{-7}	4.5×10^{-7}
⁹⁰ Y	64.1 h	2.8×10^{-6}	1.6×10^{-7}	8.6×10^{-9}	0

^{a/} Calculated from half-life and atomic weight.

^{b/} Excess cancer risk associated with lifetime exposure to 1 pCi/m³ (10^{-12} curies) per day in air (EPA 1991b).

^{c/} Excess cancer risk associated with lifetime exposure to 1 pCi (10^{-12} curies) per day in drinking water (EPA 1991b).

^{d/} Excess cancer risk associated with lifetime exposure to 1 pCi/g (10^{-12} curies/g) per day in soil (EPA 1991b).

^{e/} Excess cancer risk associated with lifetime exposure to surface soils containing 1 pCi/g of gamma-emitting radionuclides (EPA 1991b).

^{f/} External radiation risk from ^{137m}Ba, a short-lived decay product of ¹³⁷Cs.

NA No information available.

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**Table 4-32. Potential Chronic Human Health Effects of Chemicals
Detected or Disposed of at U Plant Aggregate Area.**

Page 1 of 2

Chemical	Tumor Site Inhalation Route; Oral Route [Weight of Evidence Group ^{a/}]	Non-carcinogenic Chronic Health Effects Inhalation Route; Oral Route	Reference
INORGANIC CHEMICALS			
Aluminum			
Ammonium ion		decreased pulmonary function; degrades odor, taste of water	EPA 1991a
Barium		fetotoxicity; increased blood pressure	EPA 1991b
Boron		NA; testicular lesions	EPA 1991a
Cadmium	respiratory tract [B1]; NA	cancer; renal damage	EPA 1991b
Calcium			
Chloride			
Chromium	lung [A] - Cr(VI) only; NA	nasal mucosa atrophy; hepatotoxicity	EPA 1991a
Copper		NA; gastrointestinal irritation	EPA 1991b
Fluoride		NA; dental flurosis at high levels	EPA 1991a
Iron			
Lead	[B2] ^{b/} ; [B2]	central nervous system (CNS) effects ^{b/} ; CNS effects	EPA 1991a
Magnesium			
Mercury		neurotoxicity; kidney effects	EPA 1991b
Nickel	respiratory tract [A]; NA	cancer; reduced weight	EPA 1991b
Nitrate/Nitrite		NA; methemoglobinemia in infants ^{c/}	EPA 1991a
Phosphate			
Potassium			
Silica			
Silver			

**Table 4-32. Potential Chronic Human Health Effects of Chemicals
Detected or Disposed of at U Plant Aggregate Area.** Page 2 of 2

Chemical	Tumor Site Inhalation Route; Oral Route [Weight of Evidence Group ^{a/}]	Non-carcinogenic Chronic Health Effects Inhalation Route; Oral Route	Reference
Sodium Sulfate			
Uranium (soluble salts)		NA; body weight loss, nephrotoxicity	EPA 1991a
Zinc		NA; anemia	EPA 1991b
ORGANIC CHEMICALS			
Acetone		NA; kidney and liver effects	EPA 1991a
Carbon tetrachloride	liver [B2]	NA; liver lesions	EPA 1991a
Chloroform	liver; kidney [B2]	NA; liver lesions	EPA 1991b
Methylene chloride	lung, liver [B2]; liver [B2]	NA; liver toxicity	EPA 1991a
Methyl isobutyl ketone		liver and kidney effects; liver and kidney effects	EPA 1991b
Toluene		CNS effects, eye irritation; change in liver and kidney weights	EPA 1991a
Tributyl phosphate		respiratory irritant; kidney damage	NIOSH 1987

- ^{a/} Weight of Evidence Groups for carcinogens: A - Human carcinogen (sufficient evidence of carcinogenicity in humans); B - Probable human carcinogen (B1 - Limited evidence of carcinogenicity in humans; B2 - Sufficient evidence of carcinogenicity in animals with inadequate or lack of data in humans); C - Possible human carcinogen (limited evidence of carcinogenicity in animals and inadequate or lack of human data); D - Not classifiable as to human carcinogenicity (inadequate or no evidence).
- ^{b/} Lead is considered by EPA to have both neurotoxic and carcinogenic effects; however, no toxicity criteria are available for lead at the present time.
- ^{c/} Toxic effect is considered to occur from exposure to nitrite; nitrate can be converted to nitrite in the body by intestinal bacteria.
- NA = Information not available.

5.0 HEALTH AND ENVIRONMENTAL CONCERNS

This preliminary qualitative evaluation of potential human health and environmental concerns is intended to provide input to the U Plant Aggregate Area waste management unit recommendation process (Section 9.0). This process requires consideration of immediate and long-term impacts to human health and the environment. As discussed in Section 4.2, existing U Plant Aggregate Area and waste management unit data are not adequate to support an evaluation of potential impacts on the environment. Although ecological impacts are an integral part of the complete assessment of aggregate area and waste unit potential risks, they cannot be evaluated further at this time. Ecological risk assessment is included in the listing of data uses presented in Section 8.0 with the associated data needs identified as a data gap to be addressed in future investigations. The approach that has been taken to identify potential concerns related to individual waste management units and unplanned releases is as follows:

- Contaminants of potential concern are identified for each exposure pathway that is likely to occur within the U Plant Aggregate Area. Selection of contaminants was discussed in Section 4.2. Contaminants of potential concern were selected from the list of candidate contaminants of potential concern presented in Table 4-26. This table includes contaminants that are likely to be present in the environment based on occurrence in the liquid process wastes that were discharged to soils, and also contaminants that have been detected in environmental samples within the aggregate area but have not been identified as components of U Plant Aggregate Area waste streams.
- Exposure pathways potentially applicable to individual waste management units are identified based on the presence of the above contaminants of potential concern in wastes in the waste management units, consideration of known or suspected releases from those waste management units, and the physical and institutional controls affecting site access and use over the period of interest. The relationships between waste management units and exposure pathways are summarized in the conceptual model (Section 4.2).
- Estimates of relative hazard derived for the U Plant Aggregate Area waste management units are identified using the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) Hazard Ranking System (HRS), modified Hazard Ranking System (mHRS), surface radiation survey data, and by Westinghouse Hanford Environmental Protection Group scoring. Other indicators of relative hazard, such as rate of release of contaminants and irreversible results of continuing residence of contaminants, were not used because they generally require unit-specific data that are not available for most units.

The human health concerns, and various hazard ranking scores listed above, are used to establish whether or not a site is considered a "high" priority. In the data evaluation process presented in Section 9.0, "high" priority sites are evaluated for the potential implementation of an interim remedial measure (IRM). "Low" priority sites are evaluated to determine what type of additional investigation is necessary to establish a final remedy. Further detail is presented in Section 9.0.

The data used for this evaluation are presented in the earlier sections of this report. The types of data that have been assessed include site histories and physical descriptions (Section 2.0), descriptions of the physical environment of the study area (Section 3.0) and a summary of the available chemical and radiological data for each waste management unit (Section 4.0).

The quality and sufficiency of these data are assessed in Section 8.0. This information is also used to identify potentially applicable or relevant and appropriate requirements (ARARs) (Section 6.0).

5.1 CONCEPTUAL FRAMEWORK FOR RISK-BASED SCREENING

The range of potential human health and environmental exposure pathways at the U Plant Aggregate Area was summarized in Section 4.2. In Section 4.2 the role of biota in transporting contaminants through the environment is also discussed, and biota are included as receptors in the conceptual model. However, the assessment of potential ecological risks associated with biota exposure to U Plant Aggregate Area contaminants is currently constrained by the lack of data. This gap in the U Plant Aggregate Area data is discussed in Section 8.2.3. As a result, the risk-based screening of waste management unit priorities discussed in this section is by necessity limited to potential human health risks.

The U.S. Environmental Protection Agency (EPA 1989b) considers a human exposure pathway to consist of four elements: (1) a source and mechanism for contaminant release, (2) a retention or transport medium (or media), (3) a point of potential human contact, and (4) an exposure route (e.g., ingestion) at the contact point. The probability of the existence of a particular pathway is dependent upon the physical and institutional controls affecting site access and use. In the absence of site access controls and other land use restrictions, the identified potential exposure pathways could all occur. For example, it could be hypothesized that an individual could establish a residence within the boundaries of the U Plant Aggregate Area, disrupt the soil surface and contact buried contamination, and drill a well and withdraw contaminated groundwater for drinking water and crop irrigation. However, within the five- to ten-year period of interest associated with identification and prioritization of remedial actions within the U Plant Aggregate Area, unrestricted access and uncontrolled disruption of buried contaminants have a negligible probability of occurrence.

The conceptual model presented in Section 4.2 was evaluated to identify an appropriate framework for screening waste management units and establishing their remediation priorities based on potential health hazards. Based on the five- to ten-year period of interest for waste unit prioritization, and the presence of site access controls during that period, a screening framework was developed encompassing the range of release mechanisms, affected media, and exposure routes associated with an onsite occupational receptor. The U Plant Aggregate Area is currently an industrial area. While work activities are assumed to include occasional contact with surface soils, it is assumed that no contact with buried contaminants will take place without proper protective measures.

Workers may be exposed via the following routes at the U Plant Aggregate Area:

- Ingestion of surface soils
- Inhalation of volatilized contaminants and resuspended particles
- Direct dermal contact with surface soils
- Direct exposure to radiation from surface soils and airborne resuspended particles.

Since evaluation of migration in the saturated zone is not within the scope of a source aggregate area management study (AAMS), ingestion or contact with groundwater was not evaluated as an exposure pathways. However, since migration of waste constituents within the saturated zone will be addressed in the 200 West Groundwater AAMS, contaminants likely to migrate to the water table and waste management units that have a high potential to impact groundwater will be identified.

5.2 POTENTIAL EXPOSURE SCENARIOS AND HUMAN HEALTH CONCERNS

The routes by which a Hanford Site worker could potentially be exposed to contamination at the waste management units include ingestion, inhalation, direct contact with soils, and direct exposure to radiation. To evaluate the potential for exposure at individual waste management units, it is necessary to have data available for surface soils, air, and radiation levels. Although samples have been collected from each of these media, only the surface radiation survey data (contamination levels and dose rate) are specific to individual waste management units. Therefore, only pathways associated with the surface radiological contamination and external dose rates can be evaluated with confidence at this time. Exposures by other pathways were evaluated based on available knowledge about contaminants disposed of to the waste management unit and the engineered barriers to releases.

5.2.1 External Exposure

External dose rate surveys, which are performed on a waste management unit basis, were used as the measure of a unit's potential for impacting human health through direct external radiation exposure. The contaminants of potential concern for this pathway are the radionuclides that emit moderate to high energy penetrating gamma radiation. The measured dose rates at U Plant Aggregate Area waste management units are presented in Table 5-1 from the available survey data. At 216-U-12 Crib, dose was measured over a year's time using a thermoluminescent dosimeter (TLD). The measured value of 106 mrem/yr was converted to 0.01 mrem/h on the basis of 8,760 h/yr.

For 16 of the 45 U Plant Aggregate Area waste management units, no radiation survey data are available. For those units that do have radiation survey data of some type, 16 were reported as having no contamination detected.

Westinghouse Hanford manual WHC-CM-4-10, Section 7 (WHC 1988b) was used as the basis for setting one of the criteria that are used to identify waste management units that can be considered high priority sites. The manual indicates that posting ("Radiation Area") and access controls are to be implemented at a level of 2 mrem/h for the purpose of personnel protection. With the same objective in mind, the level of 2 mrem/h is recommended as one of the criteria for distinguishing high priority from lower priority waste management units. The 216-U-14 Ditch was the only unit that exceeded the 2 mrem/h.

High levels of radiation were reportedly associated with some of the unplanned releases that are listed in Table 5-1. However, many of these releases occurred in the early years of the Hanford Site and more recent survey data are not available. Some of the releases were reportedly remediated by removing contaminated soil for disposal in burial grounds, paving or covering the area with soil, or flushing the soil with water. The effectiveness of the various remediation measures is not known, and confirmatory survey measurements are not available. Thus, with the exception of unplanned releases located within engineered waste units, which are routinely surveyed, information on the current radiological status of remediated unplanned releases is deficient, and is identified as a data gap in Section 8.0.

5.2.2 Ingestion of Soil or Inhalation of Fugitive Dust

Radionuclides and nonradioactive chemicals of concern for the soil ingestion and fugitive dust inhalation pathways are those that are nonvolatile, persistent in surface soils, and have appreciable carcinogenic or toxic effects by ingestion or inhalation. However, little information is available to evaluate the presence of specific radionuclides or nonradioactive chemicals in surface soils. Available gross activity survey data for the U Plant Aggregate Area waste management units are provided in Table 5-1.

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The Westinghouse Hanford Environmental Protection group policies state that the presence of any smearable alpha constitutes a potential threat to human health and qualifies a waste management unit for a high remediation priority (Huckfeldt 1991b). Waste management units that exhibit elevated alpha readings in radiological surveys can be presumed to have surface contamination, since alpha radiation cannot penetrate solids.

Westinghouse Hanford manual *Radiation Protection* (WHC 1988b) was also used to set criteria for identifying waste management units that can be considered high remediation priority sites. The manual indicates that posting ("Surface Contamination Area") and access controls are to be implemented at a level of 100 ct/min above background beta/gamma, and/or 20 dis/min alpha, for the purpose of personnel protection. With the same objective in mind, the levels of 100 ct/min above background beta/gamma and 20 dis/min alpha are recommended as two of the criteria for identification of high priority waste management units. For those survey readings that are in units of dis/min, a conversion will be made to ct/min assuming a survey instrument efficiency of 10%.

It should be noted that these radiation readings may indicate transient conditions (e.g., presence of contaminated vegetation) and that routine stabilization of surface contamination is carried out under the auspices of the Westinghouse Hanford Radiation Area Remedial Action (RARA) program.

Units subject to collapse of containment structures pose a potential threat of exposure by release of contaminants to the surface. Four of the older cribs are open wooden structures that could fail, which could force contaminants from the buried crib to the surface. Cribs 216-S-21, 216-U-1, 216-U-2, and 216-U-8 all have a potential for collapse and are believed to contain dispersable contaminants that would exceed reporting requirements if released.

5.2.3 Inhalation of Volatiles

As summarized in Section 4.1, the distribution of volatile organics in soils is not well-defined in the U Plant Aggregate Area. Although several semivolatile compounds, such as kerosene and tributyl phosphate, have been disposed of in the cribs, no information is available on whether these compounds are still available in the near surface soil column for transport to the soil surface.

The primary volatile radionuclide of concern is tritium. Exposure to tritium (as tritiated water vapor) and the potential for tritium release via radiolytic production of hydrogen from aqueous radioactive wastes is of concern. The mode of disposal of this material can not be determined from available information.

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5.2.4 Migration to Groundwater

Risks that could potentially occur due to migration of contaminants in groundwater to existing or potential receptors will be addressed in the 200 West Groundwater AAMS and thus, will not be discussed in the U Plant AAMS. However, the potential for individual units to impact groundwater has been discussed in Section 4.1.

In addition to direct disposal of liquid wastes to the soil column, certain units are known to be the source of subsurface contaminant migration. The 2607-W-5 Septic Tank and Drain Field is located about 50 m (164 ft) from the center of the 216-U-1 and 216-U-2 Cribs. Approximately 12,100 L (3,200 gal) of water per day are said to be disposed of through the septic tank. There is thus a significant flux of water through the vadose zone beneath the site. If lateral migration from either the septic tank or the cribs has occurred, then it is possible that the septic tank discharges are remobilizing contamination adsorbed onto the surface of soil particles. If this is the case, then the septic system could be flushing contaminated water into the aquifer that is more than 100 times the concentration standards.

5.3 ADDITIONAL SCREENING CRITERIA

In addition to determining human health concerns for a worker at each of the waste management units, previously developed site ranking criteria were investigated for the purpose of setting priorities for waste management units and unplanned releases. These criteria are the CERCLA HRS scores assigned during preliminary assessment/site inspection (PA/SI) activities performed for the Hanford Site (DOE/RL 1988), and the rankings assigned by the Westinghouse Hanford Environmental Protection Group to prioritize sites needing remedial actions for radiological control (Huckfeldt 1991b).

Both of these ranking systems take into account some measure of hazard and environmental mobility, and are thus appropriate to consider for waste unit prioritization. The HRS ranking system evaluates sites based on their relative risk, taking into account the population at risk, the hazardous waste constituent toxicity and concentration at the facility, the potential for contamination of the environment, the potential risk of fire and explosion, and the potential for exposure associated with humans or animals that come into contact with the waste management unit inventory. The HRS is thus appropriate to consider for screening waste management units.

The PA/SI screening was performed using the EPA's HRS and the mHRS. The HRS (40 CFR 300) is a site ranking methodology which was designed to determine whether sites should be placed on the CERCLA National Priorities List (NPL) based on chemical contamination history. The EPA has established the criteria for placement on the NPL to be a score of 28.5 or greater. The HRS criteria used in the PA/SI have been revised (December 14, 1990). The HRS scores are only used as available indicators of relative risk;

therefore, the revision will not impact the evaluation process. The mHRS is a ranking system developed by the Pacific Northwest Laboratory (PNL) for the U.S. Department of Energy (DOE) that uses the basic methodology of the old (pre-December 1990) HRS; however, it more accurately predicts the impacts from radionuclides. The mHRS takes into account concentration, half-life, and other chemical-specific parameters that are not considered by the old HRS. The mHRS has not been accepted by EPA as a ranking system.

Many of the U Plant Aggregate Area waste management units were ranked in the PA/SI using both the HRS and mHRS. For those waste management units that were not ranked in the PA/SI, unit type and discharge history were evaluated in comparison with ranked units for the purpose of setting priorities. If a waste management unit that has been ranked exhibits similar characteristics (e.g., construction, waste type, and volume), the value for the ranked unit was applied to the unit without an HRS or mHRS score. If no ranked waste management units exhibit similar characteristics, then the unit was not ranked; however, a high or low score was determined qualitatively through evaluation of unit configuration and contamination history.

Table 5-1 lists the HRS and mHRS rankings, as well as scores that were assigned for unranked waste management units, based on their similarity to ranked units in terms of type, construction, and quantity of waste disposed. If no similar waste management units were available for comparison, the units were not ranked but were assigned a qualitative indicator of migration potential. Table 5-1 also lists the units scored by the Westinghouse Environmental Protection Group (Huckfeld 1991b). A score of 7 or greater results in the assignment of a "high" priority to the unit. A value of 7 was chosen to represent the approximate midpoint of the scoring range.

For the HRS ranking, 13 units of the 45 U Plant Aggregate Area waste management units were given a score of 28.5 or greater. For the mHRS ranking, 8 units were given a score of 28.5 or greater (all of which had HRS scores greater than 28.5). Six units received a qualitative "high" score and 7 units received a qualitative "low" score. Each of the units that received a qualitative "high" HRS and mHRS score (4 cribs, the retention basin, and the settling tank) was given such a rating based on their discharge history of large quantities of hazardous materials, which could potentially have been transported to the groundwater. The units that received "low" scores (both burial grounds, all 3 septic tanks, and 2 unplanned releases) were given such a ranking because there is no known history of liquid hazardous material disposal that could affect groundwater beneath the U Plant Aggregate Area. Five sites did not receive a ranking, although investigated in the PA/SI, because of insufficient data. These are denoted as "ENS" according to the terminology used in "ENS" by the PA/SI to indicate sites not scored because of insufficient data.

5.4 SUMMARY OF SCREENING RESULTS

The screening process was used to sort sites as either high priority or low priority. Table 5-1 lists the U Plant Aggregate Area waste management units that exceeded one or more of the screening criteria identified in the preceding Sections. In total, 22 units were identified as high priority.

Radiation survey results (dose rate and/or contamination) were available for 29 of the 45 waste management units and unplanned releases. Sixteen were reported as having no detectable results. Of the remaining 13 units, 8 had survey results that exceeded one or more of the criteria (2 mrem/h, 100 ct/min beta/gamma, and 20 dis/min alpha).

For the HRS scores, 13 waste management units were given scores of 28.5 or greater. For the mHRS, 8 units received a score of 28.5 or greater. Six units received qualitative "high" scores. Only 2 units received an Environmental Protection Group score of 7 or greater. Some of the sites were designated as high priority for 2 or more of the criteria, hence only 22 total waste management units are designated high priority.

9 3 1 2 7 8 0 7 2 2

Table 5-1. Hazard Ranking Scores for U Plant Aggregate Area.

Site Name	Site Type	HRS Rating	mHRS Rating	ct/min	Radiation Surveys dis/min	mrem/h	Environmental Protection Score	High Priority
Tanks and Vaults								
241-U-361	Settling Tank	High	High	NA	NA	NA		Yes
Cribs and Drains								
216-S-21	Crib	47.81	31.93	NC	NC	NC		Yes
216-U-1 & U-2	Cribs	69.92	48.97	2,500 ^d	NC	NC	9	Yes
216-U-8	Crib	1.20	0.82	NC	NC	NC		No
216-U-12	Crib	High	High	NC	NC	0.01		Yes
216-U-16	Crib	High	High	NC	NC	NC		Yes
216-U-17	Crib	High	High	NC	NC	NC		Yes
216-Z-20	Crib	High	High	NC	NC	0.01		Yes
216-S-4	French Drain	47.81	32.72	NC	NC	NC		Yes
216-U-3	French Drain	47.27	33.89	NC	NC	NC		Yes
216-U-4A	French Drain	47.81	32.72	--	--	<1		Yes
216-U-4B	French Drain	45.30	30.20	3,000	--	--		Yes
216-U-7	French Drain	1.03	0.71	35,000	--	--		Yes
Reverse Wells								
216-U-4	Reverse Well	32.71	32.71	--	--	<1		Yes
Ponds, Ditches, and Trenches								
216-U-10	Pond	43.30 ^d	8.26 ^d	500	--	--		Yes
216-U-11	Trench	37.75	37.75	NC	NC	NC		Yes

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Table 5-1. Hazard Ranking Scores for U Plant Aggregate Area.

Site Name	Site Type	HRS Rating	mHRS Rating	ct/min	Radiation Surveys dis/min	mrem/h	Environmental Protection Score	High Priority
216-U-14	Ditch	45.30 ^a	8.26 ^a	200 ^a	NC	13	13	Yes
216-Z-1D	Ditch	45.30	8.26	NC	NC	NC		Yes
216-Z-11	Ditch	45.30	8.26	NA	NA	NA		Yes
216-Z-19	Ditch	45.30 ^a	8.26 ^a	NC	NC	0.01		Yes
216-U-5	Trench	1.03	0.71	NC	NC	NC		No
216-U-6	Trench	1.03	0.71	NC	NC	NC		No
216-U-13	Trench	0.98	0.60	NC	NC	NC		No
216-U-15	Trench	1.09	0.76	NC	NC	NC		No
Septic Tanks and Associated Drain Fields								
2607-W5	Septic Tank/ Drain Field	Low	Low ^a	NA	NA	NA		No
2607-W7	Septic Tank/ Drain Field	Low	Low	NA	NA	NA		No
2607-W9	Septic Tank/ Drain Field	Low	Low	NA	NA	NA		No
Basins								
207-U	Retention Basins	High ^b	High	7,000 ^a	NC	NC		Yes
Burial Sites								
Burial Ground/ Burning Pit	Burial Ground	Low	--	NA	NA	NA		No

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Table 5-1. Hazard Ranking Scores for U Plant Aggregate Area.

Site Name	Site Type	HRS Rating	mHRS Rating	ct/min	Radiation Surveys dis/min	mrem/h	Environmental Protection Score	High Priority
Construction Surface								
Laydown Area	Burial Ground	Low ^d	Low	NA	NA	NA		No
Unplanned Releases								
UN-200-W-6	Unplanned Release	ENS	--	NA	NA	NA		No
UN-200-W-19	Unplanned Release	1.00	--	NA	NA	NA		No
UN-200-W-33	Unplanned Release	1.00	--	NC	NC	NC		No
UN-200-W-39	Unplanned Release	1.00	--	NC	NC	NC		No
UN-200-W-46	Unplanned Release	ENS	--	NA	NA	NA		No
UN-200-W-48	Unplanned Release	0.90	--	NA	NA	NA		No
UN-200-W-55	Unplanned Release	1.10	--	NA	NA	NA		No
UN-200-W-60	Unplanned Release	ENS	--	NA	NA	NA		No
UN-200-W-68	Unplanned Release	1.00	--	NA	NA	NA		No
UN-200-W-78	Unplanned Release	0.90	--	NA	NA	NA		No

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Table 5-1. Hazard Ranking Scores for U Plant Aggregate Area.

Site Name	Site Type	HRS Rating	mHRS Rating	Radiation Surveys			Environmental Protection Score	High Priority
				ct/min	dis/min	mrem/h		
UN-200-W-86	Unplanned Release	Low	--	NA	NA	NA	No	
UN-200-W-101	Unplanned Release	1.00	--	35,000	--	--	Yes	
UN-200-W-117	Unplanned Release	ENS	--	NC	NC	NC	No	
UN-200-W-118	Unplanned Release	ENS	--	NC	NC	NC	No	
UN-200-W-161	Unplanned Release	Low	--	500	--	--	Yes	

NA = No data available.

NC = No contamination detected.

ENS = Classification given in the PA/SI when sufficient information was not available for scoring.

^a Value based on similarity to the 216-Z-11 Ditch.

^b A high value is given to those units for which no similarities to other ranked sites exist and a qualitative investigation indicates a "high" score.

^c A low value is given to those units for which no similarities exist to other ranked units exist and a qualitative investigation indicates a "low" score.

^d Beta/gamma measurement converted from dis/min to ct/min.

6.0 POTENTIALLY APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

6.1 INTRODUCTION

The Superfund Amendments and Reauthorization Act (SARA) of 1986 amended the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) to require that all applicable or relevant and appropriate requirements (ARARs) be employed during implementation of a hazardous waste site cleanup. "Applicable" requirements are defined by the U.S. Environmental Protection Agency (EPA) in "CERCLA Compliance With Other Laws Manual" (OSWER Directive 9234.1-01, August 8, 1988) as:

cleanup standards, standards of control and other substantive environmental protection requirements, criteria or limitations promulgated under federal or state law that specifically address a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance at a CERCLA site.

A separate set of "relevant and appropriate" requirements that must be evaluated include:

cleanup standards, standards of control, and other substantive environmental protection requirements, criteria, or limitations promulgated under federal or state law that while not "applicable" to a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance at a CERCLA site, address problems or situations sufficiently similar to those encountered at the CERCLA site that their use is well suited to the particular site.

"To-be-Considered Materials" (TBCs) are nonpromulgated advisories or guidance issued by federal or state governments that are not legally binding and do not have the status of potential ARARs. However, in many circumstances, TBCs will be considered along with potential ARARs and may be used in determining the necessary level of cleanup for protection of health or the environment.

The following sections identify potential ARARs to be used in developing and assessing various remedial action alternatives at the U Plant Aggregate Area. Specific requirements pertaining to hazardous and radiological waste management, remediation of contaminated soils, surface water protection, and air quality will be discussed.

The potential ARARs focus on federal or state statutes, regulations, criteria and guidelines. The specific types of potential ARARs evaluated include the following:

- Contaminant-specific

- Location-specific
- Action-specific.

Potential contaminant-specific ARARs are usually health or risk-based numerical values or methodologies that, when applied to site-specific conditions, result in the establishment of numerical contaminant values that are generally recognized by the regulatory agencies as allowable to protect human health and the environment. In the case of the U Plant Aggregate Area, potential contaminant-specific ARARs address chemical constituents and/or radionuclides. The potential contaminant-specific ARARs that were evaluated for the U Plant Aggregate Area are discussed in Section 6.2.

Potential location-specific ARARs are restrictions placed on the concentration of hazardous substances, or the conduct of activities, solely because they occur in specific locations. The potential location-specific ARARs that were evaluated for the U Plant Aggregate Area are discussed in Section 6.3.

Potential action-specific ARARs apply to particular remediation methods and technologies, and are evaluated during the detailed screening and evaluation of remediation alternatives. The potential action-specific ARARs that were evaluated for the U Plant Aggregate Area are discussed in Section 6.4.

The TBC requirements are other federal and state criteria, advisories, and regulatory guidance that are not promulgated regulations, but are to be considered in evaluating alternatives. Potential TBCs include U.S. Department of Energy (DOE) Orders that carry out authority granted under the Atomic Energy Act. All DOE Orders are potentially applicable to operations at the U Plant Aggregate Area. Specific TBC requirements are discussed in Section 6.5.

Potential contaminant- and location-specific ARARs will be refined during the aggregate area management study (AAMS) process. Potential action-specific ARARs are briefly discussed in this section, and will be further evaluated upon final selection of remedial alternatives. The points at which these ARARs must be achieved and the timing of the ARARs evaluations are discussed in Sections 6.6 and 6.7, respectively.

6.2 CONTAMINANT-SPECIFIC REQUIREMENTS

A contaminant-specific requirement sets concentration limits in various environmental media for specific hazardous substances, pollutants, or contaminants. Based on available information, some of the currently known or suspected contaminants that may be present in the U Plant Aggregate Area are outlined in Table 4-25. The currently identified potential federal and state contaminant-specific ARARs are summarized below.

6.2.1 Federal Requirements

Federal contaminant-specific requirements are specified in several statutes, codified in the U.S. Code (USC), and promulgated in the Code of Federal Regulations (CFR), as follows:

- **Clean Water Act (33 USC 1251).** Federal Water Quality Criteria (FWQC) (40 CFR 131) are developed under the authority of the Clean Water Act (CWA) (33 USC 1251) to serve as guidelines to the states for determining receiving water quality standards. Different FWQC are derived for protection of human health and protection of aquatic life. The human health FWQC are further subdivided according to how people are expected to use the water (e.g., drinking the water versus consuming fish caught from the water). The SARA 121(d)(2) states that remedial actions shall attain FWQC where they are relevant and appropriate, taking into account the designated or potential use of the water, the media affected, the purpose of the criteria, and current information. Many more substances have FWQC than maximum contaminant levels (MCLs) issued under the Safe Drinking Water Act (SDWA, see discussion below); consequently, EPA and other state agencies rely on these criteria more than MCLs, even though these criteria can only be considered relevant and appropriate and not applicable.

The FWQC would not be considered at the U Plant Aggregate Area, as no natural surface water bodies exist. The only existing manmade surface water bodies at U Plant Aggregate Area are waste management units: the 207-U Retention Basin and open stretches of the 216-U-14 Ditch.

- **Safe Drinking Water Act (42 USC 300 (f)).** Under the authority of the SDWA (42 USC 300 (f)), MCLs (40 CFR 141) apply when the water may be used for drinking. At present, EPA and the state of Washington apply MCLs as the standards for groundwater contaminants at CERCLA sites that could be used as drinking water sources. Groundwater contamination and application of MCLs as ARARs are addressed under a separate AAMS specific to groundwater.
- **Resource Conservation and Recovery Act (42 USC 6901, 40 CFR 260 to 271).** The Resource Conservation Recovery Act (RCRA) addresses the generation and transportation of hazardous waste, and waste management activities at facilities that treat, store, or dispose of hazardous wastes. Subtitle C (Hazardous Waste Management) mandates the creation of a cradle-to-grave management and permitting system for hazardous wastes. RCRA defines hazardous wastes (40 CFR 261) as "solid wastes" (even though the waste is often liquid in physical form) that may cause or significantly contribute to an increase in mortality or serious illness, or that poses a substantial hazard to human health or the

environment when improperly managed. In Washington State, RCRA is implemented by EPA and the authorized state agency, the Washington State Department of Ecology (Ecology).

The CERCLA sections 121 (d) and 121 (e) respectively require that CERCLA activities, including remedial actions, comply with substantive requirements and not administrative requirements such as permitting. Therefore, hazardous waste activities conducted on site at the U Plant Aggregate Area will comply with the substantive requirements of RCRA, and not the permitting requirements of RCRA, which are deemed to be potential ARARs.

Two key potential contaminant-specific ARARs have been adopted under the federal hazardous waste regulations: the Toxicity Characteristic Leaching Procedure (TCLP) designation limits promulgated under 40 CFR Part 261; and the hazardous waste land disposal restrictions (LDRs) for constituent concentrations promulgated under 40 CFR Part 268.

The TCLP designation limits define when a waste is hazardous, and are used to determine when more stringent management standards apply than would be applied to typical solid wastes. Thus, the TCLP potential contaminant-specific ARARs can be used to determine when RCRA waste management standards may be required. The TCLP limits are presented in Table 6-1.

The LDRs are numerical limits derived by EPA by reviewing available technologies for treating hazardous wastes. Until a prohibited waste can meet the numerical limits, it can be prohibited from land disposal. Two sets of limits have been promulgated: limits for constituent concentrations in waste extract, which uses the TCLP test to obtain a leached sample of the waste; and limits for constituent concentrations in waste, which addresses the total contaminant concentration in the waste. Applicability to CERCLA actions is based on determinations of waste "placement/disposal" during a remediation action. According to OSWER Directive 9347.3-05FS, EPA concludes that Congress did not intend in situ consolidation, remediations, or improvement of structural stability to constitute placement or disposal. The land disposal numerical limits can be used to determine if generated cleanup wastes can be redispersed of on site without further treatment, or must be subject to certain treatment practices prior to land disposal. The LDR limits are presented in Table 6-1 (see Section 6.4.1 for a further discussion on the applying LDR limits).

- **Clean Air Act (42 USC 7401).** The Clean Air Act (42 USC 7401) establishes National Primary and Secondary Ambient Air Quality Standards (NAAQS) (40 CFR Part 50), National Emission Standards for Hazardous Air Pollutants

(NESHAPs)(40 CFR Part 61), and New Source Performance Standards (NSPS)(40 CFR Part 60).

In general, new and modified stationary sources of air emissions must undergo a pre-construction review to determine whether the construction or modification of any source, such as a CERCLA remedial program, will interfere with attainment or maintenance of NAAQS or fail to meet other new source review requirements including NESHAPs and NSPS. However, the process applies only to "major" sources of air emissions (defined as emissions of 250 tons per year). The U Plant Aggregate Area would not constitute a major source.

Section 112 of the Clean Air Act directs EPA to establish standards at the level that provides an ample margin of safety to protect the public health from hazardous air pollutants. The NESHAP standards for radionuclides are directly applicable to DOE facilities under Subpart H of Section 112 that establishes a 10 mrem/year facility-wide standard for exposure to an offsite receptor. Further, if the maximum individual dose during remediation exceeds 1% of the NESHAPs standard (0.1 mrem/yr), a report meeting the substantive requirements of an application for approval of construction must be prepared.

6.2.2 State of Washington Requirements

Potential state contaminant-specific requirements are specified in several statutes, codified in the Revised Code of Washington (RCW) and promulgated in the Washington Administrative Code (WAC).

- **Model Toxics Control Act (RCW 70.105D, Chapter 173-340 WAC).** The Model Toxics Control Act (MTCA) (RCW 70.105D) authorized Ecology to adopt cleanup standards for remedial actions at hazardous waste sites. These regulations are considered potential ARARs for soil, groundwater, and surface water cleanup actions. The processes for identifying, investigating, and cleaning up hazardous waste sites are defined and cleanup levels are set for groundwater, soil, surface water and air in Chapter 173-340 WAC.

Under the MTCA regulations, cleanup standards may be established by one of three methods.

- **Method A** may be used if a routine cleanup action, as defined in WAC 173-340-200, is being conducted at the site or relatively few hazardous substances are involved for which cleanup standards have been specified by Tables 1, 2, or 3 of WAC 173-340-720 through -745.

- Under Method B, a risk level of 10^{-6} is established and a risk calculation based on contaminants present is determined.
- Method C cleanup standards represent concentrations that are protective of human health and the environment for specified site uses. Method C cleanup standards may be established where it can be demonstrated that such standards comply with applicable state and federal laws, that all practical methods of treatment are used, that institutional controls are implemented, and that one of the following conditions exist: (1) Method A or B standards are below background concentrations; (2) Method A or Method B results in a significantly greater threat to human health or the environment; (3) Method A or B standards are below technically possible concentrations, or (4) the site is defined as an industrial site for purposes of soil remediation.

Table 1 of Method A addresses groundwater, so it is not considered to be an ARAR for the U Plant Aggregate Area (groundwater will be addressed in the 200 West Groundwater Aggregate Area Management Study Report, AAMSR). Table 2 of Method A is intended for non-industrial site soil cleanups, and Table 3 is intended for industrial site soil cleanups. Method A industrial soil cleanup standards for preliminary contaminants of concern are provided as ARARs in Table 6-1.

In addition to Method A, Method B and Method C cleanup standards may also be considered potential ARARs for U Plant Aggregate Area. Method B and Method C cleanup standards can be calculated on a case-by-case basis in concert with Ecology. Method B and Method C should be used where Method A standards do not exist or cannot be met, or where routine cleanup actions cannot be implemented at a specific waste management unit.

- **State Hazardous Waste Management Act and Dangerous Waste Regulations (Chapter 173-303 WAC).** The state of Washington is a RCRA-authorized state for hazardous waste management, and has developed state-specific hazardous waste regulations under the authority of the State Hazardous Waste Management Act. Generally, state hazardous waste regulations (WAC 173-303) parallel the federal regulations. The state definition of a hazardous waste incorporates the EPA designation of hazardous waste that is based on the compound being specifically listed as hazardous, or on the waste exhibiting the properties of reactivity, ignitability, corrosivity, or toxicity as determined by the TCLP.

In addition, Washington State identifies other waste as hazardous. Three unique criteria are established: toxic dangerous waste; persistent dangerous waste; and carcinogenic dangerous waste. These additional designation criteria may be

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imposed by Ecology as potential ARARs for purposes of determining acceptable cleanup standards and appropriate waste management standards.

- **Ambient Air Quality Standards and Emission Limits for Radionuclides (Chapter 173-480 WAC).** These Ecology ambient air quality standards specify maximum accumulated dose limits to members of the public. Other Air Quality Standards potential applicable include carbon monoxide, ozone, and nitrogen dioxide (WAC 173-475) and volatile organic compounds (WAC 173-490). Although these standards may be potential ARARs, these standards are less restrictive than DOE public dose limits per DOE Order 5400.5, Radiation Protection of the Public and the Environment.
- **Monitoring and Enforcement of Air Quality and Emission Standards for Radionuclides (WAC 246-247).** These standards by the Washington State Department of Health (Health) adopt the Ecology standards for maximum accumulated dose limits to members of the public. These standards apply to DOE facilities as provided in WAC 246-247-010(2).
- **Controls for New Sources of Toxic Air Pollutants (Chapter 173-460 WAC).** In accordance with regulations recently promulgated by Ecology in Chapter WAC 173-460, any new emission source will be subject to Toxic Air Pollutant emission standards. The regulations establish allowable ambient source impact levels (ASILs) for hundreds of organic and inorganic compounds. Ecology's ASILs may constitute potential ARARs for cleanup activities that have a potential to affect air. ASILs for preliminary contaminants of concern are outlined in Table 6-1.
- **Water Quality Standards.** Washington State has promulgated various numerical standards related to surface water and groundwater contaminants. They are included principally in the following regulations:
 - **Public Water Supplies (Chapter 248-54 WAC).** This regulation establishes drinking water standards for public water supplies. The standards essentially parallel the federal drinking water standards (40 CFR Parts 141 and 143).
 - **Water Quality Standards for Groundwaters of the State of Washington (RCW 90.48, Chapter 173-200 WAC).** This regulation establishes contaminant standards for protecting existing and future beneficial uses of groundwater through the reduction or elimination of the discharge of contaminants to the state's groundwater.

- **Water Quality Standards for Surface Waters of the State of Washington (Chapter 173-201 WAC and Proposed Chapters 173-203 and 173-201 WAC).** Ecology has adopted numerical ambient water quality criteria for six conventional pollutant parameters (defined at WAC 173-201-025):

(1) fecal coliform bacteria; (2) dissolved oxygen; (3) total dissolved gas; (4) temperature; (5) pH; and (6) turbidity. In addition, toxic, radioactive, or deleterious material concentrations shall be below those of public health significance or which may cause acute or chronic toxic conditions to the aquatic environment or which may adversely affect any water use.

Numerical criteria currently exist for a limited number of toxic substances (WAC 173-201-047). Ecology has initiated rulemaking to incorporate numerical criteria for toxic chemicals (i.e., EPA Water Quality Criteria), and reclassify certain waters of the state to Class A or better.

Under the state Water Quality Standards, the criteria and classifications do not apply inside an authorized dilution zone surrounding a wastewater discharge. In defining dilution zones, Ecology generally follows guidelines contained in "Criteria for Sewage Works Design." Although water quality standards can be exceeded inside the dilution zone, state regulations will not permit discharges that cause mortalities of fish or shellfish within the zone or that diminish aesthetic values.

These water quality standards do not constitute ARARs for purposes of establishing cleanup standards for the U Plant Aggregate Area. Groundwater will be addressed in the 200 West Groundwater AAMSR in which pertinent groundwater-related ARARs will be covered. No surface water bodies exist within the U Plant Aggregate Area, so there will be no need to achieve ambient water quality standards during remediation activities.

The numerical water quality standards cited above may become potential ARARs if selected remedial actions could result in discharges to groundwater or surface water (e.g., if treated wastewaters are discharged to the soil column or the Columbia River). Determining appropriate standards on such discharges will depend on the type of remediation performed and will have to be established on a case-by-case basis as remedial actions are defined.

- **National Pollutant Discharge Elimination System and Water Quality Standards (R.C.W. 90.48, WAC 173-220 and 40 CFR 122).** National Pollutant Discharge Elimination System (NPDES) regulations govern point source discharges into navigable waters. Limits on the concentrations of contaminants and volumetric flowrates that may be discharged are determined on a case-by-case basis and permitted under this program. No point source discharges have been identified. The EPA implements this program in Washington State for federal

facilities, however, assumption of the NPDES program by the state is likely within five years.

6.3 LOCATION-SPECIFIC REQUIREMENTS

Potential location-specific ARARs are restrictions placed on the concentration of hazardous substances or the conduct of activities solely because they are in specific locations. Some examples of special locations include floodplains, wetlands, historic places, and sensitive ecosystems or habitats.

Table 6-2 lists various location-specific standards and indicates which of these may be potential ARARs. Potential ARARs have been identified as follows:

- **Floodplains.** Requirements for protecting floodplains are not ARARs for activities conducted within the U Plant Aggregate Area as the aggregate area is not located within flood plain boundaries (see Section 3.1). However, remedial actions selected for cleanup may require projects in or near floodplains (e.g., construction of a treatment facility outfall at the Columbia River). In such cases, location-specific floodplain requirements may be potential ARARs.
- **Wetlands, Shorelines, and Rivers and Streams.** Requirements related to wetlands, shorelines, and rivers and streams are not ARARs for activities conducted within the U Plant Aggregate Area. However, remedial actions selected for cleanup may require projects on a shoreline or wetland, or discharges to wetlands (e.g., construction of a treatment facility outfall at the Columbia River). In such cases, location-specific shoreline and wetlands requirements may be potential ARARs.
- **Threatened and Endangered Species Habitats.** As discussed in Section 3.6, various threatened and endangered species inhabit portions of the Hanford Site and may occur in the U Plant Aggregate Area (American peregrine falcon, bald eagle, white pelican, and sandhill crane). Therefore, critical habitat protection for these species would constitute a potential ARAR.
- **Wild and Scenic Rivers.** The Columbia River Hanford Reach is currently undergoing study pursuant to the federal Wild and Scenic Rivers Act. Pending results of this study, actions that may impact the Hanford Reach may be restricted. This requirement would not be an ARAR for remedial activities within the U Plant Aggregate Area. However, Wild and Scenic Rivers Act requirements may be potential ARARs for actions taken as a result of U Plant Aggregate Area cleanup efforts and that could affect the Hanford Reach.

6.4 ACTION-SPECIFIC REQUIREMENTS

Potential action-specific ARARs are requirements that are triggered by specific remedial actions at a unit. These remedial actions will not be fully defined until a remedial approach has been selected. However, the universe of action-specific ARARs defined by a preliminary screening of potential remedial action alternatives will help focus the selection process. Potential action-specific ARARs are outlined below. (Note that potential contaminant- and location- specific ARARs discussed above will also include provisions for potential action-specific ARARs to be applied once the remedial action is selected.)

6.4.1 Federal Requirements

- **Comprehensive Environmental Response, Compensation and Liability Act (42 USC 9601).** The CERCLA and regulations adopted pursuant to CERCLA contained in the National Contingency Plan (40 CFR 300) include selection criteria for remedial actions. Under the criteria, excavation and off-site land disposal options are least favored when on-site treatment options are available. Emphasis is placed on alternatives that permanently treat or immobilize contamination. Selected alternatives must be protective of human health and the environment, which implies that federal and state ARARs be met. However, a remedy may be selected that does not meet all ARARs if the requirement is technically impractical, if its implementation would produce a greater risk to human health or the environment, if an equivalent level of protection can otherwise be provided, if state standards are inconsistently applied, or if the remedy is only part of a complete remedial action which attains ARARs.

CERCLA gives state cleanup standards essentially equal importance as federal standards in guiding cleanup measures in cases where state standards are more stringent. State standards pertain only if they are generally applicable, were passed through formal means, were adopted on the basis of hydrologic, geologic, or other pertinent considerations, and do not preclude the option of land disposal by a statewide ban. Most importantly, CERCLA provides that cleanup of a site must ensure that public health and the environment are protected. Selected remedies should meet all ARARs, but issues such as cost-effectiveness must be weighed in the selection process.

- **Resource Conservation and Recovery Act (42 USC 6901, 40 CFR 260 to 271).** The RCRA (42 USC 6901) and regulations adopted pursuant to RCRA describe numerous action-specific requirements that may be potential ARARs for cleanup activities. The primary regulations are promulgated under 40 CFR Parts 262 (Standards for generators), 264 and 265 (Standards for owners and operators of

hazardous waste treatment, storage and disposal facilities), and include such action-specific requirements as follows:

- Packaging, labeling, placarding, and manifesting of offsite waste shipments
- Inspecting waste management areas to ensure proper performance and safe conditions
- Preparation of plans and procedures to train personnel and respond to emergencies
- Management standards for containers, tanks, incinerators, and treatment units
- Design and performance standards for land disposal facilities
- Groundwater monitoring system design and performance.

Many of these requirements will depend on the particular remediation activity undertaken, and will have to be identified as remediation proceeds.

One key potential area of action-specific RCRA ARARs is the 40 CFR Part 268 LDRs. In addition to the contaminant-specific constituent concentration limits established in the LDRs (as previously discussed in Section 6.2.1), EPA has identified best demonstrated available treatment technologies (BDATs) for various waste streams. The EPA could require the use of BDATs prior to allowing land disposal of wastes generated during remediation. The EPA's imposition of the LDRs and BDAT requirements will depend on various factors.

Applicability to CERCLA actions is based on determinations of waste "placement/disposal" during a remediation action. According to OSWER Directive 9347.3-05FS, EPA concludes that Congress did not intend in situ consolidation, remediation, or improvement of structural stability to constitute placement or disposal. Placement or disposal would be considered to occur if the following:

- Wastes from different units are consolidated into one unit (other than a land disposal unit within an area of contamination)
- Waste is removed and treated outside a unit and redeposited into the same or another unit (other than a land disposal unit within an area of contamination)

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- Waste is picked up from a unit and treated within the area of contamination in an incinerator, surface impoundment, or tank and then redeposited into the unit (except for in situ treatment).

Consequently, the requirement to use BDAT would not apply under the LDR standards unless placement or disposal had occurred. However, remediation actions involving excavation and treatment could trigger the requirements to use BDAT for wastes subject to the LDR standards. In addition, the agencies could consider BDAT technologies to be relevant and appropriate when developing and evaluating potential remediation technologies.

Two additional components of the LDR program should be considered with regard to an excavate and treat remedial action. First, a national capacity variance was issued by EPA for contaminated soil and debris for a two-year period ending May 8, 1992 (54 FR 26640). Second, a series of variances and exemptions may be applied under an excavate and treat scenario. These include the following:

- A no-migration petition
- A case-by-case extension to an effective date
- A treatability variance
- Mixed waste provisions of a Federal Facilities Compliance Act.

The applicability and relevance of each of these options will vary based on the specific details of a U Plant Aggregate Area excavate and treat option. An analysis of these variances can be developed once engineering data on the option becomes available.

The effect of the LDR program on mixed waste management is significant. Currently, limited technologies are available for effective treatment of these waste streams and no commercially available treatment facilities exist except for liquid scintillation counting fluids used for laboratory analysis and testing. The EPA recognized that inadequate capacity exists and issued a national capacity variance until May 8, 1992 to allow for the development of such treatment capacity.

Lack of treatment and disposal capacity also presents implications for storage of these materials. Under 40 CFR 268.50, mixed wastes subject to LDRs may be stored for up to one year. Beyond one year, the owner/operator has the burden of proving such storage is for accumulating sufficient quantities for treatment.

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On August 29, 1991, EPA issued a mixed waste storage enforcement policy providing some relief from this provision for generators of small volumes of mixed wastes. However, the policy was limited to facilities generating less than 28 m³ (1,000 ft³) of land disposal-prohibited waste per year. Congress is considering amendments to RCRA postponing the storage prohibition for another five years; however, final action on these amendments has not occurred.

- **Clean Water Act (33 USC 1251).** Regulations adopted pursuant to the CWA (33 USC 1251) under NPDES mandate use of best available treatment technologies (BAT) prior to discharging contaminants to surface waters. NPDES requirements would not be ARARs for actions conducted only within the U Plant Aggregate Area. However, NPDES requirements could constitute potential ARARs for cleanup actions which would result in discharge of treated wastewaters to the Columbia River, and associated treatment systems could be required to utilize BAT.
- **Department of Transportation Standards (49 CFR 171-177).** The Department of Transportation standards contained in 49 CFR 171-177 specify the requirements for packaging, labeling, and placarding for offsite transport of hazardous materials. These standards ensure that hazardous substances and wastes are safely transported using adequate means of transport and proper documentation.
- **Ambient Air Quality Surveillance (40 CFR 58)**

6.4.2 State of Washington Requirements

- **Hazardous Waste Management (WAC 173-303).** As discussed in Section 6.3.1, there are various requirements addressing the management of hazardous wastes that may be potential action-specific ARARs. Pertinent Washington regulations appear in Chapter 173-303 WAC (under the authority of RCW 70.105) and generally parallel federal management standards. Determination of ARARs will be on a case-by-case basis as cleanup actions proceed.
- **Solid Waste Management (WAC 173-304).** Washington State regulations describe management standards for solid waste in Chapter 173-304 WAC (under the authority of RCW 70.95). Some of these management standards may be potential ARARs for disposal of cleanup wastes within the U Plant Aggregate Area. Solid waste standards include such requirements as the following:
 - Inspecting waste management areas to ensure proper performance and safe conditions

- Management standards for incinerators and treatment units
- Design and performance standards for landfills
- Groundwater monitoring system design and performance.

Many of these requirements will depend on the particular remediation activity undertaken, and will have to be identified as remediation proceeds.

- **Water Quality Management.** Chapter 90.48 RCW, the Washington State Water Pollution Control Act (WPCA), requires use of all known, available, and reasonable treatment technologies (AKART) for treating contaminants prior to discharge to waters of the state. Implementing regulations appear principally at Chapters 173-216, 173-220, and 173-240 WAC.

The WPCA requirements for groundwater could be potential ARARs for actions conducted within the U Plant Aggregate Area if such actions would result in discharge of liquid contaminants to the soil column. In this event, Ecology would require use of AKART to treat the liquid discharges prior to the soil disposal.

The WPCA requirements for surface water would not be ARARs for actions conducted only within the U Plant Aggregate Area. However, these requirements could potentially constitute ARARs for cleanup actions that would result in discharge of treated wastewaters to the Columbia River and associated treatment systems could be required to demonstrate they meet AKART.

- **Air Quality Management (RCW 70.94).** Under the authority of the Washington Clean Air Act (RCW 70.94), the Toxic Air Pollution regulations for new air emission sources, promulgated in Chapter 173-460 WAC, require use of best available control technology for air toxics (T-BACT). The Toxic Air Pollution regulations may be potential ARARs for cleanup actions at the U Plant Aggregate Area that could result in emissions of toxic contaminants to the air. Ecology may require the use of T-BACT to treat such air emissions.
- **Water Well Construction (RCW 18.104).** This regulation establishes authority for Ecology to require the licensing of water well contractors and operators and for the regulation of water well construction.
- **Nuclear Energy and Radiation (RCW 70.98).** Chapter 70.98 RCW establishes a program to establish procedures for assumption and performance of certain regulatory responsibilities with respect to byproduct, source, and special nuclear materials.

- **Pollution Disclosure Act (RCW 90.52).** Chapter 90.52 RCW describes the authority of the state to regulate reports for any commercial or industrial discharge, other than sanitary sewage, into waters of the state.
- **Water Resources Act (RCW 90.54).** Chapter 90.54 RCW gives the state authority to implement water related resources programs.
- **Minimum Standards for Construction and Maintenance of Wells (Chapter 173-160 WAC).** Well construction regulations establish minimum standards for water well construction and require the preparation of construction reports.
- **Rules and Regulations Governing the Licensing of Well Contractors and Operators (Chapter 173-162 WAC).** Chapter 173-162 WAC establishes requirements for licensing of well drillers.
- **State Waste Discharge Permit Program (Chapter 173-216 WAC).** Chapters 173-216 WAC establishes a permit system for discharges of waste water to groundwater and surface water vis municipal sewage system.
- **Underground Injection Control Program (Chapter 173-218 WAC).** Chapter 173-218 WAC pertains to the injection of wastes into aquifers that are used for drinking water.
- **Incinerators (Chapter 173-303-670 WAC).** If incinerators are used for a remedial technology this regulation would be applicable.

6.5 OTHER CRITERIA AND GUIDANCE TO BE CONSIDERED

In addition to the potential ARARs presented, other federal and state criteria, advisories, and guidance and similar materials are TBC in determining the appropriate degree of remediation for the U Plant Aggregate Area. A myriad of resources may be potentially evaluated. The following represents an initial assessment of TBC provisions.

6.5.1 Health Advisories

The EPA Office of Drinking Water publishes advisories identifying contaminants for which health advisories have been issued.

6.5.2 International Commission on Radiation Protection/National Council on Radiation Protection

The International Commission of Radiation Protection and the National Council on Radiation Protection have a guidance standard of 100 mrem/yr whole body dose of gamma radiation. These organizations also issue recommendations on other areas of interest regarding radiation protection.

6.5.3 Environmental Protection Agency Proposed Corrective Actions for Solid Waste Management Units

In the July 27, 1990, Federal Register (55 FR 20798), EPA published proposed regulations for performing corrective actions (cleanup activities) at solid waste management units associated with RCRA facilities. The proposed 40 CFR Part 264 Subpart S includes requirements that would be TBCs for determining an appropriate level of cleanup at the U Plant Aggregate Area. In particular, EPA included an appendix, "Appendix A - Examples of Concentrations Meeting Criteria for Action Levels," which presented recommended contaminant concentrations warranting corrective action. These contaminant-specific TBCs are included in Table 6-1 for the preliminary contaminants of concern.

6.5.4 Department of Energy Standards for Radiation Protection

A number of DOE Orders exist which could be TBCs. The DOE Orders that establish potential contaminant-specific or action-specific standards for the remediation of radioactive wastes and materials are discussed below.

- **DOE Order 5400.5 - DOE Standards for Radiation Protection of the Public and Environment.** The DOE Order 5400.5 establishes the requirements for DOE facilities to protect the environment and human health from radiation including soil and air contamination. The purpose of the Order is to establish standards and requirements for operations of the DOE and DOE contractors with respect to protection of members of the public and the environment against undue risk from radiation.

The Order mandates that the exposure to members of the public from a radiation source as a consequence of routine activities shall not exceed 100 mrem/yr from all exposure sources due to routine DOE activities. In accordance with the Clean Air Act, exposures resulting from airborne emissions shall not exceed 10 mrem/yr to the maximally exposed individual at the facility boundary. The DOE Order 5400.5 provides Derived Concentration Guide (DCG) values for releases of radionuclides into the air or water. The DCG values are calculated so that, under

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conditions of continuous exposure, an individual would receive an effective dose equivalent of 100 mrem/year. Because dispersion in air or water is not accounted for in the DCG, actual exposures of maximally exposed individuals in unrestricted areas are considerably below the 100 mrem/year level.

The DOE Order 5400.5 also provides for establishment of soil cleanup levels through a site-specific pathway analysis such as the allowable residual contamination level method. The calculation of allowable residual contamination level values for radionuclides is dependent on the physical characteristics of the site, the radiation dose limit determined to be acceptable, and the scenarios of human exposure judged to be possible and to result in the upper-bound exposure.

- **DOE Order 5820.2A - Radioactive Waste Management.** The DOE Order 5820.2A applies to all DOE contractors and subcontractors performing work that involves management of waste containing radioactivity. This Order requires that wastes be managed in a manner that assures protection of the health and safety of the public, operating personnel, and the environment. The DOE Order 5820.2A establishes requirements for management of high-level, transuranic, and low-level wastes as well as wastes containing naturally occurring or accelerator produced radioactive material, and for decommissioning of facilities. The requirements applicable to the U Plant Aggregate Area remediation activities include those related to transuranic waste and low-level radioactive waste. These are summarized below.

- **Management of Transuranic Waste.** Transuranic (TRU) waste resulting from the U Plant Aggregate Area remedial action must be managed to protect the public and worker health and safety, and the environment, and performed in compliance with applicable radiation protection standards and environmental regulations. Practical and cost-effective methods must be used to reduce the volume and toxicity of TRU waste.

Transuranic waste must be certified in compliance with the Waste Isolation Pilot Plant (WIPP) Acceptance Criteria, placed in interim storage, if required, and sent to the WIPP. Any transuranic waste that the DOE has determined, with the concurrence of the EPA Administrator, does not need the degree of isolation provided by a geologic repository or transuranic waste that cannot be certified or otherwise approved for acceptance at the WIPP must be disposed of by alternative methods. Alternative disposal methods must be approved by DOE Headquarters and comply with National Environmental Policy Act (NEPA) requirements and EPA/state regulations.

- **Management of Low-Level Radioactive Waste.** The requirements for management of low-level radioactive waste presented in DOE Order

5820.2A are relevant to the remedial alternative of removal and disposal of U Plant Aggregate Area wastes. Performance objectives for this option shall ensure that external exposure to the radioactive material released into surface water, groundwater, soil, plants, and animals does not result in an effective dose greater than 25 mrem/yr to the public. Releases to the environment shall be at levels as low as reasonably achievable. An inadvertent intruder after the institutional control period of 100 years is not to exceed 100 mrem/yr for continuous exposure or 500 mrem for a single acute exposure. A performance assessment is to be prepared to demonstrate compliance with the above performance objectives.

Other requirements under DOE Order 5820.2A which may affect remediation of the U Plant Aggregate Area include waste volume minimization, waste characterization, waste acceptance criteria, waste treatment, and shipment. The low-level radioactive waste may be stored by appropriate methods prior to disposal to achieve the performance objectives discussed above. Disposal site selection, closure/post-closure, and monitoring requirements are also discussed in this Order.

6.6 POINT OF APPLICABILITY

A significant factor in the evaluation of remedial alternatives for the U Plant Aggregate Area will be the determination of the point at which compliance with identified ARARs must be achieved (i.e., the point of a specific ARAR's applicability). These points of applicability are the boundaries at which the effectiveness of a particular remedial alternative will be assessed.

For most individual radioactive species transported by either water or air, Ecology and Health standards generally require compliance at the boundaries of the Hanford Site (e.g. Clean Air Act, Section 6.2.1). The assumed point of compliance for radioactive species is the point where a member of the public would have unrestricted access to live and conduct business, and, consequently, to be maximally exposed. Although Health is responsible for monitoring and enforcing the air standards promulgated by Ecology, and generally recognizes the site boundary as the point of applicability, Ecology has recently indicated that compliance may be required at the point of emission.

The point at which compliance with identified ARARs must be achieved will be a significant factor in evaluating appropriate remedial alternatives in the U Plant Aggregate Area. Applicability of ARARs at the point of discharge, at the boundary of the disposal unit, at the boundary of the AAMS, at the boundary of the Hanford Site, and/or at the point of maximum exposure will need to be determined.

6.7 POTENTIAL APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS EVALUATION

Evaluation of ARARs is an iterative process that will be conducted at multiple points throughout the remedial process:

- When the public health evaluation is conducted to assess risks at the U Plant Aggregate Area, the contaminant-specific ARARs and advisories and location-specific ARARs will be identified more comprehensively and used to help determine the cleanup goals; and
- During detailed analyses of alternatives, all the ARARs and advisories for each alternative will be examined to determine what is needed to comply with other laws and to be protective of public health and the environment.

Following completion of the investigation, the remedial alternative selected must be able to attain all ARARs unless one of the six statutory waivers provided in Section 121 (d)(4)(A) through (f) of CERCLA is invoked. Finally, during remedial design, the technical specifications of construction must ensure attainment of ARARs. The six reasons ARARs can be waived are as follows:

- The remedial action is an interim measure, where the final remedy will attain ARARs upon completion.
- Compliance will result in greater risk to human health and the environment than will other options.
- Compliance is technically impracticable.
- An alternative remedial action will attain the equivalent performance of the ARAR.
- For state ARARs, the state has not consistently applied (or demonstrated the intention to consistently apply) the requirements in similar circumstances.
- For CERCLA-financed actions under Section 104, compliance with the ARAR will not provide a balance between the need for protecting public health, welfare, and the environment at the facility, and the need for fund money to respond to other sites (this waiver is not applicable at the Hanford Site).

Once investigations have been completed and final remedies have been selected, the ARARs that must be met will be formally identified in the Record of Decision (ROD). Compliance with those ARARs specified in the ROD will be achieved through the remedial

action. ARARs may need to be reevaluated if unanticipated circumstances are encountered during remediation which prevent the ability to satisfy the identified ARARs.

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Table 6-1. Potential Contaminant-Specific ARARs and TBCs for Preliminary Inorganic and Organic Contaminants of Concern.

INORGANIC CHEMICALS	RCRA TCLP Designation Limits	RCRA Land Ban Limits Nonwastewater		MTCA Method A Cleanup Levels Industrial Soil	Toxic Air Pollutants (ASIL)	RCRA Corrective Action Levels (Proposed)(1)	
	in mg/L	CCWE in mg/L	CCW in mg/kg	in mg/kg	in $\mu\text{g}/\text{m}^3$	Air in $\mu\text{g}/\text{m}^3$	Soil in mg/kg
Arsenic	5.0	5.0	-	200	0.00023	0.00007	80.
Barium	100	100	-	-	1.7	0.0004	4,000
Boron	-	-	-	-	10.0 ^{**}	-	-
Cadmium	1.0	1.0	-	10	0.00056	0.0006	40
Chromium (total)	5.0	5.0	-	500	0.000083	0.00009	40
Copper	-	-	-	-	3.3	-	-
Cyanide (total)	-	-	590	-	16.7	-	2,000
Fluoride	-	-	-	-	8.3	-	-
Lead	5.0	5.0	-	1,000	0.2	-	-
Manganese	-	-	-	-	16.7	-	-
Mercury	0.2	0.20 (low-level)	-	1	0.3	-	20
Nickel	-	-	-	-	3.3	-	2,000
Nitrite	-	-	-	-	-	-	-
Vanadium	-	-	-	-	-	-	-
Zinc	-	-	-	-	-	-	-
ORGANIC CHEMICALS							
Acetone	-	0.59	160	-	5,927.4	-	8,000
Carbon Tetrachloride	0.5	0.96	5.6	-	0.067	0.03	5
Chloroform	6	-	5.6	-	0.043	0.04	100
Methylene chloride	-	0.96	0.33	0.5	2.0	0.3	90
MIBK ("Hexone")	-	0.33	33	-	682.7	70	4,000
Toluene	-	0.33	28	40.6	1,248.8	7,000	20,000

ASIL = Acceptable Source Impact Level
 CCWE = Constituent Concentration in Waste Extract
 CCW = Constituent Concentration in Waste
 MTCA = Washington State Model Toxics Control Act
 RCRA = Federal Resource Conservation and Recovery Act
 TCLP = Toxicity Characteristic Leaching Procedure

mg/L = milligrams per liter
 mg/kg = milligrams per kilogram
 $\mu\text{g}/\text{m}^3$ = micrograms per cubic meter

(1) RCRA Corrective Action Levels are only proposed at this time (40 CFR Part 264 Subpart S), so are not ARARs yet; they are "To Be Considered."

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Table 6-2. Potential Location-Specific ARARs.

Location	Requirement	Prerequisite	Citation
GEOLOGICAL:			
Within 154 m (500 ft) of a fault displaced in Holocene time.	New treatment, storage or disposal of hazardous waste prohibited.	Hazardous waste management near Holocene fault.	40 CFR 264.18; WAC 173-303-282
Holocene faults and subsidence areas.	New solid waste disposal facilities prohibited over faults with displacement in Holocene time, and in subsidence areas.	New solid waste management activities near Holocene fault.	WAC 173-304-130
Unstable slopes.	New solid waste disposal areas prohibited from hills with unstable slopes.	New solid waste disposal on an unstable slope.	WAC 173-304-130
100-year floodplains.	Solid and hazardous waste disposal facilities must be designed, built, operated, and maintained to prevent washout.	Solid or hazardous waste disposal in a 100-year floodplain.	40 CFR 264.18; WAC 173-303-282; WAC 173-304-460
	Avoid adverse effects, minimize potential harm, restore/preserve natural and beneficial values in floodplains.	Actions occurring in a floodplain.	40 CFR Part 6 Subpart A; 16 USC 661 <i>et seq</i> ; 40 CFR 6.302
Salt dome and salt bed formations, underground mines, and caves.	Placement of non-containerized or bulk liquid hazardous wastes is prohibited.	Hazardous waste placement in salt dome, salt bed, mine, or cave.	40 CFR 264.18
SURFACE WATER:			
Wetlands.	New hazardous waste disposal facilities prohibited in wetlands.	Hazardous waste management within 154 m (500 ft) of wetland (one-quarter mile for land-based facilities).	WAC 173-303-282
	New solid waste disposal facilities prohibited within 61 m (200 ft) of surface water (stream, lake, pond, river, salt water body).	Solid waste disposal with 61 m (200 ft) of surface water.	WAC 173-304-130

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Table 6-2. Potential Location-Specific ARARs.

Location	Requirement	Prerequisite	Citation
	New solid waste disposal facilities prohibited in wetlands (swamps, marshes, bogs, estuaries, and similar areas).	Solid waste disposal in a wetland (swamp, marsh, bog, estuary, etc.).	WAC 173-304-130
	Discharge of dredged or fill materials into wetlands prohibited without a permit.	Discharges to wetlands and navigable waters.	40 CFR Part 230; 33 CFR Parts 303, and 320 to 330
	Minimize potential harm, avoid adverse effects, preserve and enhance wetlands.	Construction or management of property in wetlands.	40 CFR Part 6 Appendix A
Shorelines.	Actions prohibited within 61 m (200 ft) of shorelines of statewide significance unless permitted.	Actions near shorelines.	Chapter 90.58 RCW; Chapter 173-14 WAC.
Rivers and streams.	Avoid diversion, channeling or other actions that modify streams or rivers, or adversely affect fish or wildlife habitats and water resources.	Actions modifying a stream or river and affecting fish or wildlife.	40 CFR 6.302
Water code and water rights.	Specifies conditions for extracting surface water for non-domestic uses. In essence, the laws provide that water extraction must be consistent with beneficial uses of the resource and must not be wasteful.	Extracting surface water.	Chapter 90.03 RCW
GROUNDWATER:			
Water code and water rights.	Specifies conditions for extracting groundwater for non-domestic uses. In essence, the laws provide that water extraction must be consistent with beneficial uses of the resource and must not be wasteful.	Extracting groundwater.	Chapter 90.14 RCW

Table 6-2. Potential Location-Specific ARARs.

Location	Requirement	Prerequisite	Citation
Sole source aquifer.	New solid and hazardous waste land disposal facilities prohibited over a sole source aquifer.	Disposal over a sole source aquifer.	WAC 173-303-282; WAC 173-304-130
Uppermost aquifer.	Bottom of lowest liner of new solid waste disposal facility must be at least 3 m (10 feet) above seasonal high water in uppermost aquifer (1.5 m [5 feet] if hydraulic gradient controls installed).	New solid waste disposal.	WAC 173-304-130
	Protects the upper aquifers and upper aquifer zones to avoid depletions, excessive water level declines, or reductions in water quality. State regulations for upper aquifer zones are applicable to remedial alternatives that involve treating groundwater or presenting risks of groundwater contamination.	Activities within an aquifer.	Chapter 173-154 WAC
	Requires that Ecology review and approve plans for waste water treatment facilities that discharge to groundwater.	New treatment facilities discharging to the groundwater.	Chapter 173-240 WAC
Aquifer Protection Areas.	Activities restricted within designated Aquifer Protection Areas.	Activities within an Aquifer Protection Area.	Chapter 36.36 RCW.
Groundwater Management Areas.	Activities restricted within Ground Water Management Areas.	Activities within a Groundwater Management Area.	Chapter 90.44 RCW; Chapter 173-100 WAC

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Table 6-2. Potential Location-Specific ARARs.

Location	Requirement	Prerequisite	Citation
DRINKING WATER SUPPLY:			
Drinking water supply well.	New solid waste disposal areas prohibited within 305 m (1,000) feet upgradient, or 90 days travel time, of drinking water supply well.	New solid waste disposal within 305 m (1,000 feet) of drinking water supply well.	WAC 173-304-130
Watershed.	New solid waste disposal areas prohibited within a watershed used by a public water supply system for municipal drinking water.	New solid waste disposal in a public watershed.	WAC 173-304-130
AIR:			
Attainment areas.	Defines emissions standards and design and operation of solid waste incinerator facilities.	Activities in an attainment area.	Chapter 173-434 WAC
	Defines when certification of operators is necessary at incinerators and landfills.	Activities in an attainment area.	Chapter 173-300 WAC
Non-attainment areas.	Restrictions on air emissions in areas designated as non-attainment areas under state and federal air quality programs.	Activities in a designated non-attainment area.	Chapter 70.94 RCW; Chapters 173-400 and 173-403 WAC.
SENSITIVE ENVIRONMENTS:			
Endangered/threatened species habitats.	New solid waste disposal prohibited from areas designated by US Fish and Wildlife Service as critical habitats for endangered/threatened species.	New solid waste disposal in critical habitats.	WAC 173-304-130 16 USC 742 16 USC 2901 50 C.F.R. 17
	Actions within critical habitats must conserve endangered/threatened species.	Activities where endangered or threatened species exist.	50 CFR Parts 200 and 402.

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Table 6-2. Potential Location-Specific ARARs.

Location	Requirement	Prerequisite	Citation
Parks.	No new solid waste disposal areas within 305 m (1,000 feet) of state or national park.	New solid waste disposal near state/national park.	WAC 173-304-130
	Restrictions on activities in areas that are designated state parks, or recreation/conservation areas.	Activities in state parks or recreation/conservation areas.	Chapter 43.51 RCW; Chapter 352.32 WAC
Wilderness areas.	Actions within designated wilderness areas must ensure area is preserved and not impaired.	Activities within designated wilderness areas.	16 USC 1131 <u>et seq</u> ; 50 CFR 35.1 <u>et seq</u>
Wildlife refuge.	Restrictions on actions in areas that are part of the National Wildlife Refuge System.	Activities within designated wildlife refuges.	16 USC 668dd <u>et seq</u> ; 50 CFR Part 27
Natural areas preserves.	Activities restricted in areas designated as having special habitat value (Natural Heritage Resources).	Activities within identified Natural Area Preserves.	Chapter 79.70 RCW; Chapter 332-650 WAC
Wild, scenic, or recreational rivers.	Avoid actions that would have adverse effects on designated wild, scenic, or recreational rivers.	Activities near wild, scenic, and recreational rivers.	16 USC 1271 <u>et seq</u> ; 40 CFR 6.302; Chapter 79.72 RCW
Columbia River Gorge	Restrictions on activities that could affect resources in the Columbia River Gorge.	Activities within the Columbia River Gorge.	Chapter 43.97 RCW
UNIQUE LANDS AND PROPERTIES:			
Natural resource conservation areas.	Restrictions on activities within designated Conservation Areas.	Activities within designated Conservation Areas.	Chapter 79.71 RCW
Forest lands.	Activities restricted within state forest lands to minimize fire hazards and other adverse impacts.	Activities within state forest lands.	Chapter 76.04 RCW; Chapter 332-24 WAC
	Restrictions on activities in state and federal forest lands.	Activities within state and federal forest lands.	16 USC 1601; Chapter 76.09 RCW

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Table 6-2. Potential Location-Specific ARARs.

Location	Requirement	Prerequisite	Citation
Public lands.	Activities on public lands are restricted, regulated, or proscribed.	Activities on state-owned lands	Chapter 79.01 RCW
Scenic vistas.	Restrictions on activities that can occur in designated scenic areas.	Activities in designated scenic vista areas.	Chapter 47.42 RCW 16 USC 461
Historic areas.	Actions must be taken to preserve and recover significant artifacts, preserve historic and archaeological properties and resources, and minimize harm to national landmarks.	Activities that could affect historic or archaeological sites or artifacts.	16 UST 469, 470 <u>et seq</u> ; 36 CFR Parts 65 and 800; Chapters 27.34, 27.53, and 27.58 RCW.
LAND USE:			
Neighboring properties.	No new solid waste disposal areas within 30.5 m (100 feet) of the facility's property line.	New solid waste disposal within 30.5 m (100 feet) of facility property line.	WAC 173-304-130
	No new solid waste disposal areas within 76 m (250 feet) of property line of residential zone properties.	New solid waste disposal within 76 m (250 feet) of property line of residential property.	WAC 173-304-130
Proximity to airports.	Disposal of garbage that could attract birds prohibited within 3,050 m (10,000 feet) (turbojet aircraft)/(1,524 m) (5,000 feet) (piston-type aircraft) of airport runways.	Garbage disposal near airport.	WAC 173-304-130

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7.0 PRELIMINARY REMEDIAL ACTION TECHNOLOGIES

Previous sections identified contaminants of concern at the U Plant Aggregate Area, potential routes of exposure, and potentially applicable or relevant and appropriate requirements (ARARs). Section 7.0 identifies preliminary remedial action objectives (RAOs) and develops preliminary remedial action alternatives consistent with reducing the potential hazards of this contamination and satisfying potential ARARs. The overall objective of this section is to identify viable and innovative remedial action alternatives for media of concern at the U Plant Aggregate Area.

The process of identifying viable remedial action alternatives consists of several steps. In Section 7.1, RAOs are first identified. Next, in Section 7.2, general response actions are determined along with specific treatment, resource recovery, and containment technologies within the general response categories. Specific process options belonging to each technology type are identified, and these process options are subsequently screened based on their effectiveness, implementability, and cost (Section 7.3). The combining of process options into alternatives occurs in Section 7.4. Here the alternatives are described and diagrammed. Criteria are then identified in Section 7.5 for preliminary screening of alternatives that may be applicable to the waste management units and unplanned release sites identified in the U Plant Aggregate Area. Figure 7-1 is a matrix summarizing the development of the remedial action alternatives starting with media-specific RAOs.

Because of uncertainty regarding the nature and extent of contamination at the U Plant Aggregate Area waste sites, recommendations for remedial alternatives are general and cover a broad range of actions. Remedial action alternatives will be considered and more fully developed in future focused feasibility studies. The *Hanford Site Past-Practice Strategy* (DOE/RL 1992a) is used to focus the range of remedial action alternatives that will be evaluated in focused studies. In general, the *Hanford Site Past-Practice Strategy* remedial investigation (RI)/feasibility study (FS) and the Resource Conservation and Recovery Act (RCRA)/Corrective Measures Studies (CMS) are defined as the combination of interim remedial measures (IRMs), limited field investigations (LFIs) for final remedy selection where interim actions are not clearly justified, and focused or aggregate area feasibility/treatability studies for further evaluation of treatment alternatives. After completion of an IRM, data will be evaluated including concurrent characterization and monitoring data to determine if a final remedy can be selected.

A secondary purpose of the evaluation of preliminary remedial action alternatives is the identification of additional information needed to complete the evaluation. This information may include field data needs and treatability tests of selected technologies. Additional data will be developed for most sites or waste groups during future data gathering activities (e.g., LFIs, characterization supporting IRMs, or treatability studies). These data may be used to refine and supplement the RAOs and proposed alternatives identified in this initial study.

Data needs are defined in Section 8.0. Alternatives involving technologies that are not well-demonstrated under the conditions of interest are identified in Sections 7.3 and 7.5. These technologies may require bench-scale and pilot-scale treatability studies. The intent is to conduct treatability studies for promising technologies early in the RI/FS process. Conclusions regarding the feasibility of some individual technologies may change after new data become available.

The bias-for-action philosophy of addressing contamination at the Hanford Site requires an expedited process for implementing remedial actions. Implementation of general response actions may be accomplished using an observational approach in which the implementation is redirected as information is obtained. This observational approach is an iterative process of data acquisition and refinement of the conceptual model. Data needs are determined by the model, and data collected to fulfill these needs are used as additional input to the model. Use of the observational approach while conducting response actions in the 200 Areas will allow integrating these actions with longer range objectives of final remediation of similar areas and the entire 200 Areas. Site characterization and remediation data will be collected concurrently with the use of LFIs, IRMs, and treatability testing. The knowledge gained through these different activities will be applied to similar areas. The overall goal of this approach is convergence on an appropriate response action as early as possible while continuing to obtain valuable characterization information during remediation phases.

7.1 PRELIMINARY REMEDIAL ACTION OBJECTIVES

The RAOs are remediation goals for protection of human health and the environment that specify the contaminants and media of concern, exposure pathways, and allowable contaminant levels. The RAOs discussed in this section are considered to be preliminary and may change or be refined as new data are acquired and evaluated.

The fundamental objective of the corrective action process at the U Plant Aggregate Area is to protect environmental resources and/or human receptors from the potential threats that may exist because of known or suspected contamination. Specific interim and final RAOs will depend in part on current and reasonable potential future land use in the U Plant Aggregate Area and the 200 Areas. The RAOs also take into account the preference under Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) for isolation and permanent or significant reduction of volume, toxicity or mobility of hazardous substances.

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To focus remedial actions with a bias for action through implementing IRMs, preliminary RAOs are identified for the 200 Areas and U Plant Aggregate Area. The overall objective for the 200 Areas is as follows:

Reduce the risk of harmful effects to the environment and human users of the area by isolating or permanently reducing the toxicity, mobility, or volume of contaminants from the source areas to meet ARARs or risk-based levels that will allow industrial use of the area (this is a potential final RAO, and an interim action objective based on current use of the 200 Area).

The RAOs are further developed in Table 7-1 for media of concern and applicable exposure pathways (see Sections 4.1 and 4.2) for the U Plant Aggregate Area. The media of concern for the U Plant Aggregate Area include the following:

- Radionuclide-contaminated and chemically-contaminated soils that could result in direct exposure or inhalation of vapors or particles
- Contaminated soils that are or could contribute to groundwater contamination
- Vadose zone vapors that could cause ambient air impacts or contribute to the lateral and vertical migration of contaminants in the soil and to the groundwater
- Biota that could mobilize radionuclides or chemical contaminants and could thereby degrade the integrity of other controls, such as caps.

Waste materials currently stored in single-shell tanks that contribute or may contribute contaminants to environmental media will not be addressed by this aggregate area management study (AAMS) program but rather by the single-shell tank program. In addition, groundwater as an exposure medium is not addressed in this source AAMS report (AAMSR) but will be addressed in the 200 West Groundwater AAMSR.

7.2 PRELIMINARY GENERAL RESPONSE ACTIONS

General response actions represent broad classes of remedial measures that may be appropriate to achieve both interim and final RAOs at the U Plant Aggregate Area, and are presented in Table 7-2. The following are the general response actions followed by a brief description for the U Plant Aggregate Area:

- No action (applicable to specific facilities)
- Institutional controls
- Waste removal and treatment or disposal
- Waste containment
- In situ waste treatment
- Combinations of the above actions.

These general response actions are intended to cover the range of options from no action to complete remediation. Included are options that satisfy the CERCLA preference for isolation and permanent or significant reduction in volume, mobility, and toxicity of hazardous substances. No action is included for evaluations as required by the National Environmental Policy Act (NEPA) and National Contingency Plan [40 CFR 300.68 (f)(1)(v)] to provide a baseline for comparison with other response actions. The no action alternative may be appropriate for some facilities and sources of contamination if risk assessments determine acceptable natural resource or human health risks posed by those sources or facilities and no exceedances of contaminant-specific ARARs occur.

Institutional controls involve the use of physical barriers or access restrictions to reduce or eliminate public exposure to contamination. Many access and land use restrictions are currently in place at the Hanford Site and will remain in place during implementation of remedial actions. Because the 200 Areas are already committed to waste management for the long term, institutional controls will also be important for final remedial measure alternatives.

Waste removal and treatment or disposal involves excavation of contamination sources for eventual treatment and/or disposal either on a small- or large-scale basis. One approach being considered for large-scale waste removal is macro-engineering, which is based on high volume excavation using conventional surface mining technologies. Waste removal on a macro-engineering scale would be used over large areas such as groups of waste management units, operable units, or operational areas as a final remedial action. Waste removal on a

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small scale would be conducted for individual waste management units on a selective basis. Small-scale waste removal could be conducted as either an interim or final remedial action.

The alternatives for disposal of the excavated waste would depend on the volume of soil and the nature of the contaminants:

- Soil that contained low levels of radionuclides but no hazardous chemical waste could be disposed of into existing disposal sites at Hanford, or it could be shipped to licensed offsite disposal sites.
- Soil that contained chemical contaminants but no radionuclides could be disposed of at existing offsite RCRA-approved landfills, or disposed of onsite in a Hanford RCRA-approved landfill.
- Soil that was designated as "mixed waste" with both low-level radionuclides and hazardous chemical contaminants would have to be disposed of at Hanford.
- There are currently no facilities at Hanford or offsite for permanent geologic disposal of transuranic (TRU) waste. If such soil was excavated, it would have to be temporarily stored at Hanford until a geologic repository disposal site was licensed and constructed or another disposal option is identified.

One potential problem with offsite disposal of radioactive waste is the lack of an alternate disposal location that will decrease the potential human exposure over the long time required for many of the contaminants. Waste removal actions may not be needed, or only be required on a small scale, to protect human health or the environment for industrial uses of the 200 Areas.

Waste treatment involves the use of biological, thermal, physical, or chemical technologies. Typical treatment options include biological land farming, thermal processing, soil washing, and fixation/solidification/stabilization. As described in Section 7.3, some of the technologies that have been used at industrial sites may not be feasible at Hanford. Some treatment technologies must be pilot tested before they could be implemented. Waste treatment could be conducted either as an interim or final action and may be appropriate in meeting RAOs for all potential future land uses.

Waste containment includes the use of capping technologies (i.e., capping and grouting) to minimize the driving force for downward or lateral migration of contaminants. Vertical barriers can also be used to minimize lateral migration and to prevent biota from penetrating into contaminated areas. Containment also provides a radiation exposure barrier and barrier to direct exposure. In addition, these barriers provide long-term stability with relatively low maintenance requirements. Containment actions may be appropriate for either interim or final remedial actions.

In situ waste treatment includes thermal, chemical, physical, and biological technology types, of which there are several specific process options including in situ vitrification, in situ grouting or stabilization, soil flushing, and in situ biotreatment. The distinguishing feature of in situ treatment technologies is the ability to attain RAOs without removing the wastes. The final waste form generally remains in place. This feature is advantageous when exposure during excavation would be significant or when excavation is technically impractical. In situ treatment can be difficult because the process conditions may not be easily controlled.

In the next section, specific process options within these technology groups are evaluated.

7.3 TECHNOLOGY SCREENING

In this section, potentially applicable technology types and process options are identified. These process options are then screened using effectiveness, implementability, and relative cost as criteria to eliminate those process options that would not be feasible at the site. The remaining applicable processes are then grouped into remedial alternatives in Sections 7.4.

The effectiveness criteria focuses on: (1) the potential effectiveness of process options in handling the areas or volumes of media and meeting the RAOs; (2) the potential impacts to human health and the environment during the construction and implementation phase; and (3) how proven and reliable the process is with respect to the contaminants and conditions at the site. This criteria also concentrates on the ability of a process option to treat a contaminant type (organics, inorganics, metals, radionuclides, etc.) rather than a specific contaminant (nitrate, cyanide, chromium, plutonium, etc.).

The implementability criteria places greater emphasis on the institutional aspects of implementability, such as the ability to obtain necessary permits for offsite actions, the availability of treatment, storage, and disposal services, and the availability of necessary equipment and skilled workers to implement the technology. It also focuses on the process option's developmental status, whether it is an experimental or established technology.

The relative cost criterion is an estimate of the overall cost of a process, including capital and operating costs. At this stage in the process, the cost analysis is made on the basis of engineering judgement, and each process is evaluated as to whether costs are high, medium, or low relative to other process options.

A process option is rated effective if it can handle the amount of area or media required, if it does not impact human health or the environment during the construction and implementation phases, and if it is a proven or reliable process with respect to the

contaminants and conditions at the site. Also a process option is considered more effective if it treats a wide range of contaminants rather than a specific contaminant. An example of a very effective process option would be vitrification because it treats inorganics, metals, and radionuclides. On the other hand, chemical reduction may only treat chromium (VI), making it a less useful option.

An easily implemented process option is one that is an established technology, uses readily available equipment and skilled workers, uses treatment, storage, and disposal services that are readily available, and has few regulatory constraints. Preference is given to technologies that are easily implemented.

Preference is given to lower cost options, but cost is not an exclusionary criteria. A process option is not eliminated based on cost alone.

Results of the screening process are shown in Table 7-3. Brief descriptions are given of the process options, followed by comments regarding the evaluation criteria. The last column of the table indicates whether the process option is rejected or carried forward for possible alternative formation. The table first lists technologies that address soil RAOs. Next, technologies pertaining to biota RAOs are presented. All the biota-specific technologies happen to be technologies that were listed for soil RAOs. Air RAOs are dealt with as soil remediation issues because the air contamination is a result of the contaminants in the soil: addressing and remediating the air pathways would be unnecessary and ineffective as long as there is soil contamination. If the soil is remediated, the source of the air contamination would be removed.

The conclusions column of Table 7-3 indicates that no action, monitoring, 3 institutional process options, and 16 other process options are retained for further development of alternatives. These options are carried forward into the development of preliminary alternatives.

7.4 PRELIMINARY REMEDIAL ACTION ALTERNATIVES

This section develops and describes several remedial alternatives considered applicable to disposal sites that contain hazardous chemicals, radionuclides, and volatile and semi-volatile organic compounds (VOCs). These alternatives are not intended as recommended actions for any individual site, but are intended only to provide potential options applicable to most sites where multiple contaminants are present. Selection of actual remedial alternatives that should be applied to the individual sites would be partly based on future expedited or interim actions and LFIs, as recommended in Section 9.0 of this report. Selection of proper alternatives would be conducted within the framework of the *Hanford Site Past-Practice Strategy* (DOE/RL 1992a) and the strategy outlined in Section 9.4. The selection process would also be based on a preference for isolation and permanent treatment.

The remedial alternatives are developed in Section 7.4.1. Then, in Section 7.4.2 through Section 7.4.7, the remedial action alternatives are described. Detailed evaluations and costs are not provided because site-specific conditions must be further investigated before meaningful evaluations could be conducted.

7.4.1 Development of Remedial Alternatives

Potentially feasible remedial technologies were described and evaluated in Section 7.3. Some of those technologies have been proven to be effective and constructible at industrial waste sites, while other technologies are in the developmental stages. The EPA guidance (EPA 1988b) on FSs for uncontrolled waste management units recommends that a limited number of candidate technologies be grouped into "Remedial Alternatives." For this study, technologies were combined to develop remedial alternatives and provide at least one alternative for each of the following general strategies:

- No action
- Institutional controls
- Removal, above-ground treatment, and disposal
- Containment
- In situ treatment.

The alternatives are intended to treat all or a major component of the U Plant Aggregate Area contaminated waste management units or unplanned releases. Consistent with the development of RAOs and technologies, alternatives were developed based on treating classes of compounds (radionuclides, heavy metals, inorganics, and organics) rather than specific contaminants. At a minimum, the alternative must be a complete package. For example, disposal of radionuclide-contaminated soil must be combined with excavation and backfilling of the excavated site.

One important factor in the development of the preliminary remedial action alternatives is the fact that radionuclides, heavy metals, and some inorganic compounds cannot be destroyed. Rather, these compounds must be physically immobilized, contained, isolated, or chemically converted to less mobile forms to satisfy RAOs. Organic compounds can be destroyed, but may represent a smaller portion of the overall contamination at the U Plant Aggregate Area. Both no action and institutional control options are required to be considered as part of the CERCLA RI/FS guidance. The purpose of including both of these alternatives is to provide decision makers with information on the entire range of available remedial actions.

For the containment alternative, an engineered multimedia cover, with or without vertical barriers (depending on the specifics of the remediation) was selected. Two alternatives were selected to represent the excavation and treatment strategy. One of these deals with disposal of TRU contaminated soils. Finally, three in situ alternatives were identified. One deals with vapor extraction for VOCs, one with stabilization of soils and the other with vitrification of soils.

It is recognized that this does not represent an exhaustive list of all applicable alternatives. However, these do provide a reasonable range of remedial actions that are likely to be evaluated in future feasibility studies. The remedial action alternatives are summarized as follows:

- No action
- Institutional controls
- Engineered multimedia cover with or without vertical barriers (containment)
Feasible vertical barriers include slurry walls and grout curtains
- In situ grouting or stabilization of soil (in situ treatment)
- Excavation, above-ground treatment, and disposal of soil (removal, treatment and disposal). Feasible technologies for organic compounds include thermal processing and stabilization. Feasible technologies for radionuclides include soil washing, vitrification, and stabilization.
- In situ vitrification of soil (in situ treatment)
- Excavation, treatment, and geologic disposal of soil with TRU radionuclides (removal, treatment and disposal)
- In situ soil vapor extraction of VOCs (in situ treatment).

These alternatives, with the exception of no action and institutional controls, were developed because they satisfy a number of RAOs simultaneously and use technologies that are appropriate for a wide range of contaminant types. For example, constructing an engineered multimedia cover may effectively contain radionuclides, heavy metals, inorganic compounds, and organic compounds simultaneously. It satisfies the RAO of protecting human health and the environment from direct exposures from contaminated soil, bio-mobilization, and airborne contaminants. In situ soil vapor extraction is more contaminant-specific than the other alternatives, but it addresses a contaminant class (VOCs) that is not readily treated using the other options, such as in situ stabilization. It is possible

that some waste management units may require a combination of the identified alternatives to completely address all contaminants.

The use of contaminant-specific remedial technologies was avoided because there appear to be few, if any, waste management units where a single contaminant has been identified. It is possible to construct alternatives that include several contaminant-specific technologies, but the number of combinations of technologies would result in an unmanageable number of alternatives. Moreover, the possible presence of unidentified contaminants may render specific alternatives unusable. Alternatives may be refined as more contamination data are acquired. For now, the alternatives will be directed at remediating the major classes of compounds (radionuclides, heavy metals, inorganics, and organics).

In all alternatives except the no-action alternative, it is assumed that monitoring and institutional controls are required, although they may be temporary. These features are not explicitly mentioned, and details are purposely omitted until a more detailed evaluation may be performed in subsequent studies. Also, treatability studies may accompany many of the alternatives during implementation.

In the next sections, the preliminary remedial action alternatives are described in more detail, with the exception of the no-action and institutional control options.

7.4.2 Alternative 1—Engineered Multimedia Cover with or without Vertical Barriers

Alternative 1 consists of an engineered multimedia cover. Vertical barriers such as grout curtains or slurry walls may be used in conjunction with the cover. Figure 7-2 shows a schematic diagram of an engineered multimedia cover with the vertical barriers. If the affected area includes either a naturally occurring or engineered depression, then imported backfill would be placed to control runoff and run-on water. The engineered cover itself may consist of fine-grained soil, gravel, sand, asphalt, top-soil, and/or geo-synthetics. A liquid collection layer could also be included. The specific design of the cover and vertical barriers would be the subject of a focused feasibility study which may be supported by treatability studies and performance testing. The barrier would be designed to minimize infiltration of surface water by enhancing the evapotranspiration mechanism. The covered area may be fenced, and warning signs may be posted.

Alternative 1 would provide a permanent cover over the affected area. The cover would accomplish the following: minimize the migration of precipitation into the affected soil; reduce the migration of windblown dust that originated from contaminated surface soils; reduce the potential for direct exposure to contamination; and reduce the volatilization of VOCs and tritium to the atmosphere. If vertical barriers are included, they would limit the amount of lateral migration of contaminants.

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This alternative would not reduce the volume or toxicity of the contaminants, and periodic inspections, maintenance, and monitoring would be required for an indefinite period.

7.4.3 Alternative 2--In Situ Grouting or Stabilization of Soil

Radioactive and hazardous soil would be grouted in this alternative using in situ injection methods to significantly reduce the leachability of hazardous contaminants, radionuclides and/or VOCs from the affected soil. Grouting may also be used to fill voids, such as in cribs, thereby reducing subsidence. Another variation of this alternative would be to stabilize the soil using in situ mixing of soil with stabilizing compounds such as pozzolanics or fly ash.

There are two common methods of in situ grout injection that have been used at industrial sites. In the first method (Figure 7-3), grout injection wells are installed at prescribed lateral spacing (based on pilot tests) and screened through the affected vertical zones. Specially formulated grout is then injected at high pressure to provide overlapping zones of influence and allowed to cure. This first method can theoretically be used to stabilize soil deep below the ground surface. In the second method, a patented large diameter auger/mixer is used to mechanically agitate and blend grout mixtures that are injected into the soil through ports in the auger. This method has commonly been used to grout large areas of soil down to a depth of about 4.6 m (15 ft).

Alternative 2 would provide a combination of immobilization and containment of heavy metal, radionuclide, inorganic, and semi-volatile organic contamination. Thus, this alternative would reduce migration of precipitation into the affected soil; reduce the migration of windblown dust that originated from contaminated surface soils; reduce the potential for direct exposure to contaminated soils; and reduce the volatilization of VOCs.

In situ grouting has been demonstrated to be effective for stabilization of metals and semi-volatile organic compounds at several CERCLA sites. However, this is considered to be a developing technology and has not yet been fully proven. Therefore, it is expected that treatability tests would be required. Because this alternative would not remove the contaminants from the soil, it is likely that institutional controls would be required.

7.4.4 Alternative 3--Excavation, Soil Treatment, and Disposal

Under Alternative 3, radioactive and hazardous soil would be excavated using conventional techniques, with special precautions to minimize fugitive dust generation. Depending on the configuration of the area to be excavated, shoring might be required to comply with safety requirements and to reduce the quantity of excavated soil. The soil excavated would be treated above ground. Several treatment options could be selected from

the physical, chemical, and thermal treatment process options screened in Section 7.3. For example, thermal desorption with off gas treatment could be used if organic compounds are present; soil washing could be used to remove contaminated silts and sands or specific compounds; and stabilization could be used to immobilize radionuclides and heavy metals. The specific treatment method would depend on site-specific conditions. Treatability tests would be performed to determine the specific soil treatment protocols methodology. The treated soil would be backfilled into the original excavation or landfilled. Soil treatment by-products may require additional processing or treatment. Figure 7-4 shows a schematic diagram of this alternative.

Alternative 3 would be effective in treating a full range of contamination, depending on the type of treatment processes selected. Attainment of soil RAOs would depend on the depth to which the soil was excavated. If near surface soil was treated, airborne contamination, direct exposure to contaminated soil, and bio-mobilization of contamination would be minimized. Because of practical limits on deep excavation, deep contamination may not be removed and would be subject to migration into groundwater. Alternative 3 could be used in conjunction with Alternative 1 (multimedia cap) to reduce this possibility.

A combination of laboratory treatability tests and pilot scale field tests might be required to develop the optimum methods for above-ground treatment of the excavated soil. The specification of the required treatability tests would depend on the nature of the contaminants at each of the remediation sites.

7.4.5 Alternative 4—In Situ Vitrification of Soil

In this alternative, the contaminated soil in a subject site would be immobilized by in situ vitrification. Treatability tests would be performed initially to determine site-specific operating conditions. Figure 7-5 shows a schematic diagram of the alternative. Import fill would initially be placed over the affected area to reduce exposures to the remediation workers from surface contamination. High power electrodes would be used to vitrify the contaminated soil under the site to a depth below where contamination is present. A large fume hood would be constructed over the site before the start of the vitrification process to collect and treat emissions. After completion of the vitrification, the site would be built back to original grade with imported backfill. Fences and warning signs may be placed around the vitrified monolith to minimize disturbance and potential exposure.

In situ vitrification would be effective in treating radionuclides, heavy metals, and inorganic contamination and may also destroy organic contaminants. This would reduce the potential for exposures by leaching to groundwater, windblown dust and direct dermal contact. However, this alternative would not reduce the mass or toxicity of the radionuclides present onsite. Also, in situ vitrification may be limited to depths of less than about 30.5 m (100 ft), which may not be adequate to immobilize deep contamination.

If organic compounds are present in the affected area, they could migrate laterally and vertically during the vitrification process, as a result of the soil heating process. Therefore, this technology must include provisions for collection and treating organic vapors. This could be done using a combination of soil venting wells and an above-ground capture hood.

It should be noted that in situ vitrification is a relatively new technology which is experiencing some "growing pains" and has not been used for a large-scale cleanup at an industrial site. Therefore, using this technology at the Hanford Site will likely require extensive pilot testing.

7.4.6 Alternative 5--Excavation, Above-Ground Treatment, and Geologic Disposal of Soil with Transuranic Radionuclides

Some of the waste management units in the U Plant Aggregate Area may contain isolated zones where the concentrations of TRU radionuclides exceeds 100 nCi/g. For Alternative 5, the soil from those isolated zones would be excavated, stabilized or treated, and shipped to an offsite geologic disposal site. Such a disposal facility has not yet been licensed, so interim storage of the stabilized soil may be required until a final geologic repository is constructed.

Figure 7-6 shows a schematic diagram of Alternative 5. Depending on the configuration of the affected area, shoring may be required during excavation to comply with worker safety regulations and to minimize the amount of excavated soil. Special excavation procedures would have to be used to minimize fugitive dust. The excavated soil would be sorted according to TRU concentration. Soil with TRU radionuclides exceeding 100 nCi/g would be either vitrified or stabilized using an above ground treatment plant, then stored until a geologic disposal facility was available.

Some of the excavated soil could contain TRU radionuclides at concentrations less than 100 nCi/g, and could be treated using a combination of the technologies described in Section 7.3. After the non-TRU soil was treated to achieve appropriate cleanup standards, it could be backfilled into the original excavation. Alternatively, the non-TRU soil could be disposed of at an appropriate landfill. Imported fill material would be used to restore the site to its original grade. If the residual unexcavated soil or the treated soil used for backfill contained contaminants at concentrations exceeding the RAOs, then a combination of an engineered cover and vertical barriers (Alternative 1) might have to be installed at the site to prevent direct exposure or groundwater impacts.

This alternative would utilize many excavation and treatment technologies that have been only partly demonstrated at industrial sites. Extensive treatability testing would be required for the TRU-containing soil to develop optimum methods for treating or stabilizing

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the TRU radionuclides. Additional treatability studies might be required to support the above-ground treatment of the non-TRU soil.

For Alternative 5, soil containing TRU radionuclides at concentrations exceeding 100 nCi/g would be excavated, treated, and disposed. Thus, potential exposure to and migration of TRU-wastes would be minimized. Potential exposure to other contaminants would be determined by other remedial alternatives implemented. At sites containing TRU and non-TRU wastes, the use of Alternative 5 alone may not satisfy all RAOs.

7.4.7 Alternative 6--In Situ Soil Vapor Extraction for Volatile Organic Compounds

Figure 7-7 shows a schematic diagram of a representative soil vapor extraction system. Soil vapor is vented from wells that are screened in permeable soil zones that contain high organic vapor concentrations. The vented air would be treated to remove water vapor, the organic vapor of concern, particulate radionuclides that might be entrained in the air stream, and volatile radionuclides. Figure 7-7 shows one common combination of offgas treatment technologies; other technologies can also be used depending on the nature of the vapors that are extracted. Water vapor must be removed (usually by condensation) to protect the vacuum pumps. If the condensed water contains organic contamination or radionuclides, then it would have to be treated and/or disposal of in an appropriate manner. Particulate radionuclides that were entrained in the air stream can be effectively removed using banks of conventional High Efficiency Particulate Air (HEPA) filters. The organic vapors would have to be treated to satisfy Best Available Control Technology in accordance with air toxics regulations. If the disposal site is considered a RCRA facility, then the offgas treatment system must also satisfy RCRA emission control standards. Destruction efficiencies exceeding 98% have often been achieved for soil vapor extraction systems at industrial sites. The required destruction efficiency will be determined based on applicable ARARs.

A pilot-scale test would probably have to be performed to determine the required venting well spacing and the required vacuum pump design. Analysis of the vented gas during the pilot test would be done to assess what types of offgas emission controls would be required.

Some of the waste management units at the U Plant Aggregate Area contain volatile organic compounds along with other non-volatile contaminants. Alternative 6 utilizes proven technologies to remove the volatilized vapors from the vadose zone soil. In situ soil vapor extraction is a proven technology for removal of VOC from the vadose zone soils although some pilot-scale testing may be needed at specific sites. Soil vapor extraction would reduce downward migration of the VOC vapors through the vadose zone, and thereby minimize potential cross-media migration into the groundwater. Soil vapor extraction would reduce upward migration of VOC through the soil column into the atmosphere, and thereby minimize inhalation exposures to the contaminants. In some cases the radionuclides were

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discharged to the disposal sites with VOCs (e.g., hexone). Removal of the VOC by implementing soil vapor extraction could reduce the mobility of the radionuclides, and thereby reduce the potential for downward migration of the radionuclides. Finally, soil vapor extraction would enhance partitioning of the VOC off of the soil and into the vented air stream, resulting in the permanent removal and destruction of the VOC. Alternative 6 may be used in conjunction with other alternatives if contaminants other than VOCs are present. However, because of the limited number of U Plant Aggregate Area waste management units that contain VOCs, the use of soil vapor extraction will not be extensive.

7.5 PRELIMINARY REMEDIAL ACTION ALTERNATIVES APPLICABLE TO WASTE MANAGEMENT UNITS AND UNPLANNED RELEASE SITES

The purpose of this section is to discuss which preliminary remedial action alternatives could be used to remediate each U Plant Aggregate Area waste management unit or unplanned release site. The criteria used for deciding this are as follows:

- Installing an engineered multimedia cover with or without vertical barriers (Alternative 1) could be used on any site where contaminants may be leached or mobilized by surface water infiltration or if surface/near-surface contamination exists.
- In situ grouting or stabilization (Alternative 2) could be used on any waste management unit or unplanned release site that contain heavy metals, radionuclides, and/or other inorganic compounds. In situ grouting could also be effective in filling voids for subsidence control.
- Excavation and soil treatment (Alternative 3) could be used at most waste management units or unplanned release sites that contain radionuclides, heavy metals, other inorganics compounds, semi-volatile organic compounds, and VOCs.
- In situ vitrification (Alternative 4) could be used at most waste management unit or unplanned release sites, although vapor extraction may be needed when VOCs are present. Waste management units or unplanned release sites where in situ vitrification may not be effective include reverse wells and other sites where the contamination is present in a very narrow geometry. In situ vitrification is also not considered for surface spills.
- Excavation, treatment, and geologic disposal of TRU-containing soils (Alternative 5) could be used only on those sites that contain TRU radionuclides. Since a geologic repository is likely to accept only TRU radioactive soils, the non-TRU radioactive soils will not be remediated using this alternative.

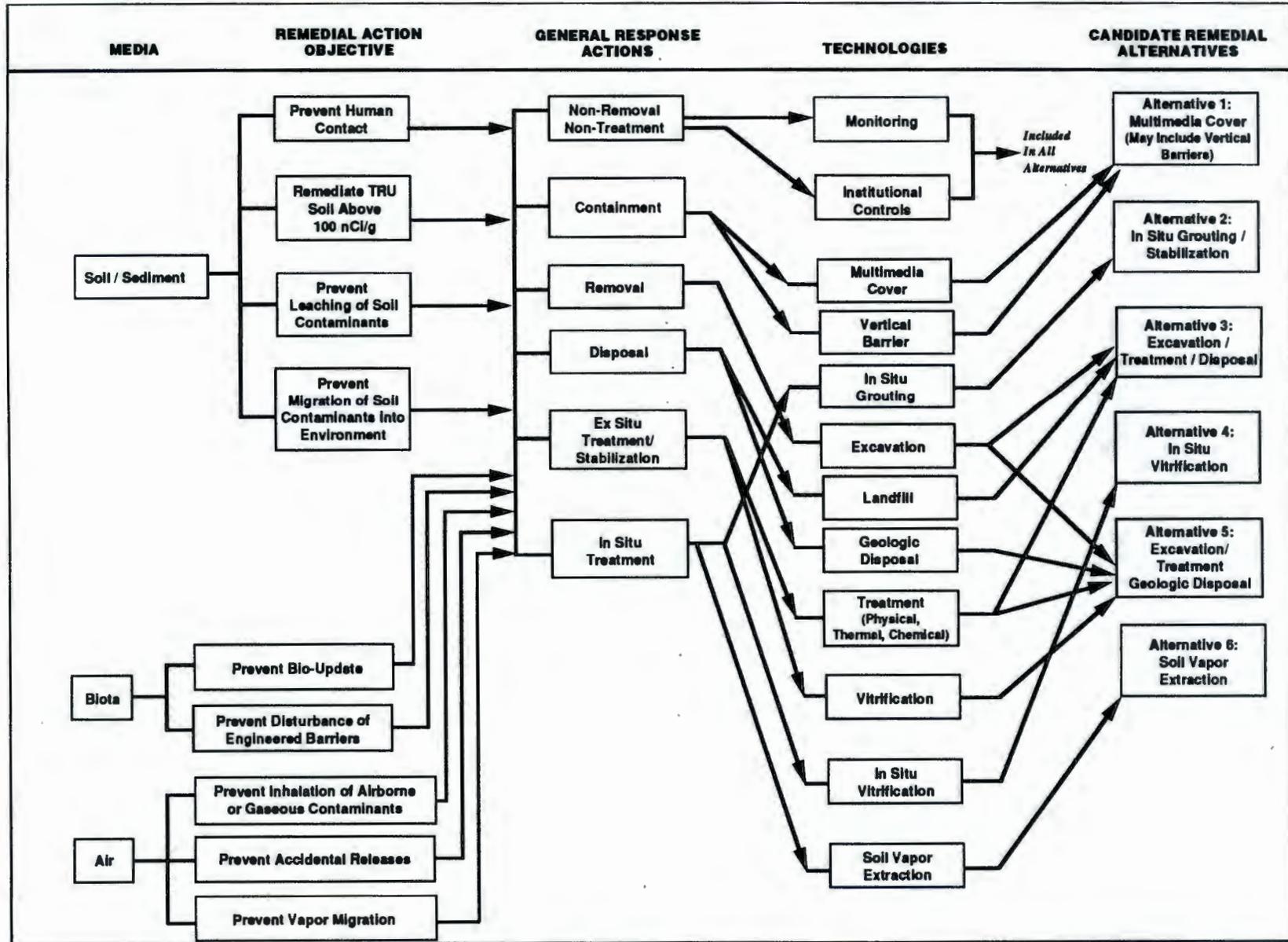
- In situ soil vapor extraction (Alternative 6) could be used on any waste management unit or unplanned release sites that contains volatile organic compounds. Such sites are not common in the U Plant Aggregate Area. Nonetheless, the 216-U-15 Trench, where hexone and/or paraffin hydrocarbons were disposed, is one site at which soil vapor extraction would be an effective remedy.

Using these criteria, Table 7-4 was created showing possible preliminary remedial action alternatives that could be used to remediate each of the waste management units and unplanned release sites. Table 7-4 excludes sites that will be addressed by other programs. For example, single-shell tanks are excluded because they will be addressed by the Single-Shell Tank Closure Program. Note that a single alternative may not be sufficient to remediate all contamination at a single site. For example, soil vapor extraction to remove organic contaminants could precede in situ vitrification. Also, different combinations of technologies are possible besides those presented in these preliminary alternatives.

Each waste management unit or unplanned release site may require just one alternative or a combination of many alternatives. Furthermore, similar sites may be remediated simultaneously. Also, more specific waste treatment alternatives could be identified and evaluated as more information is obtained.

Technology development studies will be needed for the in situ vitrification process, and treatability studies will be needed for the in situ grouting or stabilization process, and for soil treatment processes to make sure that they will effectively remediate the contaminants. Specifically, organic waste mobility may be a problem for in situ vitrification; grouting agents and the resulting reduction of contaminant leachability will need to be determined before in situ grouting can be performed; and appropriate treatment protocols and systems will need to be identified before soil washing can be used. Capping, soil vapor extraction, and disposal options are all proven processes but may require site-specific performance assessment (treatability) studies.

Focused feasibility studies (FFSs) will be required to evaluate alternative designs for all of the alternatives evaluated, as they relate to the specific waste management unit being remediated. A site-by-site economic evaluation is also required before making a decision. This evaluation will require site-specific information obtained in LFIs and FFSs.



7F-1

Figure 7-1. Development of Candidate Remedial Alternatives for U Plant Aggregate Area.

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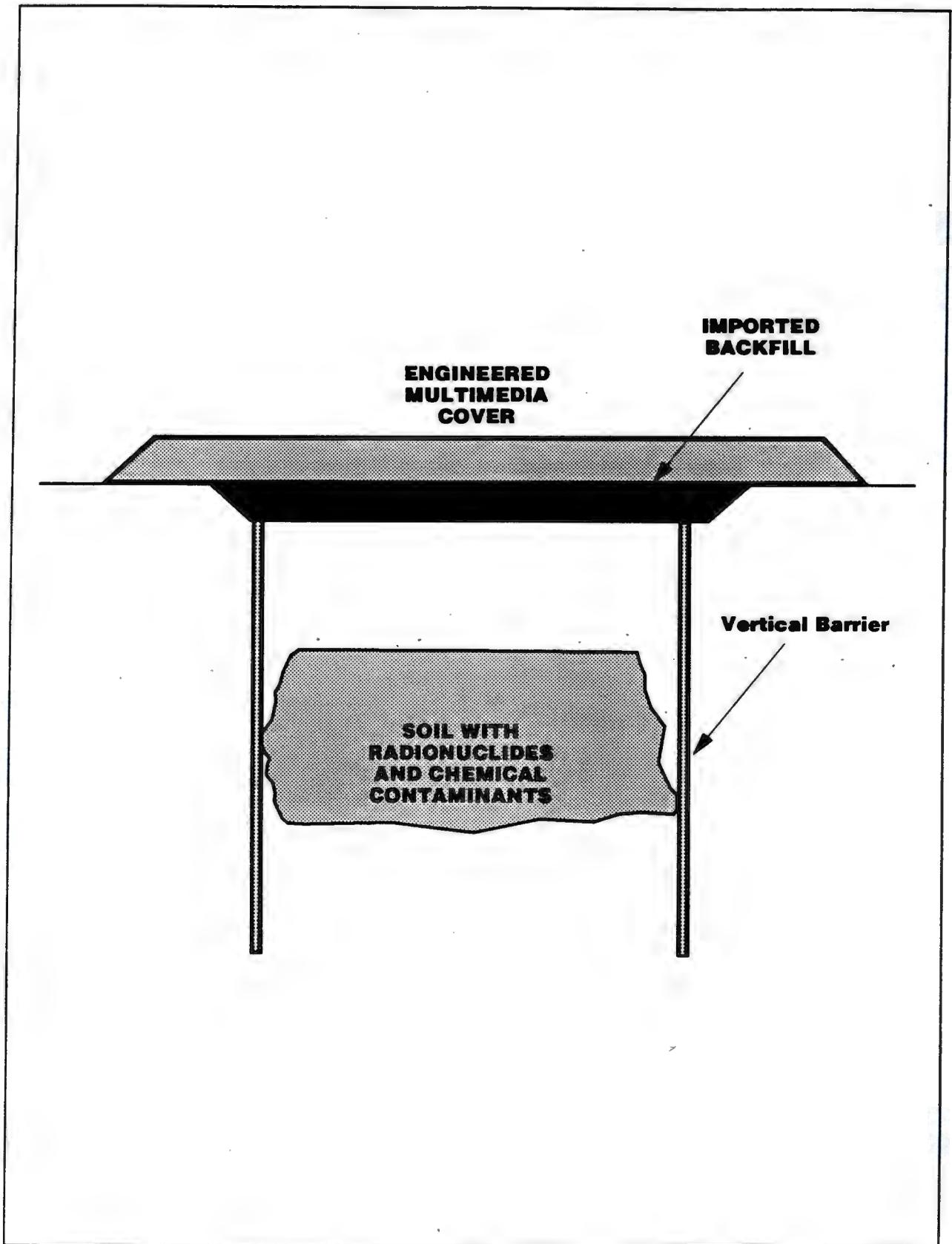


Figure 7-2. Alternative 1: Multimedia Cover With Vertical Barrier.

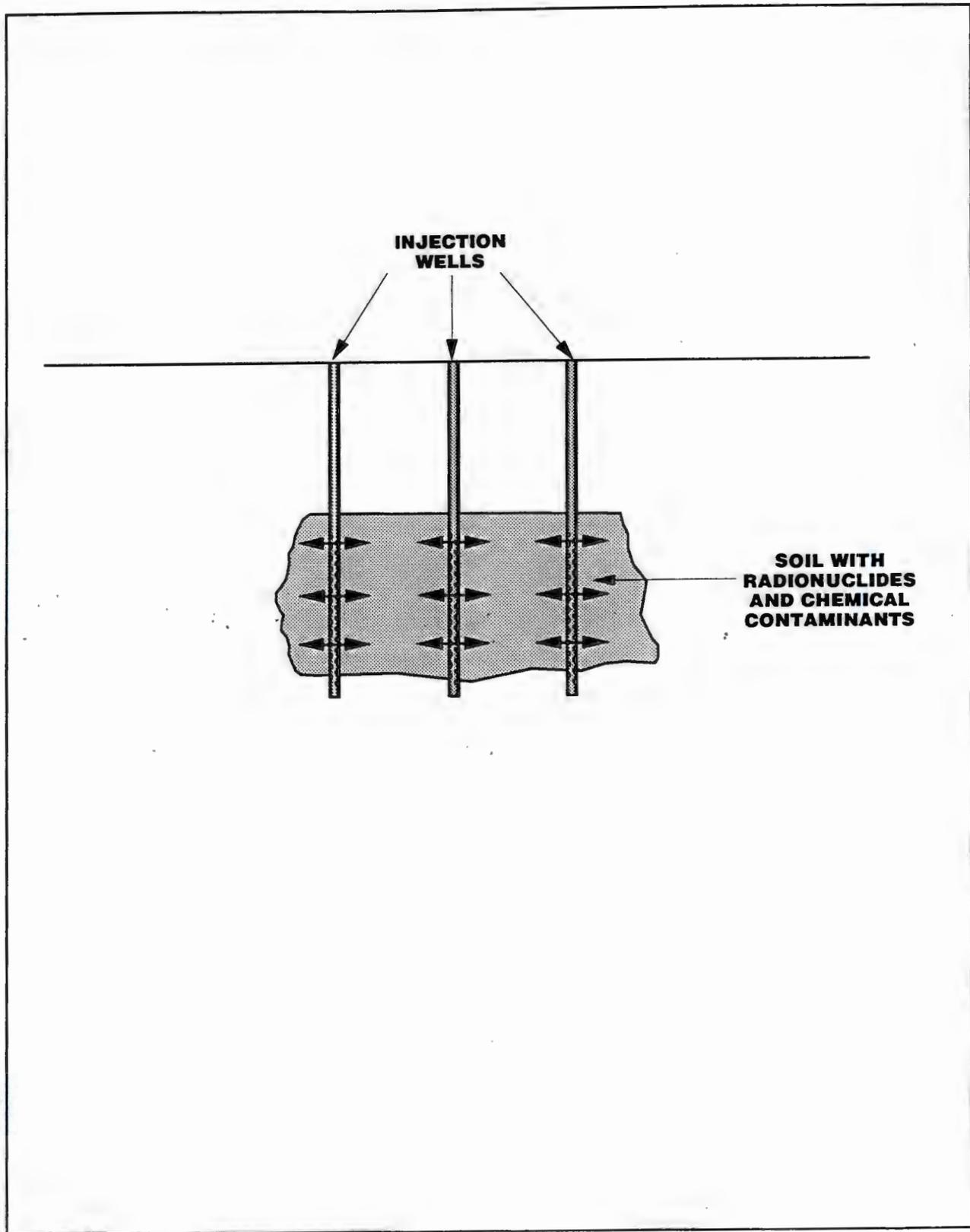
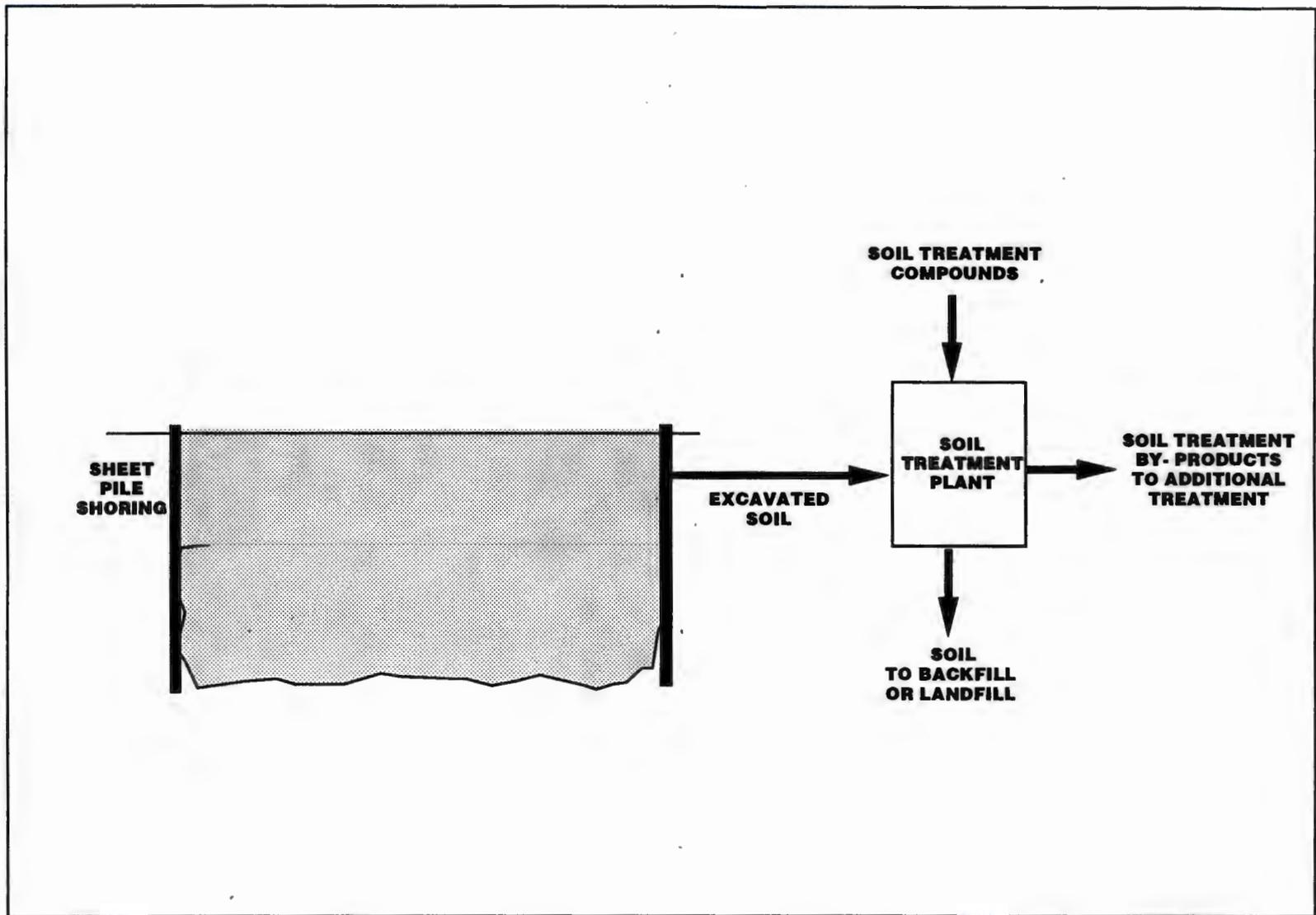


Figure 7-3. Alternative 2: In Situ Grouting of Soil.

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7F-4

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Figure 7-4. Alternative 3: Excavation, Treatment, and Disposal.

9 3 1 2 7 8 0 7 7 4

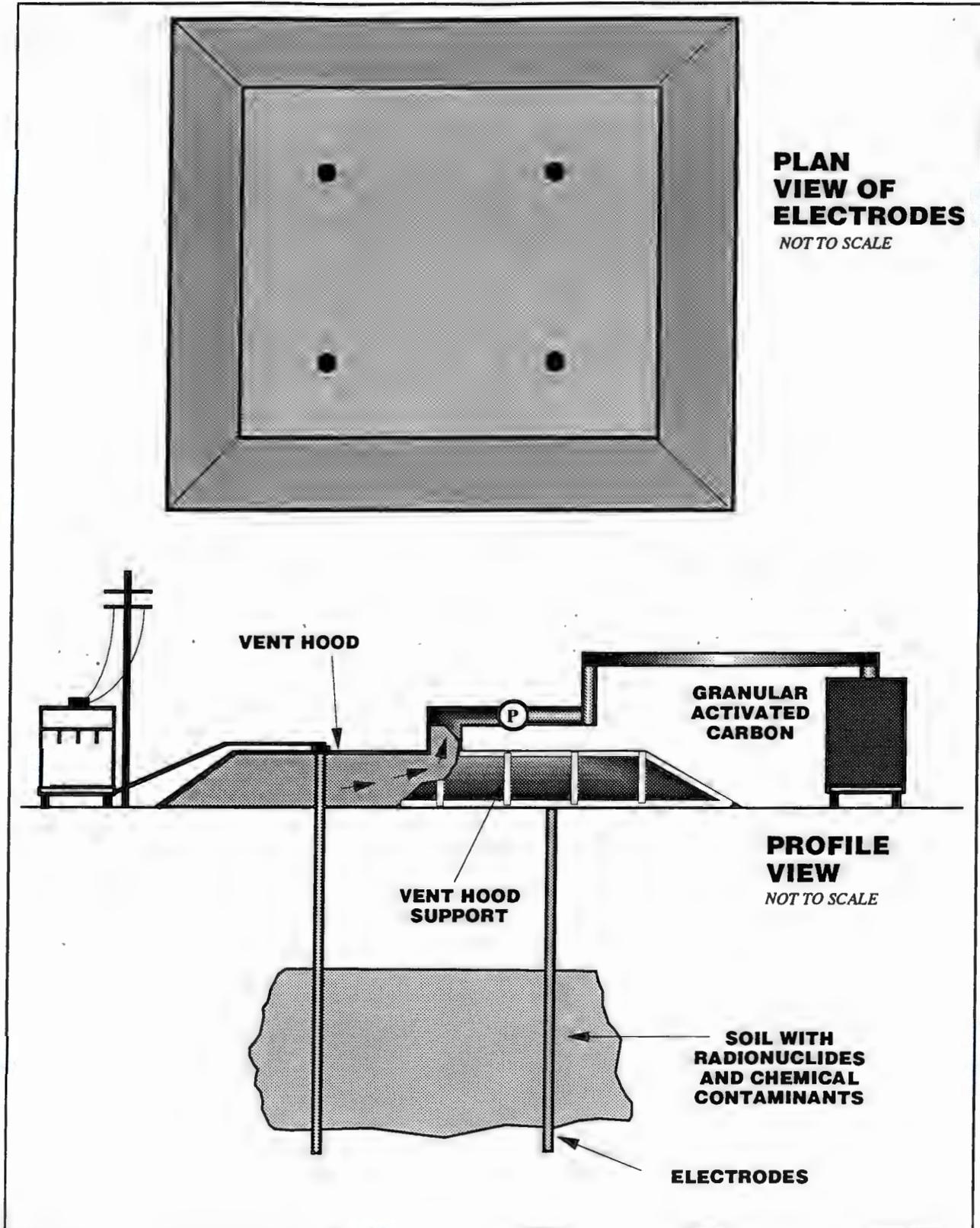


Figure 7-5. Alternative 4: In Situ Vitrification of Soil.

7F-6

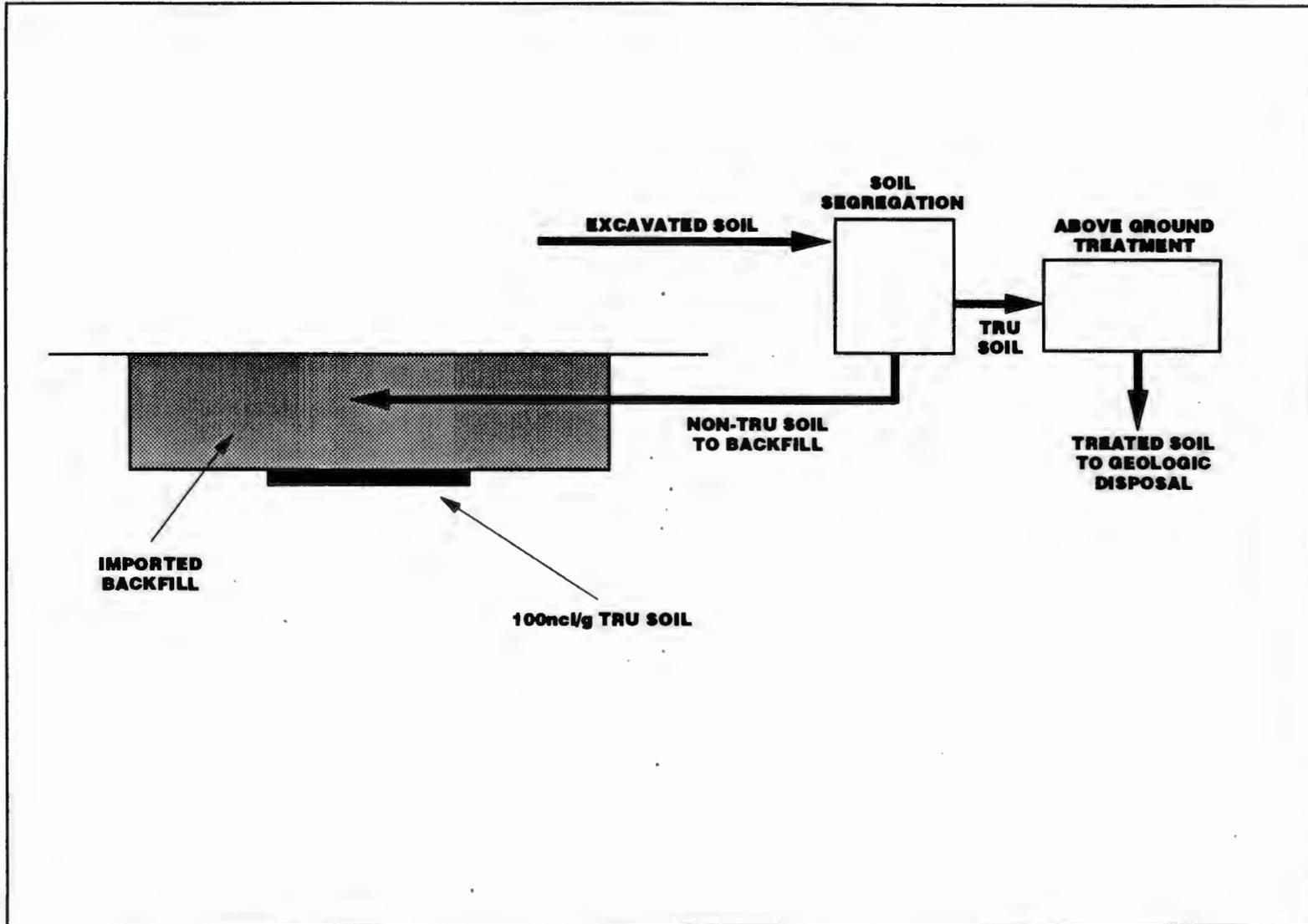


Figure 7-6. Alternative 5: Excavation, Vitrification, and Geologic Disposal of Soil with TRU Radionuclides.

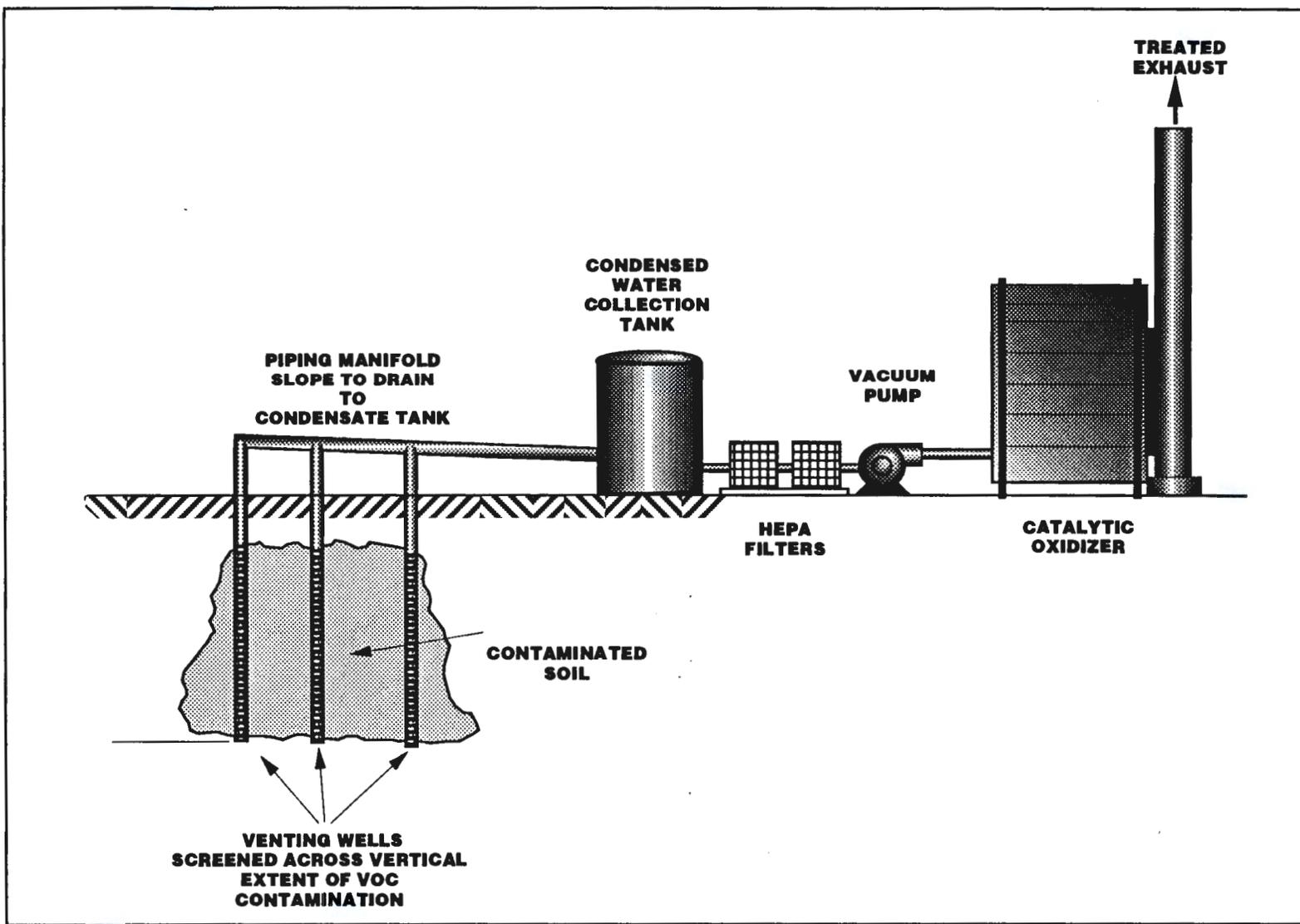


Figure 7-7. Alternative 6: Soil Vapor Extraction for VOCs.

7F-7

Table 7-1. Preliminary Remedial Action Objectives and General Response Actions.

Remedial Action Objectives			
Environmental Media	Human Health	Environmental Protection	General Response Actions
Soils/ Sediments	<ul style="list-style-type: none"> Prevent ingestion, inhalation, or direct contact with solids containing radioactive and/or hazardous constituents present at concentrations above MTCA and DOE standards for industrial sites (or subsequent risk-based standards). 	<ul style="list-style-type: none"> Prevent migration of radionuclides and hazardous constituents that would result in groundwater, surface water, air, or biota contamination with constituents at concentrations exceeding ARARs. Remediate soils containing TRU contamination above 100 nCi/g in accordance with 40 CFR 191 requirements. Prevent leaching of contaminants from the soil into the groundwater that would cause groundwater concentrations to exceed MTCA and DOE standards at the compliance point location. 	<ul style="list-style-type: none"> No Action Institutional Controls/Monitoring Containment Excavation Treatment Disposal In Situ Treatment
Biota	<ul style="list-style-type: none"> Prevent bio uptake by plants. Prevent disturbance of engineered barriers by biota. 	<ul style="list-style-type: none"> Prevent bio-uptake of radioactive contaminants. 	<ul style="list-style-type: none"> No Action Institutional Controls/Monitoring Excavation Treatment Disposal Containment In Situ Treatment
Air ^{a/}	<ul style="list-style-type: none"> Prevent inhalation of contaminated airborne particulates and/or volatile emissions exceeding MTCA and DOE limits from soils/sediments. 	<ul style="list-style-type: none"> Prevent adverse environmental impacts on local biota. Prevent accidental release from collapse of containment structures. 	

^{a/} No General Response Actions are required for the air because soil remediation will eliminate the air contamination source.

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Table 7-2. Preliminary Remedial Action Technologies.

Media	General Response Action	Technology Type	Process Option	Contaminants Treated
Soil	No Action	No Action	No Action	NA
	Institutional Controls	Land Use Restrictions	Deed Restrictions	NA
			Access Controls	NA
			Entry Control	NA
			Monitoring	NA
	Containment	Capping	Multimedia	I,M,R,O
			Vertical Barriers	I,M,R,O
			Grout Curtains	I,M,R,O
			Cryogenic Walls	I,M,R,O
			Dust & Vapor Suppression	I,M,R,O
	Excavation	Excavation	Standard Construction Equipment	I,M,R,O
	Treatment	Thermal Treatment	Vitrification	I,M,R,O
			Incineration	O
			Thermal Desorption	O
			Calcination	I,M,R,O
Chemical Treatment		Chemical Reduction	M	

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Table 7-2. Preliminary Remedial Action Technologies.

Media	General Response Action	Technology Type	Process Option	Contaminants Treated
			Hydrolysis	I,O
			Chemical Dechlorination	O
		Physical Treatment	Soil Washing	I,M,R,O
			Solvent Extraction	O
			Physical Separation	I,M,R,O
			Fixation/Solidification/ Stabilization	I,M,R,O
			Containerization	I,M,R,O
		Biological Treatment	Aerobic	O
			Anaerobic	O
	Disposal	Landfill Disposal	Onsite Landfill	I,M,R,O
			Offsite RCRA Landfill	I,M,O
		Geologic Repository	Geologic Repository	T (I,M,O, non-TRU radio-nuclides if mixed with T)
	In Situ Treatment	Thermal Treatment	Vitrification	I,M,R,O
			Thermal Desorption	O
		Chemical Treatment	Reduction	M,O
		Physical Treatment	Soil Flushing	I,M,R,O
	Vapor Extraction		O	

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Table 7-2. Preliminary Remedial Action Technologies.

Media	General Response Action	Technology Type	Process Option	Contaminants Treated
			Grouting	I,M,R
			Fixation/Solidification/ Stabilization	I,M,R,O
		Biological Treatment	Aerobic	O
			Anaerobic	O
Biota	No Action	No Action	No Action	NA
	Institutional Controls	Land Use Restrictions	Deed Restrictions	NA
		Access Controls	Signs/Fences	NA
			Entry Control	NA
		Monitoring	Monitoring	NA
	Excavation	Excavation	Standard Construction Equipment	I,M,R,O
	Disposal	Landfill Disposal	Landfill Disposal	I,M,R,O
	Containment	Capping	Multimedia	I,M,R,O

I = Other Inorganics contaminants applicability
 M = Heavy Metals contaminants applicability
 R = Radionuclide contaminants applicability
 O = Organic contaminants applicability
 NA = Not Applicable
 T = TRU Radionuclides Applicability

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Table 7-3. Screening of Process Options.

Technology Type	Process Option	Description	Effectiveness	Implementability	Relative Cost	Conclusions
SOIL TECHNOLOGIES:						
No Action	No Action	Do nothing to cleanup the contamination or reduce the exposure pathways.	Not effective in reducing the contamination or exposure pathways.	Easily implemented, but might not be acceptable to regulatory agencies, local governments, and the public.	Low	Retained as a "baseline" case.
Land Use Restrictions	Deed Restrictions	Identify contaminated areas and prohibit certain land uses such as farming.	Depends on continued implementation. Does not reduce contamination.	Administrative decision is easily implemented.	Low	Retained to be used in conjunction with other process options.
Access Controls	Signs/Fences	Install a fence and signs around areas of soil contamination.	Effective if the fence and signs are maintained.	Easily implemented. Restrictions on future land use.	Low	Retained to be used in conjunction with other process options.
	Entry Control	Install a guard/monitoring system to prevent people from becoming exposed.	Very effective in keeping people out of the contaminated areas.	Equipment and personnel easily implemented and readily available.	Low	Retained to be used in conjunction with other process options.
Monitoring	Monitoring	Analyze soil and soil gas samples for contaminants and scan with radiation detectors.	Does not reduce the contamination, but is very effective in tracking the contaminant levels.	Easily implemented. Standard technology.	Low	Retained to be used in conjunction with other process options.
Capping	Multimedia	Fine soils over synthetic membrane or other layers and covered with soil; applied over contaminated areas.	Effective on all types of contaminants, not likely to crack. Likely to hold up over time.	Easily implemented. Restrictions on future land use will be necessary.	Medium	Retained because of potential effectiveness and implementability.

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Table 7-3. Screening of Process Options.

Technology Type	Process Option	Description	Effectiveness	Implementability	Relative Cost	Conclusions
Vertical Barriers	Slurry Walls	Trench around areas of contamination is filled with a soil (or cement) bentonite slurry.	Effective in blocking lateral movement of all types of soil contamination. May not be effective for deep contamination.	Commonly used practice and easily implemented with standard earth moving equipment. May not be possible for deep contamination.	Medium	Retained for shallow contamination.
	Grout Curtains	Pressure injection of grout in a regular pattern of drilled holes.	Effective in blocking lateral movement of all types of soil contamination.	Commonly used practice and easily implementable, but depends on soil type. May be difficult to ensure continuous wall.	Medium	Retained because of potential effectiveness and implementability.
	Cryogenic Walls	Circulate refrigerant in pipes surrounding the contaminated site to create a frozen curtain with the pore water.	Effective in blocking lateral movement of all types of soil contamination.	Specialized engineering design required. Requires ongoing freezing.	Medium	Rejected because it is difficult to implement.
Dust and Vapor Suppression	Membranes/ Sealants/Wind Breaks/Wetting Agents	Using membranes, sealants, wind breaks, or wetting agents on top of the contaminated soil to keep the contaminants from becoming airborne.	Effective in blocking the airborne pathways of all the soil contaminants, but may require regular upkeep.	Commonly used practice and very easy to implement, but land restrictions will be necessary.	Low	Retained because of potential effectiveness and implementability.
Excavation	Standard Excavating Equipment	Moving soil around the site and loading soil onto process system equipment.	Effective in moving and transporting soil to vehicles for transportation, and for grading the surface.	Equipment and workers are readily available.	Low	Retained because of potential effectiveness and implementability.

Table 7-3. Screening of Process Options.

Technology Type	Process Option	Description	Effectiveness	Implementability	Relative Cost	Conclusions
Thermal Treatment	Above-ground Vitrification	Convert soil to glassy materials by application of electric current.	Effective in destroying organics and immobilizing the inorganics and radionuclides. Off-gas treatment for volatiles and gaseous radionuclides may be required.	Commercial units are available. Laboratory testing required to determine additives, operating conditions, and off gas treatment. Must pre-treat soil to reduce size of large materials.	High	Retained because of potential ability to immobilize radionuclides and destroy organics.
	Incineration	Destroy organics by combustion in a fluidized bed, kiln, etc.	Effectively destroys the organic soil contaminants. Some heavy metals will volatilize. Radionuclides will not be treated.	Technology is well developed. Mobile units are currently available for relatively small soil quantities. Off-site treatment is available. Air emissions and wastewater generation should be addressed.	High	Rejected because of potential air emissions, wastewater generation, and low concentration of organic compounds in soil.
	Thermal Desorption	Organic volatilization at 150 to 400°C (300 to 800°F) by heating contaminated soil followed by off gas treatment.	Effectively destroys the organic soil contaminants. Heavy metals less likely to volatilize than in high temperature treatments. Radionuclides will not be treated.	Successfully demonstrated on a pilot-scale level. Full-scale remediation yet to be demonstrated. Pilot testing essential.	Medium	Retained because of potential effectiveness and implementability.

Table 7-3. Screening of Process Options.

Technology Type	Process Option	Description	Effectiveness	Implementability	Relative Cost	Conclusions
Chemical Treatment	Calcination	High temperature decomposition of solids into separate solid and gaseous components without air contact.	Effective in the decomposition of inorganics such as hydroxides, carbonates, nitrates, sulfates, and sulfites. Removes organic components but does not combust them because of the absence of air. Radionuclides will not be treated.	Commercially available. Most often used for concentration and volume reduction of liquid or aqueous waste. Off-gas treatment is required.	High	Rejected because of limited effectiveness on non-liquid or aqueous wastes.
	Chemical Reduction	Treat soils with a reducing agent to convert contaminants to a more stable or less toxic form.	May be effective in treating heavy metal soil contaminants. Radioactivity will not be reduced.	Virtually untested on treating soils. Competing reactions may reduce efficiency.	Medium	Rejected because of limited applicability and implementation problems.
	Hydrolysis	Acid- or base-catalyst reaction in water to break down contaminants to less toxic components.	Very effective on compounds generally classified as reactive. Limited effectiveness on stable compounds. Radioactivity will not be reduced.	Common industrial process. Use for treatment of soils not well demonstrated.	Medium	Rejected because of limited effectiveness and unproven on soils.
	Chemical Dechlorination	Detoxify chlorinated organic chemicals by reaction with organic reagents.	Not commonly used on the chlorinated compounds that have been identified at Z Plant.	Difficult to implement. Requires soil washing or solvent extraction before use.	High	Rejected because of limited effectiveness and difficult implementation.

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Table 7-3. Screening of Process Options.

Technology Type	Process Option	Description	Effectiveness	Implementability	Relative Cost	Conclusions
Physical Treatment	Soil Washing	Leaching of waste constituents from contaminated soil using a washing solution.	Effectiveness is contaminant specific. Effective with sandy soil may work with only low-level radiation contaminated soil. May not work with humus soil. Generally more effective on contaminants that partition to the fine soil fraction. Radioactivity will not be reduced.	Treatability tests are necessary. Well developed technology and commercially available. Requires treatment of recycled water.	Medium	Retained because of potential effectiveness and implementability.
	Solvent Extraction	Contacting a solvent with contaminated soils to preferentially dissolve the contaminants into the solvent.	The selected solvent is often just as hazardous as the contaminants presented in the waste. May lead to further contamination. Radioactivity will not be reduced.	Laboratory testing necessary to determine appropriate solvent and operating conditions. Not fully demonstrated for hazardous waste applications.	Medium	Rejected because the solvent may lead to further contamination.
	Physical Separation	Separating soil into size fractions.	Effective as a concentration process for all contaminants that partition to a specific soil size fraction.	Most often used as a pretreatment to be combined with another technology. Equipment is readily available.	Low	Retained because of potential effectiveness and implementability.

Table 7-3. Screening of Process Options.

Technology Type	Process Option	Description	Effectiveness	Implementability	Relative Cost	Conclusions
	Fixation/ Solidification/ Stabilization	Form low permeability solid matrix by mixing soil with cement, asphalt, or polymeric materials.	Effective in reducing inorganic and radionuclide soil contaminant mobility. Effectiveness for organic stabilization is highly dependent on the binding agent.	Stabilization has been implemented for site remediations. Treatability studies are needed. Volume of waste is increased.	Medium	Retained because of potential effectiveness and implementability.
	Containerization	Enclosing a volume of waste within an inert jacket or container.	Effective for difficult to stabilize, extremely hazardous, or reactive waste. Reduces the mobility of radionuclides.	May be implemented for low concentration waste. Disposal or safe storage of containers required. Regulatory constraints may prevent disposal of containers of certain waste types.	Low	Retained because of potential effectiveness and implementability.
Biological Treatment	Aerobic	Microbial degradation in an oxygen-rich environment.	Effectiveness is very contaminant- and concentration-specific. Treatment has been demonstrated on a variety of organic compounds. Not effective on inorganics or radionuclides.	Various options are commercially available to produce contaminant degradation. Treatability tests are required to determine site-specific conditions.	Medium	Rejected because of limited applicability and difficult implementation.

Table 7-3. Screening of Process Options.

Technology Type	Process Option	Description	Effectiveness	Implementability	Relative Cost	Conclusions
	Thermal Desorption	Soil is heated in situ by radio-frequency electrodes or other means of heating to temperatures in the 80 to 400°C (200 to 750°F) range thereby causing desorption of volatile and semi-volatile organics from the soil.	Effective for removal of volatile and semi-volatile organics from soil. Ineffective for most inorganics and radionuclides. Contaminants are transferred from soil to air.	Implementable for shallow organics contamination. Not implementable for radionuclides and inorganics. Emission treatment and treatability studies required.	Medium	Rejected because of limited applicability.
In Situ Chemical Treatment	Chemical Reduction	Reducing agent is added to the soil to change oxidation state of target contaminant.	Effective for certain inorganics, e.g., chromium. Ineffective for organics. Limited applicability.	Difficult to implement in situ because of distribution requirements for reducing agent.	Low	Rejected because of limited applicability and implementation problems.
In Situ Physical Treatment	Soil Flushing	Solutions are injected through injection system to flush and extract contaminants.	Potentially effective for all contaminants. Effectiveness depends on chemical additives and hydrology. Flushing solutions posing environmental threat likely to be needed. Difficult recovery of flushing solution.	Difficult to implement. Not implementable for complex solvents of contaminants. Flushing solution difficult to recover. Chemical additives likely to pose environmental threat.	Medium	Rejected because of implementation problem.
	Vapor Extraction	Vacuum is applied by use of wells inducing a pressure gradient that causes volatiles to flow through air spaces between soil particles to the extraction wells.	Effective for volatile organics. Ineffective for inorganics semi-volatile organics, and radionuclides. Emission treatment required.	Easily implementable for proper site conditions. Requires emission treatment for organics and capture system for radionuclides and volatilized metals.	Medium	Retained for potential application to volatile organics.

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Table 7-3. Screening of Process Options.

Technology Type	Process Option	Description	Effectiveness	Implementability	Relative Cost	Conclusions
In Situ Biological Treatment	Grouting	Involves drilling and injection of grout to form barrier or injection to fill voids.	Effective in limiting migration of leachate, but difficult to maintain barrier integrity. Potentially effective in filling voids.	Implementable as barrier and for filling voids. Implementability depends on site conditions.	Medium	Retained because of ability to limit contaminant migration and potential use for filling void spaces.
	Fixation/Solidification/Stabilization	Solidification agent is applied to soil by mixing in place.	Effective for inorganics and radionuclides. Potentially effective for organics. Effectiveness depends on site conditions and additives used.	Implementable. Treatability studies required to select proper additives. Thorough characterization of subsurface conditions and continuous monitoring required.	Medium	Retained because of potential effectiveness and implementability.
	Aerobic	Microbial growth utilizing organic contaminants as substrate is enhanced by injection of or spraying with oxygen source and nutrients.	Effective for most organics at proper conditions. Ineffective for inorganics and radionuclides.	Difficult to implement. Treatability studies and thorough subsurface characterization required.	Low	Rejected because of limited applicability and difficult implementation.
	Anaerobic	Microbial growth utilizing organic contaminants as substrate is enhanced by addition of nutrients.	Effective for volatile and complex organics. Not effective for inorganics and radionuclides.	Difficult to implement. Anoxic ground conditions required. Treatability studies and thorough subsurface characterization necessary.	Low	Rejected because of limited applicability and difficult implementation.

Table 7-3. Screening of Process Options.

Technology Type	Process Option	Description	Effectiveness	Implementability	Relative Cost	Conclusions
BIOTA TECHNOLOGIES:						
No Action	No Action	Do nothing to clean-up the contamination or reduce the exposure pathways.	Not effective in reducing the contamination or exposure pathways.	Easily implemented, but might not be acceptable to regulatory agencies, local governments, and the public.	Low	Retained as a "baseline" case.
Land Use Restrictions	Deed Restrictions	Identify contaminated areas and prohibit certain land uses such as agriculture.	Effective if implementation is continued. Does not reduce contamination.	Administrative decision is easily implemented.	Low	Retained to be used in conjunction with other process options.
Access Controls	Signs/Fences	Install a fence and signs around areas of contamination to keep people out and the biota in.	Effective if fencing is maintained.	Easily implemented. Restrictions on future land use.	Low	Retained to be used in conjunction with other process options.
	Entry Control	Install a guard/monitoring system to eliminate people from coming in contact with the contamination.	Very effective in keeping people out of the contaminated areas.	Equipment and personnel are easily implemented and readily available.	Low	Retained to be used in conjunction with other process options.
Monitoring	Monitoring	Take biota samples and test them for contaminants.	Does not reduce the contamination, but is very effective tracking the contaminant levels.	Easily implemented. Standard Technology.	Low	Retained to be used in conjunction with other process options.
Capping	Multimedia	Fine soils over synthetic membrane or other layers and covered with soil; applied over contaminated areas.	Effective in reducing the uptake of contaminants, not likely to crack. Likely to hold up over time.	Easily implemented. Restrictions on future land use will also be necessary.	Medium	Retained because of potential effectiveness and implementability.

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Table 7-3. Screening of Process Options.

Technology Type	Process Option	Description	Effectiveness	Implementability	Relative Cost	Conclusions
Excavation	Standard Excavating Equipment	Remove affected biota and load it onto process system equipment.	Effective in moving and transporting biota to vehicles for transportation.	Equipment and workers are readily available.	Low	Retained because of potential effectiveness and implementability.
Disposal	Landfill Disposal	Place contaminated biota in an existing landfill.	Does not reduce the biota contamination but moves all of the contamination to a more secure place.	Easily implemented if sufficient storage is available in an offsite landfill area.	Medium	Retained because of potential effectiveness and implementability.

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Table 7-4. Preliminary Remedial Action Alternatives Applicable to Waste Management Units and Unplanned Release Sites.

Waste Management Unit or Unplanned Release	Alt. 1 Engineered Multimedia Cover With or Without Vertical Barriers	Alt. 2 In Situ Grouting or Stabilization	Alt. 3 Excavation, Soil Treatment, and Disposal	Alt. 4 In Situ Vitrification of Soil	Alt. 5 Excavation, Above-Ground Treatment, and Geologic Disp. of TRU Soil	Alt. 6 In Situ Soil Vapor Extraction for VOCs
Tanks and Vaults						
241-U-361 Settling Tank	•	•	•		•	
Cribs and Drains						
216-S-21 Crib	•	•	•	•	•	
216-U-1 and 216-U-2 Cribs	•	•	•	•	•	
216-U-8 Crib	•	•	•	•	•	
216-U-12 Crib	•	•	•	•	•	
216-U-16 Crib	•	•	•	•	•	
216-U-17 Crib	•	•	•	•	•	
216-Z-20 Crib	•	•	•	•	•	
216-S-4 French Drain	•	•	•	•	•	
216-U-3 French Drain	•	•	•	•	•	
216-U-4A French Drain	•	•	•	•	•	
216-U-4B French Drain	•	•	•	•	•	
216-U-7 French Drain	•	•	•	•	•	

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Table 7-4. Preliminary Remedial Action Alternatives Applicable to Waste Management Units and Unplanned Release Sites.

Waste Management Unit or Unplanned Release	Alt. 1 Engineered Multimedia Cover With or Without Vertical Barriers	Alt. 2 In Situ Grouting or Stabilization	Alt. 3 Excavation, Soil Treatment, and Disposal	Alt. 4 In Situ Vitrification of Soil	Alt. 5 Excavation, Above-Ground Treatment, and Geologic Disp. of TRU Soil	Alt. 6 In Situ Soil Vapor Extraction for VOCs
Reverse Wells						
216-U-4 Reverse Well	•	•				
Ponds, Ditches, and Trenches						
216-U-10 Pond	•	•	•	•	•	
216-U-14 Ditch	•	•	•	•	•	
216-Z-1D Ditch	•	•	•	•	•	
216-Z-11 Ditch	•	•	•	•	•	
216-Z-19 Ditch	•	•	•	•	•	
216-U-5 Trench	•	•	•	•	•	
216-U-6 Trench	•	•	•	•	•	
216-U-11 Trench	•	•	•	•	•	
216-U-13 Trench	•	•	•	•	•	
216-U-15 Trench	•	•	•	•	•	•
Septic Tanks and Associated Drain Fields						
2607-W-5 Septic Tank/Drain Field	•	•	•			

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Table 7-4. Preliminary Remedial Action Alternatives Applicable to Waste Management Units and Unplanned Release Sites.

Waste Management Unit or Unplanned Release	Alt. 1 Engineered Multimedia Cover With or Without Vertical Barriers	Alt. 2 In Situ Grouting or Stabilization	Alt. 3 Excavation, Soil Treatment, and Disposal	Alt. 4 In Situ Vitrification of Soil	Alt. 5 Excavation, Above-Ground Treatment, and Geologic Disp. of TRU Soil	Alt. 6 In Situ Soil Vapor Extraction for VOCs
2607-W-7 Septic Tank/Drain Field	•	•	•			
2607-W-9 Septic Tank/Drain Field	•	•	•			
Basins						
207-U Retention Basin	•	•	•		•	
Burial Sites						
Burial Ground/Burning Pit	•	•	•			
Construction Surface Laydown Area	•		•			•
Unplanned Releases						
UN-200-W-6	•	•	•			
UN-200-W-19	•	•	•			
UN-200-W-33	•	•	•			
UN-200-W-39	•	•	•			
UN-200-W-46						
UN-200-W-48	•					
UN-200-W-55	•	•	•			

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Table 7-4. Preliminary Remedial Action Alternatives Applicable to Waste Management Units and Unplanned Release Sites.

Waste Management Unit or Unplanned Release	Alt. 1 Engineered Multimedia Cover With or Without Vertical Barriers	Alt. 2 In Situ Grouting or Stabilization	Alt. 3 Excavation, Soil Treatment, and Disposal	Alt. 4 In Situ Vitrification of Soil	Alt. 5 Excavation, Above-Ground Treatment, and Geologic Disp. of TRU Soil	Alt. 6 In Situ Soil Vapor Extraction for VOCs
UN-200-W-60	•	•	•			
UN-200-W-68	•	•	•			
UN-200-W-78	•	•	•			
UN-200-W-86			•			
UN-200-W-101	•	•	•			
UN-200-W-117	•	•	•			
UN-200-W-118	•	•	•			
UN-200-E-161	•	•	•			
Uranium Contamination Leak	•	•	•	•		
Paint Waste Spill	•		•			•

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8.0 DATA QUALITY OBJECTIVES

As described in Section 1.2.2, this aggregate area management study (AAMS) process, as part of the *Hanford Site Past-Practice Strategy* (DOE/RL 1992a), is designed to focus the remedial investigation (RI)/feasibility study (FS) process toward comprehensive cleanup or closure of all contaminated areas at the earliest possible date and in the most effective manner. The fundamental principle of the *Hanford Site Past-Practice Strategy* is a "bias for action" which emphasizes the maximum use of existing data to expedite the RI/FS process as well as allow decisions about work that can be done at the site early in the process, such as expedited response actions (ERAs), interim remedial measures (IRMs), limited field investigations (LFIs), and focused feasibility studies (FFS). The data have already been described in previous sections (2.0, 3.0, and 4.0). Remediation alternatives are described in Section 7.0. However, data, whether existing or newly acquired, can only be used for these purposes if it meets the requirements of data quality as defined by the data quality objective (DQO) process developed by the U.S. Environmental Protection Agency (EPA) for use at Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) sites (EPA 1987). This section implements the DQO process for this, the scoping phase in the U Plant Aggregate Area.

In the guidance document for DQO development (EPA 1987), the process is described as involving three stages which have been used in the organization of the following sections:

- Stage 1--Identify decision types (Section 8.1)
- Stage 2--Identify data uses and needs (Section 8.2)
- Stage 3--Design a data collection program (Section 8.3).

8.1 DECISION TYPES (STAGE 1 OF THE DQO PROCESS)

Stage 1 of the DQO process is undertaken to identify:

- The decision makers (thus data users) relying on the data to be developed (Section 8.1.1)
- The data available to make these decisions (Section 8.1.2)
- The quality of these available data (Section 8.1.3)

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- The conceptual model into which these data must be incorporated (Section 8.1.4)
- The objectives and decisions that must evolve from the data (Section 8.1.5).

These issues serve to define, from various sides, the types of decisions that will be made on the basis of the U Plant AAMS.

8.1.1 Data Users

The data users for the U Plant AAMS and subsequent investigations such as LFIs, RI/FSs, and Resource Conservation and Recovery Act (RCRA) Facility Investigations (RFIs)/Corrective Measures Studies (CMSs) are the following:

- The decision makers for policies and strategies on remedial action at the Hanford Site. These are the signatories of the *Hanford Federal Facility Agreement and Consent Order* (Tri-Party Agreement) (Ecology et al. 1990) including the Washington State Department of Ecology (Ecology), the EPA, and the U.S. Department of Energy (DOE).

Nominally these responsibilities are assigned to the heads of these agencies (the Secretary of Energy for DOE, the Administrator of EPA, and the Director of Ecology), although the political process requires that more local policy-makers (such as the Regional Administrator of EPA and the head of the U.S. Department of Energy, Richland Field Office (DOE/RL) and, to a great extent, technical and policy-assessment staff of these agencies will have a major say in the decisions to be evolved through this process.

- Unit managers of Westinghouse Hanford and potentially other Hanford Site contractors who will be tasked with implementing remedial activities at the U Plant Aggregate Area. Staff of these contractors will have to make the lower level (tactical) decisions about appropriate scheduling of activities and allocation of resources (funding, personnel, and equipment) to accomplish the recommendations of the AAMS.
- Concerned members of the wide community involved with the Hanford Site. These may include:
 - Other state (Washington, Oregon, and other states) and federal agencies
 - Affected Indian tribes

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- Special interest groups
- The general public.

These groups will be involved in the decision process through the implementation of the Community Relations Plan (Ecology et al. 1989), and will apply their concerns through the "primary" data users, the signatories of the Tri-Party Agreement.

The needs of these users will have a pivotal role in issues of data quality. Some of this influence is already imposed by the guidance of the Tri-Party Agreement.

8.1.2 Available Information

The *Hanford Site Past-Practice Strategy* specifies a "bias for action" which intends to make the maximal use of existing data on an initial basis for decisions about remediation. This emphasis can only be implemented if the existing data are adequate for the purpose.

Available data for the U Plant Aggregate Area are presented in Sections 2.0, 3.0, and 4.0 and in topical reports prepared for this study. As described in Section 1.2.2, these data should address several issues:

- Issue 1: Facility and process descriptions and operational histories for waste sources (Sections 2.2, 2.3, and 2.4)
- Issue 2: Waste disposal records defining dates of disposal, waste types and waste quantities (Section 2.4)
- Issue 3: Sampling events of waste effluents and affected media (Section 4.1)
- Issue 4: Site conditions including the site physiography, topography, geology, hydrology, meteorology, ecology, demography, and archaeology (Section 3.0)
- Issue 5: Environmental monitoring data for affected media including air, surface water, sediment, soil, groundwater and biota (Section 4.1, except that groundwater data is presented in the separate 200 West Groundwater Aggregate Area Management Study Report, AAMSR).

A major requirement for adequate characterization of many of these issues is identification of chemical and radiological constituents associated with the sites, with a view to determine the contaminants of concern there and the extent of their distribution in the soils beneath each of the waste management units in the U Plant Aggregate Area. There was

found to be a limited amount of data in this regard. The data reported for the various waste management units in the U Plant Aggregate Area (see Section 4.1 and Tables 4-1, 4-2, and 4-3) have been found to describe:

- Inventory--generally estimated from chemical process data and emphasizing radionuclides (Issues 1 and 2). These data are especially limited regarding reconstruction of early operations activities, and even the most recent data are based on very few sampling events, possibly non-representative of the long-term activity of the waste management units. In some cases (e.g., for 216-U-15 Trench) even the location of the facility is not adequately understood.
- Surface radiological surveys--undifferentiated radiation levels, without identification of radionuclides present, presented in terms of extent of radiation and maximal levels (Issue 5). These historical data are extremely difficult to relate to the present-day distribution and nature of the radioactive contamination they purport to measure because of the lack of radionuclide identification and the likelihood that changes have occurred (at least to surface soils) since the time of these surveys.
- External radiation monitoring--similar to the surface radiological surveys but provide even less information because with a fixed-point thermoluminescent dosimeter (TLD) no spatial distribution is provided. In addition, data are also available for some TLDs placed at points not associated with specific waste management units. The TLD data also do not differentiate radionuclide species.
- Waste, soil, or sediment sampling--these include waste sampling in single-shell tanks (in the 241-U Tank Farm), sediment sampling in basins, ponds, and ditches (207-U Retention Basin, 216-U-10 Pond, 216-U-11 Trench, 216-U-14, -Z-1D, -Z-11, and -Z-19 Ditches, and four unplanned releases associated with overflows from the 216-U-10 Pond: UPR-200-W-104, -105, -106, and -107). There is one unplanned release (UPR-200-W-161, of unknown origin) which has soil sampling and analysis for radionuclides (Issue 5).

There is also a set of data of soil sampling and analysis that was conducted for several years on a grid pattern, so cannot be assigned to a particular waste management unit. These data would indicate impacts of historical operations at the Hanford Site, and in the vicinity of the grid points, but the impacts cannot be ascribed to a particular unit and so do not assist in decision making on a unit-by-unit basis but may be used to estimate background contamination levels.

- Biota sampling--only in the 207-U Retention Basin. These data could assist assessment of bio-uptake and bio-transfer pathways from this unit (Issue 5).

There are also analytical data for grid-point samples of vegetation which again cannot be assigned to a specific waste management unit but may be useful to indicate background contamination levels in vegetation.

- Borehole geophysics--these data, for a number of units which discharged to the soil column (cribs, french drains, and the 216-U-14 Ditch) and the single-shell tanks, were designed to detect the presence of radionuclides (by their gamma-ray radiation) in the subsurface and to indicate whether these materials are migrating vertically (Issue 5). A list of these surveys that have been conducted in the U Plant Aggregate Area is included in the Data Package Topical Report prepared for this study (Chamness et al. 1991). Most of the earlier data are limited by the method's inability to identify specific radionuclides and thus to differentiate naturally-occurring radioactive materials from possible releases. Variations in quality control further limit their comparability and possible use for estimation of concentrations.

Besides these historic data, additional borehole geophysical data will be available through the Radionuclide Logging System (RLS), being carried out at the time of this report and in support of the AAMS process. Like the previous (gross gamma) logging conducted at waste management units in the U Plant Aggregate Area, the RLS depends on gamma rays and so cannot detect some species of radionuclides. However, unlike the gross gamma surveys, the RLS is designed to identify individual radionuclide species through their characteristic gamma ray photon energy levels. It should thus be able to differentiate naturally-occurring radionuclides from those resulting from releases. It will also (like gross gamma logging) determine the vertical extent of the presence of the radionuclides. It will be conducted in about ten wells located in the U Plant Aggregate Area and will be available with completion of the AAMS process.

Based on the above summary, the data are considered to be of varying quality. These data have not been validated, a process generally required for risk assessment or final Record of Decision (ROD) purposes. Most of the data are based on field methods, which are generally applicable only for screening purposes and can be used to focus future activities (e.g., sampling and analysis plans).

They are considered to be deficient in one or more of the following ways:

- Methods which have been used in the past are unable to differentiate the various radionuclides which may have been present at the time of the survey.
- The release locations have been changed (especially by remediation activities) since the time of the survey or sampling, and it is likely that contaminant distributions have changed.

- The survey or sampling has been done at a location different from the waste management unit or release, and so would not be representative of the concentrations in the zone of release. This deficiency applies to horizontal and vertical differences in location: the borehole geophysical data may be at the correct depths, but the distance of the borehole from the waste management unit can severely attenuate the gamma-radiation which is used to indicate contamination; surface sampling and surveys similarly cannot establish subsurface contaminant concentrations or even disprove the possible presence of some radioactive constituents (particularly alpha-emitting transuranic elements, TRUs).
- There has been virtually no measurement of non-radioactive hazardous constituents in the sampling and analysis of media in the U Plant Aggregate Area.

As a result of these deficiencies, the data are not considered to be usable for input to a quantitative risk assessment or for comparison to ARARs. Further discussion of the data qualities is provided in Section 8.1.3.

In addition to these data, there are also data regarding site conditions (Issue 4) which do not directly relate to the presence of environmental releases but which will assist in the assessment of their potential migration if present. These data are generally summarized in the Topical Reports prepared for this AAMS. Those include the following:

- *U Plant Geologic and Geophysics Data Package for the 200 AAMS* (Chamness et al. 1991), contains tables of wells in which borehole geophysics have been conducted, the types and dates of the tests, and a reference to indicate the physical location of the logs. The package also includes a list of the data available from the drilling of each well located in the U Plant Aggregate Area, such as the logs available (driller's or geologist's; indication of their physical location; grain size, carbonate, moisture, and chemical/radiological analyses; lists of depths, dates, elevation, and coordinates for all wells); and copies of the boring logs and well completion (as-built) summaries for a selection of wells in the U Plant Aggregate Area.
- *Geologic Setting of the 200 West Area: An Update* (Lindsey et al. 1991) includes descriptions of regional stratigraphy, structural geology, and local (200 West Area) stratigraphy, with revised structure and isopach maps of the various unconsolidated strata found beneath the 200 West Area.

The data in these topical reports was obtained for the aggregate area study based on a review of driller's and geologist's logs for wells drilled in the U Plant Aggregate Area. A selection of 15 of those logs was made which best represented the geologic structures below the aggregate area and are presented in Chamness et al. (1991). Lindsey et al. (1991) then used these wells (and others from other aggregate areas in the 200 West Area) to develop

cross-sections, structure maps, and isopach maps, which were in turn adapted to the specific needs of this report and presented in Section 3.0. Only existing logs were used; no new wells were drilled as part of this study. The quality of the data varies among the logs according to the time they were drilled and the scope of the study they were supporting, but generally these data are sufficient for the general geological characterization of the site. Issues involving the potential of contaminant migration at specific sites, based on stratigraphic concerns, may not be fully addressed through any existing borings or wells because appropriate borings may not be located in close proximity; these issues should be addressed during subsequent field investigations at locations where contaminant migration is considered likely.

Another class of data which was gathered in the general area of the 200 West Area, and thus potentially appropriate to the U Plant Aggregate Area, is the result of a set of studies which were performed for the Basalt Waste Isolation Project (BWIP) (DOE 1988b), in the attempt to site a high-level radioactive waste geologic repository in the basalt beneath and in the vicinity of the Hanford Site. The proposed Reference Repository Site included the 200 West Area and some distance beyond it, mainly to the west. For this siting project, a number of geologic techniques were used, and some of the data generated by the drilling program has been used for the stratigraphic interpretation presented in Section 3.4 (all the wells denoted with an alias "BH-.." were drilled for the BWIP project) and a number of the figures used in this and other sections of Section 3.0. The program also included a number of geophysical studies, using the following techniques:

- Gravity
- Magnetics
- Seismic reflection
- Seismic refraction
- Magnetotellurics.

These data, as presented in Section 1.3.2.2.3 of DOE (1988b), were reviewed for their relevance to the present U Plant (source area) Aggregate Area Management Study. The limitations of these studies include the following aspects:

- Most of the studies covered a regional scale with lines or coverages that may have crossed the U Plant Aggregate Area (or even the 200 West Area) only in passing. Some of the surveys (e.g., the grid of gravity stations) specifically avoided the 200 West Area ("due to restricted access").

- Many of the techniques are more sensitive to the basalt than to the suprabasalt sediments of specific interest in the AAMS program, and even less sensitive to the features which are closer to the surface, as is applicable to the source area AAMS. Basalt is by nature much denser than the unconsolidated sediments (and thus also has a characteristic seismic signature) and has more consistent magnetic properties. In addition, the analysis of the data emphasized the basalt features which were apparent in the data. All this is appropriate to a study of the basalt, but does not make the studies applicable to the present study.
- Even when features potentially due to shallow sediments are identified, they are interpreted either very generally (e.g., "erosional features in the Hanford and (or) Ringold Formations") or as complications (e.g., "shallow sediment velocity variations causing stacking velocity correction errors"). There are only a very few features (and none in the U Plant Aggregate Area) which are interpreted as descriptive of the structure of the suprabasalt sediments.
- Lastly, some of the anomalies which are interpreted in terms of a sedimentary stratigraphic cause (e.g., "erosion of Middle Ringold") do not bear up under the more detailed stratigraphic interpretation carried out under the Topical Reports for the AAMS (Lindsey et al. 1991, Chamness et al. 1991).

However, these data will be reviewed in more detail for the purposes of the 200 West Groundwater AAMSR, since deeper features (including in the basalt) are of more concern for that study.

Other data, presented in Sections 2.0, 3.0, and 4.0, are broader-scale rather than site-specific like the contaminant concentrations are. These include: topography, meteorology, surface hydrology, environmental resources, and human resources, and contaminant characteristics. These data are generally of acceptable quality for the purposes of planning remedial actions in the U Plant Aggregate Area.

8.1.3 Evaluation of Available Data

The EPA (1987) has specified indicators of data quality, the five "PARCC" parameters (precision, accuracy, representativeness, completeness, and comparability), which can be used to evaluate the existing data and to specify requirements for future data collection.

- Precision--the reproducibility of the data
- Accuracy--the lack of a bias in the data.

Much of the existing data are of limited precision and accuracy due to the analytical methods which have been used historically. The gross gamma borehole geophysical logging in particular is limited by methodological problems although reproducibility has been generally observed in the data. Conditions that have contributed to lack of precision and/or accuracy include: improvements in analytical instrumentation and methodology making older data incompatible; effects of background levels (particularly regarding radioactivity and inorganics); and lack of quality control on data acquisition.

The limitations in precision and accuracy in existing data are mainly due to the progress of analytical methodologies and quality assurance (QA) procedures since the time they were collected. The *Hanford Site Past-Practice Strategy* (DOE/RL 1992a) recommends that existing data be used to the maximum extent possible, at two levels: first to formulate the conceptual model, conduct a qualitative risk assessment, and prepare work plans, but also as an initial data set which can be the basis for a fully-qualified data set through a process of review, evaluation, and confirmation.

- **Representativeness**--the degree to which the appropriate environmental parameters or media have been sampled.

This parameter highlights a shortcoming of most of the historical data. Some discussion of representativeness limitations is presented in Section 8.1.2. Limitations include the observation only of gross gamma radiation rather than differentiating it by radionuclide (e.g., through spectral surveying methods as are being used by the RLS program), the analysis of samples only for radionuclides rather than for chemicals and radionuclides, and the failure to sample (especially in the subsurface) for the full potential extent of contaminant migration.

The data are incomplete primarily because of the lack of subsurface sampling for extent of contamination. This is because no subsurface investigation has been initiated on the waste management units in the U Plant Aggregate Area yet. The lack of these data is also caused by concerns to limit the potential exposure to radioactivity of workers who would have to drill in contaminated areas and the possible release or spread of contamination through these intrusive procedures. The result of this data gap is that none of the sites can be demonstrated to have contamination either above or below levels of regulatory concern, and a full quantitative risk assessment cannot be conducted.

In addition, in many cases it has been necessary to use general data (i.e., from elsewhere in the 200 West Area or even from the vicinity of the 200 Areas) rather than data specific to a particular waste management unit. For most purposes of characterization for transport mechanisms, this procedure is

acceptable given the screening level of the present study. For example, while it is appropriate to use a limited number of boring logs to characterize the stratigraphy in the aggregate area (Chamness et al. 1991, Lindsey et al. 1991), the later, waste management unit specific, field sampling plans will require detailed consideration of more of the logs of wells drilled in the immediate vicinity, whatever their quality, as a starting point to conceptually model the geology specifically beneath that unit.

- **Completeness--the fraction of samples which are considered "valid."**

None of the data that have been previously gathered in the U Plant Aggregate Area has been "validated" in the EPA Contract Laboratory Program (CLP) sense, although varying levels of quality control have been applied to the sampling and analysis procedures. The data are generally adequate for characterization purposes, but may not be suitable for use in a formal risk assessment. The best indication of the validity of the data is the reproducibility of the results, and this indicates that validity (completeness) is one of the less significant problems with the data.

- **Comparability -- the confidence that can be placed in the comparison to two data sets (e.g., separate samplings).**

With varying levels of quality control and varying procedures for sample acquisition and analysis, this parameter is also generally poorly met. Much of this is due to the more recent development of QA procedures.

While these limitations cannot in most cases be quantified (and some such as representativeness are specifically only qualitative), most of the data gathered in the U Plant Aggregate Area can be cited as failing one or more of the PARCC parameters. As discussed in Section 8.1.2, the data are considered to be mainly deficient in completeness (the appropriate media, constituents, or locations were never sampled or analyzed). These data should, however, be used to the maximum extent in the development of work plans for site field investigations, prioritization of the various units, and to determine, to the extent possible, where contamination is or is not present.

In addition to these site-specific data, there are also a limited number of non site-specific sampling events that are being developed to determine background levels of naturally occurring constituents (Hoover and LeGore 1991). These data can be used to differentiate the effect of the environmental releases from naturally occurring background levels.

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8.1.4 Conceptual Models

The initial conceptual model of the sites in the U Plant Aggregate Area is presented and described in Section 4.2 (Figure 4-3). The model is based on best estimates of where contaminants were discharged and their potential for migration from release points. The conceptual model is designed to be conservatively inclusive in the face of a lack of data. This means that a migration pathway was included if there is any possibility of contamination travelling on it, historically or at present. In most cases there may not be a significant flux of such contamination migration for many of the pathways shown on the figure.

The one pathway on Figure 4-3 that has transported the largest amount of water is undoubtedly the releases to soil from the 216-U-10 Pond, through the vadose zone into the unconfined aquifer. Contamination can be demonstrated to have been present in the pond according to results of sediment sampling. If significant levels of dissolved constituents were present in the pond, the large quantities of water would have contributed to their mobilization and transport to the aquifer. However, there is little information about the contamination that actually has been transported along this pathway. The pathway from some of the cribs leading to adsorption of transuranic elements on vadose-zone soils is possibly more significant. These and other pathways can be traced on the conceptual model. All are possible; only a few are likely because of the conservatism inherent in including all conceivable pathways. More importantly, even if a pathway carries significant levels of a contaminant, it still may not have carried contamination to the ultimate receptors, human or ecological. This can only be assessed by sampling at the exposure point on this pathway, or sampling at some other point and extrapolation to the exposure point, to indicate the dosage to the receptors.

There are thus significant uncertainties in the contaminant levels in the contaminant migration pathways shown on the conceptual model, yet almost none of these pathways has been sampled to determine whether any contamination still exists in any of the locations implicated from the conceptual model, and if so which constituents, how much, and to what extent.

8.1.5 Aggregate Area Management Study Objectives and Decisions

The specific objectives of the U Plant AAMS are listed in Section 1.3. They include the following:

- Assemble site data (as described in Section 8.1.2)
- Describe site conditions (see Section 3.0)
- Conduct limited new site characterization work (see separate topical reports)

- Develop a preliminary site conceptual model (see Section 8.1.4)
- Identify contaminants of concern and their distribution (Section 4.0)
- Identify potential applicable, or relevant and appropriate, regulations (ARARs, Section 6.0)
- Define preliminary remedial action objectives and screen potential remedial technologies to prepare preliminary remedial action alternatives (Section 7.0), and provide recommendations for FFS (Section 9.4.1) and treatability studies (Section 9.5)
- Define data needs, establish general DQOs, and set priorities
- Recommend ERA, IRM, LFI, or other actions (Section 9.0), and
- Redefine and prioritize, as data allow, operable units, their boundaries, and work plan activities with emphasis on supporting early cleanup actions and records of decision (Sections 8.3 and 9.0)
- Integrate RCRA TSD closure activities with past practice activities (Section 9.3.4).

The decisions that will have to be made on the basis of this AAMS can best be described according to the *Hanford Site Past-Practice Strategy* (DOE/RL 1992a) flow chart (Figure 1-2 in Section 1.0) that must be conducted on a site-by-site basis. Decisions are shown on the flow chart as diamond-shaped boxes, and include the following:

- Is an ERA justified?
- Is less than six months' response needed (is the ERA time critical)?
- Are data sufficient to formulate the conceptual model and perform a qualitative risk assessment?
- Is an IRM justified?
- Can the remedy be selected?
- Can additional required data be obtained by LFI?

- Are data (from field investigations) sufficient to perform risk assessment?
- Can an Operable Unit/Aggregate Area ROD be issued?

(The last two questions will only be asked after additional data are obtained through field investigations, and so are DQO issues only in assessing scoping for those investigations.)

Most of these decisions are actually a complicated mixture of many smaller questions, and will be addressed in Section 9.0 in a more detailed flowchart for assessing the need for remediation or investigation.

Similarly, the tasks that will need to be performed after the AAMS that drive the data needs for the study are found in the rectangular boxes on the flow chart. These include the following:

- ERA (if justified)
- Definition of threshold contamination levels, and formulation of conceptual model, performance of qualitative risk assessment and FS screening (IRM preliminaries)
- FFS for IRM selection
- Determination of minimum data requirements for IRM path
- Negotiation of Scope of Work, relative priority, and incorporation into integrated schedule, performance of LFI
- Determination of minimum data needs for risk assessment and final Remedy Selection (preparation of RI/FS pathway).

These stages of the investigation must be considered in assessing data needs (Section 8.2.1).

8.2 DATA USES AND NEEDS (STAGE 2 OF THE DQO PROCESS)

Stage 2 of the DQO development process (EPA 1987) defines data uses and specifies the types of data needed to meet the project objectives. These data uses and needs are based on the Stage 1 results, but must be more specific. The elements of this stage of the DQO process include:

- Identifying data uses (Section 8.2.1)
- Identifying data types (Section 8.2.2.1)
- Identifying data quality needs (Section 8.2.2.2)
- Identifying data quantity needs (Section 8.2.2.3)
- Evaluating sampling/analysis options (Section 8.2.2.4)
- Reviewing data quality parameters (Section 8.2.2.5)
- Summarizing data gaps (Section 8.2.3).

Stage 2 is developed on the basis of the conceptual model and the project objectives. These following sections discuss these issues in greater detail.

8.2.1 Data Uses

For the purposes of the remediation in the U Plant Aggregate Area, most data uses fall into one or more of four general categories:

- Site characterization
- Public health evaluation and human health and ecological risk assessments
- Evaluation of remedial action alternatives
- Worker health and safety.

Site characterization refers to a process that includes determination and evaluation of the physical and chemical properties of any wastes and contaminated media present at a site, and an evaluation of the nature and extent of contamination. This process normally involves the collection of basic geologic, hydrologic, and meteorologic data but more importantly for the U Plant Aggregate Area waste management units, data on specific contaminants and sources that can be incorporated into the conceptual model to indicate the relative significance of the various pathways. Site characterization is not an end in itself, as stressed in the *Hanford Site Past-Practice Strategy* (DOE/RL 1992a), but rather the data must work toward the ultimate objectives of assessing the need for remediation (according to risk assessment methods, either qualitative or quantitative, or compliance with ARARs) and providing appropriate means of remediation (through an FFS, FS, or CMS. The

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understanding of the site characterization, based on existing data, is presented in Sections 2.0, 3.0, and 4.0, and summarized in the conceptual model (Section 4.2).

Data required to conduct a public health evaluation, and human health and ecological risk assessments at the sites in the U Plant Aggregate Area include the following: input parameters for various performance assessment models (e.g., the Multimedia Environmental Pollutant Assessment System); site characteristics; and contaminant data required to evaluate the threat to public and environmental health and welfare through exposure to the various media. These needs usually overlap with site characterization needs. An extensive discussion of risk assessment data uses and needs, for both human health and ecological evaluations, is presented in the *Risk Assessment Guidance for Superfund Volumes 1 and 2* (EPA 1989a,c). The EPA Region 10 has also developed its preferred methodology for these risk assessment activities (EPA 1989a, 1991a). The ecological and human health risk assessments will follow the guidance outlined in the approved M-29-03 milestone document, *Hanford Site Baseline Risk Assessment Methodology*. The data requirements for an ecological risk assessment include (1) identification of critical species, (2) identification of habitat within and surrounding the Hanford Site, (3) feeding relationships among species of concern, and (4) contaminant concentrations in environmental media and species of interest. The main deficiency in the data available for waste management units in the U Plant Aggregate Area is that a quantitative assessment of contaminant concentrations for the purposes of Risk Assessment can not be performed. The present understanding of site risks is presented in the selection of constituents of concern (Section 4.0). The data needs for quantitative risk assessments will be considered in developing site specific sampling and analysis plans according to the *Hanford Site Past-Practice Strategy*.

Data collected to support evaluation of remedial action alternatives for ERAs, IRMs, FFSs, or the full RI/FS, include site screening of alternatives, feasibility-level design, and preliminary cost estimates. Once an alternative is selected for implementation, much of the data collected during site investigations (LFI or RI) can also be used for the final engineering design. Generally, collection of information during the investigations specifically for use in the final design is not cost effective because many issues must be decided about appropriate technologies before effective data gathering can be undertaken. It is preferable to gather such specific information during a separate predesign investigation or at the time of remediation (i.e., the "observational approach" of the *Hanford Site Past-Practice Strategy* [DOE/RL 1992a]). Based on the existing data, broad remedial action technologies and objectives have been identified in Section 7.0.

The worker health and safety category includes data collected to establish the required level of protection for workers during various investigation activities. These data are used to determine if there is concern for the personnel working in the vicinity of the aggregate area. The results of these assessments are also used in the development of the various safety documents required for field work (see Health and Safety Plan, Appendix B).

It should be noted that each of these data use categories (site characterization, risk assessment needs, remedial actions, and health and safety) will be required at each decision point on the *Hanford Site Past-Practice Strategy* (DOE/RL 1992a) flow chart, as discussed at the end of Section 8.1.5. To the extent possible, however, not all sites will be investigated to the same degree but only those with the highest priority. These results will then be extended to the other, analogous sites which have similar geology and disposal histories (see Section 9.2.3).

The existing data can presently be used for two main purposes:

- Development of site-specific sampling plans (site characterization use)
- Screening for health and safety (worker health and safety use).

Table 8-1 presents a summary of the availability of existing data for these two uses.

For the purposes of developing sampling plans, existing information is available for:

- The location of sites--many of sites have surface expressions, markers, or have been surveyed in the past. The unplanned releases in particular are lacking in this information, as well as for the 216-U-15 Trench and the 2607-W-7 Septic Tank and Drain Field.
- Possible contamination found at the sites--these data are derivable from the inventories for the sites (mainly for the cribs and other disposal facilities) as well as from the limited sampling which has been done at the 216-U-10 Pond and its tributary ditches (216-U-14 and 216-Z-1D, -11, and -19).
- The likely depth of contaminants--this information is mainly obtained from the gross gamma borehole logging for many of the sites, but core sampling has been done at the 216-U-10 Pond and some of its tributary ditches.

Two types of information are available for the purposes of worker health and safety, and will be used for the development of health and safety documents:

- Levels of surface radiation--derived from the on-going periodic radiological surveys done under the Environmental Surveillance program (Schmidt et al. 1992). Table 8-1 shows where surveys have indicated no detectable levels of surface radiation and so no additional survey is required before surface activities can be conducted.

- Expected maximum contaminant levels--these data can be based mainly on the results of subsurface soil sampling. Extensive sampling of this type has only been conducted at the 216-U-10 Pond and some of its tributary ditches.

Table 8-1 also presents a first expression of the data needs for the individual waste management units in the U Plant Aggregate Area, which must be addressed for remediation approaches to be developed.

8.2.2 Data Needs

The data needs for the U Plant Aggregate Area are discussed in the following sections according to the categories of types of data (Section 8.2.2.1), quality (8.2.2.2), quantity (8.2.2.3), options for acquiring the data (8.2.2.4), and appropriate DQO (PARCC) parameters (8.2.2.5). These considerations are summarized for each category of waste management unit site in the U Plant Aggregate Area (Section 8.2.3).

8.2.2.1 Data Types. Data use categories described in Section 8.2.1 define the general purpose of collecting additional data. Based on the intended uses, a concise statement regarding the data types needed can be developed. Data types specified at this stage should not be limited to chemical parameters, but should also include necessary physical parameters such as bulk density, moisture, and hydraulic conductivity. Precipitation recharge, chemical distribution coefficients and organic complexation data appear adequate, but may require additional study based on the results of future evaluations. Since environmental media and source materials are interrelated, data types used to evaluate one media may also be useful to characterize another media.

Identifying data types by media indicates that there are overlapping data needs. Data objectives proposed for collection in the site investigations at sites in the U Plant Aggregate Area are discussed in Section 8.3 to provide focus to investigatory methods that may be employed. The data type requirements for the preliminary remedial action alternatives developed in Section 7.4 are summarized in Table 8-2.

8.2.2.2 Data Quality Needs. The various tasks and phases of a CERCLA investigation may require different levels of data quality. Important factors in defining data quality include selecting appropriate analytical levels and validation and identifying contaminant levels of concern as described below. The Westinghouse Hanford document, *A Proposed Data Quality Strategy for Hanford Site Characterization*, will be used to help define these levels (McCain and Johnson 1990). The DQOs will also be developed and defined on an operable unit basis in the work plans and, specifically, in the Quality Assurance Project Plans (QAPjPs) which will guide investigation activities.

Chemical and radionuclide laboratory analysis will be one of the most important data types, and is required at virtually all the sites in the U Plant Aggregate Area. In general, increasing accuracy, precision, and lower detection limits are obtained with increasing cost and time. Therefore, the analytical level used to obtain data should be commensurate with the intended use. Table 8-3 defines five analytical levels associated with different types of characterization efforts. While the bulk of the analysis during LFIs/RIs will be screening level (DQO Level I or II), these data will require confirmation sampling and analysis to allow final remedial decisions through quantitative risk assessment methods. Individual DQO analytical PARCC parameters for Level III or IV analytical data associated with each contaminant anticipated in the U Plant Aggregate Area (as developed in Section 5) are given in Table 8-4. These parameters will be used for the development of site-specific sampling and analysis plans and quality assurance plans for investigations and remediations in the aggregate area.

Before laboratory or even field data can be used in the selection of the final remedial action, they must first be validated. Exceptions are made for initial evaluations of the sites using existing data, which may not be appropriate for validation but will be used on a screening basis based on the *Hanford Site Past-Practice Strategy* (DOE/RL 1992a). Other screening data (e.g., estimates of contaminant concentration inferred from field analyses) may also be excepted. Validation involves determining the usability and quality of the data. Once data are validated, they can be used to successfully complete the remedial action selection process. Activities involved in the data validation process include the following:

- Verification of chain-of-custody and sample holding times
- Confirmation that laboratory data meet Quality Assurance/Quality Control (QA/QC) criteria
- Confirmation of the usability and quality of field data, which includes geological logs, hydrologic data, and geophysical surveys
- Proper documentation and management of data so that they are usable.

Validation may be performed by qualified Westinghouse Hanford personnel from the Office of Sample Management (OSM), other Westinghouse Hanford organizations, or a qualified independent participant subcontractor. Data validation of laboratory analyses will be performed in accordance with *A Proposed Data Quality Strategy for Hanford Site Characterization* (McCain and Johnson 1990) and standards set forth by Westinghouse Hanford.

To accomplish the second point, all laboratory data must meet the requirements of the specific QA/QC parameters as set up in the QAPjP for the project before it can be

considered usable. The QA/QC parameters address laboratory precision and accuracy, method blanks, instrument calibration, and holding times.

The usability of field data must be assessed by a trained and qualified person. The project geohydrologist/geophysicists will review the geologic logs, hydrologic data, geophysical surveys, and results of physical testing, on a daily basis, and senior technical reviews will be conducted periodically throughout the project.

Data management procedures are also necessary for the validation. Data management includes proper documentation of field activities, sample management and tracking, and document and inventory control. Specific consistent procedures are discussed in the Information Management Overview (Appendix D).

8.2.2.3 Data Quantity Needs. The number of samples that need to be collected during an investigation can be determined by using several approaches. In instances where data are lacking or are limited (such as for contamination in the vadose zone soils), a phased sampling approach will be appropriate. In the absence of any available data, an approach or rationale will need to be developed to justify the sampling locations and the numbers of samples selected. This will be accomplished and documented in the production of work plans and field sampling plans for each aggregate area, under the guidance and review of the Tri-Party Agreement participants. Specific locations and numbers of samples will be determined based on data collected during screening activities. For example, the number and location of beta/gamma spectrometer probe locations can be based on results of surface geophysical and radiation surveys. These may help locate some subsurface features (such as the 216-U-15 Trench), which may not be adequately documented. Details of any higher DQO level subsurface soil sampling scheme will depend on results of screening investigations such as geophysics surveys, surface radiation surveys, field chemical screening, and beta/gamma spectrometer probe surveys. In situations where and when available data are more complete, statistical techniques may be useful in determining the additional data required.

8.2.2.4 Sampling and Analysis Options. Data collection activities are structured to obtain the needed data in a cost-effective manner. Developing a sampling and analysis approach that ensures that appropriate data quality and quantity are obtained with the resources available may be accomplished by using field screening techniques and focusing the higher DQO level analyses on a limited set of samples at each site. The investigations on sites in the U Plant Aggregate Area should take advantage of this approach for a comprehensive characterization of the site in a cost-effective manner.

A combination of lower level (Levels I and II), higher level analytical data (Levels III and IV) and special analytical data (Level V) should be collected. This approach would provide the certainty necessary to determine contaminants present near the sources. Samples collected from the other media (i.e., subsurface soils, sediments) will be analyzed by *Test Methods for Evaluating Solid Wastes* (EPA 1986), CLP (EPA 1988a, EPA 1989b), *Methods*

for *Chemical Analysis of Water and Wastes* (EPA 1983), or *Prescribed Procedures for Measurement of Radioactivity in Drinking Water* (EPA 1980a).

8.2.2.5 Data Quality Parameters. The PARCC parameters are indicators of data quality. Ideally, the end use of the data collected should define the necessary PARCC parameters. Once the PARCC requirements have been identified, then appropriate analytical methods can be chosen to meet established goals and requirements. Definitions of the PARCC parameters are presented in Section 8.1.3.

In general the precision and accuracy objectives are governed by the capabilities of the available methodologies and in most cases these are more than adequate for the needs of the investigations. Chemical analyses can usually attain parts per billion detection range in soils and water, and this level is adequate to the needs of the risk assessment for most analytes. Radiological analyses reach similar levels. Table 8-4 shows detection levels, generally obtained from the method description such as the document *Test Methods for Evaluating Solid Wastes* (EPA 1986) or from experience with laboratory analysis. Some constituents (e.g., arsenic) would require analysis to much lower levels, but this is impossible because of the limitations of analytical methods and the effects of natural background levels. For example, EPA Method 200.62-C-CLP can analyze to detection levels of 500 $\mu\text{g}/\text{kg}$ in soils, while the Model Toxics Control Act (MTCA) Method C Industrial soils cleanup level is 50 $\mu\text{g}/\text{kg}$. In some cases, special analytical methods can be developed to obtain lower detection levels. In addition, risk assessment is conventionally computed only to a single digit of precision and uses conservative assumptions, which reduce the impact of measurements with lower accuracy.

For other measurements, such as physical parameters, the precision and accuracy capabilities of existing measurement technologies are sufficient for the evaluation methods used to produce characterization data, so the objectives are based on the limitations of the analysis methodologies.

Representativeness is maintained by fitting the sampling program to the governing aspects of the sources and transport processes of the site, as demonstrated in the site conceptual model (Section 4.2). Initial sampling should concentrate on sources, which are fairly well-understood, and on representative locations of anticipated transport mechanisms. If necessary, following activities can focus on aspects or locations that were not anticipated but were demonstrated by the more general results.

Completeness is generally attained by specifying redundancy on critical samples and maintaining quality control on their acquisition and analysis. As with representativeness, the initial sampling program may lead to modifications of which samples should be considered critical during subsequent sampling activities.

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Comparability will be met through the use of Westinghouse Hanford standard procedures generally incorporated into the *Environmental Investigation and Site Characterization Manual* (WHC 1988c).

8.2.3 Data Gaps

Considering the data needs developed in the subsections of Section 8.2.2, and the data available to meet these needs as presented in Section 8.1.2, it is apparent that a number of data gaps can be identified. These are summarized, on a waste management unit category basis, in Table 8-5, and should be the focus of LFIs on a waste management unit category basis, using the analogue sites approach. The contaminant concentration data are the highest priority because of the need to assess the need for remediation (through quantitative risk assessment and evaluation of compliance with ARARs) and appropriate remedial actions for each site.

In addition to these data needs specifically addressing contamination problems at sites included for consideration in this aggregate area, there are general data needs which will be required for characterization of the possible transport pathways, as presented in the conceptual model, at locations away from the individual units. These general, non-site specific needs include characterization of the following:

- Geologic stratigraphy, particularly for possible perched water zones
- Transport through the vadose zone (mobilization through natural or artificial recharge or drainage)
- Air transport of contamination
- Ecological impacts and transport mechanisms (bio-uptake, bio-concentration, secondary receptors through predation)
- Potential releases from process effluent lines between facilities and to waste disposal sites.

All of these needs will have to be addressed in the data collection program (Section 8.3). In addition, data gaps that impact groundwater are also addressed in the 200 West Groundwater AAMSR.

8.3 DATA COLLECTION PROGRAM (STAGE 3 OF THE DQO PROCESS)

The data collection program is Stage 3 of the process to develop DQOs. Conducting an investigation with a mixture of screening and higher-level data is a common method for optimizing the quantity and quality of the data collected. It would be very inefficient and overly expensive to specify beforehand all the types of samples and analyses that will yield the most complete and accurate understanding of the contamination and physical behavior of the site. Data adequate to achieve the goals and objectives for remedial action decisions are obtained at a lower cost by using the information obtained in the field to focus the ongoing investigation and remediation process.

Initial sampling should collect new data believed most necessary to confirm and refine the conceptual model particularly at priority sites. Sampling may then be extended to further reduce uncertainty, to fill in remaining data gaps, to collect more detailed information for certain points where such information is required, or to conduct any needed treatability studies or otherwise support the data needs of the remedial action selection process. An alternative of extrapolating the data from a limited number of sites to other analogous ones will also be used. The need for subsequent investigation phases will be assessed throughout the investigation and remediation activities as data become available. Assessing completeness of the investigation data through a formal statistical procedure is not possible, given the complexity and uncertainty of the parameters required to describe the site and the time to make decisions. Rather, the use of engineering judgement is considered sufficient to the decision process.

8.3.1 General Rationale

The general rationale for the investigation of sites in the U Plant Aggregate Area is to collect needed data that are not available. Because of the size of the aggregate area, the complexity of past operations, and the number of unplanned releases and waste management units, a large amount of new information will be required such as the specific radionuclides and chemicals present, their spatial distribution and form, and the presence of special migration pathways (such as perched groundwater systems).

The following work plan approach will be used for LFIs and RI/FS in the U Plant Aggregate Area. The results are described in Sections 8.3.2 and 8.3.3 in a general form.

- Existing data as described in Sections 2.0, 3.0, and 4.0 should be used to the maximum extent possible. Although existing data are not validated fully, the data are still useful in developing a preliminary conceptual model (Section 4.2) and in helping to focus and guide the planning of investigations, expedited actions, and interim measures.

- Additional data at validated and screening levels should be collected to obtain the maximum amount of useful information for the amount of time and resources invested in the investigation.
- Data should be collected to support the intended data uses identified in Section 8.2.1.
- Nonintrusive sampling (e.g., geophysical surveys, surface radiation surveys, soil gas, and spectral gamma probe surveys), and surficial and source sampling should be conducted early in any investigation effort to identify necessary interim response actions (i.e., additional ERAs or IRMs).
- Data collected from initial investigation activities should be used to confirm and refine the conceptual model (Section 4.2), refine the analyte constituents of concern, and provide information to conduct interim response actions or risk assessment activities.
- Additional investigation activities are proposed to support (if needed) quantitative baseline risk assessments for final cleanup actions and further refine the conceptual model.
- Field investigation techniques should be used to minimize the amount of hazardous or mixed waste generated. Any waste generated will be in accordance with EII 4.3, "Control of CERCLA and other Past-Practice Investigation Derived Waste" (WHC 1988c).

8.3.2 General Strategy

The overall objective of any field investigation (LFI, IRM, or RI) of the sites in the U Plant Aggregate Area will be to gather additional information to support risk assessment and remedial action selection according to the *Hanford Site Past-Practice Strategy* (DOE/RL 1992a) flow chart discussed in Section 8.1.5. The general approach or strategy for obtaining this additional information is presented below.

- Analytical parameter selection should be based on verifying overall conditions and then narrowed to specific constituents of concern, in consideration with regulatory requirements and site conditions. Periodic analyses of the long list of parameters should be conducted to verify that the list of constituents of concern has not changed, either because new constituents are identified or some of those considered as a potential concern do not appear to be significant.

- Similarly, investigations should work from a screening level (DQO Levels I or II, e.g., surface radiation surveys) to successively more specific sampling and analysis methodologies (e.g., beta/gamma spectral probes, then DQO Level III or IV soil sampling and analysis), without time consuming remobilizations.
- Dangerous and radioactive wastes may be generated during the field investigation. While efforts should be made to minimize these wastes, any waste generated will be handled in accordance with EII 4.3, "Control of CERCLA and Other Past-Practice Investigation Derived Waste" (WHC 1988c). The analyses of samples for constituents of concern analytes will allow wastes generated to be adequately designated.

8.3.3 Investigation Methodology

Initial field investigations (mainly LFIs, but also associated with IRMs at appropriate sites and possibly some RIs) may include some or all of the following integrated methodologies:

- Source Investigation (Section 8.3.3.1)
- Geological Investigation (Section 8.3.3.2)
- Surface Water Sediment Investigation (Section 8.3.3.3)
- Soil Investigation (Section 8.3.3.4)
- Air Investigation (Section 8.3.3.5)
- Ecological Investigation (Section 8.3.3.6)
- Geophysical Stratigraphic Survey (Section 8.3.3.7)
- Process Effluent Pipeline Integrity Assessment (Section 8.3.3.8)
- Geodetic Survey (Section 8.3.3.9)
- Cultural Resource Investigation (8.3.3.10).

Each investigation methodology is briefly outlined in the following sections. Specific survey methods (such as electromagnetics or ground-penetrating radar) have not been recommended to allow flexibility in the development of field sampling plans which can be sensitive to very local conditions. A summary of the applicable methods for each waste

management unit is presented in Table 8-6. In addition, some of the data needs must be addressed on an area-wide basis (e.g., stratigraphy interpretation). More detailed descriptions and specific methods and instrumentation will be included in site-specific work plans, sampling and analysis plans, and field sampling plans for LFIs/IRMs at waste management units that require these investigations.

These investigations are presented in the approximate priority of their need, with the source investigation first because of its importance to the decisions about remedial action on a site-by-site basis. The other investigations are of lower priority, and will be conducted according to the need to determine whether contamination has been transported beyond the immediate vicinity of the waste management units. To some extent, this need will depend on the results of the source investigation.

8.3.3.1 Source Investigation. The purpose of source investigation activities in the U Plant Aggregate Area is to characterize the known waste management units and unplanned releases that exist in the area and that may contribute to contamination of surface soil, vadose zone, surface water, sediment, air, and biota. The completeness of the characterization effort will be assessed according to the needs of risk assessment, ARARs compliance, and remedial action selection, which will also determine what levels of the various constituents of concern comprise "contamination."

Source sampling should be conducted at waste management units or unplanned release locations where the available data indicate that dangerous, mixed, or radioactive wastes may be present. Activities which are proposed to be performed during the source investigations include the following:

- Compile and evaluate additional existing data for the purpose of: verifying locations, specifications of engineered facilities, and pipelines, and waste stream characteristics; assessment of the construction and condition of boreholes/wells that exist in the operable unit and their suitability for use for investigation activities, QA/QC information, and raw data regarding radiological and hazardous substances monitoring; and integrating any additional environmental modeling data into the conceptual model. This has been done (on an aggregate area basis) in this report; the process will be extended to site-specific planning and on-going assessments of the investigation/remediation as it is carried out.
- Conduct surface radiological survey of suspected or known source areas to verify locations and nature of surface and subsurface radiological contamination. Conditions at specific sources within a waste management unit should also be noted in order to plan sampling/remediation activities and worker health and safety.

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- Conduct nonintrusive surface geophysical surveys at specific waste management units such as the 216-U-5 and 216-U-6 Trenches (Section 2.3.5.2.2), the 2607-W-7 Septic Tank and Drain Field (Section 2.3.6.2), and unplanned release locations to verify locations and physical characteristics of source locations. Data generated from these activities can be used in planning intrusive source sampling activities.
- Conduct beta/gamma spectrometer probe survey to screen for near-surface contamination and to confirm the absence or presence of some specific radionuclides, which may be of particular concern. Existing boreholes will be used to the maximum extent, but new boreholes may be needed at many locations (to be decided based on screening results). Logging will be done both by NaI detectors or μ R meters for rapid screening as well as the RLS high purity germanium logging system. Westinghouse Hanford will develop an EII Procedure for the beta/gamma spectrometer probe survey. The beta/gamma spectrometer probe survey serves two purposes depending on the source conditions: to confirm absence of contamination in the near-surface soils, and to serve as a screening tool to choose locations and quantities of vadose zone soil borings. The RLS procedure could demonstrate "assay quality" data for radionuclide concentrations, but will probably continue to require supporting Level III or IV soil analysis data to allow a risk assessment before final remedial decisions. The need to conduct this survey will be based (at least in part) on the screening results of the surface survey and on information about site burial.
- Soil gas surveys should be conducted at waste management units (such as cribs or the Construction Surface Laydown Area) where volatile organic chemicals are suspected, as a screening method to identify compounds such as solvents and degreasers that may have been used in processes or during construction activities. The soil gas survey should not be considered conclusive that volatile organic compounds at lower concentrations may not be present. Data from the soil gas survey can be used to help locate surface and near-surface samples and vadose zone borings.
- Collect surface and near-surface samples of contaminated soils and/or waste materials at selected locations. Specific sampling sites will be chosen to assess particular facilities or releases. Additional sampling sites may be specified based on results from nonintrusive investigations.

8.3.3.2 Geologic Investigation. A geologic investigation should be performed to better characterize the vadose zone and the nature of unsaturated soils that make up this system. The geologic investigation will include the following tasks:

- Borings may be advanced into zones where an accurate interpolation of the subsurface stratigraphy is important to understanding migration pathways in the vadose zone. An investigation of the Plio-Pleistocene unit, which may be causing perched water zones, may be especially valuable. Waste management units in areas where this unit may have an important influence are indicated in Table 8-6 according to whether perched zone monitoring wells are recommended. These recommendations were based on quantities of liquid waste received by the unit (Table 4-13) and the likelihood of the Plio-Pleistocene Unit being present at the location (Section 3.4.3.3).
- Geologic data collected during the ongoing vadose zone soil (Section 8.3.3.4) and other (deeper) investigations (e.g., geologic and geophysical logs from groundwater well installations for groundwater AAMSS) will be compared, compiled, and evaluated.

8.3.3.3 Surface Water Sediment Investigation. A surface water sediment investigation should be conducted. The investigation will include:

- Radiation survey along ditches, trenches, and ponds for health and safety purposes and to locate areas of elevated radiation for selection of specific sediment sampling locations.
- Sampling of sediment in any ditches, ponds, and trenches that still contain water. This will probably be limited to the 216-U-14 Ditch and the 207-U Retention Basin.

Milestone M-17-17 of the Tri-Party Agreement (Ecology et al. 1991) requires limitation of discharges to these facilities, and sampling and metering during a "stabilization run" of the UO₃ Plant. Sampling for this investigation will be coordinated with the activities for the stabilization run to avoid interference and to obtain optimal data.

8.3.3.4 Soil Investigation. The purpose of soil investigations is to determine physical and chemical properties of the soil and to determine the nature, type, and extent of soil contamination associated with waste management units and unplanned releases to allow initiation of interim remedial actions and to assess the quantitative risk at other sites. Sampling will include:

- Samples of vadose zone soil will be collected and analyzed for constituents of concern when wells are drilled for other studies (i.e., groundwater investigations) in the vicinity of a waste management unit or unplanned release with reported liquid disposals or spills. Organic vapor (at sites with suspected volatiles) and radiation sampling should also be performed with samples selected by onsite screening.

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- Data collected during this investigation will be evaluated to further understand the contribution of contaminants to the vadose zone from specific waste management units and/or unplanned releases and to better define the hydrology and water quality in the vadose zone system through moisture content profiles, tracking of specific contaminants, and soil hydraulic characteristics. However, the issue of contaminant transport through the vadose zone is more appropriate to studies conducted under the direction of the Groundwater AAMSRs.

8.3.3.5 Air Investigation. Air investigations (on an aggregate area scale) should consist of onsite particle sampling as part of the health and safety program. In addition, high-volume air samplers should be placed in appropriate locations on-site based on evaluation of existing meteorological data. The purpose of these samplers will be to determine if any migration of airborne contaminants occurs.

8.3.3.6 Ecological Investigation. Ecological investigation activities, on a site-wide scale, should include a literature search and data review, and a site walkthrough. Data collected during the soils characterization activities are expected to be sufficient to evaluate biota remediation technologies. These activities are intended to identify potential biota concerns which need to be addressed in the site investigation. Particular emphasis should be given to identifying potential exposure pathways to biota that migrate offsite or that introduce contaminants into the food web. Data obtained in this survey will be used to both refine the conceptual model as well as to conduct the ecological risk assessment.

8.3.3.7 Geophysical Stratigraphic Survey. A geophysical survey of subsurface stratigraphy should be conducted across the aggregate area to help characterize the geology and hydrogeology of the vadose zone. Of particular interest are perched water zones and the caliche layer (an important aquitard) in the Plio-Pleistocene Unit.

8.3.3.8 Process Effluent Pipeline Integrity Assessment. An assessment of process effluent pipeline integrity should be conducted early in site investigation activities to look for potential leaks and therefore possible areas of contamination. Initially, as part of this effort, drawings of the process lines and encasements within the aggregate area (Section 2.3.7) should be reviewed and their construction, installation, and operation evaluated. Specific lines will then be selected for integrity assessment with emphasis on lines serving the waste management units that have received large volumes of liquid (e.g., cribs). Investigation of operating high level waste transfer lines will be deferred to their respective programs. Results of the integrity assessments will be evaluated and additional sampling activities may be recommended for subsequent studies.

8.3.3.9 Geodetic Survey. Geodetic surveys will be conducted after the installation and completion of each investigation activity. The survey will be to locate the horizontal locations of surface and near-surface soil samples; corners of geophysics, soil gas, and beta/gamma probe surveys; and surface water and sediment sample locations. Horizontal and vertical locations of all vadose zone soil borings and perched zone wells will be surveyed.

The geodetic survey should be conducted by a professional surveyor licensed in the state of Washington and should be referenced to both historic (e.g., Hanford coordinates) and current coordinate datums (e.g., North American Datum of 1983 - NAD-83), both vertical and horizontal.

8.3.3.10 Cultural Resource Investigation. A cultural resource investigation should be conducted for investigation locations outside the 200 West Area to verify the locations of known archaeological sites by reviewing existing data. The focus of the investigation will be to confirm that no archaeological resources are present at proposed drilling sites.

8.3.4 Data Evaluation and Decision Making

Data will be evaluated as soon as results (e.g., soil gas, radiation screening, drilling results) become available for use in restructuring and focusing the investigation activities. Data reports will be developed that summarize and interpret new data. This includes groundwater sampling and RLS borehole logging as part of the AAMS. Data will be used to refine the conceptual model, further assess potential contaminant-specific ARARs, develop the quantitative risk assessment, and assess remedial action alternatives.

The objectives of data evaluation are:

- To reduce and integrate data to ensure that data gaps are identified and that the goals and objectives of the U Plant AAMS are met
- To confirm that data are representative of the media sampled and that QA/QC criteria have been met.

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Table 8-1. Uses of Existing Data for U Plant Aggregate Area
Waste Management Units.

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Waste Management Unit	Type of Unit	<u>Development of Sampling Plans</u>			<u>Health & Safety</u>	
		Location	Possible Contam.	Depth Contam.	Surface Rad.	Expected Max. Level
Tanks and Vaults						
241-U-361	Settling Tank	Yes	No	No	No	No
Cribs and Drains						
216-S-21	Crib	Yes	Yes	Yes	Yes	No
216-U-1 and -U-2	Cribs	Yes	Yes	Yes	No	No
216-U-8	Crib	Yes	Yes	Yes	Yes	No
216-U-12	Crib	Yes	Yes	Yes	Yes	No
216-U-16	Crib	Yes	Yes	Yes	Yes	No
216-U-17	Crib	Yes	Yes	Yes	Yes	No
216-Z-20	Crib	Yes	Yes	No	Yes	No
216-S-4	French Drain	Yes	Yes	No	Yes	No
216-U-3	French Drain	Yes	Yes	Yes	Yes	No
216-U-4A	French Drain	Yes	Yes	No	Yes	No
216-U-4B	French Drain	Yes	Yes	No	No	No
216-U-7	French Drain	Yes	Yes	No	No	No
Reverse Wells						
216-U-4	Reverse Well	Yes	Yes	No	Yes	No
Ponds, Ditches, and Trenches						
216-U-10	Pond	Yes	Yes	Yes	No	Yes
216-U-14	Ditch	Yes	Yes	Yes	No	Yes
216-Z-1D	Ditch	Yes	Yes	Yes	Yes	Yes
216-Z-11	Ditch	Yes	Yes	Yes	No	Yes
216-Z-19	Ditch	Yes	Yes	Yes	Yes	Yes
216-U-5	Trench	Yes	Yes	No	Yes	No
216-U-6	Trench	Yes	Yes	No	Yes	No
216-U-11	Trench	Yes	No	Yes	Yes	Yes
216-U-13	Trench	Yes	Yes	Yes	Yes	No
216-U-15	Trench	No	Yes	No	Yes	No
Septic Tanks and Associated Drain Fields						
2607-W-5	Septic Tank/ Drain Field	Yes	No	No	No	No

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**Table 8-1. Uses of Existing Data for U Plant Aggregate Area
Waste Management Units.**

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Waste Management Unit	Type of Unit	Development of Sampling Plans			Health & Safety	
		Location	Possible Contam.	Depth Contam.	Surface Rad.	Expected Max. Level
2607-W-7	Septic Tank/ Drain Field	No	No	No	No	No
2607-W-9	Septic Tank/ Drain Field	Yes	No	No	No	No
Basins						
207-U	Retention Basin	Yes	No	No	No	No
Burial Sites						
Burial Ground/ Burning Pit		Yes	No	No	No	No
Construction Surface Laydown Area		Yes	No	No	No	No
Unplanned Releases						
UN-200-W-6		Yes	No	No	No	No
UN-200-W-19		Yes	No	No	No	No
UN-200-W-33		Yes	No	No	Yes	No
UN-200-W-39		Yes	No	No	Yes	No
UN-200-W-46		No	No	No	No	No
UN-200-W-48		Yes	No	No	No	No
UN-200-W-55		Yes	Yes	No	No	No
UN-200-W-60		Yes	No	No	No	No
UN-200-W-68		Yes	No	No	No	No
UN-200-W-78		Yes	Yes	No	No	No
UN-200-W-86		Yes	Yes	No	No	No
UN-200-W-101		Yes	Yes	No	No	No
UN-200-W-117		Yes	No	No	Yes	No
UN-200-W-118		Yes	No	No	Yes	No
UN-200-W-161		Yes	Yes	No	No	No

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Table 8-2. Data Needs for Preliminary Remedial Action Alternatives for the U Plant Aggregate Area.

Alternative	Physical Attribute	Chemical/Radiochemical Attribute
1. Multimedia Cover (plus possible vertical barriers)	<ul style="list-style-type: none"> • areal extent • depth of contamination • structural integrity (collapse potential) • run-off/run-on potential • cover properties (permeability) 	<ul style="list-style-type: none"> • surface radiation • biologic transport potential
2. In Situ Grouting/Stabilization	<ul style="list-style-type: none"> • areal extent • depth • particle size • hydraulic properties (permeability/porosity) • stratigraphy • borehole spacing • grout/additive mix parameters 	<ul style="list-style-type: none"> • solubility • reactivity • leachability from grout medium
3. Excavation, Soil Treatment, and Disposal	<ul style="list-style-type: none"> • areal extent^{a/} • depth^{a/} • particle size • silt-size (dust) content • excavation stability 	<ul style="list-style-type: none"> • toxicity/radioactivity • levels of contaminants • solubility/reactivity • soil chemistry (relative affinity) • concentrations in PM-10 fraction • spent solvent treatment/disposal options
4. In Situ vitrification	<ul style="list-style-type: none"> • areal extent • depth • soil/waste conductivity • thermal properties • moisture content • voids • air permeability 	<ul style="list-style-type: none"> • volatility • reactivity • leachability/integrity • off-gas treatment waste disposal options
5. Excavation, Above Ground Treatment, and Geologic Disposal	<ul style="list-style-type: none"> • areal extent^{a/} • depth^{a/} • mineralogy of soil/waste • particle size • silt-size (dust) content • excavation stability • treatment parameters 	<ul style="list-style-type: none"> • concentrations of TRU • toxicity/radioactivity • levels of contaminants • concentrations in PM-10 fraction • reactivity • leachability/integrity of final waste form
6. In Situ Soil Vapor Extraction	<ul style="list-style-type: none"> • areal extent • depth • locations/depth of highest concentrations (vapors, adsorbed) • stratigraphy • soil permeability/porosity • voids 	<ul style="list-style-type: none"> • volatility of constituents (Henry's Law Constant) • non-volatile organics • levels • volatile radionuclides (Radon) • treatability (catalytic oxidization)

^{a/} May be obtained during remediation using the observational approach recommended by the *Hanford Site Past-Practice Strategy* (DOE/RL 1992a).

Table 8-3. Analytical Levels for the U Plant Aggregate Area.

Level	Description
<u>LEVEL I</u>	Field screening. This level is characterized by the use of portable instruments which can provide real-time data to assist in the optimization of sampling point locations and for health and safety support. Data can be generated regarding the presence or absence of certain contaminants (especially volatiles) at sampling locations.
<u>LEVEL II</u>	Field analysis. This level is characterized by the use of portable analytical instruments which can be used onsite, or in mobile laboratories stationed near a site (close-support laboratories). Depending on the types of contaminants, sample matrix, and personnel skill, qualitative and quantitative data can be obtained.
<u>LEVEL III</u>	Laboratory analysis using methods other than the Contract Laboratory Program (CLP) Routine Analytical Services (RAS). This level is used primarily in support of engineering studies using standard EPA-approved procedures. Some procedures may be equivalent to CLP RAS without the CLP requirements for documentation.
<u>LEVEL IV</u>	Contract Laboratory Program (CLP) Routine Analytical Services (RAS). This level is characterized by rigorous QA/QC protocols and documentation and provides qualitative and quantitative analytical data. Some regions have obtained similar support via their own regional laboratories, university laboratories, or other commercial laboratories.
<u>LEVEL V</u>	Nonstandard methods. Analyses which may require method modification and/or development are considered Level V by CLP Special Analytical Services (SAS).

Table 8-4. Data Quality Objective Parameters for Chemical/Radiochemical Analyses.

	Soil/Sediment				Water			
	Analysis Method	Practical Quantitation Limit ^{a/} (pCi/g, mg/kg)	Precision (RPD)	Accuracy (%)	Analysis Method	Practical Quantitation Limit ^{a/} (pCi/L, µg/L)	Precision (RPD)	Accuracy (%)
RADIONUCLIDES								
Gross Alpha	900.0 M	TBD	±30	±25	900.0	10	±25	±25
Gross Beta	900.0 M	TBD	±30	±25	900.0	5	±25	±25
Gamma Scan	D3699 M	TBD	±30	±25	D3649 M	TBD	±25	±25
Actinium-225	907.0 M	TBD	±30	±25	907.0	TBD	±25	±25
Actinium-227	TBD	TBD	±30	±25	TBD	TBD	±25	±25
Americium-241	Am-01	TBD	±30	±25	Am-03	TBD	±25	±25
Americium-242	TBD	TBD	±30	±25	TBD	TBD	±25	±25
Americium-242m	TBD	TBD	±30	±25	TBD	TBD	±25	±25
Americium-243	Am-01	TBD	±30	±25	Am-03	TBD	±25	±25
Antimony-126	TBD	TBD	±30	±25	TBD	TBD	±25	±25
Antimony-126m	TBD	TBD	±30	±25	TBD	TBD	±25	±25
Barium-137m	D3649 M	TBD	±30	±25	D3649 M	TBD	±25	±25
Bismuth-210	TBD	TBD	±30	±25	TBD	TBD	±25	±25
Bismuth-211	TBD	TBD	±30	±25	TBD	TBD	±25	±25
Bismuth-213	TBD	TBD	±30	±25	TBD	TBD	±25	±25
Bismuth-214	TBD	TBD	±30	±25	TBD	TBD	±25	±25
Carbon-14	C-01 M	TBD	±30	±25	TBD	TBD	±25	±25
Cesium-134	D3649 M	TBD	±30	±25	D3649 M	TBD	±25	±25
Cesium-135	901.0 M	TBD	±30	±25	901.0	TBD	±25	±25

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Table 8-4. Data Quality Objective Parameters for Chemical/Radiochemical Analyses.

	Soil/Sediment				Water			
	Analysis Method	Practical Quantitation Limit ^{a/} (pCi/g, mg/kg)	Precision (RPD)	Accuracy (%)	Analysis Method	Practical Quantitation Limit ^{a/} (pCi/L, µg/L)	Precision (RPD)	Accuracy (%)
RADIONUCLIDES (cont.)								
Cesium-137	D3649 M	TBD	±30	±25	D3649 M	TBD	±25	±25
Cobalt-60	D3649 M	TBD	±30	±25	D3649 M	TBD	±25	±25
Curium-242	907.0 M	TBD	±30	±25	907.0	TBD	±25	±25
Curium-244	907.0 M	TBD	±30	±25	907.0	TBD	±25	±25
Curium-245	907.0 M	TBD	±30	±25	907.0	TBD	±25	±25
Europium-152	D3649 M	TBD	±30	±25	D3649 M	TBD	±25	±25
Europium-154	D3649 M	TBD	±30	±25	D3649 M	TBD	±25	±25
Europium-155	D3649 M	TBD	±30	±25	D3649 M	TBD	±25	±25
Francium-221	TBD	TBD	±30	±25	TBD	TBD	±25	±25
Iodine-129	902.0 M	TBD	±30	±25	902.0	TBD	±25	±25
Lead-209	TBD	TBD	±30	±25	TBD	TBD	±25	±25
Lead-210	Pb-01 M	TBD	±30	±25	Pb-01	TBD	±25	±25
Lead-211	TBD	TBD	±30	±25	TBD	TBD	±25	±25
Lead-212	TBD	TBD	±30	±25	TBD	TBD	±25	±25
Lead-214	TBD	TBD	±30	±25	TBD	TBD	±25	±25
Neptunium-237	907.0 M	TBD	±30	±25	907.0	TBD	±25	±25
Neptunium-239	D35649 M	TBD	±30	±25	D3649 M	TBD	±25	±25
Nickel-59	TBD	TBD	±30	±25	TBD	TBD	±25	±25
Nickel-63	TBD	TBD	±30	±25	TBD	TBD	±25	±25

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Table 8-4. Data Quality Objective Parameters for Chemical/Radiochemical Analyses.

	Soil/Sediment				Water			
	Analysis Method	Practical Quantitation Limit ^{a/} (pCi/g, mg/kg)	Precision (RPD)	Accuracy (%)	Analysis Method	Practical Quantitation Limit ^{a/} (pCi/L, µg/L)	Precision (RPD)	Accuracy (%)
RADIONUCLIDES (cont.)								
Niobium-93m	TBD	TBD	±30	±25	TBD	TBD	±25	±25
Plutonium	Pu-02	TBD	±30	±25	Pu-10	TBD	±25	±25
Plutonium-238	Pu-02	TBD	±30	±25	Pu-10	TBD	±25	±25
Plutonium-239/240	Pu-02	TBD	±30	±25	Pu-10	TBD	±25	±25
Plutonium-241	TBD	TBD	±30	±25	TBD	TBD	±25	±25
Polonium-214	TBD	TBD	±30	±25	TBD	TBD	±25	±25
Polonium-215	TBD	TBD	±30	±25	TBD	TBD	±25	±25
Polonium-218	TBD	TBD	±30	±25	TBD	TBD	±25	±25
Potassium-40	D3649 M	TBD	±30	±25	D3649 M	TBD	±25	±25
Protactinium-231	TBD	TBD	±30	±25	TBD	TBD	±25	±25
Protactinium-234m	TBD	TBD	±30	±25	TBD	TBD	±25	±25
Radium	Ra-04	TBD	±30	±25	Ra-05	TBD	±25	±25
Radium-225	TBD	TBD	±30	±25	TBD	TBD	±25	±25
Radium-226	Ra-04	TBD	±30	±25	Ra-05	TBD	±25	±25
Ruthenium-106	TBD	TBD	±30	±25	TBD	TBD	±25	±25
Samarium-151	TBD	TBD	±30	±25	TBD	TBD	±25	±25
Selenium-79	TBD	TBD	±30	±25	TBD	TBD	±25	±25
Sodium-22	D3649 M	TBD	±30	±25	D3649 M	TBD	±25	±25
Strontium-90	Sr-02	TBD	±30	±25	Sr-02	TBD	±25	±25

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Table 8-4. Data Quality Objective Parameters for Chemical/Radiochemical Analyses.

	Soil/Sediment				Water			
	Analysis Method	Practical Quantitation Limit ^{a/} (pCi/g, mg/kg)	Precision (RPD)	Accuracy (%)	Analysis Method	Practical Quantitation Limit ^{a/} (pCi/L, µg/L)	Precision (RPD)	Accuracy (%)
RADIONUCLIDES (cont.)								
Technetium-99	Tc-01 M	TBD	±30	±25	Tc-01	TBD	±25	±25
Thallium-207	TBD	TBD	±30	±25	TBD	TBD	±25	±25
Thorium-227	00-06	TBD	±30	±25	00-07	TBD	±25	±25
Thorium-229	00-06	TBD	±30	±25	00-07	TBD	±25	±25
Thorium-230	00-06	TBD	±30	±25	00-07	TBD	±25	±25
Thorium-231	TBD	TBD	±30	±25	TBD	TBD	±25	±25
Tritium	906.0 M	TBD	±30	±25	906.0	300	±25	±25
Uranium	U-04	TBD	±30	±25	U-04	TBD	±25	±25
Uranium-233	U	TBD	±30	±25	908.0	TBD	±25	±25
Uranium-234	U	TBD	±30	±25	908.0	TBD	±25	±25
Uranium-235	U	TBD	±30	±25	908.0	TBD	±25	±25
Uranium-238	U	TBD	±30	±25	908.0	TBD	±25	±25
Yttrium-90	Sr-02	TBD	±30	±25	Sr-02	TBD	±25	±25
Zirconium-93	TBD	TBD	±30	±25	TBD	TBD	±25	±25
INORGANICS								
Arsenic	7061	0.02	±25	±30	7061	10	±20	±25
Barium	6010	0.02	±25	±30	6010	20	±20	±25
Boron	6010	TBD	±25	±30	6010	TBD	±20	±25
Cadmium	6010	0.09	±25	±30	6010	1	±20	±25

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Table 8-4. Data Quality Objective Parameters for Chemical/Radiochemical Analyses.

	Soil/Sediment				Water			
	Analysis Method	Practical Quantitation Limit ^{a/} (pCi/g, mg/kg)	Precision (RPD)	Accuracy (%)	Analysis Method	Practical Quantitation Limit ^{a/} (pCi/L, µg/L)	Precision (RPD)	Accuracy (%)
INORGANICS (cont.)								
Chromium	6010	0.07	±25	±30	6010	10	±20	±25
Copper	6010	0.06	±25	±30	220.2	10	±20	±25
Cyanide	9010	TBD	±25	±30	335.3	50	±20	±25
Fluoride	300 M	TBD	±25	±30	300	50	±20	±25
Iron	6010	20	±25	±30	6010	70	±20	±25
Lead	6010	0.45	±25	±30	6010	450	±20	±25
Manganese	6010	0.02	±25	±30	6010	20	±20	±25
Mercury	7471	0.02	±25	±30	245.2	2	±20	±25
Nickel	6010	1.5	±25	±30	6010	50	±20	±25
Nitrate	300 M	TBD	±25	±30	300	130	±20	±25
Nitrite	300 M	TBD	±25	±30	300	40	±20	±25
Selenium	6010	0.75	±25	±30	270.2	20	±20	±25
Silver	6010	2	±25	±30	272.2	10	±20	±25
Titanium	6010	TBD	±25	±30	6010	TBD	±20	±25
Vanadium	6010	0.08	±25	±30	286.2	40	±20	±25
Zinc	6010	0.02	±25	±30	6010	20	±20	±25
ORGANICS								
Acetone	8240	0.1	±25	±30	8240	100	±20	±25
Carbon tetrachloride	8240	0.005	±25	±30	8240	1	±20	±25

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Table 8-4. Data Quality Objective Parameters for Chemical/Radiochemical Analyses.

	Soil/Sediment				Water			
	Analysis Method	Practical Quantitation Limit ^{a/} (pCi/g, mg/kg)	Precision (RPD)	Accuracy (%)	Analysis Method	Practical Quantitation Limit ^{a/} (pCi/L, µg/L)	Precision (RPD)	Accuracy (%)
ORGANICS (cont.)								
Chloroform	8240	0.005	±25	±30	8240	5	±20	±25
Kerosene	8015M	20	±35	±30	8015M	500	±35	±25
Methylene chloride	8240	0.005	±25	±30	8240	5	±20	±25
MIBK	8015	0.5	±25	±30	8015	5	±20	±25
1,1,1-Trichloroethane	8240	0.005	±25	±30	8240	5	±20	±25
Toluene	8240	0.005	±25	±30	8240	5	±20	±25
Tributyl phosphate	TBD	TBD	±25	±30	TBD	TBD	±30	±25

TBD = To Be Determined

M = method modified to include extraction from the solid medium, extraction method is matrix and laboratory-specific

RPD = Relative Percent Difference

Prescribed Procedures for Measurement of Radioactivity in Drinking Water (EPA 1980a)*Test Methods for Evaluation Solid Waste (SW 846) Third Edition* (EPA 1986)*Methods for Chemical Analysis of Water and Waste* (EPA 1983)*Radionuclide Method for the Determination of Uranium in Soil and Air* (EPA 1980b)*EML Procedures Manual* (DOE/EML 1990)*Eastern Environmental Radiation Facility RadioChemistry Procedures Manual* (EPA 1984)*High-Resolution Gamma-Ray Spectrometry of Water* (ASTM 1985)

Precision and accuracy are goals. Since these parameters are highly matrix dependent they could vary greatly from the goals listed.

^{a/} pCi/g and pCi/L apply to radionuclides, mg/kg and µg/L apply to organic and inorganic constituents.

Table 8-5. Data Gaps by Waste Management Unit Category.

Site Category	Identified Data Gaps
Tanks and Vaults	<ul style="list-style-type: none"> • Contaminant concentrations in waste management units other than single-shell tanks • Distribution of contaminants in subsurface soils released in leaks • Constituents concentrations in related surface contamination
Cribs and Drains	<ul style="list-style-type: none"> • Containment concentrations in cribs • Containment concentrations in soils beneath cribs • Specific constituents (especially organic chemicals) • Distribution and vertical/lateral extent of contamination
Reverse Wells	<ul style="list-style-type: none"> • Containment concentrations in subsurface soils impacted by discharges • Specific constituents (especially organics) • Extent of contamination
Ponds, Ditches, and Trenches	<ul style="list-style-type: none"> • Distribution/extent of subsurface contamination • Buried contaminant concentrations in stabilized portions/units
Septic Tanks and Associated Drain Fields	<ul style="list-style-type: none"> • Actual discharge levels • Possible discharge and presence/level of non-sanitary wastes (e.g., laboratory drains)
Transfer Facilities, Diversion Boxes, and Pipelines	<ul style="list-style-type: none"> • Contamination constituents and concentrations • Direct radiation levels in facilities • Constituents/concentrations in related surface contamination • Integrity of transfer lines
Basins (207-U)	<ul style="list-style-type: none"> • Constituents and concentrations in sediments • Distribution/extent of subsurface contamination
Unplanned Releases	<ul style="list-style-type: none"> • Surface soil constituents and concentrations • Buried contamination constituents and concentrations

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Table 8-6. Applicable Characterization Investigation Methods at U Plant Aggregate Area Waste Management Units.

Waste Management Unit or Units	Source Investigation Method								Remarks
	Surface Radiation Survey	Subsurface Spectral Geophysics	Surface Geophysics	Soil Gas Survey	Surface Soil Sampling	Surface Water Sediment Sampling	Subsurface Soil Sampling	Perched Zone Monitoring Wells	
Tanks and Vaults									
241-U-361 Settling Tank	X	X	--	--	X	--	--	--	--
Cribs and Drains									
216-S-21 Crib	--	A	--	--	A	--	A	A	--
216-U-1 and 216-U-2 Cribs	X	X	--	--	X	--	X	X	--
216-U-8 Crib	X	X	--	--	X	--	X	X	--
216-U-12 Crib	--	A	--	--	A	--	A	A	--
216-U-16 Crib	--	A	--	--	A	--	A	A	--
216-U-17 Crib	--	A	--	--	A	--	A	A	--
216-Z-20 Crib	--	A	--	A	A	--	A	A	--
216-S-4 French Drain	--	A	--	--	--	--	A	--	--
216-U-3 French Drain	--	A	--	--	--	--	A	--	--
216-U-4A French Drain	X	X	--	--	--	--	X	X	--
216-U-4B French Drain	--	A	--	--	--	--	X	--	--
216-U-7 French Drain	--	A	--	--	--	--	A	--	--

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**Table 8-6. Applicable Characterization Investigation Methods at U Plant
Aggregate Area Waste Management Units.**

Waste Management Unit or Units	Source Investigation Method								Remarks
	Surface Radiation Survey	Subsurface Spectral Geophysics	Surface Geophysics	Soil Gas Survey	Surface Soil Sampling	Surface Water Sediment Sampling	Subsurface Soil Sampling	Perched Zone Monitoring Wells	
Reverse Wells									
216-U-4 Reverse Well	X	X	--	--	X	--	X	--	--
Ponds, Ditches, and Trenches									
216-U-10 Pond	X	X	--	--	X	--	X	X	--
216-U-11 Trench	--	X	--	--	X	--	X	X	--
216-U-14 Ditch	X	X	X	--	--	X	X	X	--
216-Z-1D Ditch	--	X	--	X	X	--	X	--	--
216-Z-11 Ditch	X	X	--	X	X	--	X	--	--
216-Z-19 Ditch	--	X	--	X	X	--	X	--	--
216-U-5 Trench	--	X	X	--	X	--	X	--	--
216-U-6 Trench	--	X	X	--	X	--	X	--	--
216-U-13 Trench	--	X	--	--	--	--	X	--	--
216-U-15 Trench	--	X	X	X	X	--	X	--	--

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Table 8-6. Applicable Characterization Investigation Methods at U Plant Aggregate Area Waste Management Units.

Waste Management Unit or Units	Source Investigation Method								Remarks
	Surface Radiation Survey	Subsurface Spectral Geophysics	Surface Geophysics	Soil Gas Survey	Surface Soil Sampling	Surface Water Sediment Sampling	Subsurface Soil Sampling	Perched Zone Monitoring Wells	
Septic Tanks and Associated Drain Fields									
2607-W5 Septic Tank/Drain Field	X	X	X	X	--	--	X	--	After cessation of disposal.
2607-W7 Septic Tank/Drain Field	X	X	X	X	--	--	X	--	--
2607-W9 Septic Tank/Drain Field	X	X	X	X	--	--	X	--	--
Basins									
207-U Retention Basin	--	A	--	--	--	X	X	--	--
Burial Sites									
Burial Ground/Burning Pit	X	X	X	X	X	--	X	--	--
Construction Surface Laydown Area	X	X	X	X	X	--	X	--	--
Unplanned Releases									
UN-200-W-6	X	--	--	--	X	--	--	--	--

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Table 8-6. Applicable Characterization Investigation Methods at U Plant Aggregate Area Waste Management Units.

Waste Management Unit or Units	Source Investigation Method								Remarks
	Surface Radiation Survey	Subsurface Spectral Geophysics	Surface Geophysics	Soil Gas Survey	Surface Soil Sampling	Surface Water Sediment Sampling	Subsurface Soil Sampling	Perched Zone Monitoring Wells	
UN-200-W-19	--	--	--	--	X	--	--	--	No surface radiation survey specifically due to proximity of 216-U-1&2 cribs.
UN-200-W-33	--	--	--	--	X	--	--	--	--
UN-200-W-39	--	X	X	--	--	--	--	--	Investigation after demolition of 224-UA building.
UN-200-W-46	--	--	--	--	--	--	--	--	No further investigation appropriate.
UN-200-W-48	X	--	--	--	X	--	--	--	--

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**Table 8-6. Applicable Characterization Investigation Methods at U Plant
Aggregate Area Waste Management Units.**

Waste Management Unit or Units	Source Investigation Method								Remarks
	Surface Radiation Survey	Subsurface Spectral Geophysics	Surface Geophysics	Soil Gas Survey	Surface Soil Sampling	Surface Water Sediment Sampling	Subsurface Soil Sampling	Perched Zone Monitoring Wells	
UN-200-W-55	X	--	--	--	X	--	--	--	--
UN-200-W-60	X	--	--	--	X	--	--	--	--
UN-200-W-68	X	--	--	--	X	--	--	--	--
UN-200-W-78	X	--	--	--	X	--	--	--	--
UN-200-W-86	X	--	--	--	--	--	--	--	--
UN-200-W-101	--	X	--	--	--	--	X	--	Covered with tar seal.
UN-200-W-117	--	--	--	--	X	--	--	--	--
UN-200-W-118	--	--	--	--	X	--	--	--	--
UN-200-W-161	X	--	--	--	--	--	--	--	--
Uranium Contamination Leak	--	--	--	--	--	--	--	--	Confirm release
Paint Waste Spill	--	--	--	--	--	--	--	--	Confirm release

X = investigation at each individual site.

A = investigation at representative of several analogous sites.

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9.0 RECOMMENDATIONS

The purpose of the aggregate area management study (AAMS) is to compile and evaluate the existing body of knowledge to support the *Hanford Site Past-Practice Strategy* (DOE/RL 1992a) decision making process. A primary task in achieving this purpose is to assess each waste management unit and unplanned release within the aggregate area to determine the most expeditious path for remediation within the statutory requirements of the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) and Resource Conservation and Recovery Act (RCRA). The existing body of pertinent knowledge regarding U Plant Aggregate Area waste management units and unplanned releases has been summarized and evaluated in the previous sections of this study. A data evaluation process has been established that uses the existing data to develop preliminary recommendations on the appropriate remediation path for each waste management unit. This data evaluation process is a refinement of the *Hanford Site Past-Practice Strategy* (Figure 1-2) and establishes criteria for selecting an appropriate *Hanford Site Past-Practice Strategy* path (expedited response action, ERA; interim remedial measure, IRM; limited field investigation, LFI; and final remedy selection) for individual waste management units and unplanned releases within the 200 Areas. A discussion of the criteria for path selection and the results of the data evaluation process are provided in Section 9.1 and 9.2, respectively. Figure 9-1 provides a flowchart of the data evaluation process that will be discussed. Table 9-1 provides a summary of the results of the data evaluation assessment of each unit. Table 9-2 provides the decisional matrix patterns each unit followed.

This section presents recommended assessment paths for the waste management units and unplanned releases at the U Plant Aggregate Area. These recommendations are only proposed at this time and are subject to adjustment and change. Factors that may affect development of final recommendations include, but are not limited to, comments and advice from the Washington State Department of Ecology (Ecology), U.S. Environmental Protection Agency (EPA), or U.S. Department of Energy (DOE); identification and development of new information; and modification of the criteria used in the assessment path decision-making process. The data evaluation process depicted in Figure 9-1 and discussed in Section 9.1 was developed to facilitate only the technical data evaluation step shown on the *Hanford Site Past-Practice Strategy* (Box A in Figure 1-2). Procedural and administrative requirements for implementation of the recommendations provided in this AAMS will be performed in accordance with the *Hanford Federal Facility Agreement and Consent Order* (Tri-Party Agreement) (Ecology et al. 1990) and the *Hanford Site Past-Practice Strategy*. Changes in recommendations will be addressed, and more detail on recommended assessment paths for waste management units and unplanned releases will be included in work plans as they are developed for the actual investigation and remediation activities.

Several waste management units (e.g., the U Pond System) have sufficient information to proceed with an IRM. A number of additional waste management units and unplanned

releases do not have information regarding the nature and extent of contamination necessary for quantitative or qualitative risk assessment, especially with regard to hazardous constituents, and were recommended for additional investigation (e.g., LFI). One unit, a septic tank and drain field, was recommended for an ERA and corrective action, if required, to assess whether the liquid discharged to the system is mobilizing contamination beneath the 216-U-1 and 216-U-2 Cribs. Several units and releases assessed within the ERA path were recommended for actions that fall within the scope of existing operational programs. Wooden cribs with collapse potential and sites with elevated levels of surface radionuclide contamination are addressed by the Radiation Area Remedial Action (RARA) Program.

Waste management units and unplanned releases which are addressed entirely by other programs were not subjected to the data evaluation process. This includes units and unplanned releases that are within the scope of the Single-Shell Tank Closure Program, Decommissioning and RCRA Closure Program, and Waste Management Program. Table 9-3 provides a list of the units not included in the evaluation.

A majority of facilities not addressed in the data evaluation fall within the scope of the Single-Shell Tank Closure Program. The activities associated with closure of the 200-UP-3 Operable Unit single-shell tank sites have separate Tri-Party Agreement milestones and any recommendations for disposition of these units and associated unplanned releases will be developed as part of the ongoing program addressing the single-shell tanks. The units associated with the 200-UP-3 Operable Unit that were not evaluated include single-shell tanks and associated diversion boxes, vaults, catch tanks, and high-level waste transfer lines.

A discussion of the four decision-making paths shown on Figure 9-1: ERA, IRM, LFI, and final remedy selection, is provided in Section 9.1. Section 9.2 provides a discussion of the waste management units grouped under each of these paths. A discussion of regrouping and prioritization of the waste management units is provided in Section 9.3. Recommendations for redefining operable unit boundaries and prioritizing operable units for work plan development are also provided in Section 9.3. No additional aggregate area-based field characterization activities are recommended to be undertaken as a continuation of the AAMS. All recommendations for future characterization needs (see Section 8.0) will be more fully developed and implemented through work plans. Plan development and submittal will be accomplished in accordance with requirements of the *Hanford Site Past-Practice Strategy* and the Tri-Party Agreement and could include remedial investigation (RI)/feasibility study (FS), RCRA Facility Investigation (RFI)/Corrective Measures Study (CMS), or LFI work plans. Sections 9.4 and 9.5 provide recommendations for focused feasibility and treatability studies, respectively.

9.1 DECISION-MAKING CRITERIA

The criteria used to assess the most expeditious remediation process path are based primarily on urgency for action and whether site data are adequate to proceed along a given path (Figure 9-1). All units and unplanned releases that are not completely addressed under other Hanford Site programs are assessed in the data evaluation process. All of the units and releases that are addressed in the data evaluation process are initially evaluated as candidates for an ERA. Sites where a release has occurred or is imminent are considered candidates for ERAs. Conditions that might trigger an ERA are the determination of an unacceptable health or environmental risk or a short time frame available to mitigate the problem (DOE/RL 1992a). As a result, candidate ERA units were evaluated against a set of criteria to determine whether potential for exposure to unacceptable health or environmental risks exists. Units and unplanned releases that are recommended for ERAs will undergo a formal evaluation following the selection process outlined in WHC (1991b).

Waste management units and unplanned releases that are not recommended for consideration as an ERA continue through the data evaluation process. Sites continuing through the process that potentially pose a high risk (refer to Section 5.0), become candidates for consideration as an IRM. The criteria used to determine a potential for high risk, thereby indicating a high priority site, were the Hazard Ranking System (HRS) score used for nominating waste management units for CERCLA cleanup (40 CFR 300), the modified Hazard Ranking System (mHRS) scores, surface radiation survey data, and rankings by the Environmental Protection Program (Huckfeldt 1991b). Units and unplanned releases with HRS or mHRS scores greater than 28.5 (the CERCLA cleanup criterion) were designated as candidate sites for IRM consideration. Units and unplanned releases that did not have an HRS score were compared to similar sites to establish an estimated HRS score. Sites with surface contamination greater than 2 mrem/h exposure rate, 100 ct/min beta/gamma above background or alpha greater than 20 dis/min were also designated as candidate IRM sites. The radiation and surface contamination criteria are based on the Westinghouse Hanford Radiation Protection Manual (WHC-CM-4-10) posting requirements. In addition, surface contamination sites which had an Environmental Protection Program ranking of greater than 7 were also designated as candidate IRM sites. A value of 7 was chosen because it represents the approximate midpoint of the scoring range. The candidate IRM sites are listed in Table 5-1, which summarizes the high priority sites. The four risk indicators are based on limited data (refer to Section 8.0) and therefore may not adequately represent the actual risk posed by the site. Technical judgment, including assessment of similarities in site operational histories, was used to include sites not ranked as high priority in the list of sites under consideration for an IRM. Candidate IRM sites were then further evaluated to determine if an IRM is appropriate for the site. Candidate IRM sites that did not meet the IRM criteria were placed into the final remedy selection path. As future data become available the list of units recommended for consideration as IRM sites may be altered.

For certain units and unplanned releases, it was recognized that remedial actions could be undertaken under an existing operational or other Hanford Site program (e.g., Single-Shell Tank Closure, RARA, Waste Management, or Decommissioning and RCRA Closure Programs). As a result, recommendations were made that remedial actions be undertaken (partially or completely) outside the 200 AAMS past practice program. Units or unplanned releases that could be addressed only in part by another program (e.g., surface contamination cleanup under the RARA Program) remained in the 200 AAMS data evaluation process for further consideration. If it cannot be demonstrated that these sites will be addressed under the operational program within a time frame compatible with the past practice program, they will be readdressed by the 200 AAMS process. Tracking of waste management units included in operational programs will be discussed in the work plans developed for each operable unit/aggregate area.

Units and unplanned releases recommended for complete disposition under another program (e.g., single-shell tanks and associated structures under the Single-Shell Tank Closure Program) were not considered in the 200 AAMS data evaluation process. In addition, potentially new sites that were identified during the AAMS were also not considered. It is recommended that a formal determination be made regarding the regulatory status of all new sites following established procedures before they are considered further under the 200 AAMS data evaluation process. Potentially new sites identified in the U Plant Aggregate Area are described with the other unplanned release sites in Section 2.3.10.

Specific criteria used to develop initial recommendations for ERAs, LFIs, and IRMs for units and unplanned releases within the aggregate area are provided in Sections 9.1.1 and 9.1.2. Units and unplanned releases not initially addressed under an ERA, LFI or IRM will be evaluated under the final remedy selection path discussed in Section 9.1.3.

9.1.1 Expedited Response Action Path

Candidate ERA sites are evaluated to determine if they pose an unacceptable health or environmental risk and a short time-frame available to mitigate the problem exists. All units and unplanned releases other than those recommended for complete disposition under another Hanford program are assessed against the ERA criteria. The *Hanford Site Past-Practice Strategy* describes conditions that might trigger abatement of a candidate waste management unit or unplanned release under an ERA. Generally, these conditions would rely on a determination of, or suspected, existing or future unacceptable health or environmental risk, and a short time-frame available to mitigate the problem. Conditions include, but are not limited to the following:

- Actual or potential exposure to nearby human populations, biota, or the food chain from hazardous substances and radioactive or mixed waste contaminants

- Actual or potential contamination of drinking water supplies or sensitive ecosystems
- Threats of release of hazardous substances and radioactive or mixed waste contaminants
- High levels of hazardous substances and radioactive or mixed waste contaminants in soils that pose or may pose a threat to human health or the environment, or have the potential for migration
- Weather conditions that may increase the potential for release or migration of hazardous substances and radioactive or mixed waste contaminants
- The availability of other appropriate federal or state response mechanisms to respond to the release
- Time required to develop and implement a final remedy
- Further degradation of the medium which may occur if a response action is not expeditiously initiated
- Risks of fire or explosion or potential for exposure as a result of an accident or failure of a container or handling system
- Other situations or factors that may pose threats to human health or welfare or the environment.

These conditions were used as the initial screening criteria to identify candidate waste management units and unplanned releases for ERAs. Candidate waste management units and releases that did not meet these conditions were not assessed through the ERA evaluation path. Additional criteria for further, detailed screening of ERA candidates were developed based on the conditions outlined in the *Hanford Site Past-Practice Strategy*. Quantification of these criteria for further screening were developed. These screening criteria are shown in Figure 9-1 and are described below.

The next decision point on Figure 9-1 used to assess each ERA candidate is whether a driving force to an exposure pathway exists or is likely to exist. Units or unplanned releases with contamination that is migrating or is likely to significantly migrate to a medium that can result in exposure and harm to humans required additional assessment under the ERA process. Units or unplanned releases where contamination could migrate and, therefore, potentially require significantly more extensive remedial action if left unabated were also assessed in the ERA path.

Waste management units and unplanned releases with a driving force were assessed to determine if unacceptable health or environmental risk and a short time-frame available to mitigate the problem exists from the release. The criteria used to determine unacceptable risks are based on the quantity and concentration of the release. If the release or imminent release is greater than 100 times the CERCLA reportable quantity for any constituent, the unit or unplanned release remains in consideration for an ERA. If the release or imminent release contains hazardous constituents at concentrations that are 100 times the most applicable standard, the unit or unplanned release continues to be considered for an ERA. Application of the criterion of 100 times applicable standards is for quantification of the strategy criteria which addresses "high levels of hazardous substances and radioactive or mixed waste contaminants...." The factor of 100 is based on engineering judgment of what constitutes a high level of contamination warranting expedited action. In some cases, engineering judgment was used to estimate the quantity and concentration of a postulated release. Standards applied include Model Toxics Control Act (MTCA) standards for industrial sites and DOE and Westinghouse Hanford radiation criteria (refer to Section 6.0). The application of these standards does not signify they are recognized as ARARs.

The ERA screening criteria, in addition to those presented in the *Hanford Site Past-Practice Strategy*, were applied to provide a consistent quantitative basis for making recommendations in the AAMS. The decision to implement the recommendations developed in AAMS will be made collectively between DOE, EPA and Ecology based only on the criteria established in the *Hanford Site Past-Practice Strategy*.

If a release is unacceptable with respect to health or environmental risk, a technology must be readily available to control the release for a unit or unplanned release to be considered for an ERA. An example that would require substantial technology development before implementation of cleanup would be a tritium release since no established treatment technology is available to separate low concentrations of tritium from water.

The next step in the ERA evaluation path involves determining whether implementation of the available technology would have adverse consequences that would offset the benefits of an ERA. Examples of adverse consequences include: (1) use of technologies that result in risks to cleanup personnel that are much greater than the risks of the release; (2) the ERA would foreclose future remedial actions; and (3) the ERA would prevent or greatly hinder future data collection activities. If adverse consequences are not expected, the site remains in consideration for an ERA.

The final criterion is to determine if the candidate ERA is within the scope of an operational program. Maintenance and operation of active waste management facilities are within the scope of activities administered by the Waste Management Program. Active facilities include certain transfer lines, diversion boxes, the 241-U-302 Catch Tank, the 244-U Receiver Tank, the 216-U-17 Crib, the 216-Z-20 Crib, and the section of the 216-U-14 Ditch currently in service. Generally, active facilities will not be included in past

practice investigations unless operation is discontinued prior to initiation of the investigation. The Decommissioning and RCRA Closure Program is responsible for safe and cost-effective surveillance, maintenance, and decommissioning of surplus facilities and RCRA closures at the Hanford Site. The Decommissioning and RCRA Closure Program is also responsible for RARA activities that include surveillance, maintenance, decontamination, and/or stabilization of inactive burial grounds, cribs, ponds, trenches, and unplanned release sites.

If the proposed ERA will not address all the contamination present, the unit or unplanned release continues through the process to be evaluated under a second path. For example, surface contamination cleanup under the RARA Program may not address subsurface contamination and, therefore, additional investigation may be needed.

Final decisions regarding the conduct of ERAs in the aggregate area will be made among Ecology, EPA, and DOE based, at least in part, on the recommendations provided in this section, and results of the final selection process outlined in WHC (1991b).

9.1.2 Limited Field Investigation and Interim Remedial Measure Paths

High priority waste management units and unplanned release sites were evaluated to determine if sufficient need and information exists such that an IRM could be pursued. An IRM is desired for high priority units and unplanned releases where extensive characterization is not necessary to reach defensible cleanup decisions. Implementation of IRMs at waste management units and unplanned releases with minimal characterization is expected to rely on observational data acquired during remedial activities. Successful execution of this strategy is expected to reduce both time and cost for cleanup of units and unplanned releases without impacting the effectiveness of the implemented action.

The initial step in the IRM evaluation path is to categorize the units. The exposure pathways of interest are similar for each waste management unit in a category; therefore, it is effective to evaluate candidate units as a group. The groupings used in Section 2.3 (e.g., cribs; tanks and vaults; etc.) will continue to be used to group the units for IRM assessment. This grouping approach is especially effective in reducing characterization requirements. As done in the 100 Areas using the observational approach, the LFIs can be used to characterize a representative unit or units in detail to develop a remedial alternative for the group of units. Observational data obtained during implementation of the remedial alternative could be used to meet unit specific needs. Similarities of waste management units may make it possible to remediate them using the observational approach after first characterizing only a few units. It is expected, therefore, that a LFI would provide sufficient information to proceed with an IRM for groups of similar high priority waste management units.

Data adequacy is assessed in the next step. The existing data are evaluated to determine if: (1) existing data are sufficient to develop a conceptual model and qualitative

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risk assessment; (2) the IRM will work for this pathway; (3) implementing the IRM will have adverse impacts on the environment, future remediation activities or data collection efforts; (4) the benefits of implementing the IRM are greater than the costs. If data are not adequate an assessment was made to determine if an LFI might provide enough data to perform an IRM. If an LFI would not collect sufficient data to perform an IRM, the unit was addressed in the final remedy selection path.

The final step in the IRM evaluation process is to assess if the IRM will work without significant adverse consequences. This includes: will the IRM be successful? will it create significant adverse environmental impacts (e.g., environmental releases)? will the costs outweigh the benefits? will it preclude future cleanup or data collection efforts? and will the risks of the cleanup be greater than the risks of no action? Units where remediation is considered to be possible without adverse consequences outweighing benefits of the remediation are recommended for IRMs. Low priority unplanned releases at candidate IRM units will be included in the IRM evaluations of the candidate units.

Final decisions will be made among DOE, EPA, and Ecology regarding the conduct of IRMs in the U Plant Aggregate Area based, at least in part, on the recommendation provided in this AAMSR, and the results of a supporting LFI.

9.1.3 Final Remedy Selection Path

Sites recommended for initial consideration in the final remedy selection path are those not recommended for IRMs, LFIs, or ERAs and those considered to be low priority sites. It is recognized that all units and unplanned releases within the operable unit or aggregate area will eventually be addressed collectively under the final remedy path to support a final aggregate area or operable unit Record of Decision (ROD).

The initial step in the final remedy selection process path is to assess whether the combined data from the AAMS, and any completed ERAs, IRMs, and LFIs are adequate for performing a risk assessment (RA) and selecting a final remedy. Whereas the scope of an ERA, IRM, and LFI is limited to individual waste management units or groups of similar waste management units, the final remedy selection path will likely address an entire operable unit or aggregate area.

If the data are collectively sufficient, an operable unit or aggregate area RA will be performed. If sufficient data are not available, additional needs will be identified and collected.

9.2 PATH RECOMMENDATIONS

Initial recommendations for ERA, IRM, and LFI are discussed in Section 9.2.1 through 9.2.3, respectively. Waste management units and unplanned releases proposed for initial consideration under the final remedy selection path are discussed in Section 9.2.4. Table 9-1 provides a summary of the data evaluation process path assessment. A summary of the responses to the decision points on the flowchart that led to the recommendations is provided in Table 9-2. Following approval by Ecology, EPA, and DOE, these recommendations will be further developed and implemented in work plans.

9.2.1 Proposed Sites for Expedited Response Actions

Ten waste management units and unplanned releases meet all the criteria for an ERA prior to determining whether the proposed action was within the scope of an operational program. The ten ERA candidates are:

- 207-U Retention Basin
- 216-S-21 Crib
- 216-U-1 and 216-U-2 Cribs
- 216-U-7 French Drain
- 216-U-8 Crib
- 216-U-14 Ditch
- 216-U-17 Crib
- 216-Z-20 Crib
- 2607-W-5 Septic Tank and Drain Field
- UN-200-W-101

One unit, 2607-W-5 Septic Tank and Drain Field was recommended for an ERA. Six candidate ERA units (cribs with collapse potential and surface contamination sites) were recommended for disposition under the RARA Program. Two active waste management units receiving liquid discharges were evaluated as candidate ERA units. The active units were recommended for disposition under an ongoing Waste Management Program to discontinue discharges of liquid effluent to the soil column. One waste management unit, the 216-U-14 Ditch, was recommended for disposition under the RARA Program for Surface Contamination and the Waste Management Program as an active facility. A discussion of the recommendations for these waste management units is included in this section. Since the anticipated response actions are not expected to fully remediate the ERA sites, all units will be included for further data evaluation in the assessment paths.

9.2.1.1 Sites Potentially Causing Subsurface Contaminant Migration. The 2607-W-5 Septic Tank and Drain Field is located about 50 m (164 ft) from the center of the 216-U-1 and 216-U-2 Cribs. Approximately 12,100 L (3,200 gal) of water per day are estimated to

be discharged to the drain field. There is thus a significant flux of water through the vadose zone beneath the site. This water could be remobilizing vadose zone contamination that originated at the cribs. This problem may be especially significant in the perched water zone above the Plio-Pleistocene caliche layer. At this location, there can be significant lateral movement of vadose zone water. The septic system could be flushing uranium contaminated water that is more than 100 times the reportable quantity and the quality standards into the underlying aquifer. Groundwater contamination beneath the drain field has been reported to be 3,245 pCi/L total isotopic uranium which is greater than 100 times the groundwater standard (4% Derived Concentration Guide (DCG), according to DOE Order 5400.5) for uranium of 24 pCi/L.

The 2607-W-5 Septic Tank and Drain Field should be investigated to determine if deactivation is necessary. The volume of water flowing to the facility needs to be confirmed. If the value is significant an investigation needs to be made to determine if the liquid is flushing contaminants beneath the 216-U-1 and 216-U-2 Cribs. If it is, the septic tank and drain field should be deactivated. A LFI is recommended for this site after the ERA has been completed to assess if hazardous contamination has been discharged to the site.

9.2.1.2 Cribs With Collapse Potential. Four of the older cribs are open wooden structures that could collapse and potentially expose workers. A sudden collapse could bring contaminated dust from the buried crib to the surface. Based on crib inventory data, dust derived from the bottom of the cribs would be expected to contain radionuclides at several orders of magnitude above reportable quantities and quality standards. The 216-S-21, 216-U-1 and 216-U-2, and 216-U-8 Cribs all have potential collapse problems. An interim stabilization has been completed for the area surrounding the 216-U-1 and 216-U-2 Cribs (Smith 1992).

Maintenance and contamination control measures for cribs with collapse potential are implemented under the RARA Program. Therefore, actions to mitigate environmental releases from these facilities will be performed under the RARA Program. An engineering study is planned under the RARA Program for 1993 to evaluate the potential for crib collapse.

Response actions such as the addition of clean fill material over the cribs or pressure grouting void areas within the crib to prevent collapse may be considered for these waste management units. Evaluation and recommendation of response actions for these facilities will be performed under the RARA Program.

9.2.1.3 Active Waste Management Units. Three active liquid effluent units operate within the U Plant Aggregate Area, 216-U-14 Ditch, 216-U-17 Crib, and 216-Z-20 Crib (note: only a portion of the 216-U-14 Ditch is active). Operation of these facilities provides a potential for migration of radioactive contaminants to the groundwater. Efforts are currently underway to evaluate an alternative that could be implemented that would result in

deactivation of these facilities by June 1995. In the interim, hazardous wastes will not be discharged to these units. Evaluation and deactivation of these facilities will remain with the operational program and will not be included as part of the past practices investigation. In addition, investigation of contamination associated with the facilities will be deferred until after deactivation of the facilities.

9.2.1.4 Sites With Significant Surface Contamination. There are five sites with levels of surface contamination that are high enough to be of immediate concern. Surface contamination is immediately accessible to humans (i.e., workers) and biota. The potential for transport by the wind or biota is also significant and so surface migration is also a problem. It is expected that the releases of radionuclides and potential radiation exposure levels at these sites would be greater than 100 times reportable quantities and quality standards. The corrective action for surface contamination sites is addressed within the scope of the RARA Program.

The 216-U-14 Ditch has been issued a Surveillance and Compliance Inspection Report (SCIR), and has been given a ranking of 13 out of 15 possible points. This means that the site has high surface radiation levels, that it is accessible, and that there is ongoing surface contaminant migration (Huckfeldt 1991b). Past sampling has also shown that the sediments contain radionuclide concentrations at greater than 100 times the reportable quantity and quality standards. Actions for control of surface contamination of this unit have been implemented under the RARA Program. A 230 m (750 ft) segment at the south end of the active portion of the ditch was covered with 0.6 to 1.2 m (2 to 4 ft) of coarse river gravel. This action is in addition to efforts to discontinue liquid effluent discharged to 216-U-14 Ditch (Section 9.2.1.3).

Surface contamination exists in an area surrounding 216-U-1 and 216-U-2 Cribs. This area has been issued a SCIR and has been given an Environmental Protection Program ranking of 9 (Huckfeldt 1991b). The area includes UN-200-W-19 Unplanned Release. This area has recently been stabilized as part of the interim stabilization plan (Smith 1992).

The 216-U-7 French Drain and Unplanned Release UN-200-W-101 are both within an area of surface contamination of up to 35,000 ct/min. Surface contamination control activities at this site are recommended for evaluation and implementation under the RARA Program.

The 207-U Retention Basin contains several contaminated areas with radiation counts of up to 7000 ct/min. Only half of the basin is filled with water and there is potential wind blown contaminant migration from the dry half. Surface contamination control activities at this site are recommended for evaluation and implementation under the RARA Program.

9.2.1.5 Non-ERA Sites. The primary reason most waste management units and unplanned releases were not recommended for ERAs was because of the lack of driving force to an

exposure pathway. Inactive cribs, ponds, ditches, and trenches are no longer receiving waste and, therefore, no longer have artificial recharge as a driving force to move subsurface contaminants. Natural recharge from local precipitation was not considered a significant short-term driving force. Specifics for each waste management unit or unplanned release are provided in Table 9-2.

A majority of the unplanned release sites either will be addressed by the RARA Program to eliminate the airborne release pathway or had insufficient quantity and concentration of contamination to qualify as an ERA.

9.2.2 Proposed Sites for Interim Remedial Measures

Twenty-two of the 45 waste management units and unplanned releases addressed in the U Plant Aggregate Area data evaluation process were identified as high priority units (refer to Section 5.0) and were assessed as candidates for IRMs. All but three of the 22 units designated as high priority units and unplanned releases were so designated because of high HRS and mHRS scores. The other unit and unplanned releases, 216-U-7 French Drain and Unplanned Releases UN-200-W-101 and UN-200-W-161, were designated as high priority because of surface radiation measurements. The Environmental Protection rankings did not add to the high priority sites because they had been included on the list because of the other criteria. The 216-U-8 Crib was not a high priority unit but was included in the IRM assessment path within the cribs category because of its similarity to the other facilities. Septic tanks and drain fields and unplanned releases were two primary classes of units not considered in the IRM path.

9.2.2.1 U Pond, Trench, and Ditches. The U Pond System contains over 5 km (3 mi) of trenches and ditches and 12 hectares (30 acres) of pond spreading area and consists of the following units:

- 216-U-10 Pond and associated unplanned release sites
- 216-U-11 Trench
- 216-U-14 Ditch
- 216-Z-1D Ditch
- 216-Z-11 Ditch

- 216-Z-19 Ditch
- 207-U Retention Basin.

These waste management units are all high priority and have been designated as IRM candidates. These sites have been grouped because of similarity in design and purpose along with the fact that the wastes from all the facilities commingled in the 216-U-10 Pond. Therefore, even though the Z Plant ditches are associated with a different waste generating process than the 216-U-14 Ditch, the Z Plant ditches were included in the group since it is not possible to look separately at the effects of the two ditch systems. The 207-U Retention Basin is included in this group since it is an extension of the 216-U-14 Ditch. Effluent drained to the 207-U Retention Basin was discharged directly into the 216-U-14 Ditch.

A majority of the U Pond System (with the exception of the active section of 216-U-14) has been decommissioned and backfilled. Prior to the decontamination and decommissioning operations, the pond and associated ditches were sampled (Last and Duncan 1980). Surface and near-surface samples (to approximately 4 m) were analyzed for radionuclides. Contamination isopleths for plutonium, americium, cesium, uranium and strontium are provided in Last and Duncan (1980). Transuranic contamination above the preliminary remedial action objective level (Table 7-1) of 100 nCi/g was found at 216-Z-19 delta in U Pond. Plutonium contamination as high as 12,500 nCi/g were found in the delta area of the 216-U-10 Pond. There is however, limited data on potential nonradionuclide contamination. With a small amount of confirmatory sampling to fill this data gap, sufficient data will be available to develop a conceptual model and perform a qualitative risk assessment.

Deep vadose zone sampling was limited, but sufficient information was obtained to indicate that the maximum contaminant concentrations exist at or near the surface and decreased with depth. Again, a limited amount of sampling is required to confirm this conclusion. This information will allow, if determined appropriate, for remediation of zones with the highest radionuclide contamination. Contamination of the entire soil column is likely since uranium contamination is suspected of reaching the groundwater from 216-U-10 Pond.

Two remedial alternatives which could be evaluated in a focused feasibility study (FFS) (along with other alternatives) for possible implementation at the U Pond System are capping and partial excavation followed by capping. Neither of these two alternatives are expected to have an adverse impact on possible future activities at the site. Therefore, the pond, ditches, and trenches in the (U Pond System meet all the data evaluation process criteria for recommendation as IRM sites. If Ecology, EPA, and DOE jointly concur with the recommendation, action levels should be established and a FFS should be performed. Additional field investigation may be required to support development of some alternatives evaluated in the FFS.

Investigation of the active portion of the 216-U-14 Ditch and the 207-U Retention Basin will be included in the past practices investigation of the ponds and ditches if the units are deactivated prior to the investigation. Deactivation of the units will remain with the ongoing operations program (milestone M-17-17) which is evaluating alternatives to replace the unit.

9.2.2.2 Other High Priority Sites. All of the remaining 16 candidate IRM units or releases met the criteria for IRM designation with the exception of having adequate data. No direct sampling information exists for any of these 16 units. It was determined that an LFI could gather sufficient data for 14 of the 16 units or releases; therefore, 14 units and releases remain IRM candidates. The remaining 2 sites are recommended for direct inclusion in the Final Remedy Selection Path discussed in 9.2.4.1. A discussion of the LFIs is provided in Section 9.2.3.

9.2.3 Proposed Sites for Limited Field Investigation Activities

Fourteen waste management units are recommended to undergo LFIs. The initial decision point in the IRM path is to assess whether data are adequate to conduct an IRM. For each of the fourteen units, only screening level field data and inventory estimates are available. No data are available describing the nature and extent of contamination, so LFIs are required before IRMs may be implemented. The rationale for IRM and LFI will be more completely developed in work plans; however, the following addresses possible considerations during work plan development.

Possible LFI objectives would be to:

- Evaluate the potential for releases from the waste management unit to impact underlying groundwater quality.
- Determine if contamination exists in the soil beneath the waste management unit, and if so, assess the extent.
- Assess the nature and extent of contaminant migration from the waste management unit in support of focused feasibility studies.

Each waste management unit that is recommended for an LFI will be studied as part of an analogous group. The analogous site concept is presented in the *Hanford Site Past-Practice Strategy*.

This concept emphasizes that characterization activities can be reduced by identifying select sites (analogue sites) for characterization that are representative of a group of sites (analogous groups). This concept is particularly applicable to operable units which contain a number of waste management units that are similar in design, disposal history, and geology.

Appropriate confirmatory characterization, as necessary to support remedial action, can then be performed at the sites within each analogous group during remediation. Collection of confirmatory data can again be reduced during remediation activities by emphasizing in work plans the use of the observational approach discussed in the *Hanford Site Past-Practice Strategy*.

To facilitate the implementation of these strategies in work plans, individual LFIs are assembled into analogous groups for study. Two primary analogous groups have been identified in the U Plant Aggregate Area: (1) cribs, and (2) french drains and reverse wells. Specific waste management units and unplanned releases are then identified that are considered to be representative of the analogous groups. Considerations used to select an analogue site for an analogous group include, but are not limited to, the following:

- Disposal history (including type and quantity of waste received)
- Physical and chemical setting.

Generally the selection process favored as analogue sites are those units or releases that received the most waste and were considered as conservative samples in terms of release mechanisms, media of concern, exposure routes, and receptors.

9.2.3.1 Cribs, 216-U-3 French Drain, and 241-U-361 Settling Tank. Seven waste management units have been assigned to this analogous group based upon their design. These units are:

- 216-U-1 and 216-U-2 Cribs
- 241-U-361 Settling Tank
- 216-U-3 French Drain
- 216-U-8 Crib
- 216-U-12 Crib
- 216-U-16 Crib
- 216-U-17 Crib.

The 241-U-361 Settling Tank is included since it is an integral part of the 216-U-1 and 216-U-2 Crib system. The tank is located immediately adjacent to the cribs and was used to settle solids from effluents sent to the two cribs. The tank is recommended for study along with the 216-U-1 and 216-U-2 Cribs.

The 216-U-3 French Drain is included in this group because its construction is more similar to a crib than to other french drains. The 216-U-1, 216-U-2, and 216-U-8 Cribs have collapse potential and have been recommended for actions under the RARA Program (see Section 9.2.1). The actions implemented under the RARA Program may precede the LFI activities.

The 216-S-21 and 216-Z-20 Cribs are recommended for transfer to other aggregate areas (see Section 9.3.2) and so are not included in the crib analog group.

A comparison of the crib inventories shows that the 216-U-8 Crib received more plutonium, uranium and total alpha contamination than any of the other cribs. The 216-U-1 and 216-U-2 Cribs also received two orders of magnitude more ^{137}Cs than any other crib and also reportedly received large quantities of plutonium. The 216-U-16 Crib, 216-U-17 Crib, and 216-U-3 French Drain received relatively minor inventories of radionuclides. The 216-U-12 Crib was a replacement facility for the 216-U-8 Crib and received a similar waste stream.

The physical and chemical settings for the releases from these waste management units are generally similar:

- Relatively large scale liquid releases (791,000 to 409,000,000 L) occurred at these waste management units and waste water probably reached the unconfined aquifer beneath the units (Table 4-13).
- The waste management units were completed at about the same depths and in the same stratigraphic horizons. The depth to groundwater is also similar for all of the units (57 to 66 m, 190 to 220 ft).
- The vadose zone stratigraphy is generally uniform beneath the aggregate area and would tend to favor the downward movement of fluid with little lateral spreading. The caliche layer, the primary vadose zone aquitard, occurs beneath each waste management unit.
- The 216-U-1 and 216-U-2, 216-U-8 and 216-U-12 Cribs are all reported to have received acidic waste which could aid in the vertical migration of contamination. The other waste management units are not reported to have received materials that could aid in contaminant migration.

The 216-U-1 and 216-U-2 and the 216-U-8 Cribs are proposed for analog study because they have the largest waste inventories of any of the cribs, and they both are reported to have received acidic waste. In addition, the 216-U-1 and 216-U-2 Cribs are recommended for study because contamination is documented to have reached the unconfined aquifer beneath these facilities (Section 2.3.3.1).

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9.2.3.2 French Drains and Reverse Wells. Four waste management units have been assigned to this analogous group based on their design. These units are:

- 216-U-4 Reverse Well
- 216-U-4A French Drain
- 216-U-4B French Drain
- 216-U-7 French Drain.

The 216-S-4 French Drain is recommended for transfer to another aggregate area (see Section 9.3.2), so it is not included in this french drain analog group.

A comparison of the french drain and reverse well inventories shows that all of them received similar waste inventories. No inventory data are available for the 216-U-7 French Drain, but it received about two orders of magnitude less total liquid than the other facilities, so it is believed to contain the least contamination.

The physical and chemical settings for the releases from these waste management units are generally similar:

- Relatively large scale liquid releases (7000 to 545,000 L) occurred at these waste management units and waste water probably reached the unconfined aquifer beneath each unit (Table 4-13). The 216-U-4 Reverse Well and 216-U-4A French Drain received the most liquid.
- All of the waste management units except for the 216-U-4 Reverse Well were installed near the surface in the upper coarse unit of the Hanford formation. The reverse well was installed at a depth of 23 m (80 ft), near the contact between the upper coarse and the lower fine unit of the Hanford formation. The depth to groundwater is about 70 m (230 ft) for the french drains, but only 51 m (170 ft) for the reverse well.
- The vadose zone stratigraphy is uniform beneath each of the waste management units. In particular, the caliche layer, the primary vadose zone aquitard, occurs beneath each of the waste management units.
- The 216-U-4 Reverse Well and 216-U-4A French Drain are reported to have received acidic waste, which could aid in vertical contaminant migration. The other french drains are not reported to have received waste that could aid in contaminant migration.

The 216-U-4 Reverse Well and the 216-U-4A French Drain are proposed for analog unit study because they have the largest waste inventories of the analog group and they are reported to have received acidic waste. The reverse well should also be studied because it introduced waste at a much greater depth than the french drains. These two waste management units are only located 3 m (8 ft) apart, so they may be examined together during a single unified study.

9.2.4 Proposed Sites for Final Remedy Selection

A number of unplanned releases, along with several diverse waste management units which are unique because of design, contaminants received, or operational history, have been proposed for the final remedy selection path. Section 9.2.4.2 discusses the sites proposed for direct inclusion in the final remedy selection risk assessment. Direct inclusion in the final remedy selection RI is recommended for the remainder of the waste management units and unplanned releases due to the lack of information to perform RAs and select final remedies. These waste management units and unplanned releases are discussed in Section 9.2.4.1.

9.2.4.1 Proposed Sites for Remedial Investigation. A RI has been recommended for the U Plant Aggregate Area which includes several groups of waste management units and unplanned releases. The first group consists of low priority trenches (dry trenches) which generally received one time transfers of waste. The second group contains septic tanks and drain fields which require confirmatory sampling to show that the sites do not contain hazardous or radioactive substances. The third group contains burial sites which require confirmatory sampling to show no contamination exists. The fourth group contains low priority unplanned releases which have unique contamination histories.

9.2.4.1.1 Trenches. Four trenches have been grouped as a single class because of their similarity. These trenches are basically excavations which were opened for a short duration of time then filled in. The trenches include the following:

- 216-U-5
- 216-U-6
- 216-U-13
- 216-U-15.

All trenches are low priority units which were assessed in the final remedy selection path only. The units are generally unique in the types of waste received. Three of the units, 216-U-13 being the exception, received one time transfers of waste which indicate a low

migration potential. The 216-U-13 site received small quantities of equipment decontamination waste.

The units were grouped and RA possibilities were examined. No data exists to determine the nature and extent of contamination at these sites. Therefore, a RI which includes each unit was recommended to provide data adequate to perform a RA and select a final remedy for the units. The unique nature of the units will not allow for investigation of a representative unit and applying the information to the other sites.

9.2.4.1.2 Septic Tanks and Drain Fields. Confirmatory investigation levels should be performed at each of the septic tanks and drain fields: 2607-W-5, 2607-W-7, and 2607-W-9. The investigation at 2607-W-5 should begin after an ERA has been completed. These four sites all have been assigned low HRS scores by comparison with other units.

There are no sampling or inventory data for any of the sites and so a RA cannot be performed. Therefore, these units are recommended for inclusion in the aggregate area RI to conduct confirmatory sampling. The purpose of a limited sampling program is to confirm that no contamination exists in the tanks and drain fields. If no contamination were to be found, then no further action would likely be recommended.

9.2.4.1.3 Construction Surface Laydown Area and the Burial Ground/Burning Pit. Confirmatory investigation levels should be conducted as part of the aggregate area RI activities at the Construction Surface Laydown Area and the Burial Ground/Burning Pit. These units have been assigned low HRS scores by comparison with other units and unplanned releases. There are no sampling or inventory data available for the areas, so RAs cannot be performed. Historical data on the Construction Surface Laydown Area do not indicate the disposal of any radioactive or hazardous material at this unit. The available information on the Burial Ground/Burning Pit indicates that the contamination was cleaned up. Investigation is recommended for these units to provide enough data to confirm that contamination does not exist at either of the two units. If no contamination were to be found, then no further action would be recommended.

9.2.4.1.4 Unplanned Releases. Thirteen unplanned releases with known contamination are candidates for inclusion in an aggregate area or operable unit RI and one of these sites are recommended to undergo surface radiation cleanup under the RARA Program before RI initiation. These sites are as follows:

- UN-200-W-6
- UN-200-W-19
- UN-200-W-33

- UN-200-W-39
- UN-200-W-48
- UN-200-W-55
- UN-200-W-60
- UN-200-W-68
- UN-200-W-78
- UN-200-W-101 (RARA)
- UN-200-W-117
- UN-200-W-118
- UN-200-W-161.

Confirmatory sampling is only recommended for six unplanned releases. Unplanned Releases UN-200-W-33, UN-200-W-68 and UN-200-W-78 all have HRS scores below 28.5, and do not have any data to support a RA. Sites UN-200-W-117, UN-200-W-118 and UN-200-W-60 all have insufficient information available for HRS scoring. However, each unplanned release is described as having been cleaned up or released as a radiation zone as contamination decayed to background levels. It is thus assumed that these sites would have low HRS scores. Confirmatory sampling is recommended for these unplanned releases to provide enough data to confirm that contamination does not exist at these unplanned release locations. If no contamination is found, no further action would be recommended.

The unplanned releases, with the exception of the two, all had low HRS scores and surface radiation levels and were classified as low priority. The low priority releases are assessed under the final remedy selection pathway. The one release for which surface contamination cleanup action was deferred to the RARA Program is not expected to be fully cleaned and, therefore, was regrouped with the other unplanned releases.

A lack of soil sample data and inconsistent survey data make RA completion impossible. A RI needs to be performed to identify the contaminants and their extent.

9.2.4.2 Proposed Sites for Risk Assessment. Two candidates have sufficient information for inclusion in the final RA under the final remedy selection path. One candidate, Unplanned Release UN-200-W-46, occurred during transit of a contaminated piece of equipment across the aggregate area. The other candidate, Unplanned Release UN-200-W-

86, is pigeon feces which is scattered throughout the aggregate area. There is no specific geographic area identified as contaminated and no contamination has been attributed to this release.

It is recommended that this unplanned release be included in the final RA without additional investigation. It is likely that no further action will be required for this release.

9.3 SOURCE OPERABLE UNIT REDEFINITION AND PRIORITIZATION

The investigation process can be made more efficient if units with similar histories and waste constituents are studied together. The data needs and remedial actions required for similar waste management units are generally the same. It is much easier to ensure a consistent level of effort and investigation methodology if like units are grouped together. Economies of scale also make the investigation process more cost effective if similar units are studied together.

9.3.1 Units Addressed by Other Aggregate Areas or Programs

The investigation of several sites should be transferred from the U Plant aggregate area to other aggregate areas for investigation. The 216-S-4 French Drain and the 216-S-21 Crib should be transferred to the S Plant Aggregate Area. The 216-Z-20 Crib should be transferred to the Z Plant Aggregate Area. Transfer of these units would allow them to be investigated with other units with similar waste histories.

Several additional sites are recommended to be investigated by existing programs. The programs include the Decommissioning and RCRA Closure Program, the Waste Management Program, and Single-Shell Tank Closure Program. Table 9-3 lists the waste management units and unplanned releases that are to remain in the existing programs.

All waste management units and unplanned releases in the 200-UP-3 Operable Unit are addressed by the Single-Shell Tank Closure Program. The units include the 244-UR Vault, several diversion boxes, valve pits, a catch tank, single-shell tanks, the 244-U Receiver Tank, a septic system, and associated process piping.

The 241-U-151 and 241-U-152 Diversion Boxes in the 200-UP-2 Operable Unit should be included in the 200-UP-3 Operable Unit and closed with the tank farm facilities. The two diversion boxes are on the east edge of the 200-UP-3 Operable Unit and are therefore easily incorporated in the tank farm operable unit.

The 241-UX-154 Diversion Box and 241-U-302 Catch Tank are integral parts of the tank waste cross-site transfer line and are likely to be operated for several years. These units are within the scope of the Waste Management Program.

Deactivation of active liquid effluent units should remain within the existing Waste Management Program. The active facilities include the 216-U-14 Ditch (note: only a portion of the 216-U-14 Ditch is active), 216-U-17 Crib and the 216-Z-20 Crib. Investigation of these facilities will be deferred until after deactivation.

Potentially new sites including the uranium contamination spill and the paint spill have not been verified as unplanned releases. Action on these sites is deferred until an actual release has been verified and the regulatory status of the sites determined.

9.3.2 U Plant Operable Unit Redefinition

Redefinition of the 200-UP-1 and 200-UP-2 Operable Units are suggested based on the data evaluation in this report. It is recommended that the source components of the 200-UP-1 and 200-UP-2 Operable Units be combined. The source operable unit should be designated as 200-UP-2. A separate groundwater operable unit designated as 200-UP-1 should be created. The 200-UP-1 Groundwater Operable Unit should be defined by the hydraulic regime south of the U Pond mound including the groundwater beneath the U and S Plan Aggregate Areas. This groundwater operable unit should be assigned a high priority consistent with the 200-UP-2 Source Operable Unit. The redefined 200-UP-2 Operable Unit should be as follows:

- Investigation of groundwater should be removed from the scope and included in a 200 West Area groundwater operable unit designated 200-UP-1. Groundwater beneath the source operable unit interacts with all surrounding operable units since it is not confined by the geographic boundaries. Contamination from nearby operable units has migrated beneath the 200-UP Operable Units. Similarly, the contamination originating from the operable units has migrated outside the boundaries of the operable units. These interactions with other operable units will necessitate the integration of groundwater response actions throughout the 200 West Area. This integration would likely be best handled in a combined groundwater operable unit, rather than in individual source operable units. Perched water will remain a part of the source AAMS, since this generally is a localized phenomena within the unsaturated zone attributed to specific waste management units.
- Investigation of the 216-U-17 Crib and the active section of the 216-U-14 Ditch should be deferred, since they are likely to be active during the investigation period. Investigation of facilities prior to operations ceasing would provide data

that are likely not to be representative of the conditions at the time when unit operations cease. Therefore, reinvestigation of the unit may again be necessary to determine the conditions at the end of the unit's operation. This reinvestigation would be a duplicate of the earlier investigation; therefore, the data from the earlier investigation would have limited use.

- High-level waste transfer facilities and pipelines should remain within the scope of the Waste Management Program and Decommissioning and RCRA Closure Programs. The facilities are also structures with no unplanned releases and can be dealt with more efficiently in these existing Hanford programs. The Tri-Party Agreement does not include these lines within the scope of the past-practices investigations. Effluent transfer lines associated with individual waste management units will be investigated with the respective units.
- Investigation of the 241-WR Vault is within the scope of the Decommissioning and RCRA Closure Program. This structure has had no unplanned releases to the environment and can be addressed most effectively in this existing Hanford program, since remediation is likely to be only a decontamination and decommissioning action.
- Include the 216-Z-20 Crib in the Z Plant AAMS. The waste discharges to the 216-Z-20 Crib are from the Z Plant complex. Therefore, the operational history of this crib will more closely parallel that of the Z Plant Aggregate Area cribs than the U Plant Aggregate Area cribs. The basis of the LFI strategy in the AAMS is to evaluate facilities with similar operational histories as a group, therefore, the 216-Z-20 Crib should be investigated with the other Z Plant Aggregate Area cribs.
- Include the 216-S-4 French Drain and the 216-S-21 Crib in the S Plant AAMS. Similar to the 216-Z-20 Crib, the 216-S-4 French Drain and the 216-S-21 Crib wastes resulted from operations in another aggregate area. Therefore, in an effort to investigate like facilities in a group, these facilities should be investigated with the other S Plant Aggregate Area cribs and french drains.
- Include the active Powerhouse Pond, which is incorrectly listed as a unit in the T Plant Aggregate Area. The pond is over a deactivated section of 216-U-14 Ditch and should be investigated in conjunction with the ditch.

These recommendations will be used to refine the scope of the Tri-Party Agreement interim milestone M-12-15.

9.3.3 Investigation Prioritization

Very little, if any, data exist to rank the waste management units and unplanned releases within the U Plant Aggregate Area on a risk-related basis. The HRS and surface contamination data which were used to sort the waste management units and unplanned releases into either high or low priority are indicators of potential risk but are not suitable to develop a risk-related ranking. The most useful data for indicating potential risk are probably the waste inventories and facility construction or operation information.

Based on inventories of contaminants, the cribs and french drains received the largest quantities of contamination and should be investigated first. The U Pond System received the next largest quantity of contamination and should be evaluated second. The remaining source units should be investigated after completion of the IRM and LFI investigations. The recommended groundwater operable unit should be assigned an investigation priority similar to the LFI/IRM investigation. The 200-UP-3 Operable Unit will be dispositioned under the Single-Shell Tank Closure Program. Unit-specific priorities will be developed in subsequent work plans.

9.3.4 Resource Conservation and Recovery Act Facility Interface

One RCRA waste management unit exists in the U Plant Aggregate Area which will require integration into future investigations. This RCRA unit is the 216-U-12 Crib which is scheduled to have a closure plan prepared by November 1994. The RCRA facilities associated with the 241-U Tank Farm operable unit (200-UP-3) are not assessed under this study (Table 9-3). These sites belong to a separate program with separate Tri-Party Agreement milestones. Environmental releases from these sites also are not expected to interact or commingle with the other source units in U Plant Aggregate Area within the vadose zone. Therefore, an interface with the program for assessing the tank farms is not considered to be required.

The 216-U-12 Crib received waste materials similar to other facilities that supported U Plant prior to 1981. The facility was designated as a RCRA facility because it operated past 1981 and received wastes that had a pH of less than 2. The strategy for recommending this site include clean closure under RCRA and investigation and remediation under CERCLA. Clean closure is expected to be demonstrated by showing that the soils beneath the crib are still alkaline, therefore, characteristic waste no longer exists within this facility. Data to support this position will be developed in an LFI in addition to the investigation of the analogous sites. Investigation and remediation of this facility will be included with the investigation and remediation of the LFI grouping of U Plant Aggregate Area cribs and french drains.

9.4 FEASIBILITY STUDY

Two types of the FS will be conducted to support remediation in the 200 Areas including focused and the final FS. The FFSs are studies in which a limited number of units or remedial alternatives are considered. Final FS will be prepared to provide the data necessary to support the preparation of final ROD. Insufficient data exists to prepare either a FFS or final FS for any units or group of units within the U Plant Aggregate Area. Sufficient data are considered available to prepare a FFS on selected remedial alternatives.

9.4.1 Focused Feasibility Study

Both LFIs and IRMs are planned for the U Plant Aggregate Area for individual waste management units or waste management unit groups. The IRMs will be implemented as they are approved, and the FFS will be prepared to support their implementation. The FFS applied in this manner is intended to examine a limited number of alternatives for a specific site or groups of sites. The FFS supporting IRMs will be based on the technology screening process applied in Section 7.0, engineering judgement, and/or new characterization data such as that generated by an LFI.

Recommendations for the FFS in support of IRMs are not provided in this report because of limited data availability. In most cases, LFIs will be conducted at sites initially identified for IRMs. The information gathered is considered necessary prior to making a final determination whether an IRM is actually necessary or whether a remedy can be selected.

Rather than being driven by an IRM, the FFS will also be prepared to evaluate select remedial alternatives. In this case the FFS focuses on technologies or alternatives that are considered to be viable based on their implementability, cost, and effectiveness and have broad application to a variety of sites. The following recommendations are made for FS that focus on a particular technology or alternative:

- Capping
- Ex situ treatment of contaminated soils
- In situ stabilization.

These recommendations reflect select technologies developed in Section 7.0 of this report.

The FFS is intended to provide a detailed analysis of select remedial alternatives. The results of the detailed analysis provide the basis for identifying preferred alternatives. The detailed analysis for alternatives consists of the following components:

- Further definition of each alternative, if appropriate, with respect to the volumes or areas of contaminated environmental media to be addressed, the technologies to be used, and any performance requirements associated with those technologies. Remedial investigations and treatability studies, if conducted, will also be used to further define applicable alternatives.
- An assessment and summary of each alternative against evaluation criteria specified in EPA's *Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA* (EPA 1988b).
- A comparative analysis of the alternatives that will facilitate the selection of a remedial action.

9.4.2 Final Feasibility Study

To complete the remediation process for an aggregate area, a final or summary FS will be prepared. This study will address those sites not previously evaluated and will summarize the results of preceding evaluations. The overall study and evaluation process for an aggregate area will consist of a number of FFSs, field investigations, and interim RODs. All of this study information will be summarized in one final FS to provide the data necessary for the final ROD. The summary FS will likely be conducted on an aggregate area basis; however, future considerations may indicate that a larger scope is appropriate.

9.5 TREATABILITY STUDIES

A range of technologies which are likely to be considered for remediation of sites within the U Plant Aggregate Area were discussed in Section 7.3. The range of technologies included:

- Engineered multimedia cover
- In situ grouting
- Excavation and soil treatment
- In situ vitrification
- Excavation, treatment, and disposal of transuranic (TRU) radionuclides
- In situ soil vapor extraction of volatile organic compounds (VOCs).

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Treatability testing will be required to conduct a detailed analysis for most of the technologies. Relevant EPA guidance will be relied upon to conduct these future treatability studies. A summary of existing programs and of treatability testing needs is as follows:

- **Engineered multimedia cover**--A number of cover design efforts have taken place in support of Hanford Site waste management, permitting, RARA and RCRA closure activities. Although performance testing is lacking, a number of conceptual cover designs have been developed for various types of waste management units. The feasibility/treatability process can be accelerated by utilizing existing cover design information. Long term performance and maintenance objectives, and design criteria should be established for various categories of waste management units based on the degree of protection required. The adequacy of existing conceptual designs should be evaluated against these design criteria and modified appropriately. Hydrologic performance and constructibility data needs can then be assessed by pilot-scale testing of preliminary cover designs.
- **In situ grouting**--Field pilot tests would be required to assess the required injection well spacing and the optimum grout injection methods; bench-scale and pilot-scale tests would be required to demonstrate the effectiveness for stabilizing the contaminants.
- **Excavation and soil treatment**--Testing will likely be required for several components of an excavation and treatment system. It is anticipated that the waste management units would be excavated with conventional mining and construction equipment. However, some equipment modifications may be required to ensure worker protection. If available, remote excavation equipment could be utilized to protect workers at waste management units containing high exposure potential. Testing of measures to control fugitive dust during retrieval activities will be required.

The testing required for the treatment process will depend on the type of treatment considered and the site-specific conditions. It is anticipated that most of the treatability information required could be obtained by a combination of literature research, laboratory screening, and bench-scale studies. However, pilot-scale testing may be required for certain treatment processes.

Physical separation (i.e., soil washing) pilot-scale treatability testing within the 300-FF-I Operable Unit is being planned which will be applicable for the 200 Areas. The soils of the Hanford Site are well suited for treatment with a physical separations process. The soils are predominantly coarse sand and gravel, with less than 10% silts and clay. It is expected that contaminants will be found largely adsorbed on the smaller soil particles and as coatings on larger particles.

The physical soil washing process should provide removal of the precipitate coatings from the large particles and separation of large from small particles. This would result in a large volume reduction by separating and concentrating the contaminants.

The physical separations test in the 300-FF-1 Operable Unit will be conducted in three phases. In Phase I, soils will be characterized to assess physical, chemical, and radioactive properties. Phase II testing will establish baseline operations and capabilities of a system utilizing water as the washing solution. In Phase III, performance of the system will be optimized. Phase III may consist of two parts, processing with water only, and processing using selected nonhazardous and environmentally acceptable chemical extractants, if necessary to optimize the system. Laboratory bench tests may be performed to determine the primary and secondary chemical extractants to be considered for use in Phase III testing. However, it is anticipated that in the 300 Area, physical separation resulting in a large volume reduction of contaminated soil may be achieved with water only. Chemical extracts maybe required for soil washing to be successful in other areas of the Hanford Site (i.e., 200 and 100 Areas). This will depend to a large extent on the type of contaminant at the adsorption coefficient.

If the pilot-scale test is successful in the 300 Area, then the application of this process to the 200 Areas should be tested.

- In situ vitrification--In situ vitrification has been tested and field demonstrated on soil sites contaminated with radionuclides, heavy metals, and organic wastes. As a result of this testing and demonstration program, established capabilities and limitations of the in situ vitrification technology have been identified, along with technical issues that need to be resolved for successful implementation. The In Situ Vitrification Integrated Program was created by DOE's office of Technology Development to help resolve these issues and promote deployment of the technology in the field. The In Situ Vitrification Integrated Program is currently working to resolve the following key issues for implementation at contaminated soil sites:
 - Develop methods that accurately predict, measure, and achieve significantly greater melt depth and control of the melt shape. Presently, the in situ vitrification process has been demonstrated to a depth of 5 m (16 ft).
 - Improve the understanding of and verify VOC contaminant transport behavior.
 - Determine the potential for transient gas release events while vitrifying contaminated soils under varying conditions. Better define operating

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parameters and limits to ensure containment and treatment of offgases during processing.

- Resolve secondary waste generation and handling concerns as they relate to the volatilization of ¹³⁷Cs from highly concentrated soils.

Other DOE in situ vitrification related activities include evaluating the cost of in situ vitrification against other technologies (report to be released before fiscal year end) and a field demonstration at the Idaho National Engineering Laboratory (INEL) during fiscal year 1993. Additional field demonstrations will be required before all issues surrounding implementation of in situ vitrification to contaminated soil sites can be resolved.

There is a large uncertainty whether the In Situ Vitrification Integrated Program will obtain the funding required to resolve these issues. Without resolution of these issues in situ vitrification will have very limited application to remediation at the Hanford Site.

- Excavation, treatment and disposal of transuranic radionuclides--Development and testing of methods to characterize, retrieve, treat, and package waste from TRU contaminated waste management units will be required. The DOE Office of Technology Development has established the Buried Waste Integrated Demonstration (BWID) at INEL to resolve these issues. The BWID is focused on sites containing buried waste; however, it is expected that many of the original containers at INEL degraded significantly, resulting in contamination of the immediately surrounding soil. As a result, the BWID will also be resolving some of the issues surrounding retrieval and treatment of TRU contaminated soil.

A major concern for retrieval of TRU contaminated materials will be control of fugitive dust. Testing of various types of foams and fixants, that will not interfere with treatment and disposal, will be required. In addition, development of foams and fixants for dust control will be important for non-TRU contaminated waste management units. The use of containment structures (e.g. buildings) to contain fugitive dust during remediation is very expensive and cumbersome (creating problems for both equipment and workers). A significant cost savings could be realized if foams and fixants are used in place of containment structures.

- In situ soil vapor extraction of volatile organic compounds--Development and testing of methods to characterize, retrieve, and treat waste from VOC contaminated soil will be required. The DOE has established the VOC-Arid Integration Demonstration to resolve these issues. The Z Plant Aggregate Area is currently the initial host site for the demonstration and is associated with an active ERA to remove carbon tetrachloride from the vadose zone using vapor extraction. These activities are

expected to resolve numerous design and treatability issues associated with in situ soil vapor extraction. However, additional treatability testing may be required to resolve site specific data needs.

As treatability testing of the various alternatives progresses, other parameters are likely to be identified which require further development.

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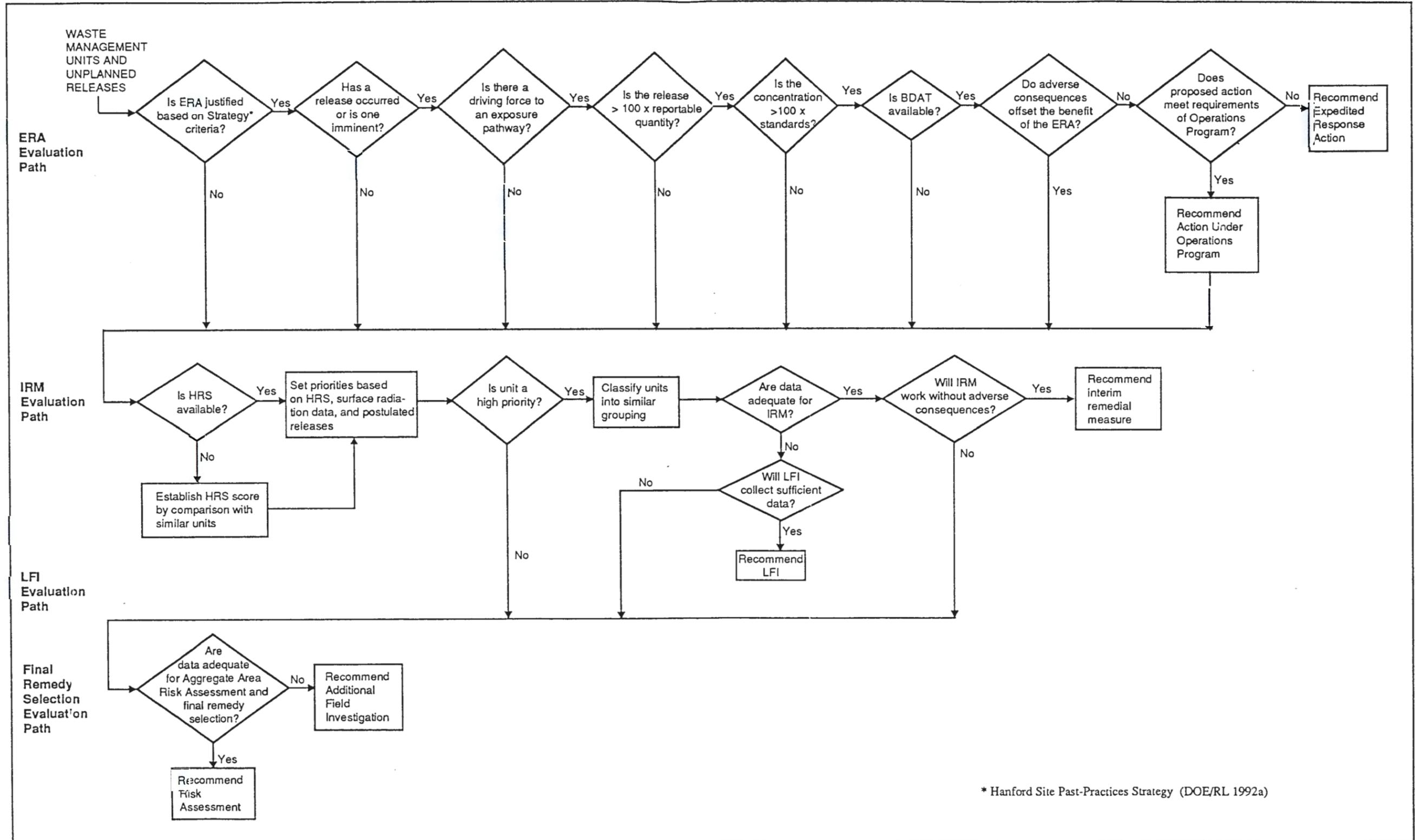


Figure 9-1. 200 Aggregate Area Management Study Data Evaluation Process.

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Table 9-1. Summary of the Results of Data Evaluation Process Assessment.

Waste Management Unit or Unplanned Release Site	Operable Unit	ERA	IRM	LFI	RA	RI	OPS	Remarks
Tanks and Vaults								
241-U-361 Settling Tank	200-UP-2	--	X	X	--	--	--	
Cribs and Drains								
216-S-21 Crib	200-UP-1	--	X	X	--	--	X	RARA - Cave-in potential Redefined to S Plant Aggregate Area
216-U-1 and 216-U-2 Cribs	200-UP-2	--	X	X	--	--	X	RARA - Cave-in potential
216-U-8 Crib	200-UP-2	--	X	X	--	--	X	RARA - Cave-in potential
216-U-12 Crib	200-UP-2	--	X	X	--	--	--	
216-U-16 Crib	200-UP-2	--	X	X	--	--	--	
216-U-17 Crib	200-UP-2	--	X	X	--	--	X	Active - Waste management
216-Z-20 Crib	200-UP-1	--	X	X	--	--	X	Active - Waste management Redefined to Z Plant Aggregate Area
216-S-4 French Drain	200-UP-1	--	X	X	--	--	--	Redefined to S Plant Aggregate Area
216-U-3 French Drain	200-UP-2	--	X	X	--	--	--	
216-U-4A French Drain	200-UP-2	--	X	X	--	--	--	
216-U-4B French Drain	200-UP-2	--	X	X	--	--	--	
216-U-7 French Drain	200-UP-2	--	X	X	--	--	X	RARA - Surface contamination
Reverse Well								
216-U-4 Reverse Well	200-UP-2	--	X	X	--	--	--	

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Table 9-1. Summary of the Results of Data Evaluation Process Assessment.

Waste Management Unit or Unplanned Release Site	Operable Unit	ERA	IRM	LFI	RA	RI	OPS	Remarks
Ponds, Ditches, and Trenches								
216-U-10 Pond	200-UP-1	--	X	--	--	--	--	Redefined to 200 UP-2 Operable Unit
216-U-14 Ditch	200-UP-2	--	X	--	--	--	X	Active - Waste management RARA - surface contamination
216-Z-1D Ditch	200-UP-1	--	X	--	--	--	--	Redefined to 200-UP-2 Operable Unit
216-Z-11 Ditch	200-UP-1	--	X	--	--	--	--	Redefined to 200-UP-2 Operable Unit
216-Z-19 Ditch	200-UP-1	--	X	--	--	--	--	Redefined to 200-UP-2 Operable Unit
216-U-5 Trench	200-UP-2	--	--	--	--	X	--	
216-U-6 Trench	200-UP-2	--	--	--	--	X	--	
216-U-11 Trench	200-UP-1	--	X	--	--	--	--	Redefined to 200-UP-2 Operable Unit
216-U-13 Trench	200-UP-1	--	--	--	--	X	--	Redefined to 200-UP-2 Operable Unit
216-U-15 Trench	200-UP-2	--	--	--	--	X	--	
Septic Tanks and Associated Drain Fields								
2607-W-5 Septic Tank/ Drain Field	200-UP-2	X	--	--	--	X	--	Active - Potential for mobilizing nearby contaminants
2607-W-7 Septic Tank/ Drain Field	200-UP-2	--	--	--	--	X	--	Active
2607-W-9 Septic Tank/ Drain Field	200-UP-1	--	--	--	--	X	--	Active

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Table 9-1. Summary of the Results of Data Evaluation Process Assessment.

Waste Management Unit or Unplanned Release Site	Operable Unit	ERA	IRM	LFI	RA	RI	OPS	Remarks
Basins								
207-U Retention Basin	200-UP-2	--	X	--	--	--	X	RARA - Surface contamination
Burial Sites								
Burial Ground/ Burning Pit	200-UP-2	--	--	--	--	X	--	
200-W Construction Surface Laydown Area	200-UP-2	--	--	--	--	X	--	
Unplanned Releases								
UN-200-W-6	200-UP-2	--	--	--	--	X	--	
UN-200-W-19	200-UP-2	--	--	--	--	X	--	
UN-200-W-33	200-UP-2	--	--	--	--	X	--	
UN-200-W-39	200-UP-2	--	--	--	--	X	--	
UN-200-W-46	200-UP-2	--	--	--	X	--	--	
UN-200-W-48	200-UP-2	--	--	--	--	X	--	
UN-200-W-55	200-UP-2	--	--	--	--	X	--	
UN-200-W-60	200-UP-2	--	--	--	--	X	--	
UN-200-W-68	200-UP-1	--	--	--	--	X	--	Redefined to 200-UP-2 Operable Unit
UN-200-W-78	200-UP-2	--	--	--	--	X	--	

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Table 9-1. Summary of the Results of Data Evaluation Process Assessment.

Waste Management Unit or Unplanned Release Site	Operable Unit	ERA	IRM	LFI	RA	RI	OPS	Remarks
Unplanned Releases (Continued)								
UN-200-W-86	200-UP-2	--	--	--	X	--	--	
UN-200-W-101	200-UP-2	--	--	--	--	X	X	RARA - Surface contamination
UN-200-W-117	200-UP-2	--	--	--	--	X	--	
UN-200-W-118	200-UP-2	--	--	--	--	X	--	
UN-200-W-161	200-UP-2	--	--	--	--	X	--	

ERA - Expedited Response Action

RI - Remedial Investigation/Feasibility Study

LFI - Limited Field Investigation

RA - Risk Assessment

IRM - Interim Remedial Measure

OPS - Operational Programs

Table 9-2. U Plant Aggregate Area Data Evaluation Decision Matrix.

Waste Management Unit	ERA Evaluation Path								IRM Evaluation Path			LFI Path	Final Remedy
	Is an ERA Justified?	Release?	Pathway ?	Quantity?	Concentration	Technology Available?	Adverse Consequences?	Operational Programs?	High Priority?	Data Adequate?	No Adverse Consequences?	Collect Data?	Data Adequate?
Tanks and Vaults													
241-U-361	Y	N	--	--	--	--	--	--	Y	N	--	Y	--
Cribs and Drains													
216-S-21	Y	Y	Y	Y	Y	Y	N	Y	Y	N	--	Y	--
216-U-1, -2	Y	Y	Y	Y	Y	Y	N	Y	Y	N	--	Y	--
216-U-8	Y	Y	Y	Y	Y	Y	N	Y	N ^w	N	--	Y	--
216-U-12	Y	Y	N	--	--	--	--	--	Y	N	--	Y	--
216-U-16	Y	Y	N	--	--	--	--	--	Y	N	--	Y	--
216-U-17	Y	Y	Y	Y	Y	Y	N	Y	Y	N	--	Y	--
216-Z-20	Y	Y	Y	Y	Y	Y	N	Y	Y	N	--	Y	--
216-S-4	Y	Y	N	--	--	--	--	--	Y	N	--	Y	--
216-U-3	Y	Y	N	--	--	--	--	--	Y	N	--	Y	--
216-U-4A	Y	Y	N	--	--	--	--	--	Y	N	--	Y	--
216-U-4B	Y	Y	N	--	--	--	--	--	Y	N	--	Y	--
216-U-7	Y	Y	Y	Y	Y	Y	N	Y	Y	N	--	Y	--
Reverse Well													
216-U-4	Y	Y	N	--	--	--	--	--	Y	N	--	Y	--

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Table 9-2. U Plant Aggregate Area Data Evaluation Decision Matrix.

Waste Management Unit	ERA Evaluation Path								IRM Evaluation Path			LFI Path	Final Remedy
	Is an ERA Justified?	Release?	Pathway ?	Quantity?	Concentration	Technology Available?	Adverse Consequences?	Operational Programs?	High Priority?	Data Adequate?	No Adverse Consequences?	Collect Data?	Data Adequate?
Ponds, Ditches, and Trenches													
216-U-10	Y	Y	N	--	--	--	--	--	Y	Y	Y	--	--
216-U-11	Y	Y	N	--	--	--	--	--	Y	Y	Y	--	--
216-U-14	Y	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	--	--
216-Z-1D	Y	Y	N	--	--	--	--	--	Y	Y	Y	--	--
216-Z-11	Y	Y	N	--	--	--	--	--	Y	Y	Y	--	--
216-Z-19	Y	Y	N	--	--	--	--	--	Y	Y	Y	--	--
216-U-5	Y	Y	N	--	--	--	--	--	N	--	--	--	N
216-U-6	Y	Y	N	--	--	--	--	--	N	--	--	--	N
216-U-13	Y	Y	N	--	--	--	--	--	N	--	--	--	N
216-U-15	Y	Y	N	--	--	--	--	--	N	--	--	--	N
Septic Tanks and Associated Drain Fields													
2607-W-5	Y	Y	Y	Y	Y	Y	N	N	N	--	--	--	N
2607-W-7	Y	N	--	--	--	--	--	--	N	--	--	--	N
2607-W-9	Y	N	--	--	--	--	--	--	N	--	--	--	N
Basins													
207-U	Y	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	--	--

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Table 9-2. U Plant Aggregate Area Data Evaluation Decision Matrix.

Waste Management Unit	ERA Evaluation Path								IRM Evaluation Path			LFI Path	Final Remedy
	Is an ERA Justified?	Release?	Pathway ?	Quantity?	Concentration	Technology Available?	Adverse Consequences?	Operational Programs?	High Priority?	Data Adequate?	No Adverse Consequences?	Collect Data?	Data Adequate?
Burial Sites													
Burial Ground/ Burning Pit	N	--	--	--	--	--	--	--	N	--	--	--	N
200-W Construction Surface Laydown Area	N	--	--	--	--	--	--	--	N	--	--	--	N
Unplanned Releases													
UN-200-W-6	N	--	--	--	--	--	--	--	N	--	--	--	N
UN-200-W-19	N	--	--	--	--	--	--	--	N	--	--	--	N
UN-200-W-33	N	--	--	--	--	--	--	--	N	--	--	--	N
UN-200-W-39	N	--	--	--	--	--	--	--	N	--	--	--	N
UN-200-W-46	N	--	--	--	--	--	--	--	N	--	--	--	Y
UN-200-W-48	N	--	--	--	--	--	--	--	N	--	--	--	N
UN-200-W-55	N	--	--	--	--	--	--	--	N	--	--	--	N

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Table 9-2. U Plant Aggregate Area Data Evaluation Decision Matrix.

Waste Management Unit	ERA Evaluation Path								IRM Evaluation Path			LFI Path	Final Remedy
	Is an ERA Justified?	Release?	Pathway ?	Quantity?	Concentration	Technology Available?	Adverse Consequences?	Operational Programs?	High Priority?	Data Adequate?	No Adverse Consequences?	Collect Data?	Data Adequate?
Unplanned Releases (Continued)													
UN-200-W-60	N	--	--	--	--	--	--	--	N	--	--	--	N
UN-200-W-68	N	--	--	--	--	--	--	--	N	--	--	--	N
UN-200-W-78	N	--	--	--	--	--	--	--	N	--	--	--	N
UN-200-W-86	N	--	--	--	--	--	--	--	N	--	--	--	Y
UN-200-W-101	Y	Y	Y	Y	Y	Y	N	Y	Y	N	--	N	N
UN-200-W-117	N	--	--	--	--	--	--	--	N	--	--	--	N
UN-200-W-118	N	--	--	--	--	--	--	--	N	--	--	--	N
UN-200-W-161	Y	Y	Y	Y	N	--	--	--	Y	N	--	N	N

^{a/} Evaluated as high priority site because of similarities with other cribs.

-- Indicates decision point not reached.

Y Yes

N No

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Table 9-3. Waste Management Units and Unplanned Releases Addressed by Other Programs.

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Site Name	Site Type	Program	Active/ Inactive	Operable Units
Tanks and Vaults				
241-U-101	Single-Shell Tank	SSTCP	Inactive	200-UP-3
241-U-102	Single-Shell Tank	SSTCP	Inactive	200-UP-3
241-U-103	Single-Shell Tank	SSTCP	Inactive	200-UP-3
241-U-104	Single-Shell Tank	SSTCP	Inactive	200-UP-3
241-U-105	Single-Shell Tank	SSTCP	Inactive	200-UP-3
241-U-106	Single-Shell Tank	SSTCP	Inactive	200-UP-3
241-U-107	Single-Shell Tank	SSTCP	Inactive	200-UP-3
241-U-108	Single-Shell Tank	SSTCP	Inactive	200-UP-3
241-U-109	Single-Shell Tank	SSTCP	Inactive	200-UP-3
241-U-110	Single-Shell Tank	SSTCP	Inactive	200-UP-3
241-U-111	Single-Shell Tank	SSTCP	Inactive	200-UP-3
241-U-112	Single-Shell Tank	SSTCP	Inactive	200-UP-3
241-U-201	Single-Shell Tank	SSTCP	Inactive	200-UP-3
241-U-202	Single-Shell Tank	SSTCP	Inactive	200-UP-3
241-U-203	Single-Shell Tank	SSTCP	Inactive	200-UP-3
241-U-204	Single-Shell Tank	SSTCP	Inactive	200-UP-3
241-U-301	Catch Tank	WMP	Active	200-UP-3
241-U-302	Catch Tank	WMP	Active	200-UP-3
244-U	Receiver Tank	WMP	Active	200-UP-2
241-WR	Vault	D&RCP	Inactive	200-UP-2
244-UR	Vault	D&RCP	Inactive	200-UP-3
Septic Tanks and Associated Drain Fields				
2607-WUT	Septic Tank/Drain Field	-	Active	200-UP-3
Transfer Facilities, Diversion Boxes, and Pipelines				
241-U-A	Valve Pit	SSTCP	Active	200-UP-3
241-U-B	Valve Pit	SSTCP	Active	200-UP-3

Table 9-3. Waste Management Units and Unplanned Releases Addressed by Other Programs.

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Site Name	Site Type	Program	Active/ Inactive	Operable Units
241-U-C	Valve Pit	SSTCP	Active	200-UP-3
241-U-D	Valve Pit	SSTCP	Active	200-UP-3
241-U-151	Diversion Box	WMP	Active	200-UP-2
241-U-152	Diversion Box	WMP	Active	200-UP-2
241-U-153	Diversion Box	SSTCP	Inactive	200-UP-3
241-U-252	Diversion Box	SSTCP	Inactive	200-UP-3
241-UR-151	Diversion Box	SSTCP	Inactive	200-UP-3
241-UR-252	Diversion Box	SSTCP	Inactive	200-UP-3
241-UR-253	Diversion Box	SSTCP	Inactive	200-UP-3
241-UR-154	Diversion Box	SSTCP	Inactive	200-UP-3
241-UX-254	Diversion Box	WMP	Active	200-UP-2
Unplanned Releases				
UN-200-W-71	Unplanned Release	SSTCP	--	200-UP-3
UN-200-W-24	Unplanned Release	SSTCP	--	200-UP-3
UPR-200-W-128	Unplanned Release	SSTCP	--	200-UP-3
UPR-200-W-154	Unplanned Release	SSTCP	--	200-UP-3
UPR-200-W-155	Unplanned Release	SSTCP	--	200-UP-3
UPR-200-W-156	Unplanned Release	SSTCP	--	200-UP-3
UPR-200-W-157	Unplanned Release	SSTCP	--	200-UP-3
Uranium Contamination Leak	Unplanned Release	a/	--	200-UP-2
Paint Waste Spill	Unplanned Release	a/	--	200-UP-2

SSTCP - Single-Shell Tank Closure Program

WMP - Waste Management Program

D&RCP - Decommissioning and RCRA Closure Program

a/ Have not officially been designated as an unplanned release.

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U PLANT AGGREGATE AREA
PLATE 1 - Facilities, Sites, & Unplanned Releases

DOE/RL-91-52, Rev. 0

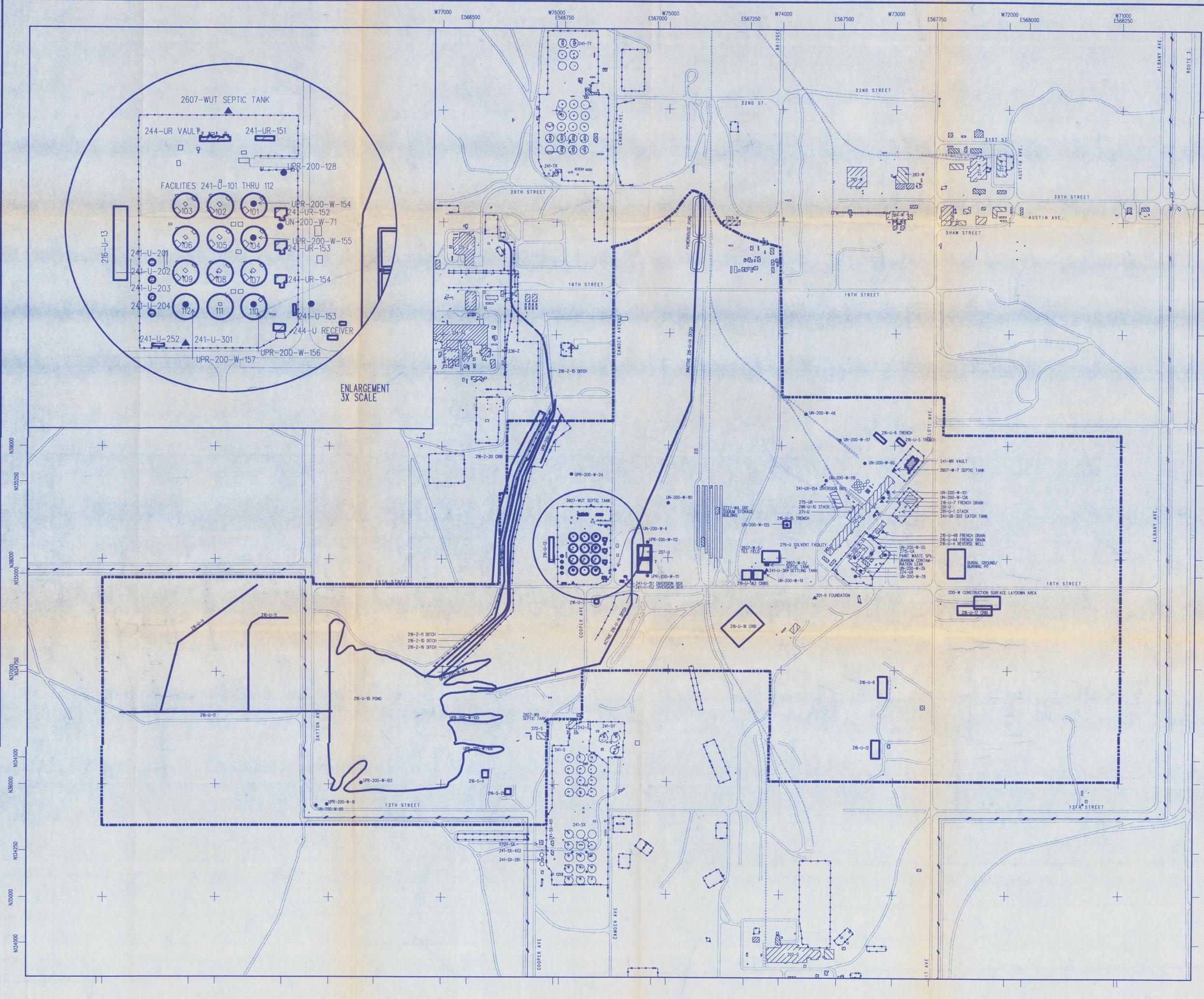
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Aggregate Area Management Studies

PLANT AGGREGATE AREA
LATE 2 - Topography

DOE/RL-91-52, Rev. 0

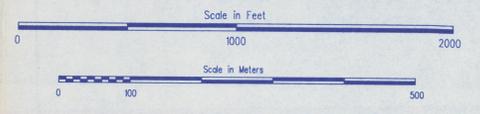
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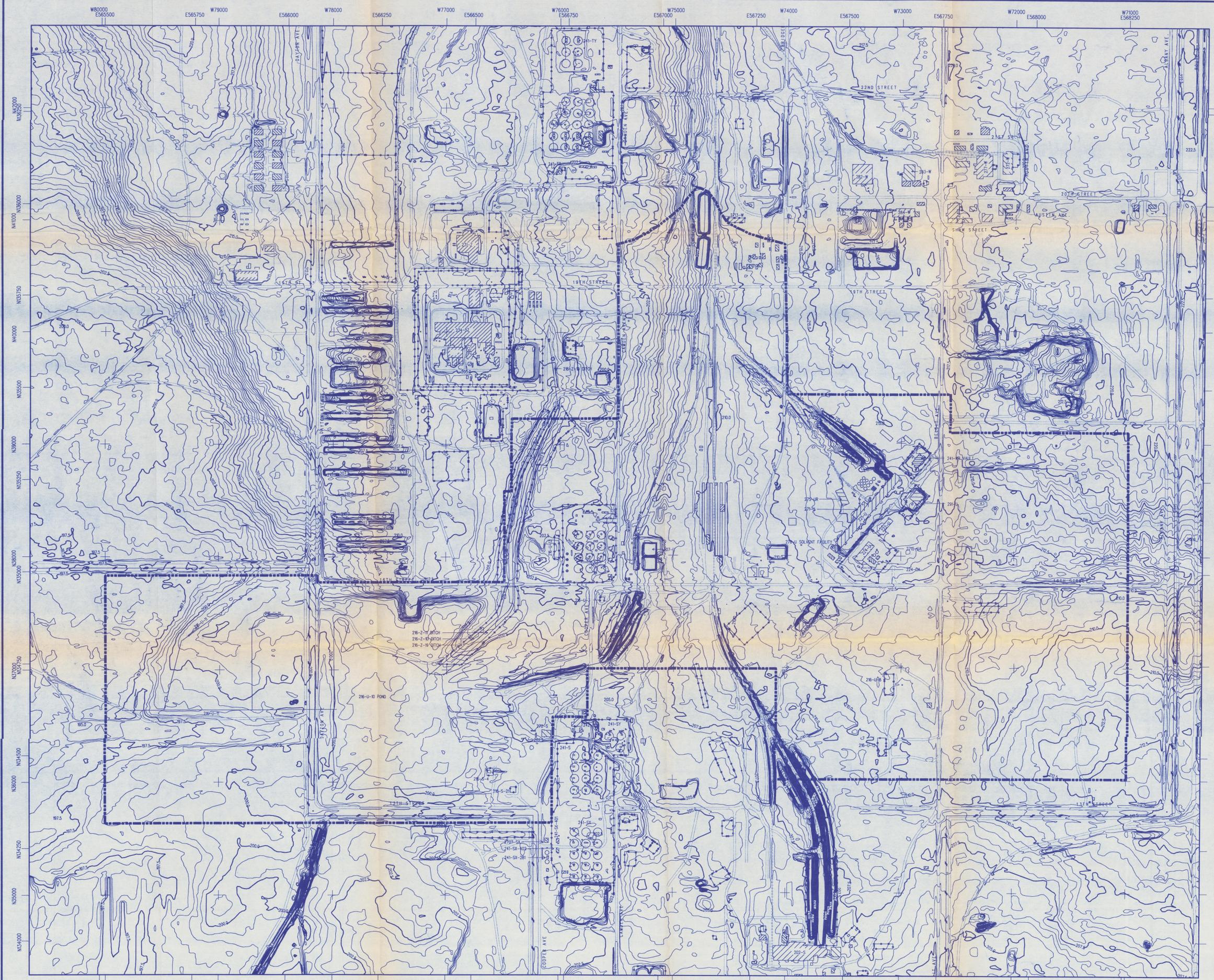
U PLANT AGGREGATE AREA
PLATE 3 - Monitoring Wells & Sample Locations



Westinghouse Hanford Company
 Aggregate Area Management Studies
 U PLANT AGGREGATE AREA
 PLATE 1 - Facilities, Sites, & Unplanned Releases

- LEGEND**
- Aggregate Area Boundary
 - Security Systems/Fences
 - Perimeter Boundary
 - Buildings
 - Waste Management Units
 - Unplanned Releases
 - Other Waste Mgmt Units



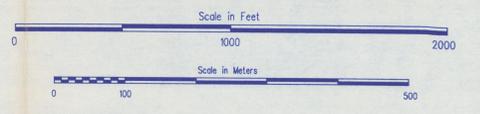


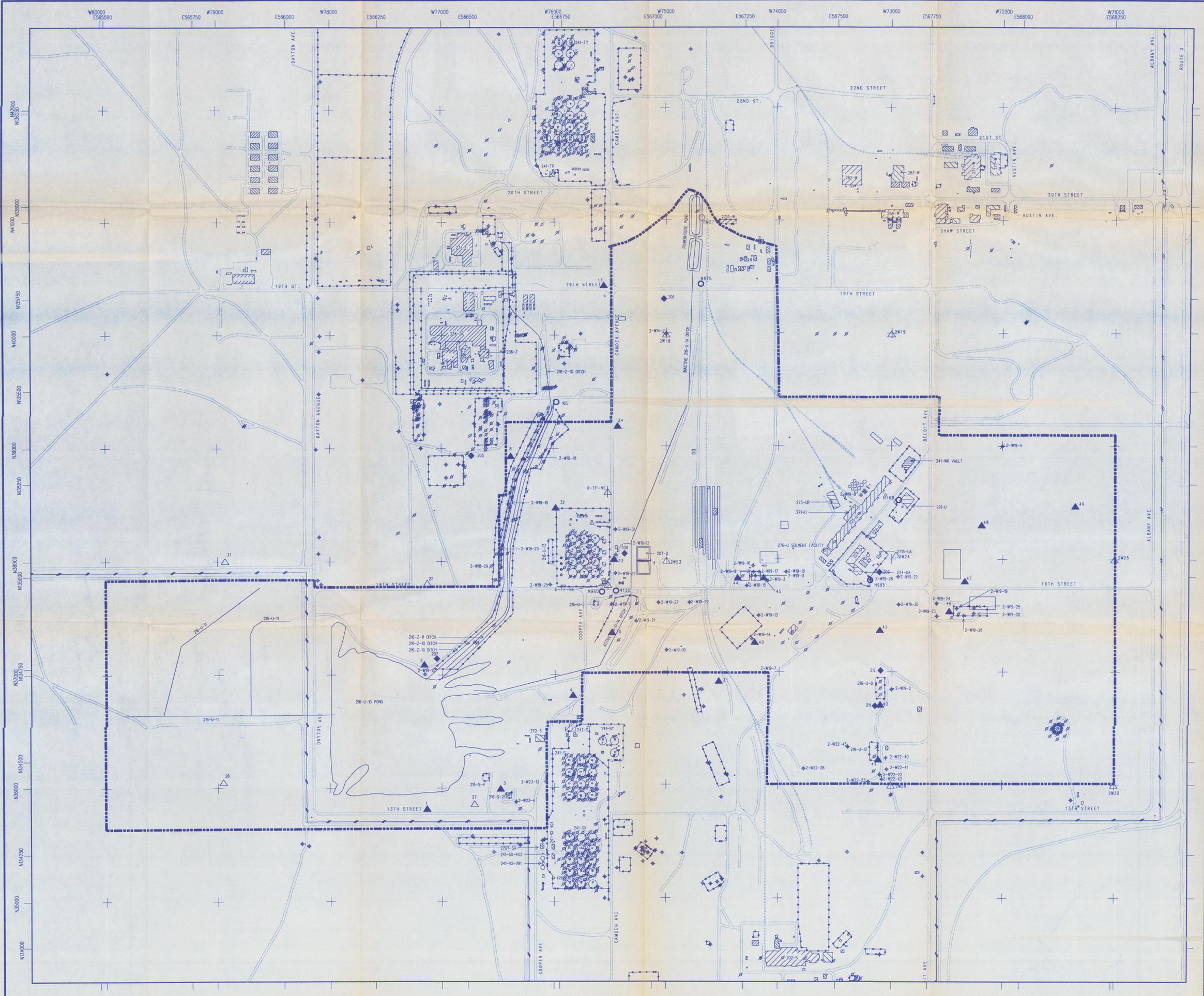
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 U PLANT AGGREGATE AREA
 PLATE 2 - Topography

LEGEND

-  Aggregate Area Boundary
-  Security Systems/Fences
-  Perimeter Boundary
-  Buildings

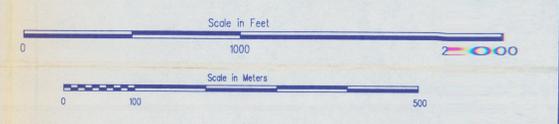
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Westinghouse Hanford Company
 Aggregate Area Management Studies
 U PLANT AGGREGATE AREA
 PLATE 3 - Monitoring Wells & Sample Locations

- LEGEND**
- Aggregate Area Boundary
 - Security Systems/Fences
 - Perimeter Boundary
 - Buildings
 - Monitoring Wells (Note: Well numbers have been abbreviated by eliminating the "09" of the first 3-digit numbering code. For example, well "2-WB-2" has the complete number "209-WB-2")
 - Other Wells
 - SAMPLING LOCATIONS (Approximate)**
 - Soil Sampling Locations
 - Former Locations (to 1989) --including TLDs
 - New Sampling Locations (1990 and following)
 - Fenceline Sampling Locations
 - Surface Water Sampling Locations
 - Air Sampling Locations
 - New TLD Sampling Locations



APPENDIX A
SUPPLEMENTAL DATA

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APPENDIX A.1
GEOPHYSICAL DATA

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A-1.0 SUBSURFACE GEOPHYSICAL LOGS

Geophysical well logging has been conducted at the U Plant Aggregate Area since at least as early as 1958, as a surveillance technique to evaluate radionuclide migration in the unsaturated zone underlying or adjacent to waste disposal or storage areas. Vadose-zone monitoring wells ("dry wells") and groundwater monitoring wells have been constructed at many of the U Plant Aggregate Area waste management units. Geophysical well logs have been acquired from monitoring wells at the following eleven waste management units:

- 216-S-21 Crib
- 216-U-1 and 216-U-2 Cribs
- 216-U-8 Crib
- 216-U-12 Crib
- 216-U-16 Crib
- 216-U-17 Crib
- 216-U-3 French Drain
- 216-U-14 Ditch
- 216-U-10 Pond
- U Plant
- 241-U Tank Farm (Tanks 101-112).

As part of this aggregate area management study (AAMS), select geophysical well logs from these eleven waste management units were examined to provide a preliminary appraisal of migration of radionuclides in the unsaturated zone. The objectives of the geophysical well log study were to qualitatively and, if possible, quantitatively evaluate the extent and rate of vertical and lateral migration of radionuclides. Several previously conducted studies provide important background information. Most notable is a study by Fecht et al. (1977), in which gross gamma-ray logs acquired between 1958 and 1976 from four U Plant Aggregate Area waste management units were qualitatively evaluated (216-S-21 Crib, 216-U-1 and 216-U-2 Cribs, 216-U-8 Crib, and the 216-U-12 Crib). Several other published and unpublished documents exist such as gross-gamma logs acquired from the 241-U Tank Farm area (Jensen 1976); periodic reports (Hanlon 1991); a crib monitoring

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summary (Brodeur 1988); a characterization of the U1/U2 uranium plume (Baker 1988); and miscellaneous and archived reports in the Tank Farm Surveillance Group files. Pertinent results of previously conducted studies or observations are discussed along with results of this study in sections describing individual waste management units.

A-1.1 AVAILABLE GEOPHYSICAL WELL LOGS

The array of geophysical logs acquired from the U Plant Aggregate Area includes gross gamma-ray logs, gamma-gamma logs, neutron-epithermal-neutron logs, density logs, sonic logs, and temperature logs. To date, no spectral gamma-ray logs have been acquired from U Plant Aggregate Area wells. The gross gamma-ray log was by far the most common log acquired, and, with the exception of the spectral gamma-ray log, is the most useful for evaluating migration of manmade radionuclides in the unsaturated zone. The interpretation of those logs, however, is complicated by several factors, including: the presence of multiple casing strings, the complications of logging in unsaturated zones, uncertainties in well construction and modifications, and questionable tool geometry and response characteristics. Consequently, the ancillary logs were not evaluated as part of this study.

Nearly all of the available U Plant Aggregate Area gross gamma-ray logs have been acquired by the Westinghouse Hanford Tank Farm Surveillance Group or the Pacific Northwest Laboratory (PNL).

The Tank Farm Surveillance Group, organized in the early 1970's, began acquiring gross gamma-ray logs from 241-U Tank Farm dry wells in 1975. The logging equipment used was designed in-house by Stong (1980) specifically for surveillance. The original design was modified from about 1976 to 1977, and implemented some time thereafter, possibly beginning about 1977. The nature of the logs do not change during that period; however, and the effects of design modifications are not apparent. The Tank Farm Surveillance Group utilized four types of gross gamma-ray probes, depending on the severity of contamination. In order of increasing radioactivity, the corresponding probe type used would be: probe number 4, utilizing a scintillation detector (also called the "S" probe); probe number 14, utilizing a shielded scintillation detector (also called the "SS" probe; seldom used); probe number 1, utilizing a Geiger-Mueller detector (also called the "green" or "GM-1" probe); and probe number 2, utilizing a shielded Geiger-Mueller detector (also called the "red" or "GM-2" probe). Several vans are outfitted for logging and so there are several copies of each probe. The probe type utilized is recorded on each log, but not the probe serial number. The electronics circuits utilized with the Surveillance Group probes do not incorporate an electronic smoothing system (i.e., a "time constant") as in typical petroleum industry logging tools or the PNL logging tools. Instead, the detector response is summed over a 0.3 m (1 ft) interval and then plotted in units of counts per second (ct/s). This method does not produce an appreciable depth lag (but it does reduce bed resolution and makes it difficult to correlate log features). The logging speed is 0.2 m/s (0.75 ft/s). The

probes are free floating (not centered or uncentered), but response variability resulting from unconstrained lateral movement in the borehole is estimated to be negligible. Instrument calibration is discussed below.

The PNL began collecting gross gamma-ray logs from U Plant monitoring wells in 1958. On the basis of log presentation, three generations of logging equipment have been used in the U Plant Aggregate Area since 1958. However, based on conversations with long-term Westinghouse Hanford and PNL employees, several more subtle equipment modifications were made within generations of logging equipment. In fact, judging from the normalization factors used (see Section 1.2), procedural, or equipment modifications may even have been made annually. Beginning in 1982, procedures were implemented to improve log quality and consistency. Further improvements in logging procedures were implemented in 1989. Since 1976, two probes with similar response characteristics have been used by PNL. Beginning in 1982, the serial number of the probe used has been recorded on the log header.

The gross gamma-ray logs utilized for this study are listed in Table A-1.1. The logs listed in Table A-1.1 constitute a comprehensive list of all logs acquired in the U Plant Aggregate Area through 1990. All available logs were reviewed as part of this study except those associated with the 241-U Tank Farm. Many thousand logs have been acquired from 241-U Tank Farm dry wells by the Tank Farm Surveillance Group and only representative sampling of logs from those wells were examined for this study (listed in Table A-1.2). Logs were selected from each of the 241-U Tank Farm dry wells so that several logs were reviewed over the operating life of each well. Logs were studied from 46 wells outside the 241-U Tank Farm area and from 62 wells inside the tank farm.

A-1.2 GROSS GAMMA LOGGING

Borehole gross gamma radiation measurements are used to determine the level of gamma activity with depth in the vicinity of the well bore. These measurements do not differentiate between the mechanisms through which gamma radiation is produced or the energy of the gamma radiation photons detected. The response of the gamma radiation detector to different energy levels is generally unknown, except perhaps for the lowest energy photon detectable (Arthur 1990). Gross gamma logs cannot be used to determine the isotopic composition of the subsurface since this is determined through the analysis of the energy spectra of the gamma radiation detected. The capability to measure the spectra of gamma radiation detected in the subsurface and assay the types and amounts of isotopes present is currently being developed (Lane 1990; Price et al. 1990).

The bulk of the gamma logs available for the U Plant Aggregate Area were collected with scintillation probes by PNL or by the Tank Farm Surveillance Analysis and Support

Group (TFSA&S). Scintillation probes detect the flash of light produced by the interaction between a gamma photon and a crystal of thallium-activated sodium iodide (NaI(Tl)) with a photomultiplier tube. The resulting pulse of electricity is amplified, routed through a signal generator and sent through the logging cable to the surface. The pulses are separated from the electrical signal with a discriminator, amplified, counted by a rate meter and output to a pen plotter which is driven at a rate determined by the logging speed (Fecht et al. 1977; Additon et al. 1978; Brodeur and Koizumi 1989; Arthur 1990).

The accuracy and precision of gamma activity measurements in the subsurface is determined by details of the logging system instrumentation, the field data acquisition methodology, the surrounding media and the radionuclides present. The relationship between the gamma activity detected by a scintillation probe and the actual activity, the distance gamma radiation may travel through geologic materials before being completely attenuated and the vertical resolution of changes in activity by the logging systems used will be discussed below.

The time required for the logging system to process a detected gamma photon, or "dead time," is an important limitation in the measurement gamma activity (Brodeur and Koizumi 1989; Arthur 1990). During this short span of time, no other photons will be processed by the instrument. The "dead time" computed for the PNL system currently in use is 17.8 microseconds (Arthur 1990). Based upon this value, the maximum count rate this logging system is capable of is about 56,000 ct/s. If the activity is above that level, the system will become "paralyzed" and read 0 ct/s until it resets itself. The maximum count rate of the TFSA&S system currently in use is about 100,000 ct/s with Probe number 4 (Strong 1980). This suggests that the "dead time" of their logging system is about 10 microseconds. There is no evidence that TFSA&S's system will become paralyzed if this activity level is exceeded.

The actual gamma activity on an interval may be computed by multiplying the "dead time" corrected activity by a factor consistent with the amount of attenuation due to well construction. The amount of attenuation the gamma radiation experiences in penetrating well casing is significant. A single string of casing reduces the count rate measured by the scintillation probe by about 25%, groundwater in an uncased hole reduces the observed count rate by 11%, and groundwater in a cased hole reduces the observed count rate by about 33% (Brodeur and Koizumi 1989; Arthur 1990).

The relationship between the gamma activity observed with a scintillation probe and the actual activity is linear over much of the system's range. However, above some threshold activity level, the relationship between the observed and actual activity becomes non-linear. At this point the tool is said to be saturated. The gross gamma logging system currently in use by PNL becomes saturated around 14,500 ct/s (Brodeur and Koizumi 1989; Arthur 1990), and that currently in use by TFSA&S with Probe number 4 becomes saturated around 70,000 ct/s (Strong 1980).

Where the relationship between the observed and actual gamma activity is linear, and complete details of well construction are available, the activity may be converted to standard units related to decay rates or to concentrations of specific radionuclides (thorium or uranium for example). Such conversions allow the direct comparison of data collected by different logging systems and quantitative analyses of the concentrations of gamma emitters with depth. To achieve this, it is necessary to calibrate the scintillation probes used with a model borehole containing intervals with known activities (Strong 1980; Brodeur and Koizumi 1989; Arthur 1990). The rigorous procedures and facilities necessary for calibrating scintillation probes have not yet been completed.

A scintillation probe is calibrated by periodically adjusting the components of the system to meet established specifications and by logging a test well with intervals of known activity under standard conditions. The probe's calibration is then verified in the field before and after each logging run using portable equipment and procedures which are correlated with those of the calibration procedure. Standard conditions are established by constructing the test borehole in a known geologic environment with background radiation levels similar to those found in the area where the probe is used. The test well should be constructed in a similar fashion to the wells to be logged by the probe (Brodeur and Koizumi 1989).

The average distance through which gamma radiation penetrates geologic and well construction materials and is still detected by the scintillation probe is known as the radius of investigation. This distance is determined by the density of the media surrounding the borehole, the well construction materials, and the energy and intensity of the gamma radiation. The average radius of investigation for gross gamma radiation measurements in an open hole is about 0.3 m (1 ft) from the wall of the borehole in sedimentary rocks (Schlumberger 1972). The radius of investigation is larger on intervals where there are high concentrations of radionuclides since higher intensities of gamma radiation will penetrate a greater thickness of a given material. The radius of investigation is decreased by well casing, grout, and groundwater since they increase the effective density of sediments. Another factor in determining the radius of investigation is the tool response to low energy (frequency gamma photons. The scintillation probe currently used by PNL has a low energy cutoff of between 46.5 and 59.5 keV (Arthur 1990). Gamma radiation with energies below this value will not be detected by that probe. The low energy cutoff for the probes used by TFSA&S is unknown.

The vertical resolution and apparent location of a change in the gamma activity measured by a scintillation probe depends upon details of how the probe signal is processed by the rate meter and the logging speed. The rate meter used in PNL's logging system differs from that used by TFSA&S. The rate meter used by PNL smooths its output using an electronic circuit (an RC circuit). The amount of smoothing is determined by the time constant of the circuit used. This removes statistical variations in the signal detected by the scintillation probe and improves the reproducibility and sensitivity of the data. However, a "lag" is introduced between the depth at which a change in the gamma activity is first

encountered by the scintillation probe and the depth at which it is plotted. The size of this "depth lag" is the distance traveled before half of the amplitude of the change in activity is recorded. One time constant is required to reach 65% of the amplitude of any change in activity. So, the "depth lag" is approximately the product of the logging speed and the time constant used (Schlumberger 1972). Before 1989, the logging speed used by PNL was 4.5 m/min (0.08 m/s) [15 ft/min, 0.25 ft/s] and the time constant used was 3 seconds. This results in a depth lag of 0.2 m (0.75 ft). The thinnest interval of elevated activity which can be resolved is also 0.2 m (0.75 ft) on these older profiles. In 1989, the logging speed was reduced to 1.5 m/min (2.5 cm/s) [5 ft/min, 1 in./s] and the time constant to 1 second. The expected vertical resolution and "depth lag" of these logs is 2.5 cm (1 in.). The rate meter used by TFSA&S sums the pulses over the period of time required for the probe to ascend through 0.3 m (1 ft) and averages the reading over time. This process does not remove the statistical variations from the data so the data are less reproducible. However, since no time constant is used, no "lag" between the depth a change in gamma activity is encountered and the depth where it is plotted is introduced. The vertical resolution of changes in activity on these logs is 0.3 m (1 ft).

A-1.3 TECHNICAL APPROACH

Scintillation probe profiles collected periodically from monitoring wells within the U Plant aggregate area have been used to qualitatively assess the location and extent of radionuclides in the subsurface, any evidence of vertical or lateral migration, and the potential for radionuclides from waste disposal activities reaching the groundwater. The approach used here is similar to that of Fecht et al. (1977). Scintillation probe profiles collected from wells monitoring a facility or group of facilities were compiled and analyzed in an attempt to gain an understanding of the subsurface distribution of gamma emitters from waste disposal activities. The conclusions reached in these evaluations should not be considered the final word since they are based on a limited data set which can only be used for qualitative purposes.

The approach used here differs from that of Fecht et al. (1977) and other previous evaluations in the manner in which the data were compiled and analyzed. Geological methods of analysis incorporating cross-sections and mapping of subsurface attributes such as the thickness of zones of elevated gamma radiation and relevant lithologic horizons were used extensively. The advantages of this approach are the clearer representation of potential subsurface conditions around the waste disposal facilities, and identification of data deficiencies.

Fecht et al. (1977) attempted to "normalize" the scintillation probe profiles used in their evaluations to a level consistent with the profiles collected in 1976. This normalization scheme involved scaling the profiles from each vintage using an average "peak to background" ratio and bulk shifting the corrected curves to correspond to the 1976 profiles.

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Since there are distinct differences between the response characteristics of each logging system and their modifications (in the saturation levels, low energy cutoff, etc.), there are doubts to the validity of such an exercise. The logs used in the evaluations presented here have not been normalized.

There has been no attempt to quantitatively compare the activity levels detected by different vintages of scintillation probes in the evaluations presented here. If gross changes in the profiles are evident, they have been noted in a qualitative sense. The criteria used to identify radionuclide decay are the significant, consistent decline of activity levels and the "narrowing" of the features representing elevated radiation on the logs over time. However, such changes may also be indicative of lateral migration of radionuclides away from a particular well. Identification of lateral migration is generally uncertain. The most reliable criteria for identifying lateral migration of radionuclides is the notable increase of activity on an interval in a well that is downgradient (of a stratigraphic or hydrologic boundary) from other wells with elevated activity on a similar interval. It is very important to consider the spacial and temporal context of the scintillation probe data in determining if lateral migration has occurred, even on a qualitative level.

Although the activity measured by the scintillation probes cannot be quantified to known standards, the activity in the subsurface may be reliably located. The location of features in the scintillation probe profiles such as the top and bottom of intervals of elevated gamma radiation are generally found at the same depth on successive logs. Care must be taken in comparing the logs collected by TFSA&S and PNL. Depth discrepancies of up to 15 m (5 ft) have been noted between these logs. This error is probably due in large part to the "depth lag" of the PNL logging system. This "depth lag" will place equivalent features on PNL logs (collected before 1989) 0.22 m (0.75 ft) shallower than those on TFSA&S logs. Also, differences in the responses of the PNL and TFSA&S systems may account for some of this discrepancy.

Three criteria were used to establish downward migration of radionuclides in the vicinity of a well. The most important of these was an unambiguous downward displacement of the top and bottom of a region of elevated radiation with time. Downward migration of other correlatable features on an interval of elevated activity may be used in support of this evidence. Secondly, the total amount of downward migration should exceed the vertical resolution of the logging system used (0.22 m [0.75 ft] for the PNL pre-1989 logs and 0.3 m (1 ft) for TFSA&S logs). Finally, any change in the point from which depths are measured during logging should be identified and accounted for, this can be inferred from stationary subsurface features, such as lithologic boundaries and bottoms of casing strings.

All of the available well data were reviewed for each area evaluated, and selected logs were used to construct cross-sections representative of subsurface conditions. These cross-sections were correlated with stratigraphic information from nearby wells, regional cross-sections and regional mapping. Any mappable attributes which could be used to

represent the location and extent of the region of elevated gamma radiation were compiled into maps. The evaluation of the scintillation probe profiles referenced these graphical representations to describe the location and extent of any zones of elevated gamma radiation, and the behavior of this zone over time, particularly in regards to vertical or lateral migration. Any evidence of gamma emitters reaching the groundwater was also noted.

To represent the logs used in the cross-sections in a clear, yet compact format and to facilitate comparisons between different vintages of data, it was necessary to digitize the original logs and to redisplay them on a semi-logarithmic scale. Depth in feet from the top of casing was represented on the linear scale, and activity in counts per second on the logarithmic scale. The cross-sections are not scaled horizontally. To obtain a true picture of the spacial relationship between the wells used in the cross-sections, the reader is instructed to inspect the location map provided on each figure containing cross-sections.

Maps of the thickness of the interval of elevated gamma radiation were produced for waste management units with zones of elevated gamma radiation. Although such maps do not give any indication of gamma activity, they do provide a reasonable representation of the potential extent of gamma emitters. Use of activity data was avoided since the data are not suitable to be used in such a quantitative fashion.

A-1.4 SITE SPECIFIC RESULTS

Results of the log interpretations for each of the waste management units are presented in the following sections.

A-1.4.1 216-S-21 Crib

The 216-S-21 Crib is located in the southern part of the 200-UP-1 Operable Unit. Well 299-W23-4 monitors the 216-S-21 Crib.

The 216-S-21 Crib has been previously evaluated by Fecht et al. (1977). The conclusions of this evaluation are consistent with Fecht et al. (1977). No gamma logs since 1976 were obtained for Well 299-W23-4.

In the 1976 log, a very pronounced peak is present between 12 and 15 m (40 and 48 ft). This peak is much more pronounced than the peak seen in the 1970 log. The peak corresponds with the top of the lower fine-grained unit of the Hanford formation. Radionuclides beneath the 216-S-21 Crib may have been moved toward Well 299-W23-4 because liquid waste discharged to the 216-S-21 Crib spread laterally above the Hanford formation lower fine-grained unit. Sediment moisture from the 216-U-10 Pond may also

have moved through the sediment beneath the crib and moved radionuclides towards Well 299-W23-4.

A-1.4.2 216-U-1 and 216-U-2 Cribs

The 216-U-1 and 216-U-2 Cribs are located in the 200-UP-2 Operable Unit. Wells 299-W19-3, 299-W19-9, 299-W19-11, 299-W19-15, 299-W19-16, 299-W19-17, and 299-W19-18 monitor the 216-U-1 and 216-U-2 Cribs.

The 216-U-1 and 216-U-2 Cribs have been previously evaluated by Fecht et al. (1977). The conclusions of this evaluation are consistent with Fecht et al. (1977).

The wells monitoring the 216-U-1 and 216-U-2 Cribs were compiled into a cross section (Figure A-1.1) and correlated with a composite lithologic column from well logs on 299-W19-3, 299-W19-11, 299-W19-16, 299-W19-18 and Lindsey et al. (1991).

Intervals of elevated gamma radiation occur in Wells 299-W19-3, 299-W19-9 and 299-W19-11. The thickness and extent of elevated gamma radiation is shown in Figure A-1.2. The thickest interval of elevated gamma radiation is found in Well 299-W19-11 where elevated readings occur between depths of 9.8 and 24 m (32 and 80 ft).

Lateral migration is indicated by the elevated gamma radiation between 23 and 31 m (75 and 102 feet) in Well 299-W19-3. The 1985 log for this well is nearly identical to the 1976 log indicating that lateral migration of gamma emitters has probably stopped. The elevated gamma radiation between 23 and 31 m (75 and 102 ft) corresponds with a gravel bed in the lower part of the Hanford formation course unit.

Baker et al. (1988) noted the presence of elevated uranium in the ground water beneath the 216-U-1 and 216-U-2 Cribs. They postulated that perched water collected at a depth of 49 m (160 ft) beneath the 216-U-16 Crib. This perched water moved under the 216-U-1 and 216-U-2 Cribs, picked up mobile uranium and then drained to the ground water through holes or thin spots in the early "Palouse" soils and Plio-Pleistocene unit. The gamma logs for the wells monitoring the 216-U-1 and 216-U-2 Cribs do not document the migration of uranium to the groundwater. The elevated gamma radiation in Well 299-W19-3 has not migrated since 1976. The other wells monitoring the 216-U-1 and 216-U-2 Cribs were constructed after uranium was detected in the groundwater.

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A-1.4.3 216-U-3 French Drain

The 216-U-3 French Drain is located on western side of the 200-UP-2 Operable Unit just south of 200-UP-3 Operable Unit. Two wells, 299-W18-177 and 299-W19-1 are located about 46m (150 ft) east of 216-U-3.

The 216-U-3 French Drain has previously been evaluated by Brodeur (1988). This evaluation is consistent with Brodeur (1988).

No elevated gamma readings are in evidence from Wells 299-W18-177 and 299-W19-1. The 1987 gamma log of Well 299-W19-1 is correlated with a composite lithologic column constructed from 299-W19-1 and 299-W18-177 well logs (Figure A-1.3). The gamma logs for these wells show a small step-up from the Hanford coarse to the Hanford fine and a small step-down from the early "Palouse" soil to the Plio-Pleistocene unit and gravel unit E of the Ringold Formation.

Wells 299-W19-1 and 299-W18-177 are too far from the 216-U-3 French Drain to properly evaluate for the presence of radionuclides.

A-1.4.4 216-U-8 Crib

The 216-U-8 Crib is located in the 200-UP-2 Operable Unit. Wells 299-W19-2, 299-W19-70 and 299-W19-71 monitor the 216-U-8 Crib. Table A-1.1 provides details on the construction of the wells used in this evaluation.

The 216-U-8 Crib has been previously evaluated by Fecht et al. (1977). They detected minor radioactive contamination. The conclusions of this evaluation are consistent with Fecht et al. (1977).

The wells monitoring the 216-U-8 Crib were compiled into a cross section (Figure A-1.4) and correlated with a composite lithologic column from the monitoring wells and Lindsey et al. (1991).

Intervals of elevated gamma radiation occur in all three monitoring wells. The thickness and extent of elevated gamma radiation is shown in Figure A-1.5. It is unclear how deeply into the vadose zone radionuclides have migrated because Wells 299-W19-70 and 299-W19-71 are fairly shallow and do not provide information about migration below 24 m (80 ft).

Logs acquired from Well 299-W19-2 indicate eastward migration of radionuclides. Slightly elevated gamma readings are present at depths of about 12 to 13 m (38 to 43 ft) and 26 to 31 m (85 to 102 ft).

A-1.4.5 216-U-12 Crib

The 216-U-12 Crib is located in the southern part of the 200-UP-2 Operable Unit. Wells 299-W22-22, 299-W22-23, 299-W22-28, 299-W22-40, 299-W22-41, 299-W2-42, 299-W22-43, 299-W22-60, 299-W22-73 (06-12-02) and 299-W22-75 (06-12-06) monitor the 216-U-12 Crib. Vadose zone Wells 299-W22-73 (06-12-02) and 299-W22-75 (06-12-06), located above the crib, were originally logged by PNL in 1982 but are currently logged annually by the Tank Farm Surveillance Group. Table A-1.1 provides details on the construction of wells used in this evaluation.

The 216-U-12 Crib has previously been evaluated by Fecht et al. (1977). This evaluation differs from that of Fecht et al. (1977) because of the greater well coverage available for this evaluation.

The wells monitoring the 216-U-12 Crib were compiled into a cross section (Figure A-1.6) and correlated with a composite lithologic column made from the monitoring wells and the stratigraphy of Lindsey et al. (1991).

Intervals of elevated gamma radiation are present in Wells 299-W22-73 and 299-W22-75. Elevated gamma readings are present between 6 and 18 m (20 and 60 ft) in Well 299-W22-75 with the most intense zone at 7.6 m (25 ft). Well 299-W22-73 has elevated gamma readings from 6.7 to 7.9 m (22 to 26 ft). Comparison of 1982 logs and 1989 logs for these wells shows that downward migration of radionuclides responsible for elevated gamma readings has not occurred.

Lateral spreading of radionuclides has not reached any of the other wells monitoring the 216-U-12 Crib (Figure A-1.7). With the notable exception of well 299-W22-22, gamma readings are near background levels. Logs from Well 299-W22-22 show an increase in gamma readings at the top of the ground water between 1965 and 1968. The intensity of the peak had diminished substantially by 1976, and was absent in the 1982 logs.

A-1.4.6 216-U-16 Crib

The 216-U-16 Crib is located in the 200-UP-2 Operable Unit. Two wells, 299-W19-13 and 299-W19-14 are located adjacent to the crib area. A third well, 299-W19-7, is located several hundred feet south of the crib.

No elevated gamma readings are in evidence for the wells around the 216-U-16 Crib. The 1985 gamma log of 299-W19-14 is correlated with a composite lithologic column constructed from 299-W19-13 and 299-W19-14 well logs (Figure A-1.8). The 1985 gamma logs of these wells are attenuated at a depth between 43 and 46 m (140 and 150 ft) just about the early "Palouse" soil zone. This attenuation may be the result of perched ground water

above the early "Palouse" soil and Plio-Pleistocene unit. Baker et al. (1988) reported perched ground water under the 216-U-16 Crib resulted from crib activity. The 1976 gamma log on Well 299-W19-7 is not attenuated above the early "Palouse" soil.

A-1.4.7 216-U-17 Crib

The 216-U-17 Crib is located in the 200-UP-2 Operable Unit. Two wells, 299-W19-89 and 299-W19-90, are located within the 216-U-17 Crib structure. Six wells, 299-W19-19, 299-W19-20, 299-W19-23, 299-W19-24, 299-W19-25, and 299-W19-26, are located around the perimeter. Table A-1.1 provides details on the construction of wells used in this evaluation.

The 216-U-17 Crib has previously been evaluated by Brodeur (1988). Brodeur (1988) noted that there were significant changes from previous logs and that gamma emitting radionuclides have migrated and reached the groundwater. This AAMS evaluation differs from that of Brodeur (1988) in that radionuclide migration does not appear to be supported by the well logs.

Logs from several wells display a complex digitate pattern of relatively low intensity peaks from depths of about 6 to 27 m (20 to 90 ft) (Wells 299-W19-19, 299-W19-26, and 299-W19-24). These well logs are significantly different than previous logs on the same wells but the changes may be a result of changes in casings between logging dates. The highest recorded peak in any of the wells is the 307 ct/s recorded at a depth of 8.2 m (27 ft) in Well 299-W19-26.

With the exception of Wells 299-W19-89 and 299-W19-90 the logs used in this evaluation and the evaluation of Brodeur (1988) were obtained prior to the construction of the 216-U-17 Crib. If the peaks seen in these wells are the result of man-made radionuclides, their presence is not a result of 216-U-17 Crib activity.

1989 well logs for Wells 299-W19-89 and 299-W19-90 do not contain any significantly high gamma readings. These logs are from after crib activity started and are from wells located within the crib area.

A-1.4.8 216-U-14 Ditch

Gross gamma-ray logs were acquired in 1986 and 1987 from six wells in the 216-U-14 Ditch. Interpretation of those logs is difficult because no log sequences are available and wells are relatively shallow making correlation difficult.

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The log from Well 299-W19-93 has an especially distinct series of peaks between depths of 4.3 and 12 m (14 and 39 ft). Vertical migration of radionuclides may have been impeded at the interface of the Hanford formation Pasco gravels and underlying basal slack-water sequence located at a depth of about 20 m (65 ft). Distinct peaks are observable in that zone in several wells, particularly Wells 299-W19-21 and 299-W19-92.

A-1.4.9 216-U-10 Pond

One gross gamma-ray log was acquired from Well 299-W18-15 in 1986. That log shows surface contamination and a contaminated zone between depths of 5.8 and 7.9 m (19 and 26 ft).

A-1.4.10 U Plant

Gross gamma-ray logs have been acquired from the monitoring wells located in the vicinity of the U Plant. Logs from Wells 299-W19-28, 299-W19-29, and 299-W19-30, located south of the U Plant do not indicate any contaminated zones. The single log acquired in 1963 from Well 299-W19-4, located east of U Plant, shows minor peaks located at depths of 10 and 15 m (34 and 50 ft). Those peaks may represent natural radionuclides. Two logs were acquired from Well 299-W19-8, located along the northwest side of the U Plant. The log acquired in 1971 indicates significant surficial contamination and a zone with moderate gross gamma-ray intensity between depths of 5.2 and 7.9 m (17 and 26 ft). The latter peak is also present on the 1985 log.

A-1.4.11 241-U Tank Farm

Gross gamma-ray logs have been acquired from 53 vadose-zone monitoring wells located around the perimeters of each of the twelve 2,017,405 L (533,000-gal) tanks (numbers 241-U-101 through -112) and from six vadose-zone monitoring wells located outside the tank farm. Those logs have been collected by the Tank Farm Surveillance Group, often on a monthly basis, since about 1975. As discussed in Section A.1.2, the calibration curves have been made to relate the tank farm log response in ct/s to Roentgen/h.

Many of the 241-U Tank Farm logs show a pronounced increase in gross gamma-ray response below a depth of 15.5 to 16.4 m (51 to 54 ft). That increase is attributed to the interface between fill material and undisturbed sediment or it may represent the top of the basal slack-water sequence. The latter explanation is preferred considering that Price and Fecht (1976) reported that the fill depth in the 241-U Tank Farm is 12 m (39 ft).

Many of the logs display slightly increased gamma-ray responses near the surface. Logs from several wells display substantial near-surface gamma-ray responses. Those wells are near tanks 241-U-102 (60-02-01), -103 (60-03-08), -110 (60-10-07), -111 (60-11-03), and -112 (60-12-01). Deeper contamination is observed in logs from a larger number of wells, but located in three areas. Logs from wells located between tanks 241-U-104, -107, and -108 show a moderate gross gamma-ray peak of a depth of about 15.8 to 18.2 m (52 to 60 ft), which corresponds to the uppermost portion of the basal slack-water sequence. Tank 241-U-104 was the probable source of the leak. Logs from Well 60-10-07, located southwest of tank 241-U-110, show major gamma-ray responses at depths of 0 to 7.6 m (0 to 25 ft) and 15 to 18.2 m (50 to 60 ft). Logs from Well 60-12-01, located northeast of tank 241-U-112, show major gamma-ray responses at depths of 0 to 3 m (0 to 10 ft) and 15 to 30 m (50 to 100 ft), and perhaps deeper. Despite the magnitude of the gamma-ray response in the latter two wells, the radionuclides apparently did not migrate laterally a significant distance, because logs from adjacent wells are not affected.

Attempts were made to quantify vertical changes as a function of time for sequences of logs from many of the wells. Very few possible relationships were found to be statistically significant.

During the course of those calculations, it was discovered that there is a systematic increase with time in the depths to all recognizable zones, both natural and man-made, of about 0.06 m/yr (0.20 ft/yr). The explanation for that observation is not clear but are probably the result of logging techniques. This could include changes in instrumentation or logging protocols through time.

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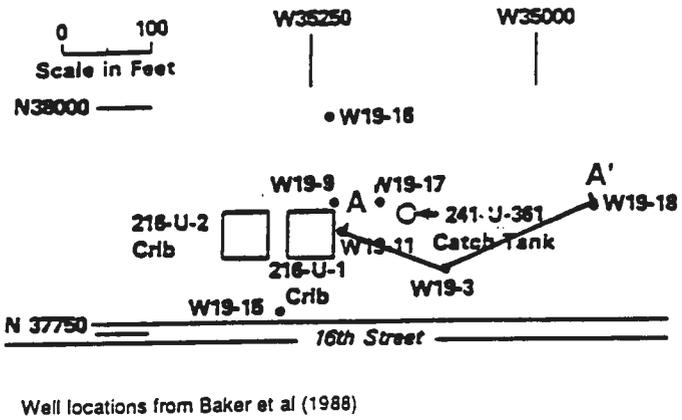
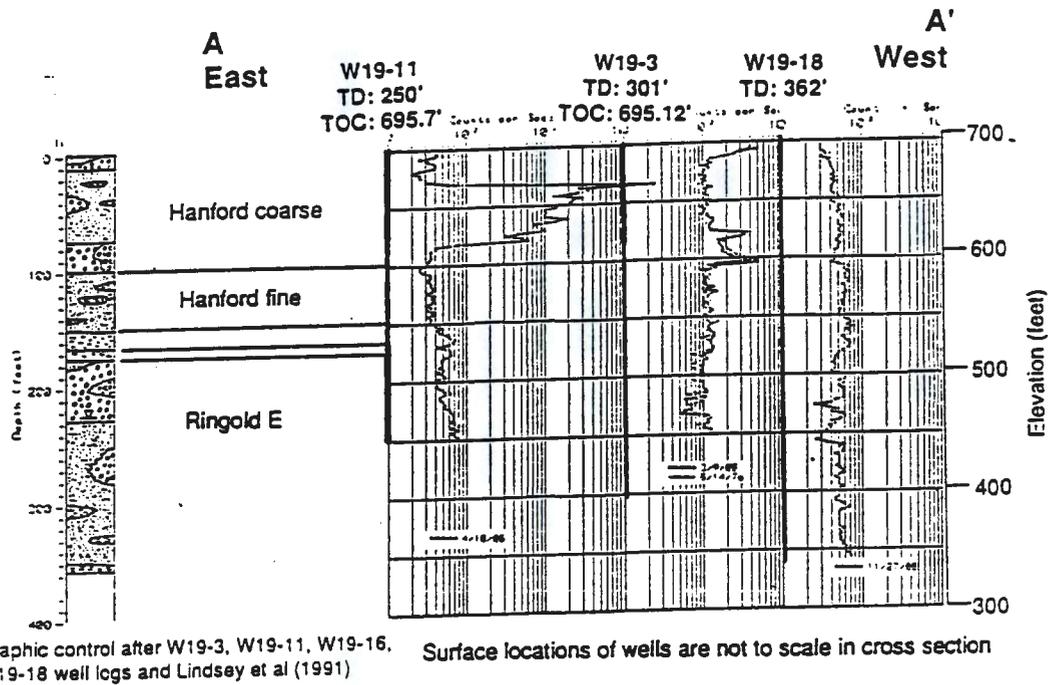


Figure A-1.1. Scintillation Probe Profile Cross-Section A-A' of the 216-U-1 and 216-U-2 Cribs.

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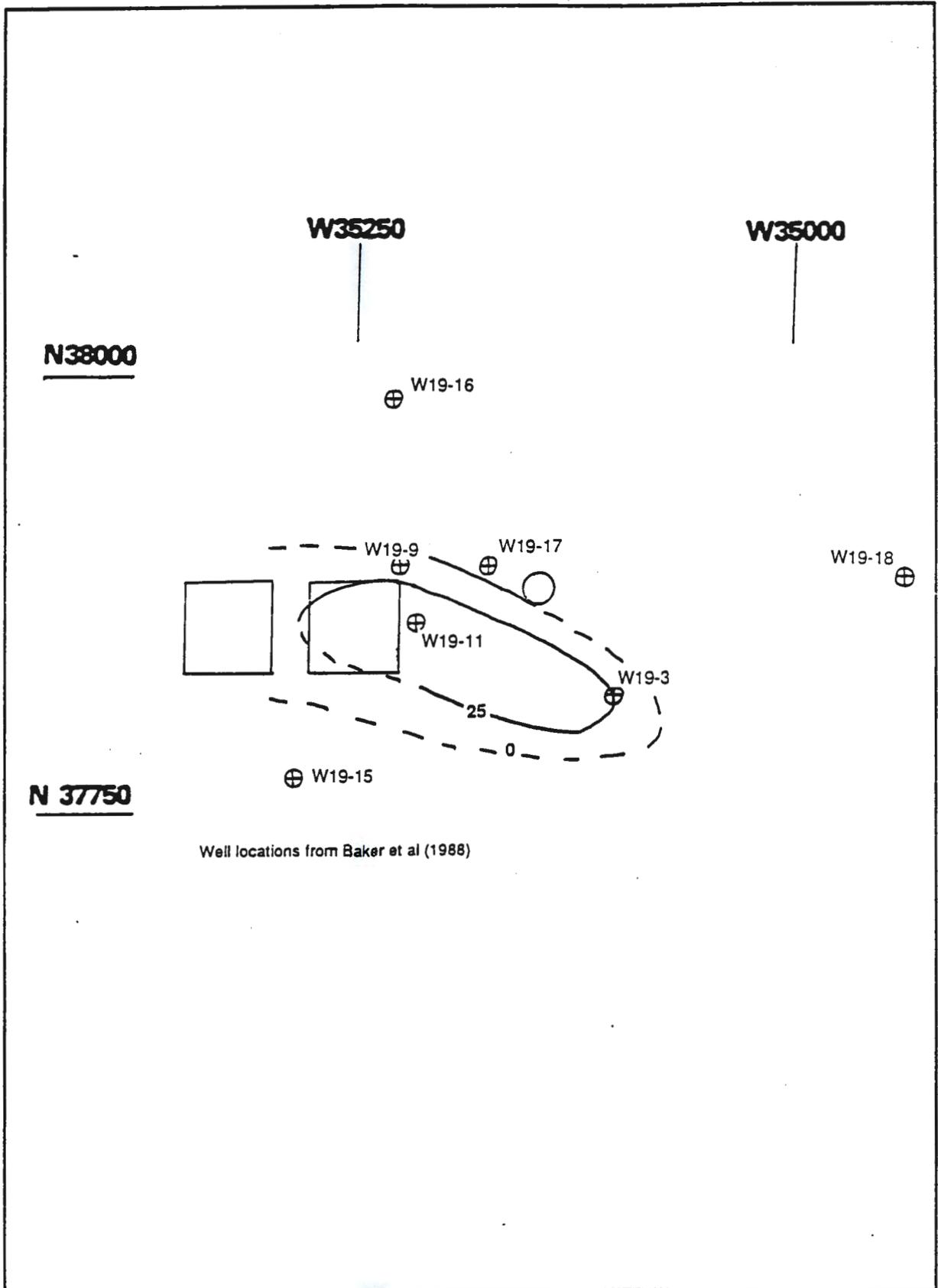


Figure A-1.2. Elevated Gamma Radiation Isopach Map of the 216-U-1 and 216-U-2 Cribs.

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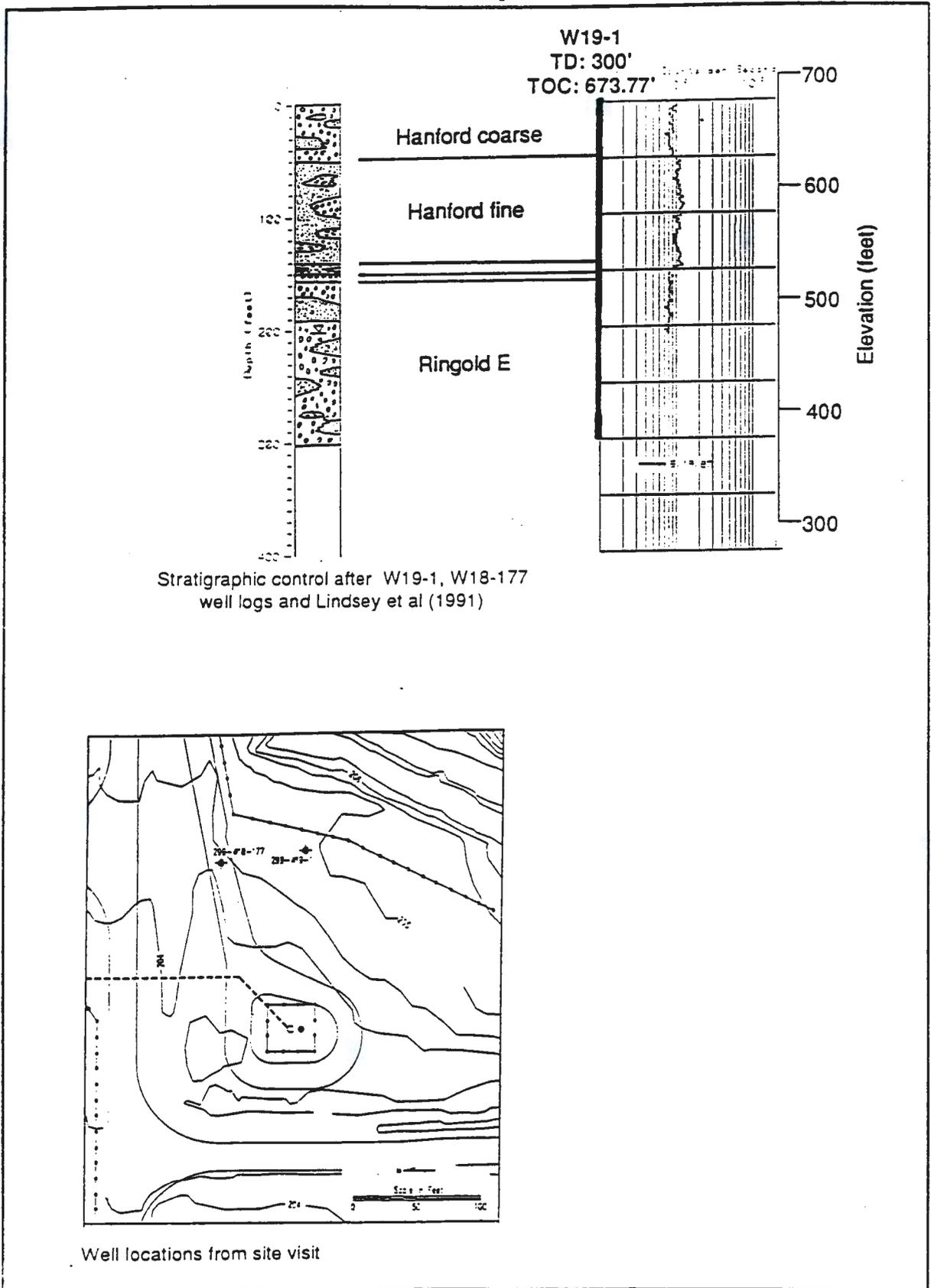


Figure A-1.3. Scintillation Probe Profile of Well 299-W19-1 at the 216-U-3 French Drain.

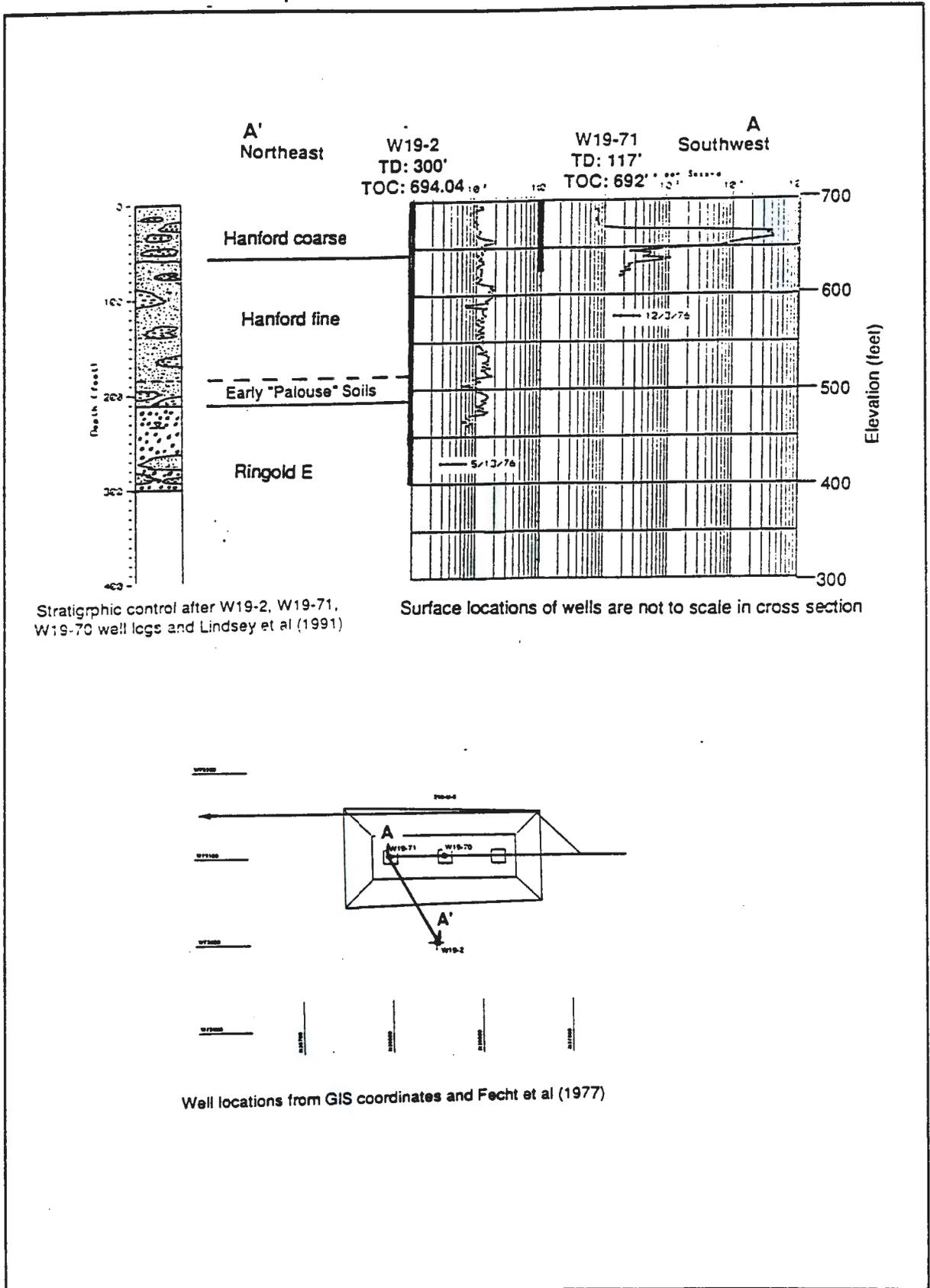


Figure A-1.4. Scintillation Probe Profile Cross-Section A-A' of the 216-U-8 Crib.

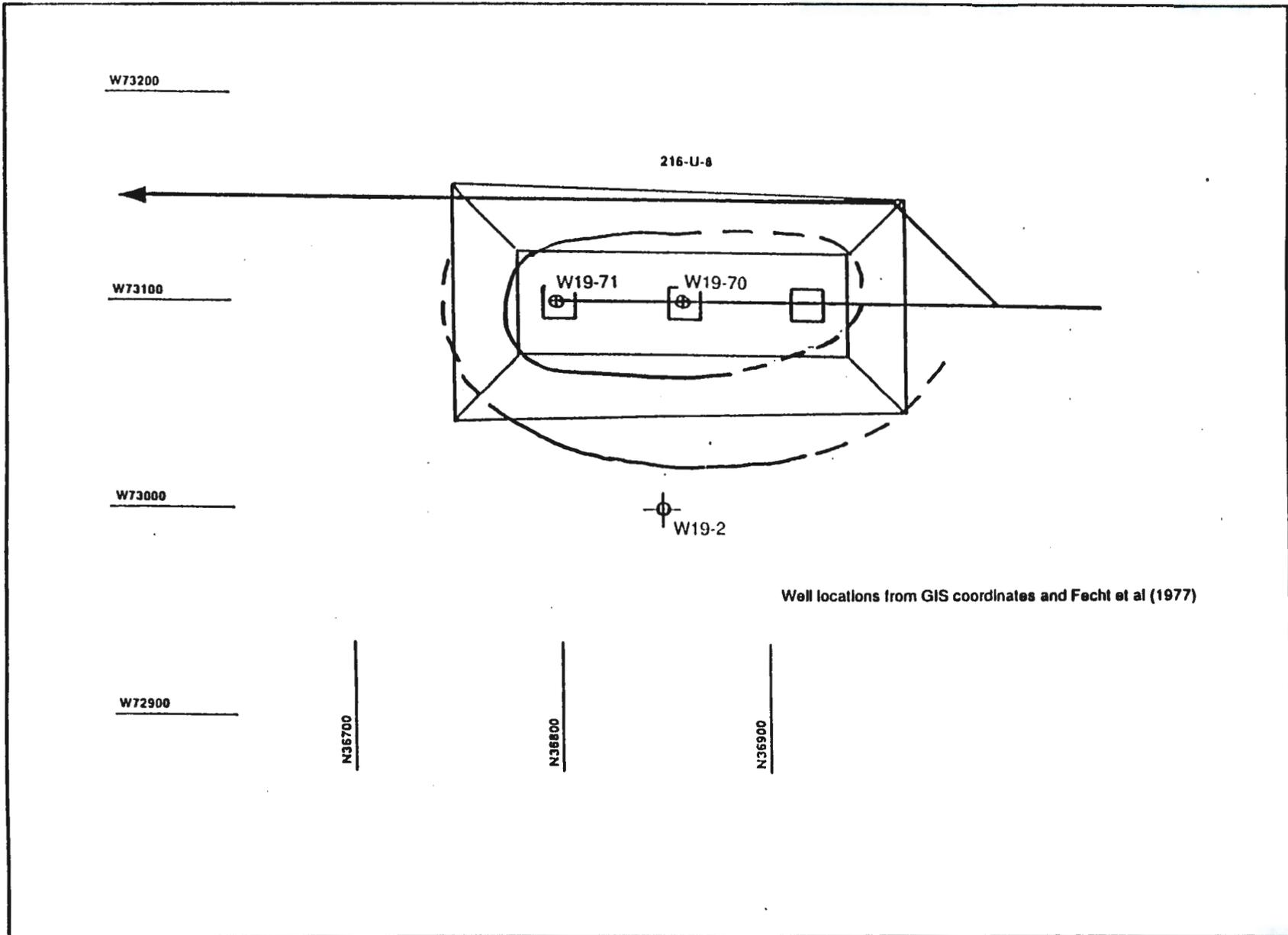


Figure A-1.5. Elevated Gamma Radiation Isopach Map of the 216-U-8 Crib.

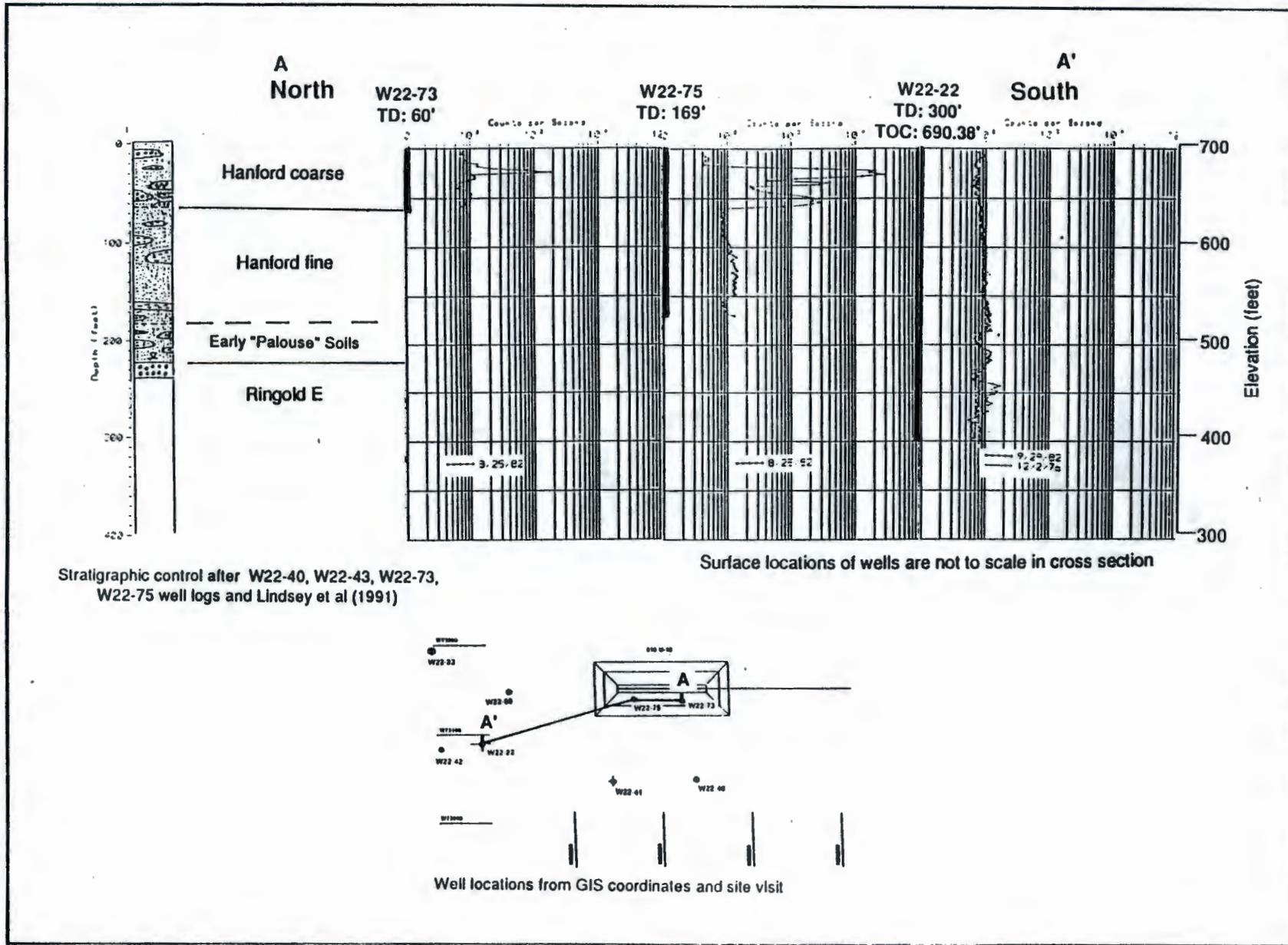
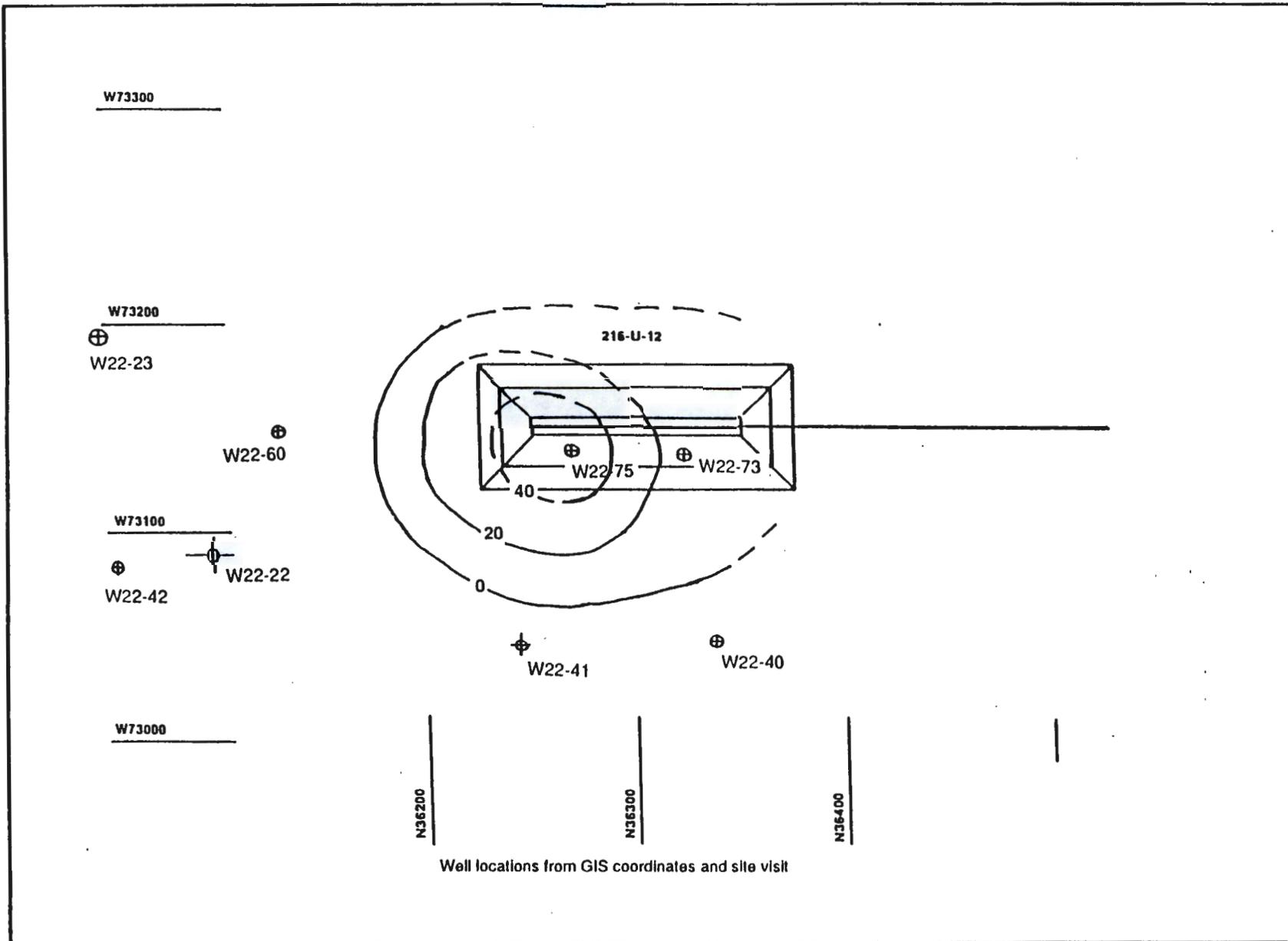


Figure A-1.6. Scintillation Probe Profile Cross-Section A-A' of the 216-U-12 Crib.

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Figure A-1.7. Elevated Gamma Radiation Isopach Map of the 216-U-12 Crib.

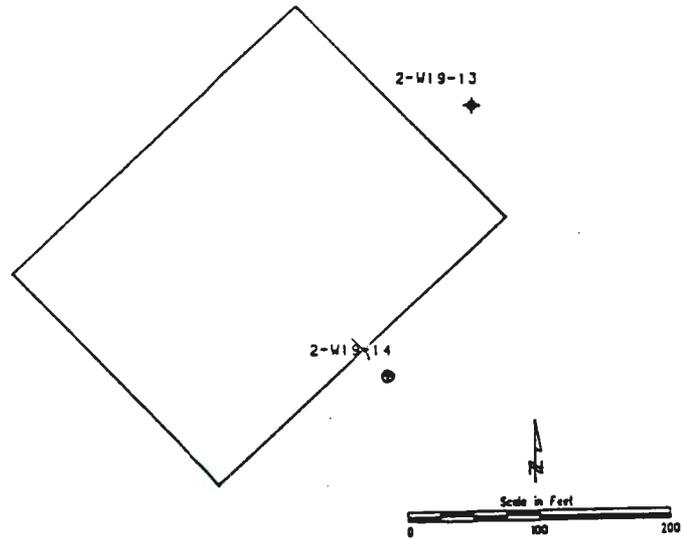
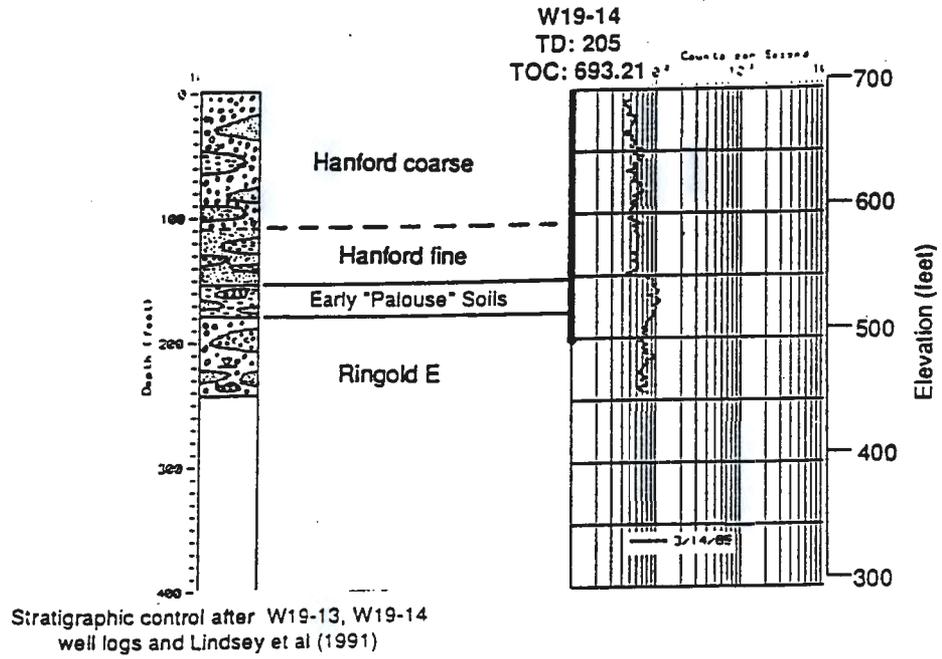


Figure A-1.8. Scintillation Probe Profile of Well 299-W19-14 at the 216-U-16 Crib.

9 8 1 2 7 3 1 9 0 2

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Table A-1.1. Details of Wells and Logs Used in Evaluations of Waste Management Units.

Well #	Northing	Westing	TOC	TD	Perforations	Logs Used
Details of Wells and Logs Used in Evaluation of WMU 216-S-21						
W23-4	35861	76335	662.82	300	180-300	2/28/58 5/7/63

Details of Wells and Logs Used in Evaluation of WMU 216-U-1 and 2

W19-3	37819	74098	695.12	301	230-280	2/28/58 7/24/59 5/6/63 7/15/65 2/23/68 2/2/70 2/18/70 5/14/76 * 3/9/85 * 4/18/85
W19-11	37860	74210	695.7	250	N/A	3/9/85 * 4/18/85
W19-9	37895	74225	693.77	302	263-302	3/9/85 5/9/85
W19-15	37775	74240	693.21	250	N/A	4/2/85 5/24/85
W19-16	37950	74230	694.96	285	N/A	4/15/85 4/20/85 5/24/85 6/12/85
W19-17	N/A	N/A	N/A	358	N/A	12/10/85
W19-18	N/A	N/A	N/A	362	N/A	11/27/85 *

Details of Wells and Logs Used in Evaluation of WMU 216-U-3

W18-177	37680	75500	N/A	89	N/A	6/24/86 9/6/87
W19-1	37613	75491	673.77	301	178-299	2/28/58 7/24/59 5/3/63 5/19/87

Details of Wells and Logs Used in Evaluation of WMU U-8

W19-2	36849	73000	694.04	300	235-295	7/24/59 5/6/63 7/2/65 2/16/68 3/26/70 5/13/76 *
W19-70	36860	73100	692	105	N/A	12/3/76 *
W19-71	36800	73100	692	117	N/A	12/3/76 *

Table A-1.1. Details of Wells and Logs Used in Evaluations of Waste Management Units.

Well #	Northing	Westing	TOC	TD	Perforations	Logs Used
Details of Wells and Logs Used in Evaluation of WMU 216-U-12						
W22-22	36094	73098	690.05	297	225-300	5/6/63 7/2/65 2/23/68 3/27/70 2/23/76 * 12/2/76 9/29/82 *
W22-23	36030	73198	690.7	231	200-300	5/6/63 7/2/65 2/23/68 5/13/76 8/25/82 *
W22-28	36150	73770	689	N/A	215-297	1/31/66 3/19/66 2/23/68
W22-60	36125	73150	689	30	N/A	7/22/60 2/23/68
W22-43	36339	73377	691.35	N/A	N/A	3/30/90 5/4/90
W22-42	36053	73080	691.16	N/A	N/A	3/5/90 4/27/90
W22-41	36142	73034	691.74	N/A	N/A	5/4/90
W22-40	36242	73042	692.23	N/A	N/A	3/30/90 5/4/90
W22-73 (06-12-02)	36339	73120	N/A	N/A	N/A	8/25/82 * 3/9/89
W22-75 (06-12-06)	36255	73145	N/A	N/A	N/A	8/25/82 * 3/9/89

Details of Wells and Logs Used in Evaluation of WMU U-16

W19-7	37000	74125	700	235	200-233	1/9/69 3/3/70 5/13/76
W19-13	37510	74180	695.08	250	N/A	3/14/85
W19-14	37300	74240	693.21	250	N/A	3/14/85 *

Details of Wells Used in Evaluation of WMU 216-U-17

W19-19	37569	72406	694.9	257	N/A	1/26/87
W19-20	37525	72252	691.04	252	N/A	6/2/86 * 6/17/86 *
W19-23	37499	72587	698.44	255	N/A	3/5/87 * 3/25/87 *
W19-24	37613	72588	696.95	255	N/A	3/12/87 * 4/16/87 *
W19-25	37575	72250	691.64	258	N/A	4/16/87
W19-26	37575	72250	691.64	248	N/A	4/7/87 * 4/16/87 *
W19-28	N/A	N/A	N/A	N/A	N/A	6/6/89 *
W19-89	37520	72390	693.85	160	N/A	2/5/87 3/9/89 3/28/89
W19-90	37553	73341	693.21	159	N/A	2/5/87 1/17/89 3/9/89

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**Table A-1.1. Details of Wells and Logs Used in
Evaluations of Waste Management Units.**

Page 3 of 3

Well #	Northing	Westing	TOC	TD	Perforations	Logs Used
Details of Wells and Logs Used in Evaluation of U Building						
W19-4	39000	71999	715.26	550	255-535	5/6/63
W19-8	38574	73268	700	585	N/A	9/22/71 4/5/85
W19-28	N/A	N/A	N/A	N/A	N/A	6/6/89 11/6/89
W19-29	N/A	N/A	N/A	N/A	N/A	6/27/89 11/6/89

Details of Wells and Logs Used in Evaluation of U-14 Ditch						
W19-21	37462	75273	678.53	226	N/A	6/2/86 7/8/86
W19-22	37628	74798	687.89	140	N/A	6/2/86 6/17/86
W19-27	37629	75072	683.65	230	N/A	4/24/87
W19-91	37617	75269	677.9	150	N/A	4/7/87
W19-92	37492	75319	677.9	150	N/A	4/7/87
W19-93	37289	75431	677.43	120	N/A	5/19/87

Details of Wells and Logs Used in Evaluation of U-10 Pond						
W18-15	36990	77152	660.76	243	170-243	9/23/86

* Digitized Logs

Source: Westinghouse GIS Listing of Well Statistics

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Table A-1.2. U-Tank Farm Gamma-ray Logs Examined. Page 1 of 5

Waste Management Unit	Well Number	Log Date	Log Type	
241-U Tank Farm Perimeter	299-W18-25	10/29/90	4c	
		11/29/90	4c	
	299-W19-31	10/22/90	4c	
		12/6/90	4c	
	299-W19-32	10/17/90	4c	
		11/13/90	4c	
	299-W18-51 (60-00-06)	5/8/63	3a	
	299-W18-52 (60-00-11)	5/8/63	3a	
	299-W18-53 (60-00-10)	5/8/63	3a	
	299-W18-55 (60-00-08)	5/8/63	3a	
	299-W19-53A (60-00-05)	5/8/63	3a	
	299-W19-54A (60-00-02)	5/8/63	3a	
	241-U-101 Tank	299-W18-135 (60-01-08)	--	5c
		299-W18-36 (60-01-10)	--	5c
241-U-102 Tank	299-W18-137 ^{a/} (60-02-01)	--	5c	
	299-W18-138 ^{a/} (60-02-05)	--	5c	
	299-W18-139 ^{a/} (60-02-07)	--	5c	
	299-W18-140 ^{a/} (60-02-08)	--	5c	
	299-W18-141 ^{a/} (60-02-10)	--	5c	
	299-W18-142 ^{a/} (60-02-11)	--	5c	
	241-U-103 Tank	299-W18-143 ^{a/} (60-03-01)	--	5c

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Table A-1.2. U-Tank Farm Gamma-ray Logs Examined. Page 2 of 5

Waste Management Unit	Well Number	Log Date	Log Type
	299-W18-144 ^{a/} (60-03-05)	--	5c
	299-W18-145 ^{a/} (60-03-08)	--	5c
	299-W18-146 ^{a/} (60-03-10)	--	5c
	299-W18-147 ^{a/} (60-03-11)	--	5c
241-U-104 Tank	299-W18-76 ^{a/} (60-04-03)	--	5c
	299-W18-124 ^{a/} (60-04-08)	--	5c
	299-W18-125 ^{a/} (60-04-10)	--	5c
	299-W18-126 ^{a/} (60-04-12)	--	5c
241-U-105 Tank	299-W18-127 ^{a/} (60-05-05)	--	5c
	299-W18-128 ^{a/} (60-05-07)	--	5c
	299-W18-129 ^{a/} (60-05-10)	--	5c
	299-W18-130 ^{a/} (60-05-04)	--	5c
	299-W18-176 ^{a/} (60-05-04)	--	5c
241-U-106 Tank	299-W18-131 ^{a/} (60-06-07)	--	5c
	299-W18-132 ^{a/} (60-06-08)	--	5c
	299-W18-133 ^{a/} (60-06-10)	--	5c
	299-W18-134 ^{a/} (60-06-11)	--	5c
241-U-107 Tank	299-W18-114 ^{a/} (60-07-01)	--	5c

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Table A-1.2. U-Tank Farm Gamma-ray Logs Examined. Page 3 of 5

Waste Management Unit	Well Number	Log Date	Log Type
241-U-108 Tank	299-W18-116 ^{u/} (60-07-10)	--	5c
	299-W18-117 ^{u/} (60-07-11)	--	5c
	299-W19-74 ^{u/} (60-07-02)	--	5c
	299-W18-54 ^{u/+} (60-08-10)	5/8/63	5c
	299-W18-115 ^{u/} (60-08-04)	--	5c
241-U-109 Tank	299-W18-118 ^{u/} (60-08-08)	--	5c
	299-W18-119 ^{u/} (60-08-09)	--	5c
	299-W18-120 ^{u/} (60-09-01)	--	5c
	299-W18-121 ^{u/} (60-09-07)	--	5c
241-U-110 Tank	299-W18-122 ^{u/} (60-09-08)	--	5c
	299-W18-123 ^{u/} (60-09-10)	--	5c
	299-W18-100 ^{u/} (60-10-01)	--	5c
	299-W18-104 ^{u/} (60-10-05)	--	5c
	299-W18-107 ^{u/} (60-10-11)	--	5c
241-U-111 Tank	299-W18-148 ^{u/} (60-10-07)	--	5c
	299-W19-75 ^{u/} (60-10-02)	--	5c
	299-W18-101 ^{u/} (60-11-06)	--	5c
	299-W18-102 ^{u/} (60-11-03)	--	5c

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Table A-1.2. U-Tank Farm Gamma-ray Logs Examined. Page 4 of 5

Waste Management Unit	Well Number	Log Date	Log Type
241-U-112 Tank	299-W18-105 ^{a/} (60-11-12)	--	5c
	299-W18-109 ^{a/} (60-11-05)	--	5c
	299-W18-110 ^{a/} (60-11-07)	--	5c
	299-W18-90 ^{a/} (60-12-07)	--	5c
	299-W18-91 ^{a/} (60-12-10)	--	5c
	299-W18-92 ^{a/} (60-12-05)	--	5c
	299-W18-103 ^{a/} (60-12-03)	--	5c
	299-W18-113 ^{a/} (60-12-01)	--	5c

* Used by Fecht et al. (1977)

+ Also logged by WHC Tank Surveillance Group.

^{a/} For each of these wells, logs from every one or two years have been collected.

Types of Natural Gamma-ray Logs (designated in "Log Type" column)

1. Battelle PNL, circa 1954-1955 (none for U Plant)
2. Battelle PNL, circa 1958-1959; Esterline-Angus Co., Inc., chart recorder
3. Battelle PNL, circa 1963-1971; video chart recorder
 - a. circa 1963-1965
 - b. circa 1966-1971, improvements in electronics
4. Battelle PNL, circa 1976-present
 - a. circa 1976; probe serial no. NG 001
 - b. circa 1982-1987; probe serial no. NG 001
 - c. circa 1985-present; probe serial no. CG 27A97
5. WHC Tank Farm Surveillance Group, circa 1975-present
 - a. Probe 1 (also called GM-1 or green Geiger-Mueller probe); unshielded Geiger-Mueller probe
 - b. Probe 2 (also called GM-2 or red Geiger-Mueller probe); shielded Geiger-Mueller probe
 - c. Probe 4 (also called S probe); unshielded scintillation probe
 - d. Probe 14 (also called SS probe); shielded scintillation probe (not used in U Plant)

APPENDIX A.2
SAMPLE DATA

9 3 1 2 7 3 0 9 5 1

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TABLES:

A-2.1 Results of Grid Soil Sampling	A2T-1
A-2.2 Results of Fenceline Soil Sampling	A2T-2
A-2.3 Results of Vegetation Sampling	A2T-3
A-2.4 Results of Air Monitoring	A2T-4

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Table A-2.1. Results of Grid Soil Sampling (pCi/g).

Location 2W18											
Radionuclide	1985		1986		1987		1988		1989		Average Result
	Result	Error	Result	Error	Result	Error	Result	Error	Result	Error	
Ce-141	--	--	--	--	--	--	--	--	--	--	--
Ce-144	--	--	--	--	--	--	--	--	--	--	--
Co-58	--	--	--	--	--	--	--	--	--	--	--
Co-60	--	--	--	--	--	--	2.6E-04	1.5E-02	--	--	2.60E-04
Cs-134	--	--	6E-02	3E-02+	--	--	--	--	--	--	6.00E-02
Cs-137	1.74E+00	1.8E-01+	1.79E+00	2.0E-01+	--	--	1.5E+00	1.6E-01+	--	--	1.68E+00
Eu-152	--	--	--	--	--	--	9.9E-02	7.7E-02+	--	--	9.90E-02
Eu-154	--	--	--	--	--	--	1.7E-02	5.0E-02	--	--	1.70E-02
Eu-155	--	--	--	--	--	--	1.3E-02	5.1E-02	--	--	1.30E-02
I-129	--	--	--	--	--	--	--	--	--	--	--
K-40	--	--	--	--	--	--	--	--	--	--	--
Mn-54	--	--	2E-02	0E+00	--	--	2.4E-03	1.4E-02	--	--	1.12E-02
Nb-95	--	--	--	--	--	--	-8.8E-03	1.7E-02	--	--	-8.80E-03
Pb-212	--	--	--	--	--	--	--	--	--	--	--
Pb-214	--	--	--	--	--	--	5.7E-01	7.7E-02+	--	--	5.70E-01
Pu-238	1.61E-02	2.1E-03+	9.4E-03	1.6E-03+	--	--	1.2E-02	1.5E-03+	--	--	1.25E-02
Pu-239	8.1E-01	7E-02+	4.8E-01	5E-02+	6.8E-03	1.2E-03+	6.9E-01	6.7E-02+	--	--	6.62E-01
Ru-106	--	--	2.1E-01	1.8E-01+	--	--	-3.4E-03	1.3E-01	--	--	1.03E-01
Sr-90	4.3E-01	8.3E-02+	2.3E-01	4.6E-02+	--	--	1.5E-01	3.1E-02+	--	--	2.7E-01
Tc-99	--	--	--	--	--	--	--	--	--	--	--
U	3.1E-01	1.1E-01+	3.9E-01	1.3E-01+	--	--	3.0E-01	9.3E-02+	--	--	3.3E-01
Zn-65	--	--	--	--	--	--	--	--	--	--	--
Zr-95	--	--	--	--	--	--	-1.7E-03	2.7E-02	--	--	-1.70E-03

+ Indicates positive detection (result greater than error).
 Source: Schmidt et al. 1990; Elder et al. 1986, 1987, 1988, 1989.

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0 5 1 1 7 3 1 9 1 1

Table A-2.1. Results of Grid Soil Sampling (pCi/g).

Location 2W21											
Radionuclide	1985		1986		1987		1988		1989		Average Result
	Result	Error	Result	Error	Result	Error	Result	Error	Result	Error	
Ce-141	--	--	--	--	2.5E-02	3.8E-02	--	--	--	--	2.5E-02
Ce-144	--	--	--	--	1.1E-01	8.8E-02+	--	--	--	--	1.1E-01
Co-58	--	--	4E-02	2E-02+	9.0E-03	1.6E-02	--	--	--	--	2.5E-02
Co-60	4.0E-02	3.0E-02+	--	--	-1.0E-02	1.9E-02	4.0E-03	1.1E-02	--	--	1.1E-02
Cs-134	--	--	2E-02	2E-02	4.9E-02	2.0E-02+	--	--	--	--	3.5E-02
Cs-137	1.4E+00	1.7E-01+	6.3E-01	8.E-02+	4.8E-01	6.0E-02+	7.9E-01	9.0E-02+	--	--	8.1E-01
Eu-152	--	--	--	--	-1.2E-02	8.7E-02	9.4E-02	6.7E-02+	--	--	4.1E-02
Eu-154	--	--	--	--	-8.0E-02	5.9E-02	-2.1E-02	4.8E-02	--	--	-5.1E-02
Eu-155	--	--	9E-02	7E-02+	4.3E-02	5.0E-02	3.2E-02	4.9E-02	--	--	5.5E-02
I-129	--	--	--	--	--	--	--	--	--	--	--
K-40	--	--	--	--	--	--	--	--	--	--	--
Mn-54	--	--	3E-02	2E-02+	8.8E-03	1.7E-02	3.4E-03	1.2E-02	--	--	2.4E-02
Nb-95	--	--	--	--	--	--	-2.7E-02	1.7E-02	--	--	-2.7E-02
Pb-212	--	--	--	--	--	--	--	--	--	--	--
Pb-214	--	--	--	--	--	--	5.6E-01	7.7E-02+	--	--	5.6E-01
Pu-238	7.5E-03	1.3E-03+	4E-04	3E-04+	6.5E-04	3.9E-04+	1.2E-03	3.5E-04+	--	--	2.4E-03
Pu-239	1.1E-01	1.0E-02+	2.0E-02	0.0E+00+	1.4E-02	2.3E-03+	3.2E-02	3.5E-03+	--	--	4.4E-02
Ru-106	--	--	--	--	-1.3E-01	1.5E-01	-7.2E-02	1.2E-01	--	--	-1.0E-01
Sr-90	7.8E-01	1.4E-01+	2.1E-01	5.E-02+	1.5E-01	4.0E-02+	1.9E-01	3.7E-02+	--	--	3.3E-01
Tc-99	--	--	--	--	--	--	--	--	--	--	--
U	3.8-01	1.3E-01+	2E-01	7E-02+	1.9E-01	5.9E-02+	2.7E-01	8.5E-02+	--	--	2.6E-01
Zn-65	1.0E-01	9.0E-02+	--	--	-3.2E-02	4.3E-02	--	--	--	--	3.4E-02
Zr-95	--	--	5E-02	53-02	8.7E-03	3.6E-02	8.1E-03	2.4E-02	--	--	2.E-02

+ Indicates positive detection (result greater than error).
 Source: Schmidt et al. 1990; Elder et al. 1986, 1987, 1988, 1989.

A2T-1b

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Table A-2.1. Results of Grid Soil Sampling (pCi/g).

Location 2W22											
Radionuclide	1985		1986		1987		1988		1989		Average Result
	Result	Error	Result	Error	Result	Error	Result	Error	Result	Error	
Ce-141	--	--	--	--	--	--	--	--	--	--	--
Ce-144	--	--	--	--	--	--	--	--	--	--	--
Co-58	--	--	--	--	--	--	--	--	--	--	--
Co-60	3.0E-02	2E-02+	--	--	--	--	-1.1E-02	1.8E-02	--	--	9.5E-03
Cs-134	--	--	3E-02	3E-02	--	--	--	--	--	--	3.0E-02
Cs-137	1.45E+00	1.6E-01+	8.3E-01	1.03-01+	--	--	1.0E+00	1.1E-01+	--	--	1.1E+00
Eu-152	2.0E-01	1.3E-01+	--	--	--	--	8.3E-02	7.6E-02+	--	--	1.4E-01
Eu-154	--	--	--	--	--	--	1.8E-02	5.1E-02	--	--	1.8E-02
Eu-155	--	--	--	--	--	--	4.5E-02	5.7E-02	--	--	4.5E-02
I-129	--	--	--	--	--	--	--	--	--	--	--
K-40	--	--	--	--	--	--	--	--	--	--	--
Mn-54	--	--	--	--	--	--	-2.4E-03	1.6E-02	--	--	-2.4E-03
Nb-95	--	--	--	--	--	--	-1.7E-02	1.9E-02	--	--	-1.7E-02
Pb-212	--	--	--	--	--	--	--	--	--	--	--
Pb-214	--	--	--	--	--	--	6.5E-01	8.6E-02+	--	--	6.5E-01
Pu-238	3.6E-03	9E-04+	1.8E-03	6E-04+	--	--	2.4E-03	5.2E-04+	--	--	2.6E-03
Pu-239	7E-02	1E-02+	3E-02	0.0E+00	--	--	7.2E-02	7.5E-03+	--	--	5.7E-02
Ru-106	4.4E-01	3.1E-01+	--	--	--	--	1.7E-02	1.4E-01	--	--	2.E3-01
Sr-90	9.4E-01	1.7E-01+	5E-01	1.0E-01+	--	--	4.6E-01	8.7E-02+	--	--	6.3E-01
Tc-99	--	--	--	--	--	--	--	--	--	--	--
U	3.1E-01	1.1E-01+	3.9E-01	1.3E-01+	--	--	3.5E-01	1.1E-01+	--	--	3.5E-01
Zn-65	--	--	--	--	--	--	--	--	--	--	--
Zr-95	--	--	--	--	--	--	3.4E-02	2.9E-02+	--	--	3.4E-02

+ Indicates positive detection (result greater than error).
 Source: Schmidt et al. 1990; Elder et al. 1986, 1987, 1988, 1989.

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Table A-2.1. Results of Grid Soil Sampling (pCi/g).

Radio-nuclide	Location 2W23										Average Result
	1985		1986		1987		1988		1989		
	Result	Error	Result	Error	Result	Error	Result	Error	Result	Error	
Ce-141	--	--	--	--	-1.5E-01	1.1E-01	--	--	-3.92E-03	2.09E-01	-7.70E-02
Ce-144	--	--	--	--	2.0E-01	2.7E-01	--	--	8.80E-02	2.66E-01	1.44E-01
Co-58	--	--	8E-02	3E-02+	-6.4E-03	2.1E-02	--	--	1.59E-03	2.49E-02	2.51E-02
Co-60	--	--	7E-02	4E-02+	6.0E-03	2.3E-02	4.0E-02	1.7E-02+	2.42E-02	1.92E-02+	3.51E-02
Cs-134	7E-02	4E-02+	4E-02	3E-02+	5.0E-02	2.3E-02+	--	--	-1.06E-01	4.03E-02	1.35E-02
Cs-137	7.68E+01	4.72E+00+	5.77E+01	5.80E+00+	4.2E+01	4.2E+00+	6.5E+01	6.5E+00+	5.80E+01	5.81E+00+	5.99E+01
Eu-152	--	--	--	--	4.9E-02	9.2E-02	4.1E-02	6.7E-02	2.75E-02	7.94E-02	3.92E-02
Eu-154	1.4E-01	9E-02+	--	--	1.5E-02	6.0E-02	3.4E-02	5.8E-02	6.66E-02	5.25E-02+	6.39E-02
Eu-155	--	--	--	--	-4.3E-02	1.6E-01	-5.6E-03	1.8E-01	-1.41E-02	1.27E-01	-2.09E-02
I-129	--	--	--	--	--	--	--	--	1.81E-01	6.06E-01	1.81E-01
K-40	--	--	--	--	--	--	--	--	1.44E+01	1.59E+00+	1.44E+01
Mn-54	--	--	--	--	1.1E-02	1.6E-02	-3.6E-03	1.6E-02	1.15E-02	1.87E-02	6.30E-03
Nb-95	--	--	--	--	--	--	-5.4E-03	1.9E-02	-6.68E-02	6.75E-02	-3.61E-02
Pb-212	--	--	--	--	--	--	--	--	6.38E-01	1.07E-01+	6.38E-01
Pb-214	--	--	--	--	--	--	6.9E-01	1.5E-01+	5.42E-01	1.19E-01+	6.16E-01
Pu-238	1.28E-02	2.0E-03+	2.49E-02	8.1E-03+	1.9E-02	4.1E-03+	2.5E-02	2.9E-03+	2.87E-02	3.33E-03+	2.21E-02
Pu-239	6.3E-01	5.8E-02+	1.68E+00	1.8E-01+	1.1E+00	1.1E-01+	1.4E+00	1.3E-01+	1.53E+00	1.53E-01+	1.27E+00
Ru-106	--	--	--	--	-4.3E-01	3.9E-01	-2.0E-02	4.0E-01	-7.18E-02	4.02E-01	-1.74E-01
Sr-90	4.9E-01	9.7E-02+	1.59E+00	2.9E-01+	2.3E+00	5.8E-01+	1.5E+00	3.0E-01+	1.54E+00	3.22E-01+	1.48E+00
Tc-99	--	--	--	--	--	--	--	--	2.35E-01	1.17E+00	2.35E-01
U	4.6E-01	1.5E-01+	4.2E-01	1.4E-01+	3.5E-01	1.0E-01+	4.2E-01	1.3E-01+	5.57E-01	1.63E-01+	4.41E-01
Zn-65	--	--	--	--	-1.8E-02	4.8E-02	--	--	-8.63E-02	5.25E-02	-5.22E-02
Zr-95	2.5E-01	1.1E-01+	--	--	-1.2E-02	4.1E-02	2.1E-02	2.8E-02	2.78E-02	5.58E-02	7.17E-02

+ Indicates positive detection (result greater than error).

Source: Schmidt et al. 1990; Elder et al. 1986, 1987, 1988, 1989.

Table A-2.1. Results of Grid Soil Sampling (pCi/g).

Radio-nuclide	Location 2W24										Average Result
	1985		1986		1987		1988		1989		
	Result	Error	Result	Error	Result	Error	Result	Error	Result	Error	
Ce-141	--	--	--	--	-1.2E-02	4.0E-02	--	--	-7.39E-02	7.83E-02	-4.30E-02
Ce-144	--	--	--	--	-1.6E-02	1.1E-01	--	--	-1.66E-02	9.22E-02	-1.63E-02
Co-58	9E-02	7E-02+	--	--	-3.7E-03	1.9E-02	--	--	-5.96E-03	2.52E-02	2.68E-02
Co-60	--	--	--	--	-5.0E-03	1.8E-02	1.7E-02	1.4E-02+	2.89E-03	1.50E-02	4.96E-03
Cs-134	--	--	5E-02	3E-02+	5.1E-02	2.0E-02+	--	--	-6.03E-02	1.80E-02	1.36E-02
Cs-137	2.45E+00	2.4E-01+	2.78E+00	3.0E-01+	2.5E+00	2.6E-01+	1.3E+00	1.4E-01+	1.0E+00	1.13E-01+	2.01E+00
Eu-152	--	--	1.3E-01	1.0E-01+	-2.9E-02	9.6E-02	1.4E-01	6.7E-02+	1.74E-02	7.65E-02	6.46E-02
Eu-154	2.4E-01	1.7E-01+	--	--	-2.7E-02	5.8E-02	-7.4E-03	5.3E-02	1.16E-02	4.53E-02	5.43E-02
Eu-155	--	--	--	--	2.2E-03	6.7E-02	7.2E-02	5.8E-02+	-2.75E-03	4.79E-02	2.38E-02
I-129	--	--	--	--	-7.1E-02	3.2E-01	--	--	2.76E-01	2.85E-01	1.03E-01
K-40	--	--	--	--	--	--	--	--	1.36E+01	1.51E+00+	1.36E+01
Mn-54	1.2E-01	5E-02+	--	--	-5.5E-03	1.7E-02	1.9E-02	1.6E-02+	1.08E-02	1.59E-02	3.61E-02
Nb-95	1.9E-01	1.1E-01+	--	--	--	--	7.3E-03	2.0E-02	-6.24E-02	5.77E-02	4.50E-02
Pb-212	--	--	--	--	--	--	--	--	6.98E-01	7.95E-02+	6.98E-01
Pb-214	--	--	--	--	--	--	6.4E-01	8.4E-02+	6.09E-01	7.90E-02+	6.25E-01
Pu-238	1.5E-03	5E-04+	2.0E-03	7E-04+	1.2E-03	4.2E-04+	1.3E-03	4.2E-04+	6.61E-04	3.47E-04+	1.33E-03
Pu-239	6E-02	1E-02+	6E-02	1E-02+	5.0E-02	5.7E-03+	4.6E-02	5.3E-03+	4.49E-02	5.62E-03+	5.22E-02
Ru-106	--	--	--	--	8.9E-02	1.8E-01	-2.8E-02	1.3E-01	1.30E-01	1.50E-01	6.37E-02
Sr-90	7.6E-01	1.4E-01+	5.1E-01	1.0E-01+	2.1E-01	5.4E-02+	2.8E-01	5.5E-02+	1.65E-01	3.46E-02+	3.85E-01
Tc-99	--	--	--	--	4.4E-01	1.1E+00	--	--	1.60E-01	1.17E+00	3.00E-01
U	--	--	7.5E-01	2.5E-01+	1.1E+00	2.9E-01+	8.3E-01	2.4E-01+	8.26E-01	2.34E-01+	8.77E-01
Zn-65	--	--	--	--	-3.7E-02	4.2E-02	--	--	-1.45E-01	5.36E-02	-9.10E-02
Zr-95	--	--	--	--	-2.3E-02	4.1E-02	-6.1E-03	2.9E-02	-5.69E-03	5.36E-02	-1.16E-02

+ Indicates positive detection (result greater than error).

Source: Schmidt et al. 1990; Elder et al. 1986, 1987, 1988, 1989.

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Table A-2.1. Results of Grid Soil Sampling (pCi/g).

Location 2W25											
Radionuclide	1985		1986		1987		1988		1989		Average Result
	Result	Error	Result	Error	Result	Error	Result	Error	Result	Error	
Ce-141	--	--	--	--	-2.2E-02	3.1E-02	--	--	--	--	-2.20E-02
Ce-144	--	--	--	--	-4.7E-02	8.7E-02	--	--	--	--	-4.70E-02
Co-58	--	--	--	--	1.9E-02	1.2E-02+	--	--	--	--	1.90E-02
Co-60	--	--	--	--	1.6E-02	1.5E-02+	-2.7E-02	1.8E-02	--	--	-5.50E-03
Cs-134	--	--	--	--	2.7E-02	1.6E-02+	--	--	--	--	2.70E-02
Cs-137	8.8E-01	1.2E-01+	--	--	8.1E-01	9.1E-02+	5.3E-01	6.7E-02+	--	--	7.40E-01
Eu-152	1.2E-01	1.1E-01+	--	--	1.2E-01	6.1E-02+	7.0E-02	7.3E-02	--	--	1.03E-01
Eu-154	1.5E-01	1.1E-01+	--	--	7.7E-03	4.5E-02	3.8E-02	5.2E-02	--	--	6.52E-02
Eu-155	--	--	--	--	6.4E-02	4.2E-02+	6.7E-03	6.0E-02	--	--	3.54E-02
I-129	--	--	--	--	--	--	--	--	--	--	--
K-40	--	--	--	--	--	--	--	--	--	--	--
Mn-54	4.0E-02	4.0E-02	--	--	1.6E-02	1.3E-02+	1.4E-02	1.7E-02	--	--	2.33E-02
Nb-95	--	--	--	--	--	--	-1.1E-02	2.1E-02	--	--	-1.10E-02
Pb-212	--	--	--	--	--	--	--	--	--	--	--
Pb-214	--	--	--	--	--	--	5.7E-01	8.3E-02+	--	--	5.70E-01
Pu-238	1.1E-03	5E-04+	--	--	7.6E-04	3.3E-04+	5.2E-04	2.7E-04+	--	--	7.93E-04
Pu-239	3.0E-02	1.0E-02+	--	--	2.9E-02	3.5E-03+	2.1E-02	2.7E-03+	--	--	2.67E-02
Ru-106	--	--	--	--	-1.4E-02	1.1E-01	3.1E-02	1.0E-01	--	--	8.50E-03
Sr-90	5.2E-01	1.0E-01+	--	--	3.1E-01	7.8E-02+	1.9E-01	3.8E-02+	--	--	3.40E-01
Tc-99	--	--	--	--	--	--	--	--	--	--	--
U	6.9E-01	2.1E-01+	--	--	8.4E-01	2.3E-01+	5.9E-01	1.7E-01+	--	--	7.07E-01
Zn-65	--	--	--	--	-3.1E-02	3.3E-02	--	--	--	--	-3.10E-02
Zr-95	--	--	--	--	4.0E-02	2.7E-02+	-6.0E-03	3.2E-02	--	--	1.70E-02

+Indicates positive detection (result greater than error).

Source: Schmidt et al. 1990; Elder et al. 1986, 1987, 1988, 1989.

Table A-2.1. Results of Grid Soil Sampling (pCi/g).

Location 2W26											
Radionuclide	1985		1986		1987		1988		1989		Average Result
	Result	Error	Result	Error	Result	Error	Result	Error	Result	Error	
Ce-141	--	--	--	--	--	--	--	--	--	--	--
Ce-144	--	--	--	--	--	--	--	--	--	--	--
Co-58	--	--	--	--	--	--	--	--	--	--	--
Co-60	--	--	--	--	--	--	1.0E-02	1.5E-02	--	--	1.0E-02
Cs-134	--	--	--	--	--	--	--	--	--	--	--
Cs-137	--	--	--	--	--	--	3.1E-01	4.4E-02+	--	--	3.1E-01
Eu-152	--	--	--	--	--	--	1.1E-01	6.8E-02+	--	--	1.1E-01
Eu-154	--	--	--	--	--	--	-6.8E-03	5.2E-02	--	--	-6.8E-03
Eu-155	--	--	--	--	--	--	5.4E-02	5.1E-02+	--	--	5.4E-02
I-129	--	--	--	--	--	--	--	--	--	--	--
K-40	--	--	--	--	--	--	--	--	--	--	--
Mn-54	--	--	--	--	--	--	5.6E-03	1.5E-02	--	--	5.6E-03
Nb-95	--	--	--	--	--	--	1.6E-02	1.1E-02+	--	--	1.6E-02
Pb-212	--	--	--	--	--	--	--	--	--	--	--
Pb-214	--	--	--	--	--	--	6.0E-01	7.7E-02+	--	--	6.0E-01
Pu-238	--	--	--	--	--	--	8.6E-04	3.1E-04+	--	--	8.6E-04
Pu-239	--	--	--	--	--	--	2.4E-02	2.7E-03+	--	--	2.4E-02
Ru-106	--	--	--	--	--	--	-4.6E-02	1.4E-01	--	--	-4.6E-02
Sr-90	--	--	--	--	--	--	1.9E-01	3.8E-02+	--	--	1.9E-01
Tc-99	--	--	--	--	--	--	--	--	--	--	--
U	--	--	--	--	--	--	2.4E-01	7.4E-02+	--	--	2.4E-01
Zn-65	--	--	--	--	--	--	--	--	--	--	--
Zr-95	--	--	--	--	--	--	1.8E-02	2.7E-02	--	--	1.8E-02

+ Indicates positive detection (result greater than error).
 Source: Schmidt et al. 1990; Elder et al. 1986, 1987, 1988, 1989.

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Table A-2.1. Results of Grid Soil Sampling (pCi/g).

Location 2W27											
Radionuclide	1985		1986		1987		1988		1989		Average Result
	Result	Error	Result	Error	Result	Error	Result	Error	Result	Error	
Ce-141	--	--	--	--	-7.6E-03	4.0E-02	--	--	--	--	-7.6E-03
Ce-144	--	--	--	--	-1.1E-02	1.1E-01	--	--	--	--	-1.1E-02
Co-58	--	--	--	--	-3.8E-03	1.9E-02	--	--	--	--	-3.8E-03
Co-60	--	--	--	--	-4.6E-03	1.8E-02	-1.9E-02	1.8E-02	--	--	-1.2E-02
Cs-134	--	--	5E-02	2E-02+	5.9E-02	2.0E-02+	--	--	--	--	5.5E-02
Cs-137	--	--	1.66E+00	1.8E-01+	2.6E+00	2.8E-01+	4.1E+00	4.2E-01+	--	--	2.8E+00
Eu-152	--	--	--	--	1.1E-01	5.8E-02+	7.9E-02	7.2E-02+	--	--	9.5E-02
Eu-154	--	--	--	--	-2.5E-02	5.4E-02	4.5E-03	4.7E-02	--	--	-1.0E-02
Eu-155	--	--	--	--	6.8E-02	5.8E-02+	1.6E-02	4.8E-02	--	--	4.2E-02
I-129	--	--	--	--	3.3E-01	3.3E-01	--	--	--	--	3.3E-01
K-40	--	--	--	--	--	--	--	--	--	--	--
Mn-54	--	--	--	--	7.9E-03	1.7E-02	-4.2E-03	1.4E-02	--	--	1.9E-03
Nb-95	--	--	--	--	--	--	-2.4E-03	1.7E-02	--	--	-2.4E-03
Pb-212	--	--	--	--	--	--	--	--	--	--	--
Pb-214	--	--	--	--	--	--	5.5E-01	7.8E-02+	--	--	5.5E-01
Pu-238	--	--	1.4E-03	6E-04+	1.4E-03	4.2E-04+	2.8E-03	6.0E-04+	--	--	1.9E-03
Pu-239	--	--	4E-02	0.0E+00	2.9E-02	3.4E-03+	6.9E-02	7.3E-03+	--	--	4.6E-02
Ru-106	--	--	--	--	2.3E-01	1.2E-01+	-4.9E-02	1.4E-01	--	--	9.1E-02
Sr-90	--	--	5.5E-01	1.1E-01+	7.7E-01	1.9E-01+	6.2E-01	1.2E-01+	--	--	6.5E-01
Tc-99	--	--	--	--	4.1E-01	8.5E-01	--	--	--	--	4.1E-01
U	--	--	3.9E-01	1.3E-01+	2.4E-01	7.2E-02+	3.7E-01	1.1E-01+	--	--	3.3E-01
Zn-65	--	--	--	--	7.5E-04	4.1E-02	--	--	--	--	7.5E-04
Zr-95	--	--	--	--	6.1E-04	3.3E-02	1.5E-02	2.5E-02	--	--	7.8E-03

+ Indicates positive detection (result greater than error).
 Source: Schmidt et al. 1990; Elder et al. 1986, 1987, 1988, 1989.

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2 4 1 3 7 3 1 9 1 1

Table A-2.1. Results of Grid Soil Sampling (pCi/g).

Location 2W29											
Radionuclide	1985		1986		1987		1988		1989		Average Result
	Result	Error	Result	Error	Result	Error	Result	Error	Result	Error	
Ce-141	--	--	--	--	-1.8E-02	4.2E-02	--	--	--	--	-1.80E-02
Ce-144	--	--	2.7E-01	2.3E-01+	-7.6E-02	1.0E-01	--	--	--	--	9.70E-02
Co-58	--	--	--	--	5.2E-03	1.6E-02	--	--	--	--	5.20E-03
Co-60	--	--	--	--	2.6E-02	1.5E-02+	6.7E-03	1.7E-02	--	--	1.64E-02
Cs-134	--	--	4E-02	3E-02+	1.6E-02	2.1E-02	--	--	--	--	2.80E-02
Cs-137	2.43E+00	2.3E-01+	1.54E+00	1.8E-01+	1.1E+00	1.2E-01+	1.4E+00	1.5E-01+	--	--	1.62E+00
Eu-152	--	--	--	--	1.0E-01	6.9E-02+	1.1E-01	6.8E-02+	--	--	1.05E-01
Eu-154	--	--	--	--	4.1E-02	5.5E-02	2.5E-02	5.1E-02	--	--	3.30E-02
Eu-155	--	--	--	--	1.2E-02	5.6E-02	6.8E-02	5.8E-02+	--	--	4.00E-02
I-129	--	--	--	--	--	--	--	--	--	--	--
K-40	--	--	--	--	--	--	--	--	--	--	--
Mn-54	--	--	--	--	-2.9E-03	1.9E-02	7.9E-03	1.6E-02	--	--	2.50E-03
Nb-95	--	--	--	--	--	--	-1.3E-02	2.2E-02	--	--	-1.30E-02
Pb-212	--	--	--	--	--	--	--	--	--	--	--
Pb-214	--	--	--	--	--	--	6.5E-01	8.9E-02+	--	--	6.50E-01
Pu-238	1.00E-02	1.7E-03+	4.7E-03	1.1E-03+	2.4E-03	6.1E-04+	5.0E-03	9.1E-04+	--	--	5.53E-03
Pu-239	6.0E-02	1E-02+	5.0E-02	1E-02+	5.0E-02	5.8E-03+	1.2E-01	1.3E-02+	--	--	7.00E-02
Ru-106	9.5E-01	3.9E-01+	--	--	2.5E-02	1.4E-01	-7.5E-02	1.2E-01	--	--	3.00E-01
Sr-90	1.18E+00	2.2E-01+	4.9E-01	9.6E-02+	4.6E-01	1.2E-01+	8.1E-01	1.5E-01+	--	--	7.35E-01
Tc-99	--	--	--	--	--	--	--	--	--	--	--
U	4.2E-01	1.4E-01+	5.7E-01	1.9E-01+	2.7E-01	8.0E-02+	3.1E-01	9.4E-02+	--	--	3.93E-01
Zn-65	--	--	--	--	-6.8E-03	4.4E-02	--	--	--	--	-6.80E-03
Zr-95	--	--	--	--	-2.6E-02	3.8E-02	2.6E-02	3.1E-02	--	--	0.00E+00

+Indicates positive detection (result greater than error).

Source: Schmidt et al. 1990; Elder et al. 1986, 1987, 1988, 1989.

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Table A-2.1. Results of Grid Soil Sampling (pCi/g).

Radionuclide	Location 2W30										Average Result
	1985		1986		1987		1988		1989		
	Result	Error	Result	Error	Result	Error	Result	Error	Result	Error	
Ce-141	--	--	--	--	--	--	--	--	-3.11E-02	8.34E-02	-3.11E-02
Ce-144	--	--	--	--	--	--	--	--	3.34E-03	9.87E-02	3.34E-03
Co-58	9E-02	4E-02 +	--	--	--	--	--	--	1.57E-02	2.72E-02	5.29E-02
Co-60	--	--	--	--	--	--	-1.8E-04	2.2E-02	5.45E-03	1.54E-02	2.64E-03
Cs-134	1.2E-01	5E-02 +	--	--	--	--	--	--	-1.56E-02	1.59E-02	5.22E-02
Cs-137	1.95E+00	2.0E-01 +	--	--	--	--	7.7E-01	9.3E-02 +	8.16E-01	9.48E-02 +	1.18E+00
Eu-152	--	--	--	--	--	--	1.1E-01	9.3E-02 +	7.77E-02	8.66E-02	9.39E-02
Eu-154	--	--	--	--	--	--	-1.7E-02	6.9E-02	2.04E-02	4.98E-02	1.70E-03
Eu-155	--	--	--	--	--	--	3.2E-02	7.8E-02	3.61E-02	4.99E-02	3.41E-02
I-129	--	--	--	--	--	--	--	--	-2.53E-01	3.32E-01	-2.53E-01
K-40	--	--	--	--	--	--	--	--	1.52E+01	1.71E+00 +	1.52E+01
Mn-54	--	--	--	--	--	--	8.4E-03	1.9E-02	7.92E-03	1.83E-02	8.16E-03
Nb-95	--	--	--	--	--	--	5.6E-03	2.3E-02	-2.87E-02	6.61E-02	-1.16E-02
Pb-212	--	--	--	--	--	--	--	--	7.92E-01	9.01E-02 +	7.92E-01
Pb-214	--	--	--	--	--	--	6.7E-01	9.2E-02 +	6.42E-01	8.71E-02 +	6.56E-01
Pu-238	8.9E-03	1.7E-03 +	--	--	--	--	2.0E-03	5.5E-04 +	2.60E-03	5.66E-04 +	4.50E-03
Pu-239	2.1E-01	2E-02 +	--	--	--	--	4.1E-02	4.9E-03 +	6.36E-02	6.74E-03 +	1.05E-01
Ru-106	--	--	--	--	--	--	8.3E-03	1.5E-01	7.96E-03	1.46E-01	8.13E-03
Sr-90	6.8E-01	1.3E-01 +	--	--	--	--	3.1E-01	6.1E-02 +	2.36E-01	4.80E-02 +	4.09E-01
Tc-99	--	--	--	--	--	--	--	--	1.64E-01	1.17E+00	1.64E-01
U	1.73E+00	4.9E-01 +	--	--	--	--	5.9E-01	1.7E-01 +	8.91E-01	2.53E-01 +	1.07E+00
Zn-65	--	--	--	--	--	--	--	--	-4.94E-02	5.11E-02	-4.94E-02
Zr-95	--	--	--	--	--	--	2.0E-02	3.5E-02	-2.78E-02	5.64E-02	-3.90E-03

+ Indicates positive detection (result greater than error).
 Source: Schmidt et al. 1990; Elder et al. 1986, 1987, 1988, 1989.

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Table A-2.2. Results of Fenceline Soil Sampling (pCi/g).

Radio-nuclide	Location U-TF-SE										Average Result
	1985		1986		1987		1988		1989		
	Result	Error	Result	Error	Result	Error	Result	Error	Result	Error	
Ce-141	--	--	--	--	-1.4E-02	3.4E-02	5.7E-02	3.9E-02+	-3.99E-02	7.21E-02	1.03E-03
Ce-144	--	--	--	--	-5.6E-02	1.2E-01	--	--	2.47E-02	9.64E-02	-1.57E-02
Co-58	--	--	5.1E-02	3.2E-02+	6.6E-03	1.4E-02	--	--	6.15E-03	2.38E-02	2.13E-02
Co-60	2.4E-02	1.4E-02+	--	--	2.5E-03	1.4E-02	--	--	1.33E-02	1.49E-02	1.33E-02
Cs-134	2.6E-02	1.7E-02+	2.9E-02	2.5E-02+	3.1E-02	2.1E-02+	8.3E-03	1.9E-02	-8.09E-03	1.34E-02	1.72E-02
Cs-137	6.90E+00	4.32E-01+	1.09E+01	1.11E+00+	5.8E+00	5.9E-01+	1.4E+01	1.4E+00+	1.85E+00	1.97E+00+	7.89E+00
Eu-152	--	--	8.5E-02	7.8E-02+	1.2E-02	6.7E-02	6.0E-02	6.0E-02	9.06E-02	6.45E-02+	6.19E-02
Eu-154	--	--	7.8E-02	5.4E-02+	-5.3E-02	5.7E-02	6.5E-02	5.2E-02+	2.83E-02	5.64E-02	2.96E-02
Eu-155	--	--	--	--	4.1E-02	6.4E-02	-4.6E-02	7.6E-02	3.38E-02	4.82E-02	9.60E-03
K-40	--	--	--	--	--	--	--	--	1.45E+01	1.61E+00+	1.45E+01
Mn-54	2.8E-02	1.2E-02+	--	--	1.7E-02	1.6E-02+	1.8E-02	1.5E-02+	3.26E-03	1.82E-02	1.66E-02
Nb-95	--	--	--	--	--	--	--	--	-2.71E-02	-5.75E-02+	-2.71E-02
Pb-212	--	--	--	--	--	--	--	--	6.47E-01	7.50E-02+	6.47E-01
Pb-214	--	--	--	--	--	--	--	--	6.12E-01	8.37E-02+	6.12E-01
Pu-238	4E-04	3E-04+	1.9E-03	7E-04+	2.1E-03	7.6E-04+	2.2E-03	5.5E-04+	--	--	1.65E-03
Pu-239	3.8E-02	4.7E-03+	8.2E-02	9.4E-03+	8.9E-02	1.0E-02+	1.0E-01	1.1E-02+	--	--	7.73E-02
Ru-106	--	--	--	--	-4.7E-02	1.7E-01	5.5E-02	1.9E-01	1.70E-02	1.29E-01	8.33E-03
Sr-90	7.31E-01	1.38E-01+	1.99E+00	3.68E-01+	8.4E-01	2.1E-01+	1.5E+00	2.8E-01+	--	--	1.27E+00
U	2.97E-01	1.01E-01+	6.16E-01	2.03E-01+	3.3E-01	1.6E-01+	2.8E-01	9.0E-02+	--	--	3.81E-01
Zn-65	--	--	--	--	-4.4E-02	3.9E-02	--	--	-5.58E-03	4.30E-02	-2.48E-02
Zr-95	--	--	--	--	2.1E-02	2.7E-02	2.7E-02	2.9E-02	1.53E-02	4.74E-02	2.11E-02

+ Indicates positive detection (result greater than error).

Source: Schmidt et al. 1990; Elder et al. 1986, 1987, 1988, 1989.

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Table A-2.2. Results of Fenceline Soil Sampling (pCi/g).

Radio-nuclide	Location U-TF-W										Average Result
	1985		1986		1987		1988		1989		
	Result	Error	Result	Error	Result	Error	Result	Error	Result	Error	
Ce-141	--	--	--	--	4.4E-02	3.0E-02+	--	--	1.13E-02	8.06E-02	2.77E-02
Ce-144	--	--	--	--	8.1E-02	9.1E-02	-1.4E-03	2.2E-02	-1.98E-02	1.10E-01	1.99E-02
Co-58	1.4E-02	1.4E-0	--	--	1.6E-02	1.3E-02+	--	--	-1.68E-02	2.60E-02	4.40E-03
Co-60	--	--	--	--	-6.0E-03	1.5E-02	--	--	4.35E-03	1.93E-02	-3.00E-03
Cs-134	--	--	5.6E-02	2.3E-02+	5.0E-02	1.6E-02+	1.3E-02	1.2E-02+	-7.32E-02	2.06E-02	1.15E-02
Cs-137	1.06E+00	8.0E-02+	1.39E+00	1.57E-01+	1.7E-01	1.8E-01	1.4E+00	1.5E-01+	1.78E+00	1.90E-01+	1.16E+00
Eu-152	1.23E-01	6.5E-02+	1.42E-01	6.2E-02+	1.0E-01	6.5E-02+	8.8E-02	6.6E-02+	7.98E-02	8.31E-02	1.07E-01
Eu-154	--	--	--	--	6.5E-02	3.9E-02+	2.7E-02	4.0E-02	-6.19E-02	5.82E-02	1.00E-02
Eu-155	6.9E-02	5.1E-02+	--	--	6.0E-02	5.1E-02+	4.8E-02	4.7E-02+	2.35E-02	5.52E-02	5.01E-02
K-40	--	--	--	--	--	--	--	--	-1.44E+01	1.61E+00	-1.44E+01
Mn-54	--	--	--	--	1.8E-02	1.3E-02+	1.1E-02	1.1E-02	5.50E-03	1.69E-02	1.15E-02
Nb-95	--	--	--	--	--	--	--	--	-3.74E-02	6.13E-02	-3.74E-02
Pb-212	--	--	--	--	--	--	--	--	7.52E-01	8.77E-02+	7.52E-01
Pb-214	--	--	--	--	--	--	--	--	5.87E-01	7.95E-02+	5.87E-01
Pu-238	1.14E-02	1.9E-03+	1.27E-02	2.1E-03+	7.4E-03	1.1E-03+	9.9E-03	1.5E-03+	--	--	1.04E-02
Pu-239	6.27E-01	6.0E-01+	5.70E-01	5.9E-02+	3.9E-01	3.9E-02+	5.6E-01	5.9E-02+	--	--	5.37E-01
Ru-106	--	--	--	--	8.7E-02	1.2E-01	-7.0E-02	1.1E-01	2.46E-02	1.62E-01	1.39E-02
Sr-90	4.6E-02	8.3E-02	1.62E+00	3.01E-01+	7.6E-01	1.9E-01+	4.0E-01	7.6E-02+	--	--	1.85E+00
U	2.03E-01	7.4E-01	3.44E-01	1.12E-01+	2.2E-01	1.1E-01+	3.7E-01	1.1E-01+	--	--	2.84E-01
Zn-65	--	--	--	--	-1.9E-02	3.9E-02	--	--	-1.28E-01	5.54E-02	-7.35E-02
Zr-95	--	--	--	--	6.5E-02	2.7E-02+	4.9E-03	2.2E-02	2.92E-02	5.34E-02	3.30E-02

+Indicates positive detection (result greater than error).

Source: Schmidt et al. 1990; Elder et al. 1986, 1987, 1988, 1989.

Table A-2.2. Results of Fenceline Soil Sampling (pCi/g).

Radionuclide	Location U-TF-NE										Average Result
	1985		1986		1987		1988		1989		
	Result	Error	Result	Error	Result	Error	Result	Error	Result	Error	
Ce-141	--	--	--	--	--	--	--	--	-5.20E-02	3.07E-01	-5.20E-02
Ce-144	--	--	--	--	--	--	--	--	8.14E-02	4.23E-01	8.14E-02
Co-58	--	--	--	--	--	--	--	--	-2.19E-02	2.86E-02	-2.19E-02
Co-60	--	--	--	--	--	--	--	--	2.12E-02	1.83E-02+	2.12E-02
Cs-134	--	--	--	--	--	--	--	--	8.75E-03	6.41E-02	8.75E-03
Cs-137	3.13E+02	--	2.87E+02	--	2.5E+02	--	3.0E+02	--	1.29E+02	1.29E+01+	2.56E+02
Eu-152	--	--	--	--	--	--	--	--	1.65E-02	7.81E-02	1.65E-02
Eu-154	--	--	--	--	--	--	--	--	-3.95E-02	6.32E-02	-3.95E-02
Eu-155	--	--	--	--	--	--	--	--	6.63E-02	2.22E-01	6.63E-02
K-40	--	--	--	--	--	--	--	--	1.39E+01	1.58E+00+	1.39E+01
Mn-54	--	--	--	--	--	--	--	--	1.10E-02	1.91E-02	1.10E-02
Nb-95	--	--	--	--	--	--	--	--	-2.65E-02	6.36E-02	-2.65E-02
Pb-212	--	--	--	--	--	--	--	--	5.10E-01	1.38E-01+	5.10E-01
Pb-214	--	--	--	--	--	--	--	--	4.31E-01	1.78E-01+	4.31E-01
Pu-238	--	--	--	--	--	--	--	--	--	--	--
Pu-239	8.1E+00	--	5.0E-01	--	4.0E-01	--	<1.0E+00	--	--	--	3.00E+00
Ru-106	--	--	--	--	--	--	--	--	-2.92E-01	6.93E-01	-2.92E-01
Sr-90	7.1E+01	--	8.3E+01	--	7.5E+01	--	5.1E+01	--	--	--	7.00E+01
U	--	--	--	--	--	--	--	--	--	--	--
Zn-65	--	--	--	--	--	--	--	--	-1.17E-01	5.89E-02	-1.17E-01
Zr-95	--	--	--	--	--	--	--	--	4.57E-02	5.93E-02	4.57E-02

+Indicates positive detection (result greater than error).
 Source: Schmidt et al. 1990; Elder et al. 1986, 1987, 1988, 1989.

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Table A-2.3. Results of Vegetation Sampling (pCi/g).

Radionuclide	Location 2W18										Average Result
	1985		1986		1987		1988		1989		
	Result	Error	Result	Error	Result	Error	Result	Error	Result	Error	
Be-7	--	--	--	--	--	--	--	--	--	--	--
Ce-141	--	--	--	--	--	--	--	--	--	--	--
Co-58	--	--	--	--	--	--	--	--	--	--	--
Co-60	--	--	--	--	--	--	2.7E-03	1.6E-02	--	--	2.70E-03
Cs-134	--	--	1.50E-01	3.2E-02+	--	--	--	--	--	--	1.50E-01
Cs-137	1.68E-01	4.9E-02+	3.49E-01	4.9E-02+	--	--	1.6E-01	2.8E-02+	--	--	2.26E-01
Eu-152	9.1E-02	8.2E-02+	--	--	--	--	1.7E-02	6.5E-02	--	--	5.40E-02
Eu-154	--	--	--	--	--	--	1.9E-02	4.8E-02	--	--	1.90E-02
Eu-155	--	--	--	--	--	--	1.2E-02	3.6E-02	--	--	1.20E-02
I-129	--	--	--	--	--	--	--	--	--	--	--
K-40	--	--	--	--	--	--	--	--	--	--	--
Nb-95	--	--	--	--	--	--	-8.0E-03	2.8E-02	--	--	-8.00E-03
Pb-212	--	--	--	--	--	--	--	--	--	--	--
Pb-214	--	--	--	--	--	--	--	--	--	--	--
Pu-238	--	--	--	--	--	--	--	--	--	--	--
Pu-239	--	--	--	--	--	--	--	--	--	--	--
Ru-103	--	--	1.70E-01	7.3E-02+	--	--	--	--	--	--	1.70E-01
Ru-106	--	--	2.93E-01	1.47E-01+	--	--	--	--	--	--	2.93E-01
Sr-90	--	--	--	--	--	--	4.8E-02	1.1E-02+	--	--	4.80E-02
Tc-99	--	--	--	--	--	--	--	--	--	--	--
Zr-95	--	--	--	--	--	--	--	--	--	--	--

+ Indicates positive detection (result greater than error).
 Source: Schmidt et al. 1990; Elder et al. 1986, 1987, 1988, 1989.

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Table A-2.3. Results of Vegetation Sampling (pCi/g).

Location 2W21											
Radionuclide	1985		1986		1987		1988		1989		Average Result
	Result	Error	Result	Error	Result	Error	Result	Error	Result	Error	
Be-7	--	--	--	--	--	--	--	--	--	--	--
Ce-141	--	--	--	--	--	--	--	--	--	--	--
Co-58	--	--	--	--	--	--	--	--	--	--	--
Co-60	7.7E-02	3.9E-02+	--	--	1.1E-02	1.5E-02	-2.0E-02	1.7E-02	--	--	2.3E-02
Cs-134	--	--	1.05E-01	2.3E-02+	3.9E-02	1.6E-02+	--	--	--	--	7.2E-02
Cs-137	6.4E-02	5.6E-02+	2.26E-01	3.7E-02+	1.3E-01	2.4E-02+	1.5E-01	2.6E-02+	--	--	1.4E-01
Eu-152	2.35E-01	1.50E-01+	--	--	-4.3E-02	6.8E-02	4.4E-02	6.5E-02	--	--	8.0E-01
Eu-154	3.56E-01	1.78E-01+	--	--	6.6E-02	4.2E-02+	2.9E-02	4.7E-02	--	--	1.5E-01
Eu-155	--	--	3.6E-02	3.3E-02+	--	--	5.8E-03	4.2E-02	--	--	2.1E-02
I-129	--	--	--	--	--	--	--	--	--	--	--
K-40	--	--	--	--	--	--	--	--	--	--	--
Nb-95	9.7E-02	7.1E-02+	--	--	-1.5E-02	2.6E-02	-3.1E-02	5.6E-02	--	--	1.7E-02
Pb-212	--	--	--	--	--	--	--	--	--	--	--
Pb-214	--	--	--	--	--	--	--	--	--	--	--
Pu-238	--	--	--	--	--	--	--	--	--	--	--
Pu-239	--	--	--	--	--	--	--	--	--	--	--
Ru-103	--	--	7.7E-02	5.0E-02+	--	--	--	--	--	--	--
Ru-106	--	--	--	--	--	--	--	--	--	--	7.7E-02
Sr-90	--	--	--	--	--	--	--	--	--	--	--
Tc-99	--	--	--	--	--	--	--	--	--	--	--
Zr-95	--	--	--	--	2.4E-02	3.2E-02	--	--	--	--	2.4E-02

+ Indicates positive detection (result greater than error).

Source: Schmidt et al. 1990; Elder et al. 1986, 1987, 1988, 1989.

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Table A-2.3. Results of Vegetation Sampling (pCi/g).

Location 2W22											
Radionuclide	1985		1986		1987		1988		1989		Average Result
	Result	Error	Result	Error	Result	Error	Result	Error	Result	Error	
Be-7	--	--	--	--	--	--	--	--	--	--	--
Ce-141	--	--	--	--	--	--	--	--	--	--	--
Co-58	--	--	--	--	--	--	--	--	--	--	--
Co-60	--	--	--	--	--	--	6.4E-03	1.8E-02	--	--	6.4E-03
Cs-134	--	--	1.77E-01	3.7E-02+	--	--	--	--	--	--	1.77E-01
Cs-137	--	--	2.57E-01	4.7E-02+	--	--	1.1E-01	2.6E-02+	--	--	1.4E-01
Eu-152	--	--	--	--	--	--	-2.7E-02	8.7E-02	--	--	-2.7E-02
Eu-154	--	--	--	--	--	--	7.1E-03	5.3E-02	--	--	7.1E-03
Eu-155	--	--	--	--	--	--	3.7E-02	4.7E-02	--	--	3.7E-02
I-129	--	--	--	--	--	--	--	--	--	--	--
K-40	--	--	--	--	--	--	--	--	--	--	--
Nb-95	--	--	--	--	--	--	5.5E-02	7.3E-02	--	--	5.5E-02
Pb-212	--	--	--	--	--	--	--	--	--	--	--
Pb-214	--	--	--	--	--	--	--	--	--	--	--
Pu-238	--	--	--	--	--	--	--	--	--	--	--
Pu-239	--	--	--	--	--	--	--	--	--	--	--
Ru-103	--	--	1.69E-01	6.0E-02+	--	--	--	--	--	--	1.69E-01
Sr-90	--	--	--	--	--	--	1.9E-02	3.7E-02	--	--	1.9E-02
Tc-99	--	--	--	--	--	--	--	--	--	--	--
Zr-95	--	--	--	--	--	--	--	--	--	--	--

+ Indicates positive detection (result greater than error).
 Source: Schmidt et al. 1990; Elder et al. 1986, 1987, 1988, 1989.

A2T-3c

DCE/RL-91-52, Rev. 0

Table A-2.3. Results of Vegetation Sampling (pCi/g).

Radio-nuclide	Location 2W23										Average Result
	1985		1986		1987		1988		1989		
	Result	Error	Result	Error	Result	Error	Result	Error	Result	Error	
Be-7	--	--	--	--	--	--	--	--	1.75E+00	3.35E-01+	1.75E+00
Ce-141	--	--	--	--	--	--	--	--	9.33E-03	2.46E-02	9.33E-03
Co-58	--	--	--	--	--	--	--	--	--	--	--
Co-60	--	--	--	--	2.3E-02	1.7E-02+	1.7E-02	1.5E-02+	7.44E-03	1.75E-02	1.58E-02
Cs-137	1.90E+00	2.24E-01+	8.41E-01	1.09E-01+	5.2E+00	5.3E-01+	1.9E+00	2.0E-01+	2.15E+00	2.26E-01+	2.40E+00
Eu-152	--	--	--	--	4.9E-02	8.3E-02	4.1E-02	6.8E-02	3.96E-02	8.77E-02	4.32E-02
Eu-154	--	--	--	--	2.7E-02	6.0E-02	9.8E-03	4.6E-02	-7.90E-03	6.02E-02	9.63E-03
Eu-155	--	--	--	--	--	--	-1.0E-02	4.0E-02	3.90E-02	4.76E-02	1.45E-02
I-129	--	--	--	--	--	--	--	--	8.27E-02	1.77E-01	8.27E-02
K-40	--	--	--	--	--	--	--	--	1.54E+01	1.72E+00+	1.54E+01
Nb-95	--	--	1.27E-01	9.0E-02+	-1.0E-02	4.6E-02	1.5E-02	2.6E-02	-6.83E-03	2.32E-02	3.13E-02
Pb-212	--	--	--	--	--	--	--	--	1.37E-02	3.16E-02	1.37E-02
Pb-214	--	--	--	--	--	--	--	--	6.46E-02	4.05E-02+	6.46E-02
Pu-238	--	--	--	--	--	--	--	--	1.39E-03	4.81E-04+	1.39E-03
Pu-239	--	--	--	--	--	--	--	--	5.86E-02	6.93E-03+	5.86E-02
Ru-103	--	--	6.6E-02	5.4E-02+	--	--	--	--	--	--	6.60E-02
Sr-90	--	--	3.76E-01	8.3E-02+	--	--	--	--	2.26E-01	4.59E-02+	3.01E-01
Tc-99	--	--	--	--	--	--	--	--	7.69E-01	1.10E+00	7.69E-01
Zr-95	2.11E-01	1.43E-01+	--	--	-1.1E-02	4.8E-02	--	--	1.02E-02	3.28E-02	7.01E-02

+ Indicates positive detection (result greater than error).
 Source: Schmidt et al. 1990; Elder et al. 1986, 1987, 1988, 1989.

A2T-3d

DOE/RL-91-52, Rev. 0

Table A-2.3. Results of Vegetation Sampling (pCi/g).

Radio-nuclide	Location 2W24										Average Result
	1985		1986		1987		1988		1989		
	Result	Error	Result	Error	Result	Error	Result	Error	Result	Error	
Be-7	--	--	--	--	--	--	--	--	2.20E+00	3.28E-01+	2.20E+00
Ce-141	--	--	--	--	--	--	--	--	-7.38E-03	2.38E-02	-7.38E-03
Co-58	--	--	--	--	--	--	--	--	--	--	--
Co-60	--	--	--	--	-1.7E-03	1.7E-02	7.2E-03	1.7E-02	5.86E-03	1.44E-02	3.79E-03
Cs-134	--	--	1.14E-01	3.0E-02+	--	--	--	--	--	--	1.14E-01
Cs-137	2.25E-01	6.1E-02+	4.19E-01	6.4E-02+	8.7E-01	9.8E-02+	2.8E-01	3.9E-02+	1.85E-01	2.90E-02+	3.96E-01
Eu-152	--	--	--	--	1.3E-02	6.9E-02	3.8E-02	8.1E-02	-3.68E-03	6.87E-02	1.58E-02
Eu-154	--	--	8.0E-02	7.1E-02+	-5.9E-02	6.0E-02	-2.1E-03	5.7E-02	-9.60E-03	4.91E-02	2.33E-03
Eu-155	--	--	--	--	--	--	2.8E-02	5.6E-02	-1.05E-02	3.31E-02	8.75E-03
I-129	--	--	--	--	3.2E-01	2.3E-01+	-3.3E-01	3.2E-01	1.01E-01	1.52E-01	3.03E-02
K-40	--	--	--	--	--	--	--	--	1.11E+01	1.28E+00+	1.11E+01
Nb-95	--	--	--	--	2.0E-02	3.2E-02	4.2E-02	6.3E-02	9.26E-03	2.21E-02	2.38E-02
Pb-212	--	--	--	--	--	--	--	--	3.27E-02	2.46E-02+	3.27E-02
Pb-214	--	--	--	--	--	--	--	--	2.16E-02	2.77E-02	2.16E-02
Pu-238	--	--	--	--	6.7E-04	3.4E-04+	4.6E-04	3.1E-04+	2.88E-04	1.88E-04+	4.73E-04
Pu-239	--	--	--	--	2.5E-02	3.4E-03+	1.1E-02	2.0E-03+	5.48E-03	9.32E-04+	1.38E-02
Ru-103	--	--	8.9E-02	6.4E-02+	--	--	--	--	--	--	8.90E-02
Ru-106	--	--	2.42E-01	1.77E-01+	--	--	--	--	--	--	2.42E-01
Sr-90	--	--	--	--	2.5E-01	6.4E-02+	1.1E-01	2.3E-02+	7.09E-02	1.50E-02+	1.44E-01
Tc-99	--	--	--	--	8.8E+00	1.4E+00+	1.3E+01	2.9E+00+	8.11E-00	1.80E+00+	9.97E+00
Zr-95	--	--	--	--	-8.6E-03	3.9E-02	--	--	-1.84E-02	2.91E-02	-1.35E-02

+ Indicates positive detection (result greater than error).
 Source: Schmidt et al. 1990; Elder et al. 1986, 1987, 1988, 1989.

A2T-3e

DOE/RL-91-52, Rev. 0

Table A-2.3. Results of Vegetation Sampling (pCi/g).

Location 2W25											
Radionuclide	1985		1986		1987		1988		1989		Average Result
	Result	Error	Result	Error	Result	Error	Result	Error	Result	Error	
Be-7	--	--	--	--	--	--	--	--	--	--	--
Ce-141	--	--	--	--	--	--	--	--	--	--	--
Co-58	--	--	--	--	--	--	--	--	--	--	--
Co-60	6.3E-02	3.2E-02+	--	--	--	--	-6.4E-03	1.3E-02	--	--	2.83E-02
Cs-134	--	--	--	--	--	--	--	--	--	--	--
Cs-137	1.83E-01	5.4E-02+	--	--	--	--	5.0E-01	6.1E-02+	--	--	3.42E-01
Eu-152	--	--	--	--	--	--	3.7E-02	6.6E-02	--	--	3.70E-02
Eu-154	--	--	--	--	--	--	7.3E-03	4.3E-02	--	--	7.30E-03
Eu-155	--	--	--	--	--	--	1.9E-02	3.9E-02	--	--	1.90E-02
I-129	--	--	--	--	--	--	--	--	--	--	--
K-40	--	--	--	--	--	--	--	--	--	--	--
Nb-95	--	--	--	--	--	--	-2.7E-04	1.8E-02	--	--	-2.70E-04
Pb-212	--	--	--	--	--	--	--	--	--	--	--
Pb-214	--	--	--	--	--	--	--	--	--	--	--
Pu-238	--	--	--	--	--	--	--	--	--	--	--
Pu-239	--	--	--	--	--	--	--	--	--	--	--
Ru-103	--	--	--	--	--	--	--	--	--	--	--
Ru-106	--	--	--	--	--	--	--	--	--	--	--
Sr-90	--	--	--	--	--	--	--	--	--	--	--
Tc-99	--	--	--	--	--	--	--	--	--	--	--
Zr-95	--	--	--	--	--	--	--	--	--	--	--

+ Indicates positive detection (result greater than error).
 Source: Schmidt et al. 1990; Elder et al. 1986, 1987, 1988, 1989.

A2T-3f

DOE/RL-91-52, Rev. 0

Table A-2.3. Results of Vegetation Sampling (pCi/g).

Location 2W26											
Radionuclide	1985		1986		1987		1988		1989		Average Result
	Result	Error	Result	Error	Result	Error	Result	Error	Result	Error	
Be-7	--	--	--	--	--	--	--	--	--	--	--
Ce-141	--	--	--	--	--	--	--	--	--	--	--
Co-58	--	--	--	--	--	--	--	--	--	--	--
Co-60	--	--	--	--	--	--	1.4E-02	1.3E-02 +	--	--	1.4E-02
Cs-134	--	--	--	--	--	--	--	--	--	--	--
Cs-137	--	--	--	--	--	--	1.5E-01	2.5E-02 +	--	--	1.5E-01
Eu-152	--	--	--	--	--	--	4.9E-02	5.4E-02	--	--	4.9E-02
Eu-154	--	--	--	--	--	--	-3.8E-02	4.8E-02	--	--	-3.8E-02
Eu-155	--	--	--	--	--	--	-2.5E-02	3.2E-02	--	--	-2.5E-02
I-129	--	--	--	--	--	--	--	--	--	--	--
K-40	--	--	--	--	--	--	--	--	--	--	--
Nb-95	--	--	--	--	--	--	-3.8E-03	1.5E-02	--	--	-3.8E-03
Pb-212	--	--	--	--	--	--	--	--	--	--	--
Pb-214	--	--	--	--	--	--	--	--	--	--	--
Pu-238	--	--	--	--	--	--	--	--	--	--	--
Pu-239	--	--	--	--	--	--	--	--	--	--	--
Ru-103	--	--	--	--	--	--	--	--	--	--	--
Ru-106	--	--	--	--	--	--	--	--	--	--	--
Sr-90	--	--	--	--	--	--	--	--	--	--	--
Tc-99	--	--	--	--	--	--	--	--	--	--	--
Zr-95	--	--	--	--	--	--	--	--	--	--	--

+ Indicates positive detection (result greater than error).
 Source: Schmidt et al. 1990; Elder et al. 1986, 1987, 1988, 1989.

A2T-3g

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Table A-2.3. Results of Vegetation Sampling (pCi/g).

Location 2W27											
Radionuclide	1985		1986		1987		1988		1989		Average Result
	Result	Error	Result	Error	Result	Error	Result	Error	Result	Error	
Be-7	--	--	--	--	--	--	--	--	--	--	--
Ce-141	--	--	--	--	--	--	--	--	--	--	--
Co-58	--	--	--	--	--	--	--	--	--	--	--
Co-60	--	--	--	--	--	--	-4.5E-03	1.5E-02	--	--	-4.5E-03
Cs-134	--	--	7.5E-02	2.8E-02+	--	--	--	--	--	--	7.5E-02
Cs-137	--	--	2.97E-01	4.9E-02+	--	--	2.0E-01	3.1E-02+	--	--	2.5E-01
Eu-152	--	--	--	--	--	--	-1.0E-02	7.5E-02	--	--	-1.0E-02
Eu-154	--	--	--	--	--	--	-1.5E-00	4.4E-02	--	--	-1.5E-02
Eu-155	--	--	--	--	--	--	9.6E-03	3.9E-02	--	--	9.6E-03
I-129	--	--	--	--	--	--	--	--	--	--	--
K-40	--	--	--	--	--	--	--	--	--	--	--
Nb-95	--	--	9.5E-02	6.9E-02+	--	--	3.1E-01	3.2E-02+	--	--	2.0E-01
Pb-212	--	--	--	--	--	--	--	--	--	--	--
Pb-214	--	--	--	--	--	--	--	--	--	--	--
Pu-238	--	--	--	--	--	--	--	--	--	--	--
Pu-239	--	--	--	--	--	--	--	--	--	--	--
Ru-103	--	--	9.5E-02	7.7E-02+	--	--	--	--	--	--	9.5E-02
Ru-106	--	--	--	--	--	--	1.3E-01	2.7E-02+	--	--	1.3E-01
Sr-90	--	--	--	--	--	--	--	--	--	--	--
Tc-99	--	--	--	--	--	--	--	--	--	--	--
Zr-95	--	--	8.3E-02	5.6E-02+	--	--	--	--	--	--	8.3E-02

+ Indicates positive detection (result greater than error).
 Source: Schmidt et al. 1990; Elder et al. 1986, 1987, 1988, 1989.

A2T-3h

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7 8 1 2 7 3 1 9 1 4

Table A-2.3. Results of Vegetation Sampling (pCi/g).

Location 2W29											
Radionuclide	1985		1986		1987		1988		1989		Average Result
	Result	Error	Result	Error	Result	Error	Result	Error	Result	Error	
Be-7	--	--	--	--	--	--	--	--	--	--	--
Ce-141	--	--	--	--	--	--	--	--	--	--	--
Co-58	9.7E-02	4.6E-02+	--	--	--	--	--	--	--	--	9.70E-02
Co-60	8.1E-02	4.3E-02+	--	--	--	--	1.9E-02	1.5E-02+	--	--	5.00E-02
Cs-134	--	--	9.00E-02	2.7E-02+	--	--	--	--	--	--	9.00E-02
Cs-137	--	--	2.05E-01	4.0E-02+	--	--	1.1E+00	1.2E-01+	--	--	6.53E-01
Eu-152	--	--	1.18E-01	6.0E-02+	--	--	1.1E-01	6.9E-02+	--	--	1.14E-01
Eu-154	--	--	--	--	--	--	6.6E-02	4.7E-02+	--	--	6.60E-02
Eu-155	--	--	--	--	--	--	3.7E-03	4.7E-02	--	--	3.70E-03
I-129	--	--	--	--	--	--	--	--	--	--	--
K-40	--	--	--	--	--	--	--	--	--	--	--
Nb-95	--	--	--	--	--	--	-1.3E-02	4.0E-02	--	--	-1.30E-02
Pb-212	--	--	--	--	--	--	--	--	--	--	--
Pb-214	--	--	--	--	--	--	--	--	--	--	--
Pu-238	--	--	--	--	--	--	--	--	--	--	--
Pu-239	--	--	--	--	--	--	--	--	--	--	--
Ru-103	--	--	8.10E-02	5.7E-02+	--	--	--	--	--	--	8.10E-02
Ru-106	--	--	--	--	--	--	--	--	--	--	--
Sr-90	--	--	--	--	--	--	4.2E-01	8.0E-02+	--	--	4.20E-01
Tc-99	--	--	--	--	--	--	--	--	--	--	--
Zr-95	--	--	--	--	--	--	--	--	--	--	--

+Indicates positive detection (result greater than error).
 Source: Schmidt et al. 1990; Elder et al. 1986, 1987, 1988, 1989.

A2T-3i

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Table A-2.3. Results of Vegetation Sampling (pCi/g).

Location 2W30											
Radionuclide	1985		1986		1987		1988		1989		Average Result
	Result	Error	Result	Error	Result	Error	Result	Error	Result	Error	
Be-7	--	--	--	--	--	--	--	--	3.14E+00	4.34E-01+	3.14E+00
Ce-141	--	--	--	--	--	--	--	--	-4.83E-03	2.85E-02	-4.83E-03
Co-58	--	--	--	--	--	--	--	--	--	--	--
Co-60	--	--	--	--	--	--	6.10E-03	1.60E-02	2.94E-02	2.00E-02+	1.78E-02
Cs-134	--	--	--	--	--	--	--	--	--	--	--
Cs-137	3.45E-01	7E-02+	--	--	--	--	2.20E-01	3.10E-02+	1.31E-01	3.10E-02+	2.32E-01
Eu-152	1.48E-01	1.12E-01+	--	--	--	--	-9.30E-02	7.80E-02	4.78E-02	7.29E-02	3.43E-02
Eu-154	--	--	--	--	--	--	-4.10E-03	5.20E-02	-7.12E-02	6.22E-02	-3.77E-02
Eu-155	--	--	--	--	--	--	-1.80E-02	3.80E-02	-3.06E-03	4.05E-02	-1.05E-02
I-129	--	--	--	--	--	--	--	--	-2.86E-01	2.43E-01	-2.86E-01
K-40	--	--	--	--	--	--	--	--	1.22E+01	1.41E+00+	1.22E+01
Nb-95	--	--	--	--	--	--	-2.20E-02	6.00E-02	-1.94E-02	2.58E-02	-2.07E-02
Pb-212	--	--	--	--	--	--	--	--	5.07E-02	3.26E-02+	5.07E-02
Pb-214	--	--	--	--	--	--	--	--	3.85E-02	3.04E-02+	3.85E-02
Pu-238	6E-04	3E-04+	--	--	--	--	--	--	4.69E-04	2.24E-04+	5.35E-04
Pu-239	9E-03	2E-03+	--	--	--	--	--	--	9.78E-03	1.41E-03+	9.39E-03
Ru-103	--	--	--	--	--	--	--	--	--	--	--
Ru-106	--	--	--	--	--	--	--	--	--	--	--
Sr-90	2.05E+00	4.05E-01+	--	--	--	--	1.50E-01	3.00E-02+	7.60E-02	1.66E-02+	7.59E-01
Tc-99	--	--	--	--	--	--	--	--	1.48E+00	1.16E+00+	1.48E+00
Zr-95	--	--	--	--	--	--	--	--	2.42E-02	3.58E-02	2.42E-02

+ Indicates positive detection (result greater than error).

Source: Schmidt et al. 1990; Elder et al. 1986, 1987, 1988, 1989.

0 0 1 1 1 3 3 2 0 0

Table A-2.4. Results of Air Monitoring (pCi/m³).

Location N155: U Tank Farm Adj to 960											
Radionuclide	1985		1986		1987		1988		1989		Average Result [†]
	Result	Error	Result	Error	Result	Error	Result	Error	Result	Error	
Sr-90	1.01E-02	--	2.49E-04	--	1.50E-04	--	1.3E-04	9.0E-05+	3.96E-06	5.62E-05	--
	4.98E-05	--	1.28E-04	--	-1.13E-05	--	4.9E-05	9.3E-05	-3.00E-05	8.06E-05	--
	2.59E-03	1.00E-02	1.88E-04	1.10E-04+	6.46E-05	1.38E-04	9.3E-05	4.0E-05+	-1.00E-05	6.87E-05	5.85E-04
Cs-137	7.86E-04	--	1.38E-03	--	7.79E-04	--	1.5E-03	8.2E-04+	1.46E-02	2.04E-03+	--
	0.00E+00	--	6.53E-04	--	-2.34E-04	--	3.3E-04	5.3E-04	1.05E-04	5.15E-04	--
	3.51E-04	6.94E-04	9.96E-04	6.53E-04+	3.14E-04	8.35E-04	6.6E-04	5.8E-04+	3.88E-03	9.08E-04+	1.24E-03
Pu-239	7.27E-05	--	3.48E-05	--	3.60E-05	--	2.4E-05	9.9E-06+	4.22E-05	9.95E-06+	--
	5.30E-06	--	7.05E-06	--	1.48E-05	--	1.7E-05	7.0E-06+	6.65E-06	3.80E-06+	--
	3.73E-05	6.54E-05	1.62E-05	2.52E-05	2.40E-05	2.09E-05+	1.6E-05	6.2E-06+	2.10E-05	6.60E-06+	2.29E-05
U (total)	2.12E-04	--	7.20E-05	--	3.45E-05	--	-3.1E-06	1.8E-05	6.85E-05	2.71E-05+	--
	7.56E-05	--	1.81E-05	--	2.04E-05	--	2.3E-05	2.3E-05	1.36E-06	2.09E-05	--
	1.18E-04	1.26E-04	3.70E-05	5.07E-05	2.74E-05	1.39E-05+	6.8E-06	1.2E-05	3.86E-05	2.40E-05+	4.56E-05

+ Indicates positive detection (result greater than error).
 Source: Schmidt et al. 1990; Elder et al. 1986, 1987, 1988, 1989.

A2T-4a

DOE/RL-91-52, Rev. 0

Table A-2.4. Results of Air Monitoring (pCi/m³).

Location N165: 216-Z-19 Ditch (covered)											
Radionuclide	1985		1986		1987		1988		1989		Average Result
	Result	Error	Result	Error	Result	Error	Result	Error	Result	Error	
Sr-90	8.96E-03	--	2.68E-03	--	7.34E-05	--	6.2E-05	7.3E-05	1.70E-04	9.92E-05+	--
	4.46E-05	--	9.57E-05	--	-1.88E-05	--	4.1E-05	6.6E-05	-3.00E-05	5.38E-05	--
	2.33E-03	8.84E-03	7.89E-04	2.53E-03	3.53E-05	9.15E-05	5.5E-05	1.0E-05+	6.46E-05	7.89E-05	6.55E-04
Cs-137	7.31E-04	--	6.43E-04	--	1.10E-03	--	7.6E-05	6.1E-04	4.46E-04	4.12E-04+	--
	-3.40E-04	--	-6.22E-05	--	-2.98E-04	--	-6.2E-04	5.7E-04	-1.09E-04	4.03E-04	--
Pu-239	1.88E-04	8.48E-04	1.99E-04	6.14E-04	3.45E-04	1.39E-03	-2.3E-04	3.6E-04	1.81E-04	4.52E-04	1.37E-04
	1.18E-04	--	4.82E-04	--	3.41E-04	--	9.0E-04	1.2E-04+	2.84E-04	3.82E-05+	--
	7.91E-05	--	3.65E-05	--	6.49E-05	--	1.6E-04	2.7E-05+	1.09E-05	4.91E-06+	--
U (total)	9.50E-05	3.92E-05+	3.07E-04	3.88E-04	1.98E-04	2.96E-04	4.2E-04	3.4E-04+	1.64E-04	2347E-05+	2.37E-04
	1.94E-04	--	8.73E-05	--	3.20E-05	--	1.9E-05	2.5E-05	3.82E-05	1.81E-05+	--
	5.27E-05	--	3.94E-05	--	9.05E-06	--	-7.0E-07	1.9E-05	0.00E+00	1.79E-05	--
	1.25E-04	1.18E-05+	6.07E-05	4.92E-05+	1.86E-05	1.93E-05	5.4E-06	1.3E-05	1.30E-05	1.68E-05	4.45E-05

+Indicates positive detection (result greater than error).

Source: Schmidt et al. 1990; Elder et al. 1986, 1987, 1988, 1989.

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Table A-2.4. Results of Air Monitoring (pCi/m³).

Location N168: U-Stack Adj to U-Stack											
Radionuclide	1985		1986		1987		1988		1989		Average Result
	Result	Error	Result	Error	Result	Error	Result	Error	Result	Error	
Sr-90	9.89E-03	--	2.80E-03	--	1.27E-04	--	1.1E-04	8.5E-05 +	4.49E-05	6.85E-05	--
	1.56E-04	--	1.19E-04	--	1.31E-05	--	2.2E-04	1.1E-04 +	-2.00E-05	5.01E-05	--
	2.70E-03	9.59E-03	8.92E-04	2.57E-03	5.75E-05	9.75E-05	1.4E-04	5.3E-05 +	1.56E-05	5.83E-05	7.61E-04
Cs-137	1.23E-03	--	9.52E-04	--	1.29E-03	--	1.3E-04	8.5E-04	7.89E-04	5.84E-04 +	--
	5.45E-05	--	2.04E-04	--	-1.00E-04	--	1.7E-04	5.2E-04	2.84E-04	4.53E-04	--
	8.32E-04	1.09E-03	6.77E-04	6.52E-04 +	3.48E-04	1.31E-03	8.2E-04	5.2E-04 +	5.05E-04	5.76E-04	6.36E-04
Pu-239	3.20E-05	--	3.22E-05	--	2.67E-05	--	2.2E-05	7.6E-06 +	3.37E-04	4.51E-05 +	--
	1.71E-05	--	5.12E-06	--	6.25E-06	--	1.4E-06	2.3E-06	4.70E-06	3.33E-06 +	--
	2.32E-05	1.39E-05 +	1.49E-05	2.39E-05	1.42E-05	1.88E-05	9.2E-06	9.4E-06	1.27E-04	1.96E-05 +	3.77E-05
U (total)	1.06E-03	--	5.89E-04	--	3.25E-04	--	2.2E-04	7.4E-05 +	2.89E-04	8.84E-05 +	--
	2.41E-04	--	2.66E-04	--	8.64E-05	--	2.0E-05	2.2E-05	4.31E-05	2.83E-05 +	--
	5.59E-04	7.01E-04	4.26E-04	3.23E-04 +	1.70E-04	2.15E-04	1.2E-04	8.5E-05 +	1.85E-04	6.36E-05 +	2.92E-04

+ Indicates positive detection (result greater than error).

Source: Schmidt et al. 1990; Elder et al. 1986, 1987, 1988, 1989.

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Table A-2.4. Results of Air Monitoring (pCi/m³).

Location N960: U Tank Farm (replicate) at Camden & 16th, SE of 241-U											
Radionuclide	1985		1986		1987		1988		1989		Average Result
	Result	Error	Result	Error	Result	Error	Result	Error	Result	Error	
Sr-90	7.23E-03	--	1.78E-03	--	1.53E-04	--	8.1E-05	8.0E-05 +	2.06E-04	1.12E-04 +	--
	1.15E-04	--	1.08E-04	--	3.94E-06	--	3.6E-05	9.8E-05	-4.00E-05	4.66E-05	--
	1.94E-03	7.05E-03	5.80E-04	1.60E-03	8.39E-05	1.50E-04	5.0E-05	2.3E-05 +	6.37E-05	7.16E-05	5.44E-04
Ca-137	1.45E-03	--	1.11E-03	--	6.63E-04	--	4.8E-04	7.3E-04	8.95E-04	7.43E-04 +	--
	5.36E-04	--	1.66E-04	--	2.04E-04	--	2.3E-04	6.2E-04	-2.67E-04	5.61E-04	--
	1.04E-03	7.57E-04 +	4.85E-04	8.50E-04	3.47E-04	8.06E-04	3.1E-04	1.4E-04 +	3.02E-04	6.15E-04	4.97E-04
Pu-239	4.25E-05	--	3.32E-05	--	7.06E-05	--	3.8E-05	1.1E-05 +	4.20E-05	9.88E-06 +	--
	4.64E-06	--	8.07E-06	--	1.59E-05	--	6.7E-06	4.7E-06 +	8.90E-06	4.56E-06 +	--
	2.59E-05	3.34E-05	1.91E-05	2.13E-05	3.77E-05	4.82E-05	2.1E-05	1.4E-05 +	2.25E-05	6.92E-06 +	2.52E-05
U (total)	1.72E-04	--	1.09E-04	--	4.02E-05	--	3.6E-05	2.6E-05 +	5.10E-05	2.27E-05 +	--
	4.35E-05	--	3.47E-05	--	1.02E-05	--	-1.2E-06	1.9E-05	2.39E-05	2.36E-05 +	--
	1.21E-04	1.12E-04 +	6.08E-05	6.60E-05	2.59E-05	2.89E-05	8.2E-06	1.9E-05	3.60E-05	2.24E-05 +	5.04E-05

+ Indicates positive detection (result greater than error).

Source: Schmidt et al. 1990; Elder et al. 1986, 1987, 1988, 1989.

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Table A-2.4. Results of Air Monitoring (pCi/m³).

Location N975: E of Z Plant Along 16th St by RR tracks SE Powerhouse Pond												
Radio-nuclide	1985		1986		1987		1988		1989		Average Result	
	Result	Error	Result	Error	Result	Error	Result	Error	Result	Error		
Sr-90	1.09E-03	--	4.77E-03	--	1.14E-04	--	1.6E-04	1.1E-04+	2.04E-04	1.07E-04+	--	
	1.23E-04	--	1.39E-04	--	3.27E-05	--	6.9E-05	1.0E-04	-3.00E-05	5.45E-05	--	
	4.13E-04	9.08E-04	1.33E-03	4.59E-03	7.81E-05	6.81E-05+	1.2E-04	4.1E-05+	7.01E-05	8.26E-05	4.02E-04	
Cs-137	6.31E-04	--	7.77E-04	--	2.35E-04	--	4.8E-04	3.8E-04+	2.83E-04	5.63E-04	--	
	-4.21E-04	--	-2.01E-04	--	1.34E-04	--	-3.6E-04	5.6E-04	-2.00E-04	6.93E-04	--	
	5.30E-05	9.13E-04	3.64E-04	8.43E-04	1.91E-04	1.02E-04+	1.6E-04	3.9E-04	3.09E-05	5.52E-04	1.60E-04	
Pu-239	3.92E-05	--	5.42E-05	--	2.10E-05	--	5.5E-05	1.3E-05+	1.94E-05	6.77E-06+	--	
	1.31E-05	--	1.12E-05	--	9.06E-06	--	7.8E-06	5.7E-06+	1.02E-05	5.63E-06+	--	
	3.11E-05	2.44E-05+	3.06E-05	3.60E-05	1.30E-05	1.11E-05+	2.5E-05	2.1E-05+	1.42E-05	5.94E-06+	2.28E-05	
U (total)	1.89E-04	--	7.51E-05	--	4.18E-05	--	5.5E-05	3.1E-05+	7.98E-05	3.02E-05+	--	
	4.33E-05	--	5.93E-05	--	2.17E-05	--	-6.7E-06	1.8E-05	2.21E-06	1.97E-05	--	
	8.86E-05	1.36E-04	6.73E-05	1.78E-05+	3.08E-05	1.90E-05+	8.4E-06	3.2E-05	3.83E-05	2.36E-05+	4.67E-05	

+Indicates positive detection (result greater than error).

Source: Schmidt et al. 1990; Elder et al. 1986, 1987, 1988, 1989.

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2 4 1 2 7 3 3 2 5 1

Table A-2.4. Results of Air Monitoring (pCi/m³).

Location N995: S of U Plant											
Radionuclide	1985		1986		1987		1988		1989		Average Result
	Result	Error	Result	Error	Result	Error	Result	Error	Result	Error	
Sr-90	--	--	3.42E-04	--	--	--	--	--	--	--	--
	--	--	2.00E-04	--	--	--	--	--	--	--	--
	--	--	2.71E-04	2.01E-04 +	--	--	--	--	--	--	2.71E-04
Cs-137	--	--	1.92E-03	--	--	--	--	--	--	--	--
	--	--	8.18E-04	--	--	--	--	--	--	--	--
	--	--	1.37E-03	1.56E-03	--	--	--	--	--	--	1.37E-03
Pu-239	--	--	6.50E-05	--	--	--	--	--	--	--	--
	--	--	2.16E-05	--	--	--	--	--	--	--	--
	--	--	4.33E-05	6.14E-05	--	--	--	--	--	--	4.33E-05
U (total)	--	--	9.78E-04	--	--	--	--	--	--	--	--
	--	--	8.80E-05	--	--	--	--	--	--	--	--
	--	--	5.33E-04	1.26E-03	--	--	--	--	--	--	5.33E-04

+Indicates positive detection (result greater than error).

Source: Schmidt et al. 1990; Elder et al. 1986, 1987, 1988, 1989.

A2T-4f

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APPENDIX A.3

FISCAL YEAR 1987 INACTIVE CRIB MONITORING REPORT

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From: Geosciences Group
Phone: 3-2119 SO-04
Date: May 10, 1988
Subject: FISCAL YEAR 1987 INACTIVE CRIB MONITORING REPORT

80230-88-004

EBEL - WHC / E91-38 / ADM
SD-91-146

To: V. W. Hall R1-15

3.12

cc: M. R. Adams R2-78 K. A. Gasper R1-15
T. A. Curran R2-84 JRB File/LB

This is a letter report discussing the fiscal year 1987 inactive crib monitoring work.

The crib monitoring program is specified by a program plan provided in Last (et al., 1984). This current program does not satisfy the objectives specified in the program plan because it has not been fully implmented. New equipment, calibration facilities and more personnel would be required to fully implement such a program.

For 1987, the scope of the monitoring effort was redirected from that specified in the plan. The scope was directed at determining qualitative change in the characteristics of the gross gamma logs from vadose zone monitoring wells at inactive cribs. This includes qualitative assessments of the distribution of gamma emitting radionuclides along the boreholes and an indication of significant changes evidenced by changes in the shapes of the gamma-ray curves.

An attempt was made by the logging contractor (Pacific Northwest Laboratory) to standardize the gross gamma-ray logging tool by repeated logging of a borehole dubbed to be a site "standard". Although this is not a "calibration", it provides an indication that the tool is working and may allow a qualitative comparison of the logs from year to year. This limited standardization does not allow the quantitative comparison of gamma activity levels nor does it necessarily allow a precise determination of the location of gamma emitting radionuclides.

In 1987, approximately 140 wells were logged with a gross gamma-ray geophysical logging tool. Those wells are associated with 39 of the inactive crib sites. Table 1 provides a listing of cribs at which vadose zone wells were logged along with some comments on the sites. Those comments are limited to a qualitative assessment of any changes in the gamma-ray curves compared to previous logs. If the data indicate that radionuclides are migrating to the groundwater, this is also identified in the comment section of Table 1.

All gross gamma-ray geophysical logs are on file and available in Geotechnical Engineering Unit files.

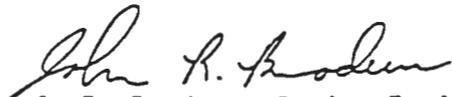
V. W. Hall
Page 2
March 16, 1988

Twenty-three of the 39 cribs that were monitored in 1987, show no significant changes in the gross gamma logs from previous logs, based on a comparison of the curve shapes and amplitudes relative to an assumed background.

For cribs 216-A-2, 216-A-27, 216-B-9, 216-C-9 and 216-S-20, comparison with previous logs was not possible because no previous logs exist, because the data were not recorded in the same manner, or because the instrumentation was not working properly, resulting in bad data.

In the past, several cribs show elevated gamma activity in the groundwater as evidenced by previous reports or old gross gamma logs. These include 216-A-6, 216-A-36A and B, 216-B-5, the entire BC crib area, the BY cribs, 216-S-1 and 2, 216-T-3 and 216-U-17. In each of these cribs or crib areas, no significant changes can be seen in the logs. This suggests that the radionuclides deposited below and around the cribs are not migrating. However, more data would be required to make that determination. The groundwater beneath cribs 216-A-36 and 216-U-17 is currently being monitored and some remedial investigations are being conducted at these sites.

Two problem areas are identified in Table 1. The T trenches (216-T-14, 15, 16 and 17) and the 216-T-26, 27 and 28 cribs show significant changes in the gross gamma log signatures (changes in the shapes of the curves) as compared to previous years. It is not known if the radionuclides are migrating or being redistributed. To make that assessment, quantitative radionuclide monitoring data are needed as well as water content data from a compensated neutron porosity geophysical log. Additional definition of the geology would also be required.


J. R. Brodeur, Senior Engineer
Geotechnical Engineering Unit

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Attachment

Table I CRIB MONITORING SUMMARY

CRIDS	BOREHOLES	DATE LOGGED	PAST LOGS	Comments
A- 2	299-E24- 53 299-E24- 65	-- 9-87	8-82 ---	Activity from 30 to 45 ft; Comparison with previous logs not possible, no previous data.
A- 4	299-E24- 54	9-87	8-82	Activity from 20 ft to TD; No change in logs.
A- 5	299-E24- 1 299-E24- 56 299-E24- 57 299-E24- 58	9-87 9-87 9-87 9-87	6-84, 8-82, 2-76, 4-70, 5-69 6-84, 8-82, 4-76, 5-69, 5-59 6-84, 8-82, 4-76, 5-69, 5-59 6-84, 8-82, 4-76, 5-69, 5-59	Two activity peaks (60 and 90 ft.); Some activity is seen at water table; Previous logs show relatively high gamma activity in groundwater, Gamma radionuclides have migrated to groundwater in the past, No recent change in gamma logs.
A- 6	299-E25- 3 299-E25- 53	7-87 8-87	7-84, 6-84, 2-76, 4-68, 5-69 8-84, 5-76	Activity at 35 feet; No change in gamma logs.
A-24	299-E26- 2 299-E26- 3 299-E26- 4 299-E26- 5 299-E26- 7	8-87 8-87 8-87 8-87 --	2-86, 6-84 2-86, 6-84 2-86, 6-84 2-86, 6-84 6-84	Activity between 200 and 240 ft in well E26-3, E26-4 and E26-5; Gamma emitting radionuclides have migrated to groundwater; Currently, little activity is seen in the vadose zone.
A-27	299-E17- 2 299-E17- 3	7-87 --	6-84 7-76, 4-70, 5-69	High gamma at water table in E17-3; No activity at is seen at the water table in E17-2; Contaminated groundwater, source unknown. Comparison with previous logs not possible due to different tool response.
A-31	299-E24- 9	9-87	2-76, 4-70, 5-69	No activity evident; No change in log.
A-36 AUB	299-E17- 4 299-E17- 5 299-E17- 7	7-87 -- 7-87	7-86, 6-84, 8-82, 2-76, 4-70 9-82, 2-76, 4-70, 4-68, 10-65 6-84, 4-76, 4-70, 3-67	Activity from 60 to 140 ft and in groundwater; Groundwater contamination has occurred, probably from 36A crib; GH monitoring in progress.
A-38	299-E17- 8 299-E24- 11	-- 7-87	4-76, 4-70, 4-68 2-76, 4-70, 4-68	Crib was never used; Activity evident only in groundwater; No change in logs.
A- 8	299-E28- 3 299-E28- 7 299-E28- 24 299-E28- 73 299-E28- 74	-- 7-87 7-87 -- --	7-86, 5-76, 5-69, 8-59 9-86	Activity evident in the groundwater; Groundwater contamination is caused by this injection well; Little change is seen in the gamma logs.

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Table I CONTINUED

CRIBS	BOREHOLES	DATE LOGGED	PAST LOGS	Comments
D-9	299-E20-53	--	5-76, 5-69	Only one monitoring well logged; no gamma activity is evident; Additional data are needed.
	299-E20-54	--	5-76, 5-69	
	299-E20-55	--	5-76, 5-69	
	299-E20-56	--	5-76	
	299-E20-57	--	--	
	299-E20-58	--	5-76, 5-69	
	299-E20-59	8-07	5-76, 5-69	
	299-E20-60	--	5-76	
	299-E20-61	--	5-76, 5-69	
B-12	299-E20-9	8-07	5-76	Gamma activity in well E20-76; Little change in this well
	299-E20-12	--	3-84, 6-89, 8-82	
	299-E20-16	--	5-76	
	299-E20-64	--	5-76, 9-67	
	299-E20-65	--	5-76, 9-60	
	299-E20-66	--	5-76, 9-60	
	299-E20-76	8-87	3-84	
216-DC Cribs A3-4	299-E13-1	7-87	3-85, 4-76, 4-60	Three of the logs show gamma activity from the surface down to and into the groundwater; Lateral migration of radio-nuclides may also have occurred; 1977 report indicates breakthrough; Current logs support this conclusion.
	B-14	7-87	3-85, 4-76, 4-60	
	B-15	7-87	4-85, 3-85, 4-76, 4-60	
	B-16	7-87	3-85, 5-59	
	B-17	--	5-85, 3-85	
	B-18	7-87	4-85, 1-85	
	B-19	7-87	3-85	
	299-E13-21	7-87	3-85, 4-76, 4-60	
DC Area Cribs	299-E13-7	7-87	3-84, 4-76, 4-60	Elevated gamma activity is seen in the groundwater near wells E13-12 and E13-18; Well E13-7 is the only groundwater well showing near surface gamma activity (20-40 ft). All nearby shallow vadose wells show gamma activity from the surface to about 40 ft. This suggests that the gross gamma monitoring equipment is not adequately sensitive for monitoring through groundwater wells. Contamination of the groundwater has occurred in the past. Little change is seen from previous logs.
	B-20	7-87	4-84, 2-76, 4-60	
	B-21	7-87	3-84, 4-76, 4-60	
	B-22	7-87	3-84, 4-76, 4-60	
	B-23	7-87	3-84, 4-76	
	B-24	7-87	3-84, 4-76	
	B-25	--	4-60, 5-69	
	B-26	--	3-84, 5-76, 4-60	
	B-27	7-87	3-84, 5-76, 4-60	
	B-28	7-87	3-84, 4-76, 4-60	
	B-29	7-87	3-84, 5-76	
	B-30	7-87	3-84, 5-76, 5-69	
	B-31	7-87	4-84	
	B-32	7-87	3-84	
B-33	7-87	3-84		

Table I CONTINUED

CRIBS	BOREHOLES	DATE LOGGED	PAST LOGS	Comments	
DC AREA CRIBS					
B-34	299-E13- 56	7-07	3-04		
B-52	299-E13- 57	7-07	3-04		
B-53A	299-E13- 58	7-07	3-04		
B-53B	299-E13- 59	7-07	3-04		
B-54	299-E13- 60	7-07	3-04		
D-50	299-E13- 61	7-07	3-04		
216-D Trenches					
B-35	299-E33- 8	--	2-76, 5-59	The data available for this group of cribs show stratified gamma activity from 20 to 50 ft. No data are available at depths greater than 50 feet. Little change in gamma logs	
B-36	299-E33- 10	--	--		
B-37	299-E33- 21	--	5-76, 4-70, 5-63, 5-59		
B-38	299-E33- 28	--	--		
B-39	299-E33- 29	--	--		
B-39	299-E33-206	7-07	3-84		
B-40	299-E33-207	7-07	3-84		
B-41	299-E33-208	7-07	3-84		
B-42	299-E33-209	7-07	3-84		
B-42	299-E33-290	7-07	3-84		
216-BY Cribs					
A3-5	299-E33- 1	--	4-76, 4-60, 5-63	All groundwater wells show gamma activity throughout the vadose zone and into the groundwater. Little change in gamma logs.	
	B-43	299-E33- 2	7-07		9-86, 5-76, 4-70, 5-63
	B-44	299-E33- 3	--		5-76, 4-70, 5-63
	B-45	299-E33- 4	7-07		9-86, 7-76, 4-70, 5-63
	B-46	299-E33- 5	--		5-76, 4-70, 5-63
	B-47	299-E33- 6	7-07		5-76, 4-70, 5-63
	B-48	299-E33- 7	7-07		2-76, 4-60, 1-59
	B-49	299-E33- 13	7-07		5-76
	B-50	299-E33- 22	7-07		9-86, 5-76, 9-65
	B-50	299-E33- 23	7-07		9-86, 5-76, 4-70, 9-65
B-56	299-E20- 14	5-87	5-76	Gamma activity is evident 15 ft below the water table. No gamma activity is seen on the log in the vadose zone. No change	
C- 9	299-E27- 1	7-07	--	No gamma activity is seen in the vadose zone in this well. Elevated activity occurs in the bottom of this well. No previous logs to allow comparison.	

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Table I CONTINUED

CRIDS	BOREHOLES	DATE LOGGED	PAST LOGS	Comments		
S- 1	299-N22- 1			Some wells show elevated gamma activity throughout the vadose zone. Gamma activity may have decreased in some wells. Cribs have broken through to groundwater sometime in the past as evidence by gamma logs.		
S- 2	299-N22- 2		5-76, 4-70, 2-60			
	299-N22- 5	8-87	5-76, 2-60, 5-63			
	299-N22- 6	8-87	2-86, 5-76, 2-60			
	299-N22- 10	3-87	2-86, 5-76, 2-60, 5-63			
	299-N22- 11	8-87	2-86			
	299-N22- 15	8-87	2-86, 5-76, 5-63, 4-66			
	299-N22- 16	8-87	2-86, 5-76, 4-70, 5-63			
	299-N22- 17	8-87	2-86, 5-76, 2-60			
	299-N22- 18	8-87	2-86, 5-76, 2-60, 5-63			
	299-N22- 29	--	2-86, 5-76, 2-60			
	299-N22- 30	--	6-80, 5-76, 2-60			
	299-N22- 31	--	2-86, 5-76, 2-60			
	299-N22- 36	--	5-76, 2-60			
	299-N22- 67	8-87	2-86, 5-76, 2-60			
A3-6	S- 7	299-N22- 12	--		2-76, 2-60, 2-50	Older logs suggest radionuclides have reached the groundwater. Current logs show slightly elevated gamma activity which may or may not be due to contaminants. Most activity is confined to the vadose zone.
		299-N22- 13	8-87		5-76, 2-60, 5-63	
		299-N22- 14	--	2-87, 5-76, 5-63, 2-58		
		299-N22- 32	--	5-76, 2-60		
	299-N22- 33	8-87	5-76, 2-60			
S- 9	299-N22- 25	8-87	9-86, 2-76, 3-70, 2-60	There appears to be elevated gamma activity at the top of the groundwater table. The level appears to be low however, and may be due to natural activity. No change		
	299-N22- 26	--	5-76, 3-70, 3-66			
	299-N22- 34	8-87	9-86, 5-76			
	299-N22- 35	8-87	9-86, 5-76			
S-20	299-N22- 19	--	3-84, 2-76, 2-60, 7-63	Gamma activity is evident in vadose zone in well N22-74. Gamma log is not comparable with previous log because of poor recording		
	299-N22- 20	--	5-76, 2-60, 5-63			
	299-N22- 74	2-87	3-84			
T- 3	299-N11- 1	7-87	--	Gamma activity is only seen above the water table. Well N11-79 shows gamma activity along length and into GW. Minimal change.		
	299-N11- 7	8-87	7-86, 2-76, 2-70, 6-59			
	299-N11- 79	--	7-86, 4-84			
T- 5	299-N10- 1	8-87	2-76, 5-63, 6-59	Low level activity. No change		

Table I CONTINUED

CRIDS	BOREHOLES	DATE LOGGED	PAST LOGS	Comments		
T- 6	299-N11- 1	7-87	5-76, 2-60	Some of the current logs show high activity between 90 and 40 ft. No change in logs.		
	299-N11- 54	--	5-76, 4-63, 2-50			
	299-N11- 55	--	5-76, 4-63, 2-50			
	299-N11- 56	--	5-76, 4-63			
	299-N11- 57	7-87	5-76, 4-63			
	299-N11- 58	--	5-76, 4-63			
	299-N11- 59	7-87	5-76, 4-63			
	299-N11- 60	--	5-76, 4-63			
	299-N11- 61	--	5-76, 4-63			
	299-N11- 62	--	5-76, 4-63			
	299-N11- 63	7-87	5-76, 4-63			
	299-N11- 64	--	5-76, 4-63			
	299-N11- 65	7-87	5-76, 4-63			
	299-N11- 66	--	5-76, 4-63			
	299-N11- 67	7-87	5-76, 4-63			
	T- 71	299-N10- 2	7-87		--	The gamma log from well N10-72 shows several high gamma activity zones. All other current logs do not show significantly high gamma activity. Decrease from previous logs is due to migration or decay of radionuclides.
		299-N10- 3	--		7-86, 2-76, 4-70, 6-59	
299-N10- 59		--	5-63			
299-N10- 60		--	--			
299-N10- 61		--	5-63			
299-N10- 62		--	--			
299-N10- 63		--	4-63			
299-N10- 66		--	--			
299-N10- 67		--	5-63			
299-N10- 68		--	5-63			
299-N10- 69		8-87	5-76, 5-63			
299-N10- 70		8-87	5-76, 5-63			
299-N10- 71		8-87	5-76, 5-63			
299-N10- 72		8-87	5-76, 5-63			
299-N10- 74		8-87	--			
299-N10- 77		8-87	5-76			
299-N10- 78		8-87	--			
299-N10- 79	8-87	--				
299-N10- 80	--	5-76, 5-63				
299-N10- 81	8-87	5-76				
216-T Trenches				Current well logs show a zone of gamma activity between 90 and 100 ft. Changes in shapes of gamma curves are significant. Quantitative data are required to assess changes.		
T-14	299-N11- 68	7-87	6-86, 5-76, 4-63			
T-15	299-N11- 69	7-87	5-76, 4-63			
T-16 T-17						

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Table I CONTINUED

CRIDS	BOREHOLES	DATE LOGGED	PAST LOGS	Comments	
T-26	299-W11- 11	--	--	Two zones of gamma activity are seen. One centered near 25 ft; one at 95 ft. Changes in gamma logs are evident. Quantitative data are required to assess changes.	
T-27	299-W11- 70	8-87	3-86, 4-84		
T-28	299-W11- 82	8-87	3-86, 4-84		
	299-W14- 1	7-87	9-86		
	299-W14- 2	--	--		
	299-W14- 3	8-87	9-86		
	299-W14- 4	8-87	9-86		
	299-W14- 53	8-87	7-86, 4-84		
	299-W14- 62	8-87	7-86, 4-84		
T-33	299-W11- 14	7-87		Two possible contamination zones; 100 ft and 170 ft. Levels are low relative to an assumed background. Little change from previous logs.	
T-34	299-W11- 15	--	5-76, 2-70, 2-60	No high activity is seen in W11-16. Little change from previous logs.	
	299-W11- 16	7-87	5-76, 2-70, 2-60		
A3-8	T-35	299-W11- 17	7-87	5-76, 2-70, 2-67	No high activity is seen in the gamma logs. Previously recorded gamma activity has decayed or migrated.
		299-W11- 18	--	2-76, 2-70, 3-67	
		299-W11- 19	7-87	5-76, 2-70	
		299-W11- 20	7-87	5-76, 2-70	
		299-W11- 21	7-87	5-76	
T-36	299-W10- 2	7-87	5-76	No high activity is seen in W10-2. Little change from previous logs.	
	299-W10- 4	--	5-76, 4-63, 7-59		
U- 9	299-W19- 1	5-87	--	No high gamma activity is seen in this well	
U-17	299-W19- 19	1-87	--	Gamma activity is evident throughout wells W19-19, W19-20, W19-23, and W19-24. Gamma emitting radionuclides have migrated recently and they have migrated to ground-water. Ground-water monitoring is occurring. Significant changes from previous logs.	
	299-W19- 20	--	6-86		
	299-W19- 23	3-87	--		
	299-W19- 24	--	--		
	299-W19- 25	4-87	--		
	299-W19- 26	4-87	--		

Table I CONTINUED

CRIBS	BOREHOLES	DATE LOGGED	PAST LOGS	Comments
Z-9	299-H15-6	3-87	15-76, 2-68, 5-69	Data from this crib show several strata with gamma emitting radionuclides in the unsaturated zone. No gamma activity is seen in the saturated zone. Minimal changes from previous logs.
	299-H15-8	3-87	4-73, 2-70, 10-68	
	299-H15-9	3-87	15-76, 4-73, 2-67	
	299-H15-02	3-87	15-76, 5-69	
	299-H15-04	3-87	15-76, 4-73, 5-69	
	299-H15-05	3-87	15-76, 4-73, 5-69	
	299-H15-06	3-87	15-76, 4-73	
	299-H15-95	3-87	15-76, 4-73, 5-69	
	299-H15-101	--	--	
Z-12	299-H10-2	--	15-76, 2-68, 5-69	No gamma activity is seen in the groundwater in these wells. Little activity is seen in the unsaturated zone. Little change in the well logs.
	299-H10-4	8-87	--	
	299-H10-5	--	15-73, 2-68, 2-67	
	299-H10-8	--	--	
	299-H10-69	--	2-68, 2-67	
	299-H10-70	--	--	
	299-H10-71	8-87	15-73, 2-70	
	299-H10-72	8-87	17-86	
	299-H10-73	8-87	15-73	
	299-H10-74	8-87	15-73	
	299-H10-75	--	17-86	
	299-H10-151	--	17-86	
	299-H10-152	--	17-86	
	299-H10-153	--	17-86	
	299-H10-154	--	17-86	
299-H10-155	--	17-86		
299-H10-156	--	--		
299-H10-157	--	17-86		
Z-10	299-H10-9	7-87	17-86	Several high gamma activity peaks are found between 20 and 70 ft. One zone of high gamma activity may occur between 124 and 146 ft. The three groundwater wells in this area do not indicate any gamma activity in the groundwater. Little change from previous logs.
	299-H10-10	--	--	
	299-H10-11	7-87	2-86	
	299-H10-12	--	--	
	299-H10-13	--	--	
	299-H10-02	7-87	16-86	
	299-H10-93	7-87	17-86	
	299-H10-94	7-87	17-86	
	299-H10-95	7-87	17-86	
	299-H10-96	7-87	17-86	
	299-H10-97	7-87	17-86	
	299-H10-98	7-87	17-86	
299-H10-177	9-87	16-86		

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ACRONYMS AND ABBREVIATIONS

AAMS	aggregate area management study
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act of 1980
CFR	Code of Federal Regulations
DOE	U.S. Department of Energy
EII	Environmental Investigations Instructions
HEHF	Hanford Environmental Health Foundation
HSP	Health and Safety Plan
HWOP	Hazardous Waste Operations Permit
JSA	Job Safety Analysis
NIOSH	National Institute for Occupational Safety and Health
OSHA	Occupational Safety and Health Administration
RCRA	Resource Conservation and Recovery Act
RWP	radiation work permit
SCBA	self-contained breathing apparatus
WISHA	Washington Industrial Safety and Health Act

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1.0 GENERAL CONSIDERATIONS AND REQUIREMENTS

1.1 INTRODUCTION

The purpose of this Health and Safety Plan (HSP) is to outline standard health and safety procedures for Westinghouse Hanford Company (Westinghouse Hanford) employees and contractors engaged in investigation activities in the U Plant Source Aggregate Area Management Study (U PLANT AAMS). These activities will include surface investigation, drilling and sampling boreholes, and environmental sampling in areas of known chemical and radiological contamination. Appropriate site-specific safety documents (e.g., Hazardous Waste Operations Permit [HWOP] or Job Safety Analysis [JSA]) will be written for each task or group of tasks. A more complete discussion of Westinghouse Hanford environmental safety procedures is presented in the Westinghouse Hanford manual *Health and Safety for Hazardous Waste Field Operations*, WHC-CM-4-3 vol. 4 (WHC 1992).

All employees of Westinghouse Hanford or any other contractors who are participating in onsite activities in the U PLANT AAMS shall read the site-specific safety document and attend a pre-job safety or tailgate meeting to review and discuss the task.

1.2 DESIGNATED SAFETY PERSONNEL

The field team leader and site safety officer are responsible for site safety and health. Specific individuals will be assigned on a task-by-task basis by project management, and their names will be properly recorded before the task is initiated.

All activities onsite must be cleared through the field team leader. The field team leader has responsibility for the following:

- Allocating and administering resources to successfully comply with all technical and health and safety requirements
- Verifying that all permits, supporting documentation, and clearances are in place (e.g., electrical outage requests, welding permits, excavation permits, HWOP or JSA, sampling plan, radiation work permits [RWP], and onsite/offsite radiation shipping records)
- Providing technical advice during routine operations and emergencies
- Informing the appropriate site management and safety personnel of the activities to be performed each day
- Coordinating resolution of any conflicts that may arise between RWPs and the implementation of the HWOP or JSA with health physics

- Handling emergency response situations as may be required
- Conducting pre-job and daily tailgate safety meetings
- Interacting with adjacent building occupants and/or inquisitive public.

The site safety officer is responsible for implementing the HWOP at the site. The site safety officer shall do the following.

- Monitor chemical, physical, and (in conjunction with the health physics technician) radiation hazards to assess the degree of hazard present; monitoring shall specifically include organic vapor detection, radiation screening, and confined space evaluation where appropriate.
- Determine protection levels, clothing, and equipment needed to ensure the safety of personnel in conjunction with the health physics department.
- Monitor the performance of all personnel to ensure that the required safety procedures are followed.
- Halt operations immediately, if necessary, due to safety or health concerns.
- Conduct safety briefings as necessary.
- Assist the field team leader in conducting safety briefings as necessary.

The health physics technician is responsible for ensuring that all radiological monitoring and protection procedures are being followed as specified in the Radiation Protection Manual and in the appropriate RWP. Westinghouse Hanford Industrial Safety and Fire Protection personnel will provide safety overview during drilling operations consistent with Westinghouse Hanford policy and, as requested, will provide technical advice. Also, downwind sampling for hazardous materials and radiological contaminants and other analyses may be requested from appropriate contractor personnel as required.

The ultimate responsibility and authority for employee's health and safety lies with the employee and the employee's colleagues. Each employee is responsible for exercising the utmost care and good judgment in protecting his or her personal health and safety and that of fellow employees. Should any employee observe a potentially unsafe condition or situation, it is the responsibility of that employee to immediately bring the observed condition to the attention of the appropriate health and safety personnel, as designated previously. In the event of an immediately dangerous or life-threatening situation, the employee automatically has temporary "stop work" authority and the responsibility to immediately notify the field team leader or site safety officer. When work is temporarily halted because of a safety or

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health concern, personnel will exit the exclusion zone and meet at a predetermined place in the support zone. The field team leader, site safety officer, and health physics technician will determine the next course of action.

1.3 MEDICAL SURVEILLANCE

All field team members engaged in operable unit activities at sites governed by an HWOP must have baseline physical examinations and be participants in Westinghouse Hanford (or an equivalent) hazardous waste worker medical surveillance program.

Medical examinations will be designed to identify any pre-existing conditions that may place an employee at high risk, and will verify that each worker is physically able to perform the work required by this plan without undue risk to personal health. The physician shall determine the existence of conditions that may reduce the effectiveness or prevent the employee's use of respiratory protection. The physician shall also determine the presence of conditions that may pose undue risk to the employee while performing the physical tasks of this work plan using level B personal protection equipment. This would include any condition that increases the employee's susceptibility to heat stress.

The examining physician's report will not include any nonoccupational diagnoses unless directly applicable to the employee's fitness for the work required.

1.4 TRAINING

Before engaging in any onsite activities, each team member is required to have received 40 hours of health and safety training related to hazardous waste site operations and at least 8 hours of refresher training each year thereafter as specified in 29 Code of Federal Regulations (CFR) 1910.120. In addition, each inexperienced employee (never having performed site characterization) will be directly supervised by a trained/experienced person for a minimum of 24 hours of field experience.

The field team leader and the site safety officer shall receive an additional 8 hours of training (in addition to the refresher training previously discussed).

1.5 TRAINING FOR VISITORS

For the purposes of this plan, a visitor is defined as any person visiting the Hanford Site, who is not a Westinghouse Hanford employee or a Westinghouse Hanford contractor directly involved in the Resource Conservation and Recovery Act (RCRA)/Comprehensive Environmental Response, Compensation and Liability Act of 1980 (CERCLA) facility investigation activities, including but not limited to those engaged in surveillance, inspection, or observation activities.

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Visitors who must, for whatever reason, enter a controlled (either contamination reduction or exclusion) zone, shall be subject to all of the applicable training, respirator fit testing, and medical surveillance requirements discussed in Westinghouse Hanford Environmental Investigations and Site Characterization Manual Environmental Investigations Instructions (EII) 1.1 (WHC 1988).

All visitors shall be informed of potential hazards and emergency procedures by their escorts and shall conform to EII 1.1 (WHC 1988).

1.6 RADIATION DOSIMETRY

All personnel engaged in onsite activities shall be assigned dosimeters according to the requirements of the RWP applicable to that activity. All visitors shall be assigned basic dosimeters, as a minimum, that will be exchanged annually.

1.7 REQUIREMENTS FOR THE USE OF RESPIRATORY PROTECTION

All employees of Westinghouse Hanford and subcontractors who may be required to use air-purifying or air-supplied respirators must be included in the medical surveillance program and be approved for the use of respiratory protection by the Hanford Environmental Health Foundation (HEHF) or other licensed physician. Each team member must be trained in the selection, limitations, and proper use and maintenance of respiratory protection (existing respiratory protection training may be applicable towards the 40-hour training requirement).

Before using a negative pressure respirator, each employee must have been fit-tested (within the previous year) for the specific make, model, and size according to Westinghouse Hanford fit-testing procedures. Beards (including a few days' growth), large sideburns, or moustaches that may interfere with a proper respirator seal are not permitted.

Subcontractors must provide evidence to Westinghouse Hanford that personnel are participants in a medical surveillance and respiratory protection program that complies with 29 CFR 1910.120 and 29 CFR 1910.134, respectively.

2.0 GENERAL PROCEDURES

The following personal hygiene and work practice guidelines are intended to prevent injuries and adverse health effects. A hazardous waste site poses a multitude of health and safety concerns because of the variety and number of hazardous substances present. These guidelines represent the minimum standard procedures for reducing potential risks associated with this project and are to be followed by all job-site employees at all times.

2.1 GENERAL WORK SAFETY PRACTICES

2.1.1 Work Practices

The following work practices must be observed.

- Eating, drinking, smoking, taking certain medications, chewing gum, and similar actions are prohibited within the exclusion zone. All sanitation facilities shall be located outside the exclusion zone; decontamination is required before using such facilities.
- Personnel shall avoid direct contact with contaminated materials unless necessary for sample collecting or required observation. Remote handling of such things as casings and auger flights will be practiced whenever practical.
- While operating in the controlled zone, personnel shall use the "buddy system" where appropriate, or be in visual contact with someone outside of the controlled zone.
- The buddy system will be used where appropriate for manual lifting.
- Requirements of Westinghouse Hanford radiation protection and RWP manuals shall be followed for all work involving radioactive materials or conducted within a radiologically controlled area.
- Onsite work operations shall only be carried out during daylight hours, unless the entire control zone is adequately illuminated with artificial lighting. A new tour (shift) will operate the drilling rig after completion of each shift.
- Do not handle soil, waste samples, or any other potentially contaminated items unless wearing the protective equipment specified in the HWOP or JSA.
- Whenever possible, stand upwind of excavations, boreholes, well casings, drilling spoils, and the like, as indicated by an onsite windsock.

- Stand clear of trenches during excavation. Always approach an excavation from upwind.
- Be alert to potentially changing exposure conditions as evidenced by such indications as perceptible odors, unusual appearance of excavated soils, or oily sheen on water.
- Do not enter any test pit or trench deeper than 1 m (4 ft) unless in accordance with procedures specified in the HWOP.
- Do not under any circumstances enter or ride in or on any backhoe bucket, materials hoist, or any other similar device not specifically designed for carrying passengers.
- All drilling team members must make a conscientious effort to remain aware of their own and others' positions in regards to rotating equipment, cat heads, or u-joints. Drilling operations members must be extremely careful when assembling, lifting, and carrying flights or pipe to avoid pinch-point injuries and collisions.
- Tools and equipment will be kept off the ground whenever possible to avoid tripping hazards and the spread of contamination.
- Personnel not involved in operation of the drill rig or monitoring activities shall remain a safe distance from the rig as indicated by the field team leader.
- Follow all provisions of each site-specific hazardous work permit as addressed in the HWOP, including cutting and welding, confined space entry, and excavation.
- Catalytic converters on the underside of vehicles are sufficiently hot to ignite dry prairie grass. Team members should not drive over dry grass that is higher than the ground clearance of the vehicle and should be aware of the potential fire hazard posed by catalytic converters at all times. Never allow a running or hot vehicle to sit in a stationary location over dry grass or other combustible materials.
- Follow all provisions of each site-specific RWP.
- Team members will attempt to minimize truck tire disturbance of all stabilized sites.

2.1.2 Personal Protective Equipment

- Personal protective equipment will be selected specifically for the hazards identified in the HWOP. The site safety officer in conjunction with Westinghouse Hanford Health Physics and Industrial Hygiene and Safety is responsible for choosing the appropriate type and level of protection required for different activities at the job site.
- Levels of protection shall be appropriate to the hazard to avoid either excessive exposure or additional hazards imposed by excessive levels of protection. The HWOP will contain provisions for adjusting the level of protection as necessary. These personal protective equipment specifications must be followed at all times, as directed by the field team leader, health physics technician, and site safety officer.
- Each employee must have a hard hat, safety glasses, and substantial protective footwear available to wear as specified in the HWOP or JSA.
- The exclusion zone around drilling or other noisy operations will be posted "Hearing Protection Required" and team members will have had noise control training.
- Personnel should maintain a high level of awareness of the limitations in mobility, dexterity, and visual impairment inherent in the use of level B and level C personal protective equipment.
- Personnel should be alert to the symptoms of fatigue, heat stress, and cold stress and their effects on the normal caution and judgment of personnel.
- Rescue equipment as required by Occupational Safety and Health Administration (OSHA), Washington Industrial Safety and Health Act (WISHA), or standards for working over water will be available and used.

2.1.3 Personal Decontamination

- The HWOP will describe in detail methods of personnel decontamination, including the use of contamination control corridors and step-off pads when appropriate.
- Thoroughly wash hands and face before eating or putting anything in the mouth to avoid hand-to-mouth contamination.

- At the end of each work day or each job, disposable clothing shall be removed and placed in (chemical contamination) drums, plastic-lined boxes or other containers as appropriate. Clothing that can be cleaned may be sent to the Hanford Site laundry.
- Individuals are expected to thoroughly shower before leaving the work site or Hanford Site if directed to do so by the health physics technician, site safety officer, or field team leader.

2.1.4 Emergency Preparation

- A multipurpose dry chemical fire extinguisher, a fire shovel, a complete field first-aid kit, and a portable pressurized spray wash unit shall be available at every site where there is potential for personnel contamination.
- Prearranged hand signals or other means of emergency communication will be established when respiratory protection equipment is to be worn, because this equipment seriously impairs speech.
- The Hanford Fire Department shall be initially notified before the start of the site investigation project. This notification shall include the location and nature of the various types of field work activities as described in the work plan. A site location map shall be included in this notification.

2.2 CONFINED SPACE/TEST PIT ENTRY PROCEDURES

The following procedures apply to the entry of any confined space, which for the purpose of this document shall be defined as any space having limited egress (access to an exit) and the potential for the presence or accumulation of a toxic or explosive atmosphere. This includes manholes, certain trenches (particularly those through waste disposal areas), and all test pits greater than 1 m (4 ft) deep. If confined spaces are to be entered as part of the work operations, a hazardous work permit (filled out for confined space entry) must be obtained from Industrial Safety and Fire Protection.

The identified remedial investigation activities on the U PLANT AAMS should not require confined space entry. Nevertheless, the hazards associated with confined spaces are of such severity that all employees should be familiar with the safe work discussed in the following paragraphs.

No employee shall enter any test pit or trench deeper than 1 m (4 ft) unless the sides are shored or laid back to a stable slope as specified in OSHA 29 CFR 1926.652 or equivalent state occupational health and safety regulations.

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When an employee is required to enter a pit or trench 1 m (4 ft) deep or more, an adequate means of access and egress, such as a slope of at least 2:1 to the bottom of the pit or a secure ladder or steps shall be provided.

Before entering any confined space, including any test pit, the atmosphere will be tested for flammable gases, oxygen deficiency, and organic vapors. If other specific contamination, such as radioactive materials or other gases and vapors may be present, additional testing for those substances shall be conducted. Depending on the situation, the space may require ventilation and retesting before entry.

An employee entering a confined or partially confined space must be equipped with an appropriate level of respiratory protection in keeping with the monitoring procedures discussed previously and the action levels for airborne contaminants (see "Warnings and Action Levels" in HWOP).

No employee shall enter any test pit requiring the use of level B protection, unless a backup person also equipped with a pressure-demand self-contained breathing apparatus (SCBA) is present. No backup person shall attempt any emergency rescue unless a second backup person equipped with an SCBA is present, or the appropriate emergency response authorities have been notified and additional help is on the way.

3.0 SITE BACKGROUND

Specific details on the U PLANT AAMS background and known and suspected contamination are described in Chapters 2.0 through 10.0 of the plan. The U Plant Aggregate Area is situated within the 200 West Area of the DOE's Hanford Site, in the south-central portion of the state of Washington. The 200 West Area is located in Benton County in the central portion of the Hanford Site. It is adjacent to the 200 East Area, located roughly 5 km to the west.

The U-Plant Area at the Hanford Site was used by the U.S. Government as a chemical separations area in the process to produce plutonium for nuclear weapons. These operations resulted in the release of chemical and radioactive wastes into the soil, air, and water of the area. Each waste site in the aggregate area is described separately in this document. Close relationships between waste units, such as overflow from one to another, are also discussed.

4.0 SCOPE OF WORK AND POTENTIAL HAZARDS

While the information presented in Chapters 2.0 through 10.0 of the plan are believed to be representative of the constituents and quantities of wastes at the time of discharge, the present chemical nature, location, extent, and ultimate fate of these wastes in and around the liquid disposal facilities are largely unknown. The emphasis of the investigation in the U PLANT AAMS will be to characterize the nature and extent of contamination in the vadose (unsaturated subsurface soil) zone.

4.1 WORK TASKS

Work tasks are described in Chapter 5.0 of the plan.

4.2 POTENTIAL HAZARDS

Onsite tasks will involve noninvasive surface sampling procedures and invasive soil sampling either directly in or immediately adjacent to areas known or suspected to contain potentially hazardous chemical substances, toxic metals, and radioactive materials.

Surface radiological contamination and fugitive dust will be the potential hazards of primary concern during noninvasive mapping and sampling activities.

Existing data indicate that hazardous substances may be encountered during invasive sampling; these include radionuclides, heavy metals, and corrosives. In addition, volatile organics may also be associated with certain facilities such as the solvent storage buildings or underground storage tanks.

Potential hazards include the following:

- External radiation (gamma and to a lesser extent, beta) from radioactive materials in the soil
- Internal radiation resulting from radionuclides present in contaminated soil entering the body by ingestion or through open cuts and scratches
- Internal radiation resulting from inhalation of particulate (dust) contaminated with radioactive materials
- Inhalation of toxic vapors or gases such as volatile organics or ammonia
- Inhalation or ingestion of particulate (dust) contaminated with inorganic or organic chemicals, and toxic metals

- Dermal exposure to soil or groundwater contaminated with radionuclides
- Dermal exposure to soil or groundwater contaminated with inorganic or organic chemicals, and toxic metals
- Physical hazards such as noise, heat stress, and cold stress
- Slips, trips, falls, bumps, cuts, pinch points, falling objects, other overhead hazards, crushing injuries, and other hazards typical of a construction-related job site
- Unknown or unexpected underground utilities
- Biological hazards; snakes, spiders, etc.

4.3 ASSESSMENT AND MITIGATION OF POTENTIAL HAZARDS

The likelihood of significant exposure (100 mR/h or greater) to external radiation is remote and can be readily monitored and controlled by limiting exposure time, increasing distance, and employing shielding as required.

Internal radiation by inhalation or inadvertent ingestion of contaminated dust is a realistic concern and must be continuously evaluated by the health physics technician. Appropriate respiratory protection, protective clothing, and decontamination procedures will be implemented as necessary to reduce potential inhalation, ingestion, and dermal exposure to acceptable levels.

Dermal exposure to toxic chemical substances is not expected to pose a significant problem for the identified tasks given the use of the designated protective clothing. The appropriate level of personal protective clothing and respiratory protection will vary from work site to work site.

5.0 ENVIRONMENTAL AND PERSONAL MONITORING

The site safety officer or authorized delegate shall be present at all times during work activities which require an HWOP, and shall be in charge of all environmental/personal monitoring equipment. Industrial Hygiene and Safety shall review all activities involving or potentially involving radiological exposure or contamination control and shall prescribe the appropriate level of technical support and/or monitoring requirements. Other equipment deemed necessary by the site safety officer or Industrial Hygiene and Safety shall be obtained

at their direction; work will be initiated or continued until such equipment is in place. These instruments are to be used only by persons who are trained in their usage and who understand their limitations. No work shall be done unless instrumentation is available and in proper working order.

Air sampling may be required downwind of the referenced waste sites to monitor particulates and vapors before job startup. Siting of such sampling devices will be determined by Health Physics, the site safety officer, and HEHF, if appropriate. Any time personnel exposure monitoring, other than radiological, is required to determine exposure levels, it must be done by HEHF. Discrete sampling of ambient air within the work zone and breathing zones will be conducted using a direct-reading instrument, as specified in the site-specific safety document, and other methods as deemed appropriate (e.g., pumps with tubes, O₂ meters). The following standards will be used in determining critical levels:

- "Radionuclide Concentrations in Air," in Chapter XI, DOE Order 5480.1B (DOE 1986)
- "Air Contaminants - Permissible Exposure Limits," in 29 CFR 1910.1000
- *Threshold Limit Values and Biological Exposure Indices for 1990-1991* (ACGIH 1991)
- *Occupational Safety and Health Standards*, 29 CFR 1910.1000
- *Pocket Guide to Chemical Hazards* (NIOSH 1991), which provides National Institute for Occupational Safety and Health (NIOSH)-recommended exposure limits for substances that do not have either a threshold limit value or a permissible exposure limit.

5.1 AIRBORNE RADIOACTIVE AND RADIATION MONITORING

An onsite health physics technician will monitor airborne radioactive contamination levels and external radiation levels. Action levels will be consistent with derived air concentrations and applicable guidelines as specified in the radiation protection manual WHC-CM-4-10 (WHC 1988).

Appropriate respiratory protection shall be required when conditions are such that the airborne contamination levels may exceed an 8-hour derived air concentration (e.g., the presence of high levels of uncontained, loose contamination on exposed surfaces or operations that may raise excessive levels of dust contaminated with airborne radioactive materials, such as excavation or drilling under extremely dry conditions).

Specific conditions requiring the use of respiratory protection because of radioactive materials in air will be incorporated into the RWP. If, in the judgement of the health physics technician, any of these conditions arise, work shall cease until appropriate respiratory protection is provided.

6.0 PERSONAL PROTECTIVE EQUIPMENT

The level of personal protective equipment required initially at a site will be specified in the site-specific safety document for each task or group of tasks. Personal protective clothing and respiratory protection shall be selected to limit exposure to anticipated chemical and radiological hazards. Work practices and engineering controls may be used to control exposure.

7.0 SITE CONTROL

The field team leader, site safety officer, and health physics technician are designated to coordinate access control and security on the site. Special site control measures will be necessary to restrict public access. The zones will be clearly marked with rope and/or appropriate signs. The size and shape of the control zone will be dictated by the types of hazards expected, the climatic conditions, and specific operations required.

Control zone boundaries may be increased or decreased based on results of field monitoring, environmental changes, or work technique changes. The site RWP and the contractor's standard operating procedures for radiation protection may also dictate the boundary size and shape. All team members must be surveyed for radioactive contamination when leaving the controlled zone if in a radiation zone.

The onsite command post and staging area will be established near the upwind side of the control zone as determined by an onsite windsock. Exact location for the command post is to be determined just before start of work. Vehicle access, availability of utilities (power and telephone), wind direction, and proximity to sample locations should be considered in establishing a command post location.

8.0 DECONTAMINATION PROCEDURES

Remedial investigation activities will require entry into areas of known chemical and radiological contamination. Consequently, it is possible that personnel and equipment could be contaminated with hazardous chemical and radiological substances.

During site activities, potential sources of contamination may include airborne vapors, gases, dust, mists, and aerosols; splashes and spills; walking through contaminated areas; and handling contaminated equipment. Personnel who enter the exclusion zone will be required to go through the appropriate decontamination procedures on leaving the zone. Decontamination procedures shall be consistent with EII 5.4, "Field Decontamination of Drilling, Well Development, and Sampling Equipment," and EII 5.5, "1706 KE Laboratory Decontamination of Equipment for RCRA/CERCLA Sampling" (WHC 1988), or other approved decontamination procedures.

9.0 CONTINGENCY AND EMERGENCY RESPONSE PLANS

As a general rule, in the event of an unanticipated, potentially hazardous situation indicated by instrument readings, visible contamination, unusual or excessive odors, or other indications, team members shall temporarily cease operations and move upwind to a predesignated safe area as specified in the site-specific safety documentation.

10.0 REFERENCES

- ACGIH, 1991, *Threshold Limit Values and Biological Exposure Indices for 1990-1991*, American Conference of Governmental Industrial Hygienists, Cincinnati, Ohio.
- DOE, 1986, *Environment, Safety & Health Program for DOE Operations*, DOE Order 5480.1B, U.S. Department of Energy, Washington, D.C.
- DOE-RL, 1988, *Industrial Hygiene Program*, DOE/RL Order 5480.10A, U.S. Department of Energy, Richland Operations Office, Richland, Washington.
- NIOSH, 1991, *Pocket Guide to Chemical Hazards*, National Institute for Occupational Safety and Health, U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control, Washington, D.C.

WHC, 1988, *Radiation Protection*, WHC-CM-4-10, Westinghouse Hanford Company, Richland, Washington.

WHC, 1988, *Environmental Investigations and Site Characterization Manual*, WHC-CM-7-7, Westinghouse Hanford Company, Richland, Washington.

WHC, 1992, *Health and Safety for Hazardous Waste Field Operations*, WHC-CM-4-3 Vol. 4, Westinghouse Hanford Company, Richland, Washington.

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APPENDIX C
PROJECT MANAGEMENT PLAN

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ACRONYMS AND ABBREVIATIONS

CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act of 1980
DOE	U.S. Department of Energy
Ecology	Washington State Department of Ecology
EPA	U.S. Environmental Protection Agency
FS	feasibility study
MCS	Management Control System
PMP	Project Management Plan
PNL	Pacific Northwest Laboratory
RCRA	Resource Conservation and Recovery Act
RI	remedial investigation
Tri-Party Agreement	Hanford Federal Facility Agreement and Consent Order

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1.0 INTRODUCTION

This Project Management Plan (PMP) defines the administrative and institutional tasks necessary to support the U Plant Aggregate Area investigations at the Hanford Site. Also, this PMP defines the responsibilities of the various participants, the organizational structure, and the project tracking and reporting procedures. This PMP is in accordance with the provisions of the *Hanford Federal Facility Agreement and Consent Order* (Tri-Party Agreement) dated August 1990 (Ecology et al. 1990). Any revisions to the Tri-Party Agreement that would result in changes to the project management requirements would supersede the provisions of this chapter.

2.0 PROJECT ORGANIZATION AND RESPONSIBILITIES

2.1 INTERFACE OF REGULATORY AUTHORITIES AND THE U.S. DEPARTMENT OF ENERGY

The U Plant Aggregate Area consists of active and inactive waste management units to be remedied under either the Resource Conservation and Recovery Act (RCRA) or the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA). The Washington State Department of Ecology (Ecology) has been designated as the lead regulatory agency, as defined in the Tri-Party Agreement. Accordingly, Ecology is responsible for overseeing remedial action activity at this aggregate area and ensuring that the applicable authorities of both the U.S. Environmental Protection Agency (EPA) and the U.S. Department of Energy (DOE) are applied. The specific responsibilities of EPA, Ecology, and DOE are detailed in the Tri-Party Agreement.

2.2 PROJECT ORGANIZATION AND RESPONSIBILITIES

The project organization for implementing remedial activities at the U Plant Aggregate Area is shown in Figure C-1. The following sections describe the responsibilities of the individuals shown in Figure C-1.

2.2.1 Project Managers

The EPA, DOE, and Ecology have each designated one individual as project manager for remedial activities at the Hanford Site. These project managers will serve as the primary point of contact for all activities to be carried out under the Tri-Party Agreement. The responsibilities of the project managers are given in Section 4.1 of the Tri-Party Agreement.

2.2.2 Unit Managers

As shown in Figure C-1, EPA, DOE, and Ecology will each designate an individual as a unit manager for the U Plant Aggregate Area.

The unit manager from Ecology will serve as the lead unit manager. The Ecology unit manager will be responsible for regulatory oversight of all activities required for the U Plant Aggregate Area.

The unit manager from EPA will be responsible for making decisions related to issues for which the supporting regulatory agency maintains authority. All such decisions will be made in consideration of recommendations made by the Ecology unit manager.

The unit manager from DOE will be responsible for maintaining and controlling the schedule and budget and keeping the EPA and Ecology unit managers informed as to the status of the activities at the U Plant Aggregate Area, particularly the status of agreements and commitments.

2.2.3 Quality Assurance Lead

The quality assurance lead will be a designated person within the Westinghouse Hanford Quality Assurance Organization. This designated person will be responsible for monitoring overall environmental restoration activities for this project. The designated personnel shall have the necessary organizational independence and authority to identify conditions adverse to quality and to systematically seek corrective action.

This individual is responsible for the preplanned surveillance and audit activities for this project. A quality assurance report shall be provided to the technical lead, annually as a minimum, for inclusion in the project final report generated by the technical organization. The quality assurance report shall summarize the surveillance and audit activities as well as associated corrective actions that may have been taken during the interval.

2.2.4 Health and Safety Officer (Environmental Division/Environmental Field Services)

The health and safety officer is responsible for monitoring all potential health and safety hazards, including those associated with radioactive, volatile, and/or toxic compounds during sample handling and sampling decontamination activities. The health and safety officer has the responsibility and authority to halt field activities resulting from unacceptable health and safety hazards.

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2.2.5 Technical Lead

The technical lead will be a designated person within the Westinghouse Hanford Environmental Engineering Group. The responsibilities of the technical lead will be to plan, authorize, and control work so that it can be completed on schedule and within budget, and to ensure that all planning and work performance activities are technically sound.

2.2.6 Remedial Investigation/Feasibility Study Coordinators

The remedial investigation (RI) and feasibility study (FS) coordinators will be responsible for coordinating all activities related to the RI and FS, respectively, including data collection, analysis, and reporting. The RI and FS coordinators will be responsible for keeping the technical lead informed as to the RI and FS work status and any problems that may arise.

2.2.7 Resource Conservation and Recovery Act Facility Investigation/Corrective Measures Study Contractor

Figure C-1 shows the organizational relationship of an offsite contractor. Assuming a contractor is used to perform the RI/FS for the U Plant Aggregate Area, the contractor would assume responsibilities of the RI and FS coordinators, as described above. In this instance, the contractor will be directly responsible for planning data collection activities and for analyzing and reporting the results of the data-gathering in the RI and FS reports. However, the Westinghouse Hanford coordinator would retain the responsibility for securing and managing the field sampling efforts of the Hanford Site technical resource teams, described below. Figure C-2 shows a sample organizational structure for an RI/FS contractor team.

2.2.8 Hanford Site Technical Resources

The various technical resources available on the Hanford Site for performing the field studies are shown in Table C-1. These resources will be responsible for performing data collection activities and analyses, and for reporting the results of specific technical activities. Figures C-3 through C-6 show the detailed organizational structure of specific technical teams. Internal and external work orders and subcontractor task orders will be written by the Westinghouse Hanford technical lead to use these technical resources, which are under the control of the technical lead. Statements of work will be provided to the technical teams and will include a discussion of authority and responsibility, a schedule with clearly defined milestones, and a task description including specific requirements. Each technical team will keep the coordinator informed of the work status performed by that group and any problems that may arise.

3.0 DOCUMENTATION AND RECORDS

All plans and reports will be categorized as either primary or secondary documents as described by Section 9.1 of the Tri-Party Agreement. The process for document review and comment will be as described in Section 9.2 of the Tri-Party Agreement. Revisions, should they become necessary after finalization of any document, will be in accordance with Section 9.3 of the Tri-Party Agreement. Changes in the work schedule, as well as minor field changes, can be made without having to process a formal revision. The process for making these changes will be as stated in Section 12.0 of the Tri-Party Agreement. Administrative records, which must be maintained to support the Hanford Site activities, will be in accordance with Section 9.4 of the Tri-Party Agreement.

4.0 FINANCIAL AND PROJECT TRACKING REQUIREMENTS

4.1 MANAGEMENT CONTROL

Westinghouse Hanford will have the overall responsibility for planning and controlling the investigation activities, and providing effective technical, cost, and schedule baseline management. If a contractor is used, the contractor will assume the direct day-to-day responsibilities for these management functions. The management control system used for this project must meet the requirements of DOE Order 4700.1, Project Management System and DOE Order 2250.1C, Cost and Schedule Control Systems Criteria. The Westinghouse Hanford Management Control System (MCS) meets these requirements. The primary goals of the Westinghouse Hanford MCS are to provide methods for planning, authorizing, and controlling work so that it can be completed on schedule and within budget, and to ensure that all planning and work performance activities are technically sound and in conformance with management and quality requirements.

The schedule developed for the U Plant Aggregate Area will be updated at least annually, to expand the new current fiscal year and the follow-on year. In addition, any approved schedule changes (see Section 12.0 of the Tri-Party Agreement for the formal change control system) would be incorporated at this time, if not previously incorporated. This update will be performed in the fourth quarter of the previous fiscal year (e.g., July to September) for the upcoming current fiscal year. The work schedule can be revised at any time during the year if the need arises, but the changes would be restricted to major changes that would not be suitable for the change control process.

4.2 MEETINGS AND PROGRESS REPORTS

Both project and unit managers must meet periodically to discuss progress, review plans, and address any issues that have arisen. The project managers' meeting will take place at least quarterly, and is discussed in Section 8.1 of the Tri-Party Agreement.

Unit managers shall meet monthly to discuss progress, address issues, and review near-term plans pertaining to their respective operable units and/or treatment, storage, and disposal groups/units. The meetings shall be technical in nature, with emphasis on technical issues and work progress. The assigned DOE unit manager for the U Plant Aggregate Area will be responsible for preparing revisions to the aggregate area schedule prior to the meeting. The schedule shall address all ongoing activities associated with the U Plant Aggregate Area, including actions on specific source units (e.g., sampling). This schedule will be provided to all parties and reviewed at the meeting. Any agreements and commitments (within the unit manager's level of authority) resulting from the meeting will be prepared and signed by all parties as soon as possible after the meeting. Meeting minutes will be issued by the DOE unit manager and will summarize the discussion at the meeting, with information copies given to the project managers. The minutes will be issued within five working days following the meeting. The minutes will include, at a minimum, the following information:

- Status of previous agreements and commitments
- Any new agreements and commitments
- Schedules (with current status noted)
- Any approved changes signed off at the meeting in accordance with Section 12.1 of the Tri-Party Agreement.

Project coordinators for each operable unit also will meet on a monthly basis to share information and to discuss progress and problems.

The DOE shall issue a quarterly progress report for the Hanford Site within 45 days following the end of each quarter. Quarters end on March 31, June 30, September 30, and December 31. The quarterly progress reports will be placed in the public information repositories as discussed in Section 10.2 of the Tri-Party Agreement. The report shall include the following:

- Highlights of significant progress and problems.
- Technical progress with supporting information, as appropriate.

- Problem areas with recommended solutions. This will include any anticipated delays in meeting schedules, the reason(s) for the potential delay, and actions to prevent or minimize the delay.
- Significant activities planned for the next quarter.
- Work schedules (with current status noted).

5.0 REFERENCES

Ecology, EPA, and DOE, 1990, *Hanford Federal Facility Agreement and Consent Order*, (First Amendment), 89-10, Rev.1, Olympia, Washington.

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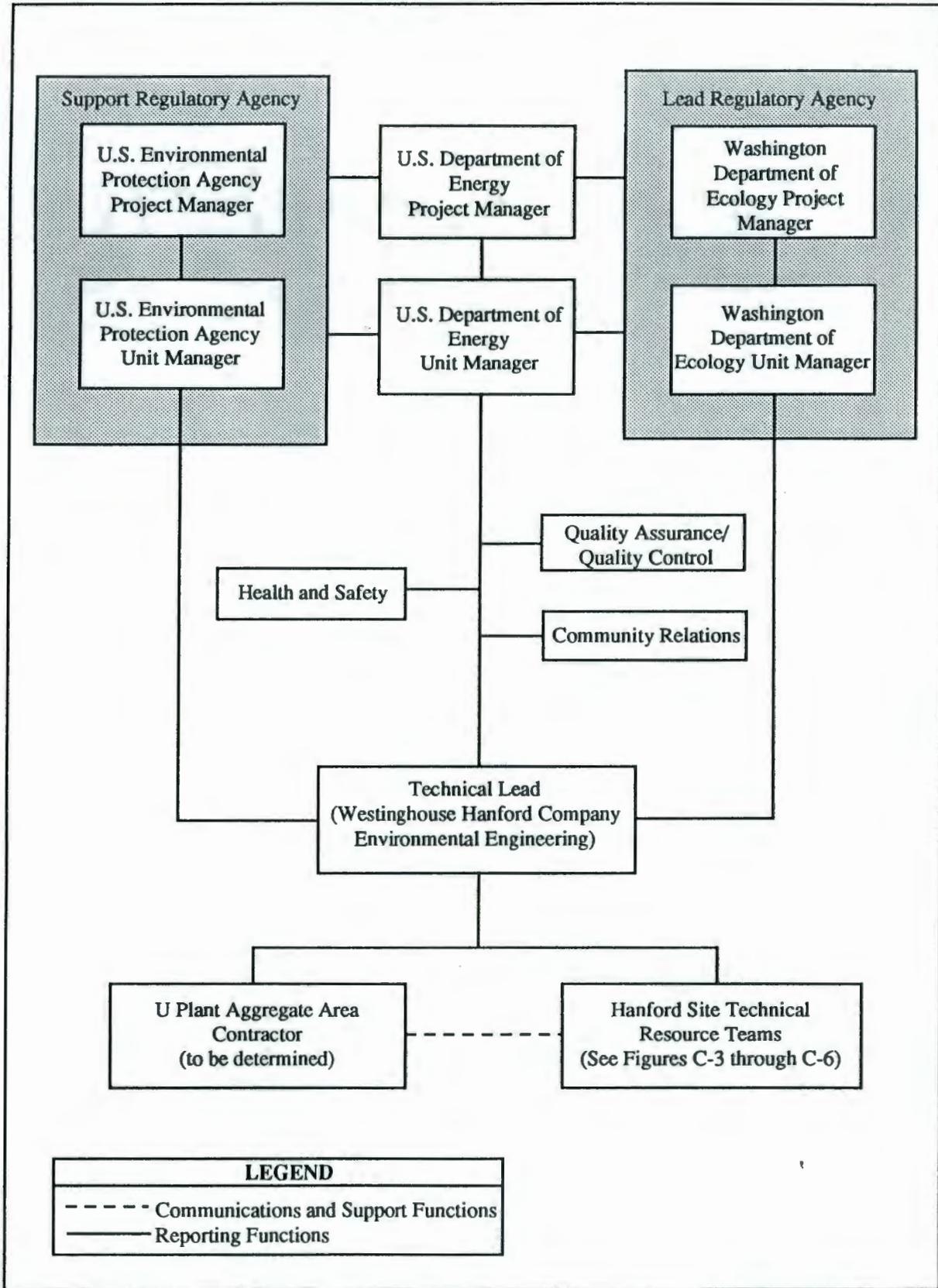


Figure C-1. Project Organization for the U Plant Aggregate Area Project.

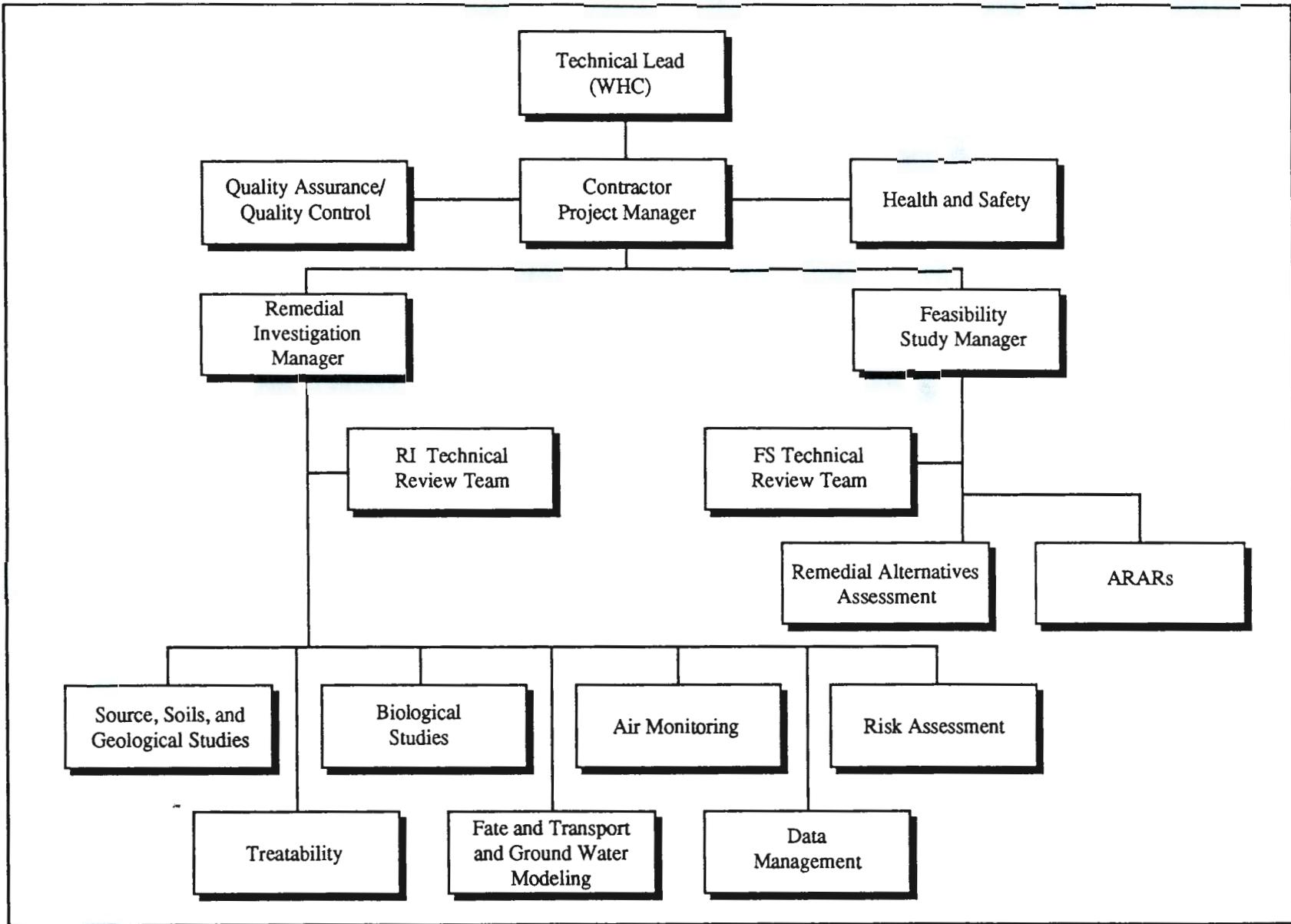


Figure C-2. Example Project Organization for the U Plant Aggregate Area

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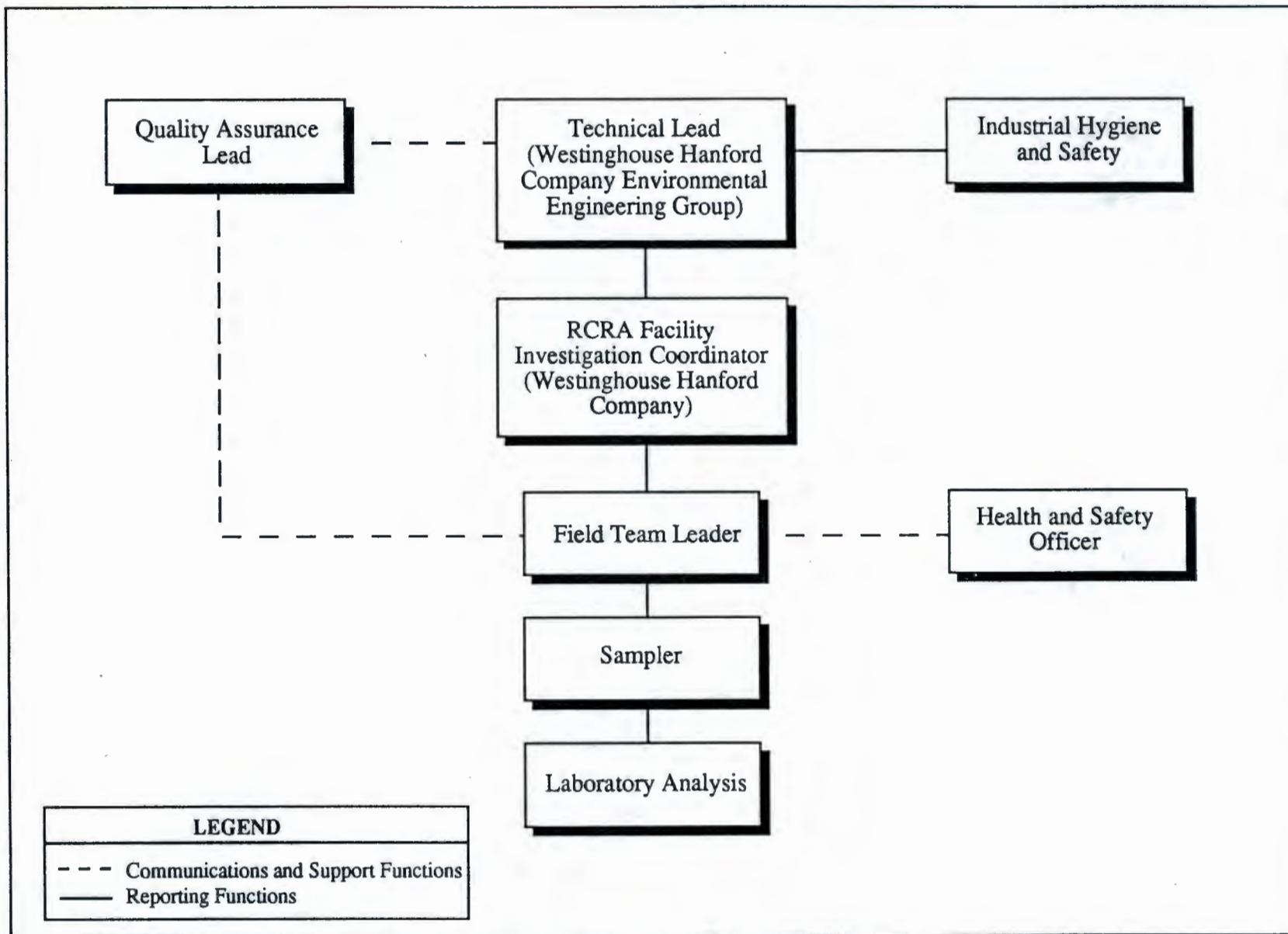
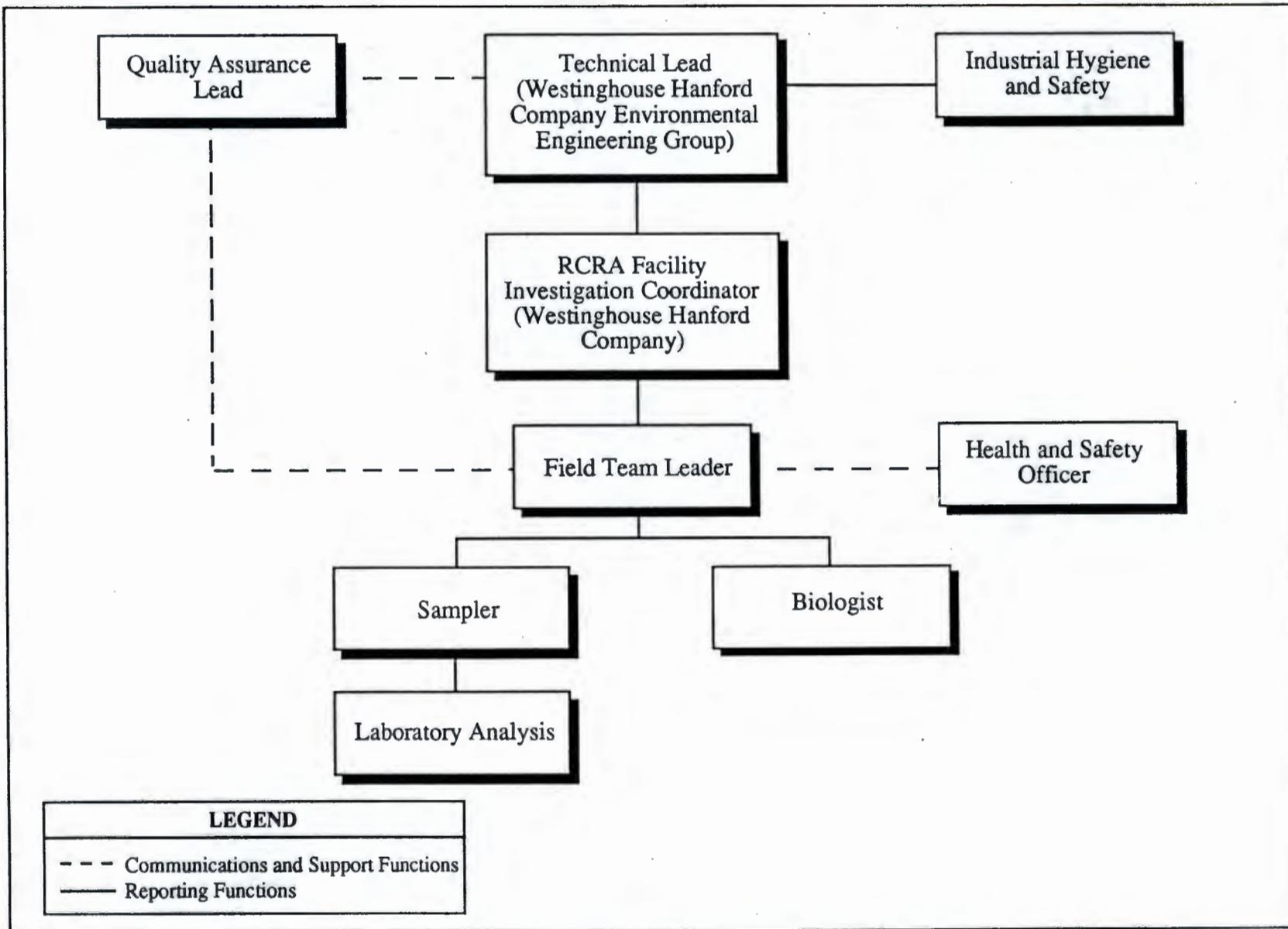


Figure C-3. The Hanford Site Soil Sampling Team.



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Figure C-4. The Hanford Site Biological Sampling Team.

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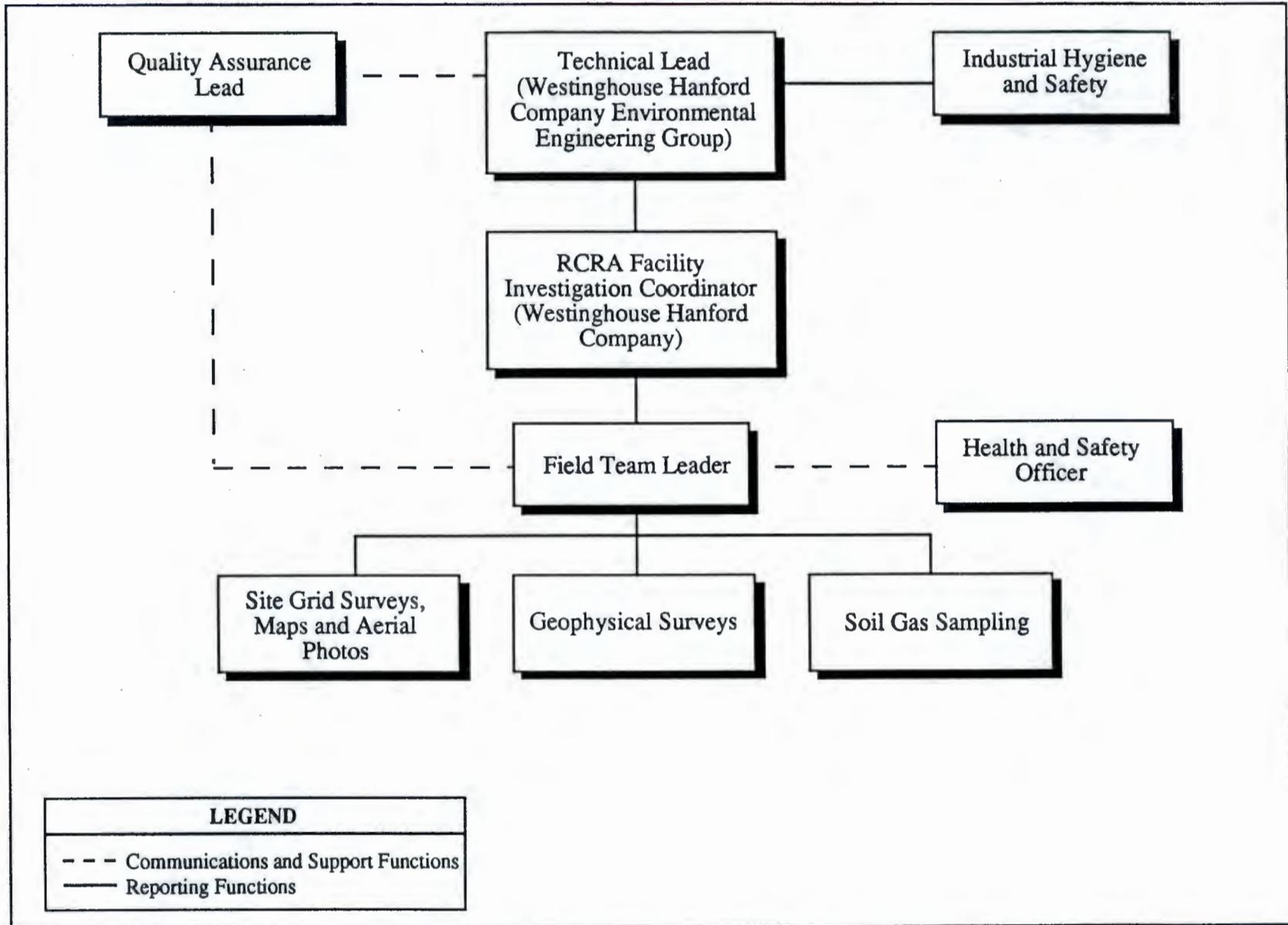


Figure C-5. The Hanford Site Physical and Geophysical Survey Team.

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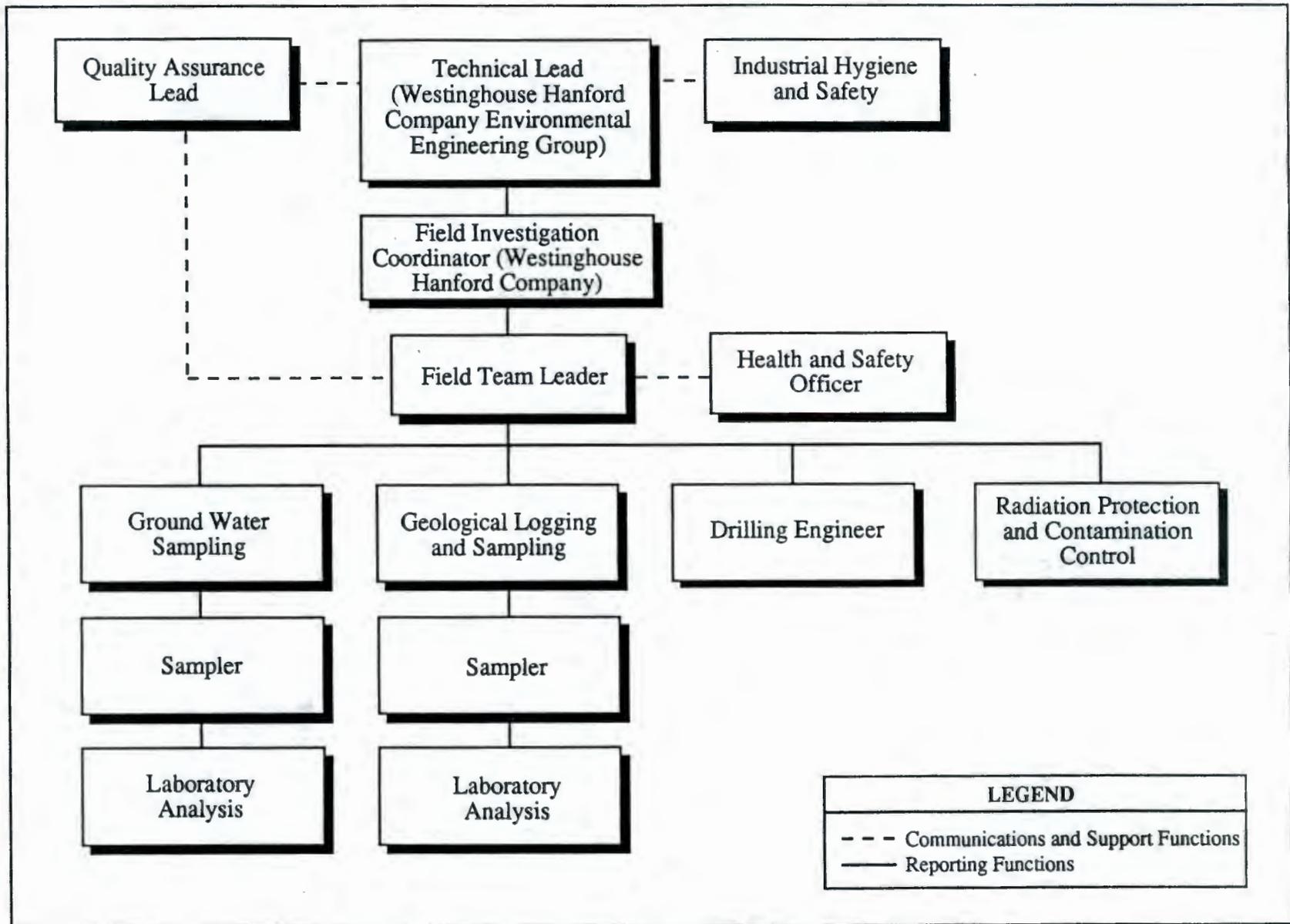


Figure C-6. Drilling, Sampling, and Well-Development Team.

Table C-1. Hanford Site RI/FS Technical Resources.

Subject/Activity	Technical Resources	
	RI	FS
Hydrology and geology	Westinghouse Hanford/Geosciences PNL/Earth and Environmental Sciences Center	Westinghouse Hanford/Geosciences
Toxicology and risk/endangerment assessment	Westinghouse Hanford/Environmental Technology PNL/Earth and Environmental Sciences Center PNL/Life Sciences Center	Westinghouse Hanford/ Environmental Technology
Environmental chemistry	Westinghouse Hanford/Geosciences PNL/Earth and Environmental Sciences Center	Westinghouse Hanford/Geosciences
Geotechnical and civil engineering	Westinghouse Hanford/Geosciences (Planning) Environmental Field Services	NA
Geotechnical and civil engineering	NA	Westinghouse Hanford/ Environmental Engineering PNL/Waste Technology Center
Groundwater treatment engineering	NA	Westinghouse Hanford/ Environmental Engineering PNL/Waste Technology Center
Waste stabilization and treatment	NA	Westinghouse Hanford/ Environmental Engineering PNL/Waste Technology Center
Surveying	Kaiser Engineers Hanford	NA

Table C-1. Hanford Site RI/FS Technical Resources.

Subject/Activity	Technical Resources	
	RI	FS
Soil and water sampling and analysis	Westinghouse Hanford/Environmental Engineering Westinghouse Office of Sampling Management PNL/Earth and Environmental Sciences Center PNL/Materials and Chemical Sciences Center	NA
Drilling and well installation	Westinghouse Hanford/Geosciences Environmental Field Services Kaiser Engineers	NA
Radiation monitoring	Westinghouse Hanford/Operational Health Physics	NA

NA = Not applicable.

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APPENDIX D
INFORMATION MANAGEMENT OVERVIEW

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ACRONYMS AND ABBREVIATIONS

AR	administrative record
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act of 1980
CMS	Corrective Measures Study
DOE	U.S. Department of Energy
DOE/RL	U.S. Department of Energy, Richland Operations Office
Ecology	Washington Department of Ecology
EDMC	Environmental Data Management Center
EHPSS	Environmental Health and Pesticide Services Section
EII	Environmental Investigations Instructions
EIMP	Environmental Information Management Plan
EPA	U.S. Environmental Protection Agency
ER	environmental restoration
ERRA	Environmental Restoration Remedial Action
FOMP	Field Office Management Plan
FS	feasibility study
GIS	geographic information system
HEHF	Hanford Environmental Health Foundation
HEIS	Hanford Environmental Information System
HLAN	Hanford Local Area Network
HMS	Hanford Meteorological Station
IMO	Information Management Overview
KEH	Kaiser Engineers Hanford
OSM	Office of Sample Management
PNL	Pacific Northwest Laboratory
QA	quality assurance
QAPP	Quality Assurance Project Plan
QC	quality control
RFI	RCRA Facility Investigation
RI	remedial investigation
ROD	record of decision
TR	training records
Tri-Party Agreement	Hanford Federal Facility Agreement and Consent Order
TSD	treatment, storage, and disposal
Westinghouse Hanford	Westinghouse Hanford Company

DEFINITIONS OF TERMS

Action Plan. Action plan for implementation of the *Hanford Federal Facility Agreement and Consent Order* (Ecology et al. 1990). A negotiation between the U.S. Environmental Protection (EPA), the U.S. Department of Energy (DOE), and the State of Washington Department of Ecology (Ecology). The Action Plan defines the methods and processes by which hazardous waste permits will be obtained, and by which closure and post-closure actions under the Resource Conservation and Recovery Act of 1976 (RCRA) and by which remedial actions under the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) will be conducted on the Hanford Site.

Administrative Record (AR). In CERCLA, the official file that contains all information that was considered or relied on by the regulatory agency in arriving at a final remedial action decision, as well as all documentation of public participation throughout the process. In RCRA, the official file that contains all documents to support a final RCRA permit determination.

Administrative Record File. The assemblage of documents compiled and maintained by an agency pertaining to a proposed project of administrative action and designated as AR or that are candidates for inclusion in the AR once a record of decision (ROD) is attained.

Data Management. The planning and control of activities affecting data.

Data Quality. The totality of features and characteristics of data that bears on its ability to satisfy a given purpose. The characteristics of major importance are accuracy, precision, completeness, representativeness, and comparability.

Data Validation. The process whereby data are accepted or rejected based on a set of criteria. This aspect of quality assurance involves establishing specified criteria for data validation. The quality assurance project plan (QAPP) must indicate the specified criteria that will be used for data validation.

ENCORE. The name given to the combination of hardware, software, and administrative subsystems that serve to integrate the management of the Hanford Site environmental data.

Environmental Data Management Center (EDMC). The central facility and services that provide a files management system for processing environmental information.

Environmental Information. Data related to the protection or improvement of the Hanford Site environment, including data required to satisfy environmental statutes, applicable DOE orders, or the Tri-Party Agreement.

Field File Custodian. An individual who is responsible for receipt, validation, storage, maintenance, control, and disposition of information or other records generated in support of Environmental Division activities.

Hanford Environmental Information System (HEIS). A computer-based information system under development as a resource for the storage, analysis, and display of investigative data collected for use in site characterization and remediation activities. Subject areas currently being developed include geophysics/soil gas, vadose zone soil (geologic), atmospherics, and biota.

Information System. Collection of components relate to the management of data and reporting of information. Information systems typically include computer hardware, computer software, operating systems, utilities, procedures, and data.

Lead Agency. The regulatory agency (EPA or Ecology) that is assigned the primary administrative and technical responsibility with respect to actions at a particular operable unit.

Nonrecord Material. Copies of material that are maintained for information, reference, and operating convenience and for which another office has primary responsibility.

Operable Unit. An operable unit at the Hanford Site is a group of land disposal and groundwater sites placed together for the purposes of doing a remedial investigation/feasibility study. The primary criteria for placement of a site into an operable unit are geographic proximity, similarity of waste characteristics and site types, and the possibility for economies of scale.

Primary Document. A document that contains information on which key decisions are made with respect to the remedial action or permitting process. Primary documents are subject to dispute resolution and are part of the administrative record file.

Project Manager. The individual responsible for implementing the terms and conditions of the Action Plan on behalf of his respective party. The EPA, DOE, and Ecology will each designate one project manager.

Quality Affecting Record. Information contained on any media, including but not limited to, hard copy, sample material, photo copy, and electronic systems, that is complete in terms of appropriate content and that furnishes evidence of the quality of items and/or activities affecting quality.

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Quality Assurance. The systematic actions necessary to provide adequate confidence that a material, component, system, process, or facility performs satisfactorily or as planned in service.

Quality Assured Data. Data developed under an integrated program for assurance of the reliability of data.

Raw Data. Unprocessed or unanalyzed information.

Record Validation. A review to determine that records are complete, legible, and meet records requirements. Documents are considered valid records only after the validation process has been completed.

Retention Period. The length of time records must be held before they can be disposed of. The time is usually expressed in years from the date of the record, but may also be expressed as contingent on the occurrence of an event.

Secondary Document. A document providing information that does not, in itself, reflect or support key decisions. A secondary document is subject to review by the regulatory agencies and may be part of the administrative record field. It is not subject to dispute resolution.

Validated Data. Data that meet criteria contained in an approved company procedure.

Verified Data. Data that have been checked for accuracy and consistency following a transfer action (e.g., from manual log to computer, or from distributed database to centralized data repository).

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D-1 Types of Related Administrative Data DT-1

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1.0 INTRODUCTION AND OBJECTIVES

1.1 INTRODUCTION

An extensive amount of data will be generated over the next several years in connection with the activities planned for the U Plant Aggregate Area. The quality of these data are extremely important to the full remediation of the aggregate area as agreed on by the U.S. Department of Energy (DOE), the U.S. Environmental Protection Agency (EPA) the Washington Department of Ecology (Ecology), and interested parties.

The Information Management Overview (IMO) provides an overview of the data management activities at the operable unit level. It identifies the type and quantity of data to be collected and references the procedures which control the collection and handling of data. It provides guidance for the data collector, aggregate area investigator, project manager, and reviewer to fulfill their respective roles.

This IMO addresses handling of data generated from activities associated with the aggregate area activities. All data collected will be in accordance with the Environmental Investigations Instructions (EII) contained in the Westinghouse Hanford Company's (Westinghouse Hanford) *Environmental Investigations and Site Characterization Manual* (WHC 1991a).

Development of a comprehensive plan for the management of all environmental data generated at the Hanford Site is under way. The *Environmental Information Management Plan* (EIMP) (Steward et al. 1989), released in March 1989, described activities in the Environmental Data Management Center (EDMC) and long-range goals for management of scientific and technical data. The scientific and technical data part of the EIMP was reviewed, revised, and expanded in fiscal year 1990 (Michael et al. 1990). An *Environmental Restoration Remedial Action Program Records Management Plan* (WHC 1991b) issued in July 1991, enables the program office to identify, control, and maintain the quality assurance (QA), decisional, or regulatory prescribed records generated and used in support of the Environmental Restoration Remedial Action (ERRA) Program.

1.2 OBJECTIVES

This IMO describes the process for the collection and control procedures for validated data, records, documents, correspondence, and other information associated with this aggregate area. This IMO addresses the following:

- Types of data to be collected
- Plans for managing data
- Organizations controlling data

- Databases used to store the data
- EIMP
- Hanford Environmental Information System (HEIS).

2.0 TYPES OF DATA

2.1 TYPES OF DATA

The general types of technical data to be collected and the associated controlling procedures are as follows:

<u>Type of data</u>	<u>Procedure</u>
Historical reports	EII 1.6
Aerial photos	EII 1.6
Chart recordings	EII 1.6
Technical memos	EII 1.6
Validated samples analyses	EII 1.6
Reports	EII 1.6
Logbooks	EII 1.5
Chain-of-custody forms	EII 5.1
Sample quality assurance/ quality control (QA/QC)	Office of Sample Management (OSM)

All such data are submitted to the EDMC for entry into the administrative record (AR).

General types of related administrative data is shown in Table D-1, which is organized in terms of general types of personnel and compliance/regulatory data. Table D-1 references the appropriate procedures and the record custodians. Data associated with aggregate area investigations will be submitted to the EDMC for entry into the AR, as appropriate.

2.2 DATA COLLECTION

Data will be collected according to the aggregate area sampling and analysis plans and the Quality Assurance Project Plan (QAPP). Section 2.1 listed the controlling procedures for data collection and handling before turnover to the organization responsible for data storage. All procedures for data collection shall be approved in compliance with the Westinghouse Hanford *Environmental Investigations and Site Characterization Manual* (WHC 1991a).

2.3 DATA STORAGE AND ACCESS

Data will be handled and stored according to procedures approved in compliance with applicable Westinghouse Hanford procedures (WHC 1988). The EDMC is the central files manager and process facility. All data entering the EDMC will be indexed, recorded, and placed into safe and secure storage. Data designated for placement into the AR will be copied, placed into the Hanford Site AR file, and distributed by the EDMC to the user community. The hard copy files are the primary sources of information; the various electronic data bases are secondary sources.

Normal access to data is through EDMC which is responsible for the AR. The Administrative Record Public Access Room is located in the 345 Hills Street Facility in Richland, Washington. This facility includes AR file documents (including identified guidance documents and technical literature).

Project participants may access data that are not in the AR by requesting it at the monthly unit managers' meeting for the operable unit of concern. As the project moves to completion, it is expected that all of the relevant data will be contained in the AR and the need to access data will be minimal.

The following types of data will be accessed from and reside in locations other than the EDMC:

<u>Data Type</u>	<u>Data location</u>
• QA/QC laboratory data	OSM (Westinghouse Hanford)
• Sample status	OSM (Westinghouse Hanford)
• Archived samples	Laboratory performing analyses
• Training records	Technical Training Support Section (Westinghouse Hanford)
• Meteorological data	Hanford Meteorological Station (HMS) (Pacific Northwest Laboratory [PNL])
• Health and safety records	Hanford Environmental Health Foundation (HEHF)
• Personal protective fitting	Environmental Health and Pesticide Services Section (Westinghouse Hanford)
• Radiological exposure	Pacific Northwest Laboratory.

2.4 DATA QUANTITY

Data quantities for the investigative activities will be estimated based on the sampling and analysis plans developed for investigation of sites within the aggregate area.

3.0 DATA MANAGEMENT

3.1 OBJECTIVE

A considerable amount of data will be generated through the implementation of the aggregate area sampling and analysis plans. The QAPP will provide the specific procedural direction and control for obtaining and analyzing samples in conformance with requirements to ensure quality data results. The sampling and analysis plans will provide the basis for selecting the location, depth, frequency of collection, etc., of media to be sampled and methods to be employed to obtain samples of selected media for cataloging, shipment, and analysis. Figure D-1 displays the general data management model for data generated through work plan activities.

3.2 ORGANIZATIONS CONTROLLING DATA

This section addresses the organizations that will receive data generated from aggregate area activities.

3.2.1 Environmental Engineering Group

The Westinghouse Hanford Environmental Engineering Group provides the operable unit technical coordinator. The technical coordinator is responsible for maintaining and transmitting data to the designated storage facility.

3.2.2 Office of Sample Management

The Westinghouse Hanford OSM will validate all analytical data packages received from the laboratory. Validated summary data (sample results and copies of chain-of-custody forms) will be forwarded to the technical coordinator. Nonvalidated data will be forwarded to the technical coordinator on request. Preliminary data will be clearly labeled as such. The OSM will maintain raw sample data, QA/QC laboratory data, and the archived sample index.

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3.2.3 Environmental Data Management Center

The EDMC is the Westinghouse Hanford Environmental Division's central facility and service that provides a file management system for processing environmental information. The EDMC manages and controls the AR and Administrative Record Public Access Room at the Hanford Site. Part 1 of the EIMP (Michael et al. 1990) describes the central file system and services provided by the EDMC. The following procedures address data transmittal to the EDMC:

- EII 1.6, Records Management (WHC 1991a)
- EII 1.11, Technical Data Management (WHC 1991a)
- TPA-MP-02, Information Transmittals and Receipt Controls (DOE/RL 1990)
- TPA-MP-07, Administrative Record Collection and Management (DOE/RL 1990)

3.2.4 Information Resource Management

Information Resource Management is the designated records custodian (permanent storage) for Westinghouse Hanford. The procedural link from the EDMC to the Information Resource Management is currently under development.

3.2.5 Hanford Environmental Health Foundation

The HEHF performs the analyses on the nonradiological health and exposure data (Section 3.3.2) and forwards summary reports to the Fire and Protection Group and the Environmental Health and Pesticide Services Section within the Westinghouse Hanford Environmental Division. Nonradiological and health exposure data are maintained also for other Hanford Site contractors (PNL and Kaiser Engineers Hanford [KEH]) associated with aggregate area activities. The HEHF provides summary data to the appropriate site contractor. EII 2.1, Preparation of Hazardous Waste Operations Permits, and EII 2.2, Occupational Health Monitoring (WHC 1991a) address the preparation of health and safety plans and occupational health monitoring, respectively.

3.2.6 Environmental Health and Pesticide Services Section

The Westinghouse Hanford Environmental Health and Pesticide Services Section maintains personal protective equipment fitting records and maintains nonradiological health field exposure and exposure summary reports provided by HEHF for Westinghouse Hanford Environmental Division and subcontractor personnel.

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3.2.7 Technical Training Records and Scheduling Section

The Westinghouse Hanford Technical Training Records and Scheduling Section provides training and maintains training records (Section 3.3.4).

3.2.8 Pacific Northwest Laboratory

The PNL operates the HMS and collects and maintains meteorological data (Section 3.3.1). Data management is discussed in Andrews (1988).

The PNL collects and maintains radiation exposure data (Section 3.3.3).

3.3 DATABASES

This section addresses databases that will receive data generated from the aggregate area activities. These and other databases are described in the EIMP (Michael et al. 1990). All of these databases exist independently of this aggregate area and serve other site functions. Data pertinent to the operable unit, housed in these databases, will be submitted to the AR.

3.3.1 Meteorological Data

The HMS collects and maintains meteorological data. Their database contains meteorological data from 1943 to the present, and Andrews (1988) is the document containing meteorological data management information.

3.3.2 Nonradiological Exposure and Medical Records

The HEHF collects and maintains data for all nonradiological exposure records and medical records.

3.3.3 Radiological Exposure Records

The PNL collects and maintains data on occupational radiation exposure. This database contains respiratory personal protective equipment fitting records, work restrictions, and radiation exposure information.

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3.3.4 Training Records

Training records for Westinghouse Hanford and subcontractor personnel are managed by the Westinghouse Hanford Technical Training Support Section. Other Hanford Site contractors (PNL and KEH) maintain their own personnel training records. Training records for non-Westinghouse personnel are entered into the Westinghouse (soft reporting) database to document compliance.

Training records include:

- Initial 40-h hazardous waste worker training
- Annual 8-h hazardous waste worker training update
- Hazardous waste generator training
- Hazardous waste site specific training
- Radiation safety training
- Cardiopulmonary resuscitation
- Scott air pack
- Fire extinguisher
- Noise control
- Mask fit.

3.3.5 Environmental Information/Administrative Record

Environmental information and the AR are managed by Westinghouse Hanford EDMC personnel. They provide an index and key information on all data transmitted to the EDMC. This database is used to assist in data retrieval and to produce index lists as required.

3.3.6 Sample Status Tracking

The OSM maintains the sample status tracking database. This database contains information about each sample. Information maintained includes sample number, ship date, receipt date, and laboratory identification.

4.0 ENVIRONMENTAL INFORMATION AND RECORDS MANAGEMENT PLAN

This section briefly discusses the EIMP (Michael et al. 1990) that was developed to provide an overview of an integrated approach to managing Hanford Site environmental data, and the *Environmental Restoration Remedial Action Program Records Management Plan* (WHC 1991b).

4.1 ENVIRONMENTAL INFORMATION MANAGEMENT PLAN

The EIMP provides an overview of how information is managed throughout the lifetime of Hanford Site environmental programs.

The Environmental Division of Westinghouse Hanford is responsible for the protection and improvement of the Hanford Site environment. To fulfill responsibility, the Environmental Division has assumed a management role with respect to Hanford Site environmental information. This management role includes (1) establishing standards for how data are validated and controlled, (2) developing and maintaining a supporting computer-based environment, and (3) sustaining a centralized file management system.

Hanford Site environmental information is defined as data related to the protection or improvement of the Hanford Site environment, including data required to satisfy environmental statutes, applicable DOE orders, or the *Hanford Federal Facility Agreement and Consent Order* (Ecology et al. 1990), (Tri-Party Agreement).

Environmental information falls into several overlapping categories, such as administrative versus technical and electronic versus manual or hard copy. A considerable amount of data are recorded in documents, which are governed by company-wide document and records control practices. Other data are collected or generated by computer and, therefore, exist in electronic form. The name ENCORE has been given to the combination of administrative, hardware, and software systems that serve to integrate the management of this electronic data.

Administrative information (e.g., budgets and schedules) is subject to accounting and other standard business practices. Scientific and technical data are subject to a different set of legal, classification, release, and engineering requirements.

Superimposed over these categories is the files management system for environmental information. This management system, has been developed to meet a number of Environmental Division needs, including requirements for compilation of AR files. The AR files are compilations of all material related to environmental restoration and remedial action records of decision (ROD) for each operable unit and treatment, storage, and disposal (TSD) group described in the Tri-Party Agreement.

Data in electronic form flows from information systems in the ENCORE realm to both scientific/technical and administrative documents. Environmental documents distributed within the Hanford Site and from regulatory agencies are received by the EDMC for storage and future processing.

Part I of the EIMP describes the overall Westinghouse Hanford systems that are generally applied to documents and records. Part I also describes, in greater detail, the files management system developed to manage the AR file information. The EDMC compiles the

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AR files and provides controlled distribution of specified information to the AR files held by DOE, Ecology, and the EPA. The EDMC also provides controlled distribution of specified community relations information to regional information repositories.

Part II addresses computer-based information, with an emphasis on scientific and technical data. The long-term nature of environmental programs and the complex interrelationships of environmental data require that the data be preserved, retrievable, traceable, and sufficient for future use. To ensure data availability for response to regulatory and agency requirements, the plan is directed toward optimizing the use of automated techniques for managing data. The current processing environment and the proposed ENCORE realm are described, and the plans for implementation of ENCORE are addressed.

4.2 ENVIRONMENTAL RESTORATION REMEDIAL ACTION PROGRAM RECORDS MANAGEMENT PLAN

The ERRA Program records management plan was developed to fulfill the requirements of the U.S. Department of Energy, Richland Operations Office (DOE/RL) *Environmental Restoration Field Office Management Plan* (FOMP) (DOE/RL 1989). The FOMP describes the plans, organization, and control systems to be used for management of the Hanford Site ERRA Program. The Westinghouse Hanford ERRA Program Office has developed this ERRA Program records management plan to fulfill the requirements of the FOMP. This records management plan will enable the program office to identify, control, and maintain the quality assurance, decisional, or regulatory prescribed records generated and used in support of the ERRA Program.

The ERRA Program records management plan describes how the applicable records management requirements will be implemented for the ERRA Program. The plan also develops the criteria for identifying the appropriate requirements for each individual piece of information related to ERRA work activities.

This records management plan applies to all ERRA Program records and documents generated, used, or maintained in support of ERRA-funded work activities on the Hanford Site. The terms, information, documents, nonrecord material, records, record material, and QA records used throughout the ERRA records management plan are interpreted as ERRA information, ERRA documents, ERRA nonrecord material, ERRA records, ERRA record material, and ERRA QA records.

5.0 HANFORD ENVIRONMENTAL INFORMATION SYSTEM

5.1 OBJECTIVE

The Hanford Environmental Information System (HEIS) has been developed by PNL for Westinghouse Hanford as a primary resource for computerized storage, retrieval, and analysis of quality-assured technical data associated with Comprehensive Environmental Response, Compensation and Liability Act of 1980 (CERCLA) remedial investigation/feasibility study (RI/FS) activities and RCRA Facility Investigation/Corrective Measures Study (RFI/CMS) activities being undertaken at the Hanford Site. The HEIS will provide a means of interactive access to data sets extracted from other databases relevant to implementation of the Tri-Party Agreement (Ecology et al. 1990). The HEIS will support graphics analysis, including a geographic information system. Implementation of HEIS will serve to ensure that data consistency, quality, traceability, and security are achieved through incorporation of all environmental data within a single controlled database.

The following is a list of data subjects proposed to be entered into HEIS:

- Geologic
- Geophysics
- Atmospheric
- Biotic
- Site characterization
- Soil gas
- Waste site information
- Surface monitoring
- Groundwater.

5.2 STATUS OF THE HANFORD ENVIRONMENTAL INFORMATION SYSTEM

The HEIS, a computerized database containing technical data and information used to support the Hanford environmental restoration (ER) activities, is operational. The data for the Hanford groundwater wells and groundwater samples is currently accessible via the Hanford Local Area Network (HLAN) to local users and to offsite users via a modem link to the HEIS database computer. Additional data, including geologic, biota, and other pertinent environmental sample results, are being entered into the HEIS database.

The *Hanford Environmental Information System (HEIS) User's Manual* (WHC 1990) was issued in October 1990. An operator manual is being prepared and is expected to be issued in 1992.

The HEIS geographic information system (GIS) will display detailed maps for the Hanford restoration sites including data from the HEIS database. Such spatially related data will be used to support analysis of waste site technical issues and restoration options. The combination of the HEIS for data and the GIS spatial displays offers some powerful tools for many users to analyze and collectively evaluate the environmental data from the ER and site-wide monitoring programs.

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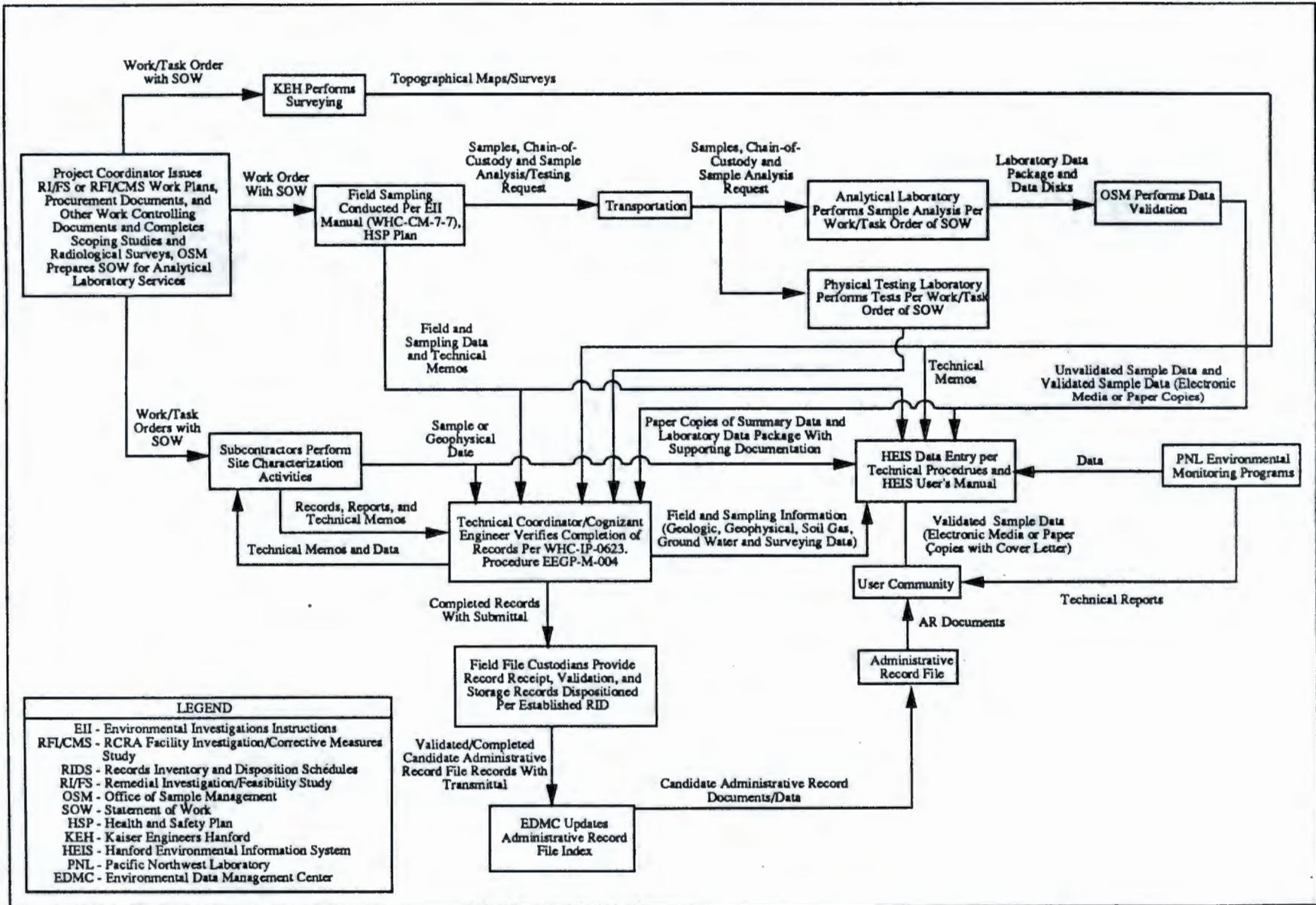


Figure D-1. Environmental Engineering, Technology and Permitting Data Management Model.

Table D-1. Types of Related Administrative Data.

Type of Data	Controlling document/procedure	Record Custodians				
		TR	HEHF	PNL	EDMC	EHPSS
<u>Personnel</u>						
Personnel training and qualifications	EII 1.7 ^{a/}	X				
Occupational exposure records (nonradiological)	EII 2.2 ^{a/}		X			X
Radiological exposure records				X		
Respiratory protection fitting						X
Personnel health and safety records	EII 2.1 ^{a/}		X			X
<u>Compliance/regulatory</u>						
Action-specific requirements/screening levels	EII 1.6 ^{a/}				X	
Guidance document tracking	EII 1.6 ^{a/}				X	
Compliance issues	EII 1.6 ^{a/}				X	
Problem resolution	EII 1.6 ^{a/}				X	
Administrative record	TPA-MP-11 ^{b/}				X	

^{a/} WHC 1991a, *Environmental Investigations and Site Characterization Manual*.

^{b/} DOE/RL 1990, *Hanford Federal Facility Agreement and Consent Order (Tri-Party Agreement) Handbook*.

EDMC = Environmental Data Management Center (Westinghouse Hanford Company).

EHPSS = Environmental Health and Pesticide Services Section (Westinghouse Hanford Company).

EII = Environmental Investigations Instructions.

HEHF = Hanford Environmental Health Foundation.

TR = training records (Westinghouse Hanford Company, Pacific Northwest Laboratory [PNL], Kaiser Engineers Hanford [KEH]).

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