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Z PLANT SOURCE AAMS EXECUTIVE SUMMARY

This report presents the results of an aggregate area management study (AAMS) for the Z 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.

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 Z 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 km^2 (560 mi^2) 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 Z Plant Aggregate Area is located within the 200 West Area, near the middle of the Hanford Site. There are three operable units within the Z Plant Aggregate Area.

The major processes conducted in the Z Plant Aggregate Area included producing metallic plutonium and recovering plutonium and americium from plutonium scrap solutions. The Z Plant Aggregate Area is also the site of 12 low-level burial grounds. Between 1945 and 1989, plutonium was recovered from plutonium nitrate solutions produced in one of Hanford's chemical separation facilities (B Plant or T Plant). Operations of the primary plutonium recovery facility, the Plutonium Finishing Plant (PFP) are currently suspended pending completion of a readiness review and regulatory approval.

The Z Plant Aggregate Area contains a variety of waste disposal and storage units in addition to its plutonium finishing and recovery facilities and support facilities. Historically, high-level wastes were discharged to the soil column through cribs, trenches, and other

facilities. Low-level wastes such as cooling and condensate water were allowed to percolate into the ground through drains and open ditches. Currently, only sanitary wastes from various on-site office and laboratory facilities and cooling and condensate water from the finishing and recovery facilities are discharged to the soil column through septic drain fields, a seepage basin, and a crib. Based on construction, purpose, or origin, the Z 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
- 3 Tanks and Vaults
- 13 Cribs and Drains
- 1 Reverse Well
- 3 Ponds, Ditches and Trenches
- 5 Septic Tanks and Associated Drain Fields
- 3 Transfer Facilities, Diversion Boxes, and Pipelines
- 2 Basins
- 14 Burial Sites
- 21 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 Z Plant Aggregate Area (Section 2.7). These programs include RCRA, the Hanford Decommissioning and RCRA Closure Program, the Radiation Area Remedial Action (RARA) Program, and the Waste Management Program. Nine units (primarily low-level burial grounds) 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. Seven unplanned releases closely associated with these facilities are also recommended to be addressed by these other programs. An additional seven waste management units will be partially addressed by an ongoing program in addition to the actions recommended in the Z 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 Z 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.

Potential ARARs to be used in developing and assessing various remedial action alternatives at the Z 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 Z 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 Z 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 Z Plant Aggregate Area are developed in Section 9.1. As a result of the data evaluation process, five waste management units were recommended for ERAs, no units were recommended for IRMs, 32 units were recommended for LFIs which could lead to IRMs and 18 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 241-Z Treatment Tank RCRA TSD facility and seven RCRA burial grounds. 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.

Table ES-1. Summary of Results of Data Evaluation Process Assessment for Z Plant Aggregate Area. (Sheet 1 of 4)

Waste Management Unit or Unplanned Release	Current Operable Unit	ERA	IRM	LFI	RA	RI	OPS	Remarks
Tanks and Vaults								
216-Z-8 Settling Tank	200-ZP-2	X	X	X	-	-	-	Remove drainable liquids
241-Z-361 Settling Tank	200-ZP-1	X	X	X	-	-	-	Remove drainable liquids Redefined to 200-ZP-2 Operable Unit
Cribs and Drains								
216-Z-1 & 216-Z-2 Cribs	200-ZP-1	-	X	X	-	-	X	RARA - Surface Contamination Redefined to 200-ZP-2 Operable Unit
216-Z-3 Crib	200-ZP-1	-	X	X	-	-	-	Redefined to 200-ZP-2 Operable Unit
216-Z-5 Crib	200-ZP-2	-	X	X	-	-	X	RARA - Cave-in Potential
216-Z-6 Crib	200-ZP-2	-	X	X	-	-	X	
216-Z-7 Crib	200-ZP-2	-	X	X	-	-	X	
216-Z-12 Crib	200-ZP-1	-	X	X	-	-	-	Redefined to 200-ZP-2 Operable Unit
216-Z-16 Crib	200-ZP-2	-	X	X	-	-	-	
216-Z-18 Crib	200-ZP-1	X	X	X	-	-	-	Carbon Tetrachloride ERA Proposal Unit Redefined to 200-ZP-2 Operable Unit
216-Z-8 French Drain	200-ZP-2	-	-	-	-	X	-	
216-Z-13 French Drain	200-ZP-1	-	-	-	-	X	-	Redefined to 200-ZP-2 Operable Unit
216-Z-14 French Drain	200-ZP-1	-	-	-	-	X	-	Redefined to 200-ZP-2 Operable Unit
216-Z-15 French Drain	200-ZP-1	-	-	-	-	X	-	Redefined to 200-ZP-2 Operable Unit
216-Z-1A Tile Field	200-ZP-1	X	X	X	-	-	X	RARA - Surface Contamination; Carbon Tetrachloride ERA Proposal Unit Redefined to 200-ZP-2 Operable Unit

Table ES-1. Summary of Results of Data Evaluation Process Assessment for Z Plant Aggregate Area. (Sheet 2 of 4)

Waste Management Unit or Unplanned Release	Current Operable Unit	ERA	IRM	LFI	RA	RI	OPS	Remarks
Reverse Well								
216-Z-10 Reverse Well	200-ZP-2	-	-	-	-	X	-	
Ponds, Ditches, and Trenches								
216-Z-4 Trench	200-ZP-2	-	X	X	-	-	-	
216-Z-9 Trench	200-ZP-2	X	X	X	-	-	-	Carbon Tetrachloride ERA Proposal Unit
216-Z-17 Trench	200-ZP-2	-	X	X	-	-	-	
Septic Tanks and Associated Drain Fields								
2607-Z Septic Tank and Drain Field	200-ZP-2	-	-	-	-	X	-	Active-Waste Management
2607-Z-1 Septic Tank and Drain Field	200-ZP-2	-	-	-	-	X	-	Active-Waste Management
2607-WA Septic Tank and Drain Field	200-ZP-2	-	-	-	-	X	-	Active-Waste Management
2607-WB Septic Tank and Drain Field	200-ZP-2	-	-	-	-	X	-	Active-Waste Management
2607-W-8 Septic Tank and Drain Field	200-ZP-2	-	-	-	-	X	-	Active-Waste Management
Transfer Facilities, Diversion Boxes, and Pipelines								
241-Z Diversion Box No. 1	200-ZP-1	-	X	X	-	-	-	Redefined to 200-ZP-2 Operable Unit
241-Z Diversion Box No. 2	200-ZP-1	-	X	X	-	-	-	Redefined to 200-ZP-2 Operable Unit
231-Z-151 Sump	200-ZP-1	-	X	X	-	-	-	Redefined to 200-ZP-2 Operable Unit
Basins								
241-Z Retention Basin	200-ZP-2	-	-	-	-	X	-	
216-Z-21 Seepage Basin	200-ZP-2	-	-	-	-	X	X	Active-Waste Management Potential for migration of contaminants

Table ES-1. Summary of Results of Data Evaluation Process Assessment for Z Plant Aggregate Area. (Sheet 3 of 4)

Waste Management Unit or Unplanned Release	Current Operable Unit	ERA	IRM	LFI	RA	RI	OPS	Remarks
Burial Sites								
218-W-1	200-ZP-3	-	X	X	-	-	-	
218-W-1A	200-ZP-3	-	X	X	-	-	-	
218-W-2	200-ZP-3	-	X	X	-	-	X	RARA - Surface Contamination
218-W-3	200-ZP-3	-	X	X	-	-	-	
218-W-4A	200-ZP-3	-	X	X	-	-	X	RARA - Surface Contamination
218-W-11	200-ZP-3	-	X	X	-	-	-	
Z Plant Burn Pit	200-ZP-2	-	-	-	-	X	-	Redefined to 200-ZP-3 Operable Unit
Unplanned Releases								
UN-200-W-11	200-ZP-3	-	X	X	-	-	-	
UPR-200-W-16	200-ZP-3	-	X	X	-	-	-	
UN-200-W-23	200-ZP-1	-	-	-	-	X	-	Redefined to 200-ZP-2 Operable Unit
UPR-200-W-26	200-ZP-3	-	X	X	-	-	-	
UN-200-W-44	200-ZP-3	-	-	-	-	X	-	
UPR-200-W-53	200-ZP-3	-	X	X	-	-	-	
UPR-200-W-72	200-ZP-3	-	X	X	-	-	-	
UPR-200-W-84	200-ZP-3	-	X	X	-	-	-	
UN-200-W-89	200-ZP-1	-	-	-	-	X	-	Redefined to 200-ZP-2 Operable Unit
UN-200-W-90	200-ZP-1	-	-	-	-	X	-	Redefined to 200-ZP-2 Operable Unit
UN-200-W-91	200-ZP-1	-	-	-	-	X	-	Redefined to 200-ZP-2 Operable Unit
UN-200-W-103	200-ZP-1	-	-	-	-	X	-	Redefined to 200-ZP-2 Operable Unit
UN-200-W-130	200-ZP-2	-	X	X	-	-	-	
UPR-200-W-134	200-ZP-3	-	X	X	-	-	-	

Table ES-1. Summary of Results of Data Evaluation Process Assessment for Z Plant Aggregate Area. (Sheet 4 of 4)

Waste Management Unit or Unplanned Release	Current Operable Unit	ERA	IRM	LFI	RA	RI	OPS	Remarks
UPR-200-W-158	200-ZP-3	-	X	X	-	-	-	Only the portion of the release associated with 218-W-1A Burial Ground.
UN-200-W-159	200-ZP-1	-	-	-	X	-	-	Redefined to 200-ZP-2 Operable Unit

Notes:

ERA Expedited Response Action
IRM Interim Remedial Measure
LFI Limited Field Investigation
RA Risk Assessment
RI Remedial Investigation; Feasibility study will be conducted if RA indicates remedial action necessary.
OPS Operational Programs

Table ES-2. Z Plant Aggregate Area Data Evaluation Decision Matrix. (Sheet 1 of 4)

	ERA Evaluation Path								IRM Evaluation Path			LFI Path	Final Remedy
Waste Management Unit or Unplanned Release	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													
216-Z-8 Settling Tank	Y	Y	Y	Y	Y	Y	N	N	N	-	-	-	N
241-Z-361 Settling Tank	Y	Y	Y	Y	Y	Y	N	N	N	-	-	-	N
Cribs and Drains													
216-Z-1 & 216-Z-2 Cribs	Y	Y	Y	Y	Y	Y	N	Y	Y	N	-	Y	-
216-Z-3 Crib	Y	Y	N	-	-	-	-	-	N[a]	N	-	Y	-
216-Z-5 Crib	Y	Y	Y	Y	Y	Y	N	Y	Y	N	-	Y	-
216-Z-6 Crib	Y	Y	Y	Y	Y	Y	N	Y	N[a]	N	-	Y	-
216-Z-7 Crib	Y	Y	Y	Y	Y	Y	N	Y	Y	N	-	Y	-
216-Z-12 Crib	Y	Y	N	-	-	-	-	-	N[a]	N	-	Y	-
216-Z-16 Crib	Y	Y	N	-	-	-	-	-	N[a]	N	-	Y	-
216-Z-18 Crib	Y	Y	Y	Y	Y	Y	N	N	N[a]	N	-	Y	-
216-Z-8 French Drain	Y	Y	N	-	-	-	-	-	N	-	-	-	N
216-Z-13 French Drain	Y	N	-	-	-	-	-	-	N	-	-	-	N
216-Z-14 French Drain	Y	N	-	-	-	-	-	-	N	-	-	-	N
216-Z-15 French Drain	Y	N	-	-	-	-	-	-	N	-	-	-	N
216-Z-1A Tile Field	Y	Y	Y	Y	Y	Y	N	N	Y	N	-	Y	-

Table ES-2. Z Plant Aggregate Area Data Evaluation Decision Matrix. (Sheet 2 of 4)

	ERA Evaluation Path								IRM Evaluation Path			LFI Path	Final Remedy
Waste Management Unit or Unplanned Release	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?
Reverse Well													
216-Z-10 Reverse Well	Y	Y	Y	Y	Y	N	-	-	Y	N	-	N	N
Ponds, Ditches, and Trenches													
216-Z-4 Trench	Y	Y	N	-	-	-	-	-	N[a]	N	-	Y	-
216-Z-9 Trench	Y	Y	Y	Y	Y	Y	N	N	N[a]	N	-	Y	-
216-Z-17 Trench	Y	Y	N	-	-	-	-	-	Y	N	-	Y	-
Septic Tanks and Associated Drain Fields													
2607-Z Septic Tank and Drain Field	Y	N	-	-	-	-	-	-	N	-	-	-	N
2607-Z-1 Septic Tank and Drain Field	Y	N	-	-	-	-	-	-	N	-	-	-	N
2607-WA Septic Tank and Drain Field	Y	N	-	-	-	-	-	-	N	-	-	-	N
2607-WB Septic Tank and Drain Field	Y	N	-	-	-	-	-	-	N	-	-	-	N
2607-W-8 Septic Tank and Drain Field	Y	N	-	-	-	-	-	-	N	-	-	-	N
Transfer Facilities, Diversion Boxes, and Pipelines													
241-Z Diversion Box No. 1	Y	N	-	-	-	-	-	-	N[a]	N	-	Y	-

Table ES-2. Z Plant Aggregate Area Data Evaluation Decision Matrix. (Sheet 3 of 4)

	ERA Evaluation Path								IRM Evaluation Path			LFI Path	Final Remedy
Waste Management Unit or Unplanned Release	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?
241-Z Diversion Box No. 2	Y	N	-	-	-	-	-	-	N[a]	N	-	Y	-
231-Z-151 Sump	Y	Y	N	-	-	-	-	-	N[a]	N	-	Y	-
Basins													
241-Z Retention Basin	Y	N	-	-	-	-	-	-	N	-	-	-	N
216-Z-21 Seepage Basin	Y	Y	Y	Y	Y	Y	Y	Y	N	-	-	-	N
Burial Sites													
218-W-1	Y	Y	N	-	-	-	-	-	N[a]	N	-	Y	-
218-W-1A	Y	Y	N	-	-	-	-	-	N	-	-	-	N
218-W-2	Y	Y	Y	Y	Y	Y	N	Y	Y	N	-	Y	-
218-W-3	Y	Y	N	-	-	-	-	-	N[a]	N	-	Y	-
218-W-4A	Y	Y	Y	Y	Y	Y	N	Y	Y	N	-	Y	-
218-W-11	Y	Y	N	-	-	-	-	-	N	-	-	-	N
Burn Pit	Y	Y	N	-	-	-	-	-	N	-	-	-	N
Unplanned Releases													
UN-200-W-11	Y	Y	N	-	-	-	-	-	N	-	-	-	N
UPR-200-W-16	Y	Y	N	-	-	-	-	-	N	-	-	-	N
UN-200-W-23	Y	Y	N	-	-	-	-	-	N	-	-	-	N
UPR-200-W-26	Y	Y	N	-	-	-	-	-	N	-	-	-	N
UN-200-W-44	Y	Y	N	-	-	-	-	-	N	-	-	-	N

Table ES-2. Z Plant Aggregate Area Data Evaluation Decision Matrix. (Sheet 4 of 4)

	ERA Evaluation Path								IRM Evaluation Path			LFI Path	Final Remedy
Waste Management Unit or Unplanned Release	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?
UPR-200-W-53	Y	Y	N	-	-	-	-	-	N	-	-	-	N
UPR-200-W-72	Y	Y	N	-	-	-	-	-	N	-	-	-	Y
UPR-200-W-84	Y	Y	N	-	-	-	-	-	N	-	-	-	Y
UN-200-W-89	Y	Y	N	-	-	-	-	-	N	-	-	-	N
UN-200-W-90	Y	Y	N	-	-	-	-	-	N	-	-	-	N
UN-200-W-91	Y	Y	N	-	-	-	-	-	N	-	-	-	N
UN-200-W-103	Y	Y	N	-	-	-	-	-	N	-	-	-	N
UN-200-W-130	Y	Y	N	-	-	-	-	-	N	-	-	-	N
UPR-200-W-134	Y	Y	N	-	-	-	-	-	N	-	-	-	Y
UPR-200-W-158 (1)	Y	Y	N	-	-	-	-	-	N	-	-	-	N
UN-200-W-159	Y	Y	N	-	-	-	-	-	N	-	-	-	Y

Y Yes
N No
- Indicates decision point not reached.
[a] Evaluated as high priority site because of proximity and/or similarity to other high priority sites.
(1) Only the part of unplanned release UPR-200-W-158 associated with the 218-W-1A Burial Ground.

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	*Comprehensive Environmental Response, Compensation, and Liability Act of 1980*
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	*Resource Conservation and Recovery Act of 1976*
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 Z 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

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

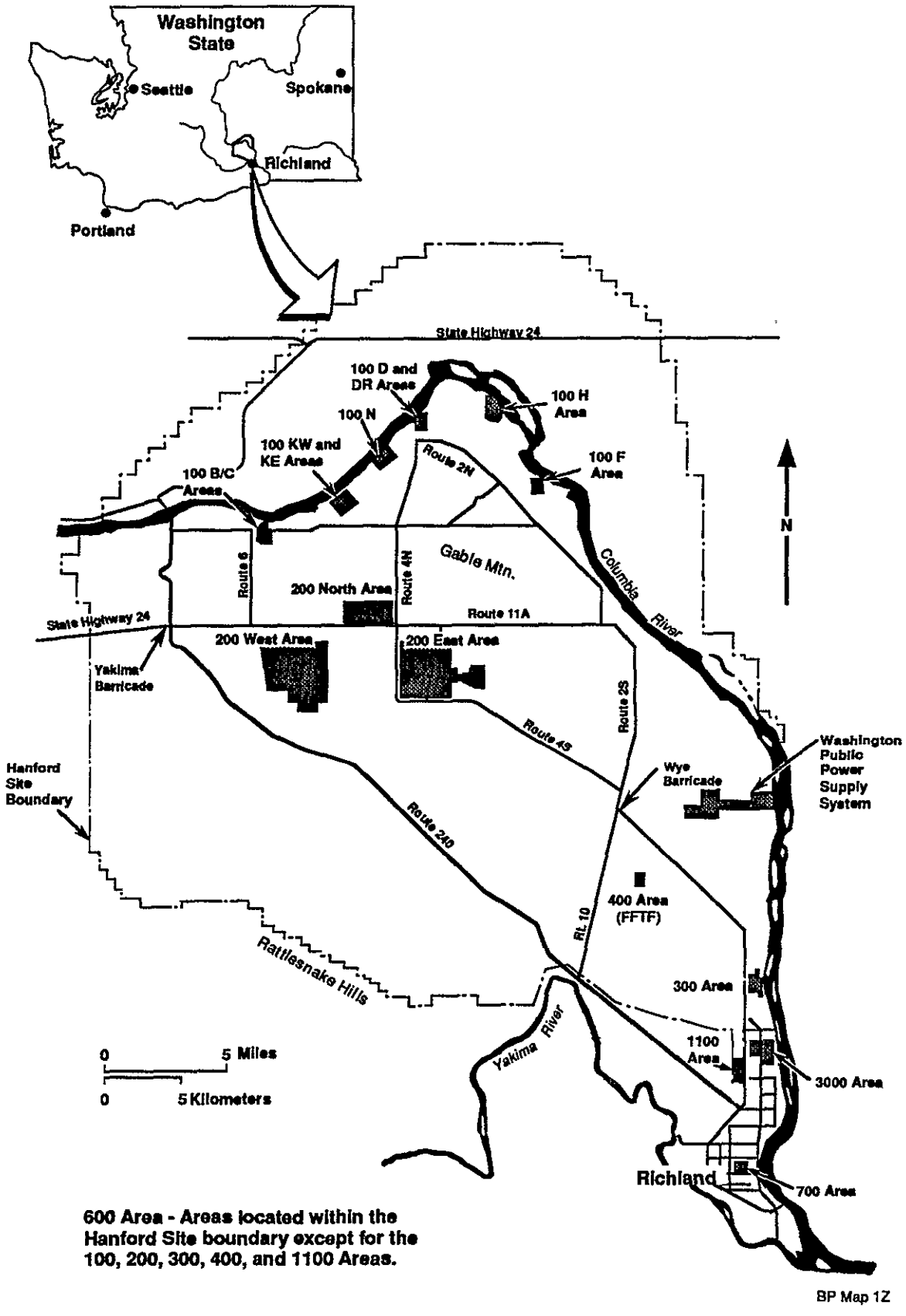


Figure 1-1. Hanford Site Map.

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.

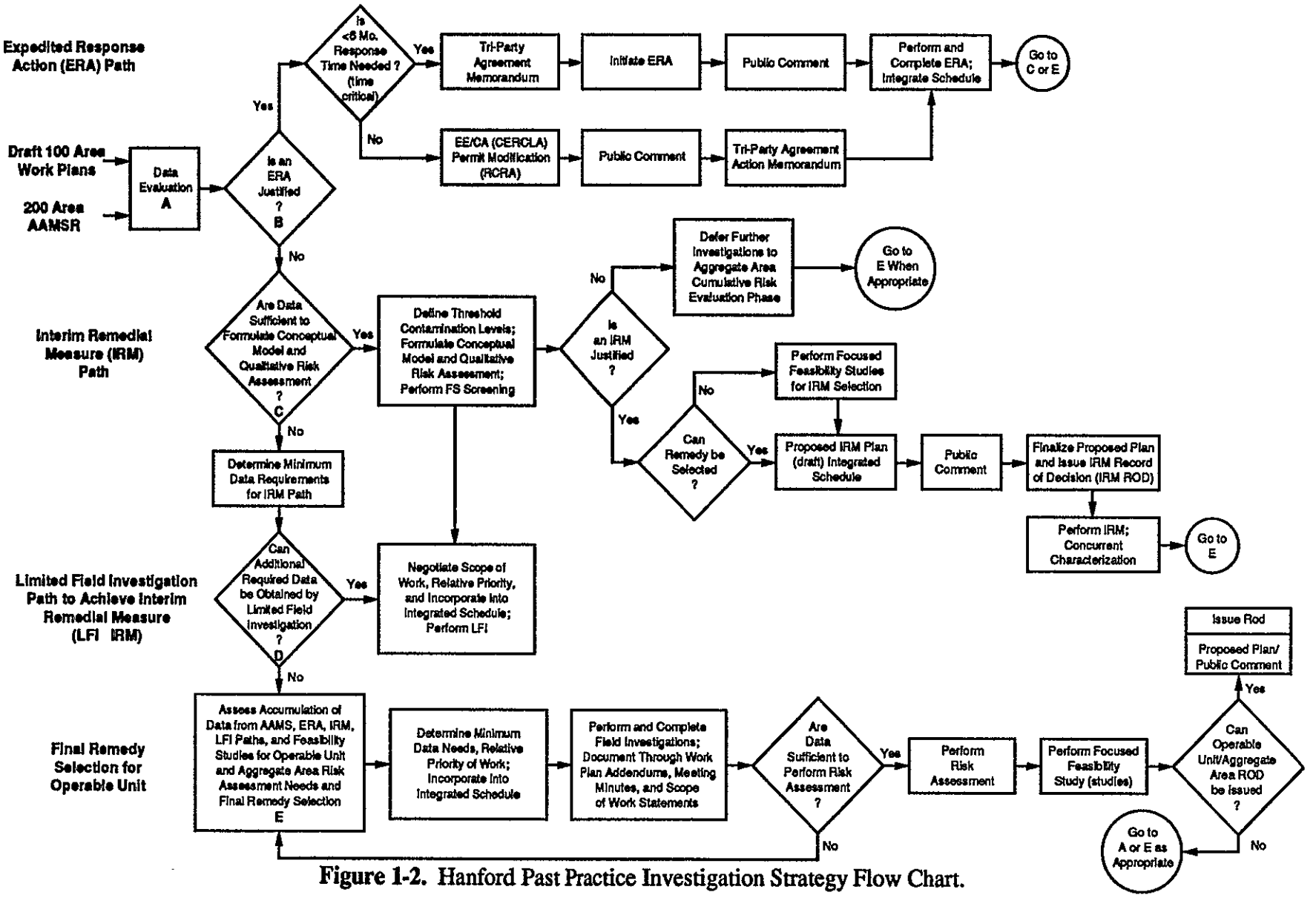


Figure 1-2. Hanford Past Practice Investigation Strategy Flow Chart.

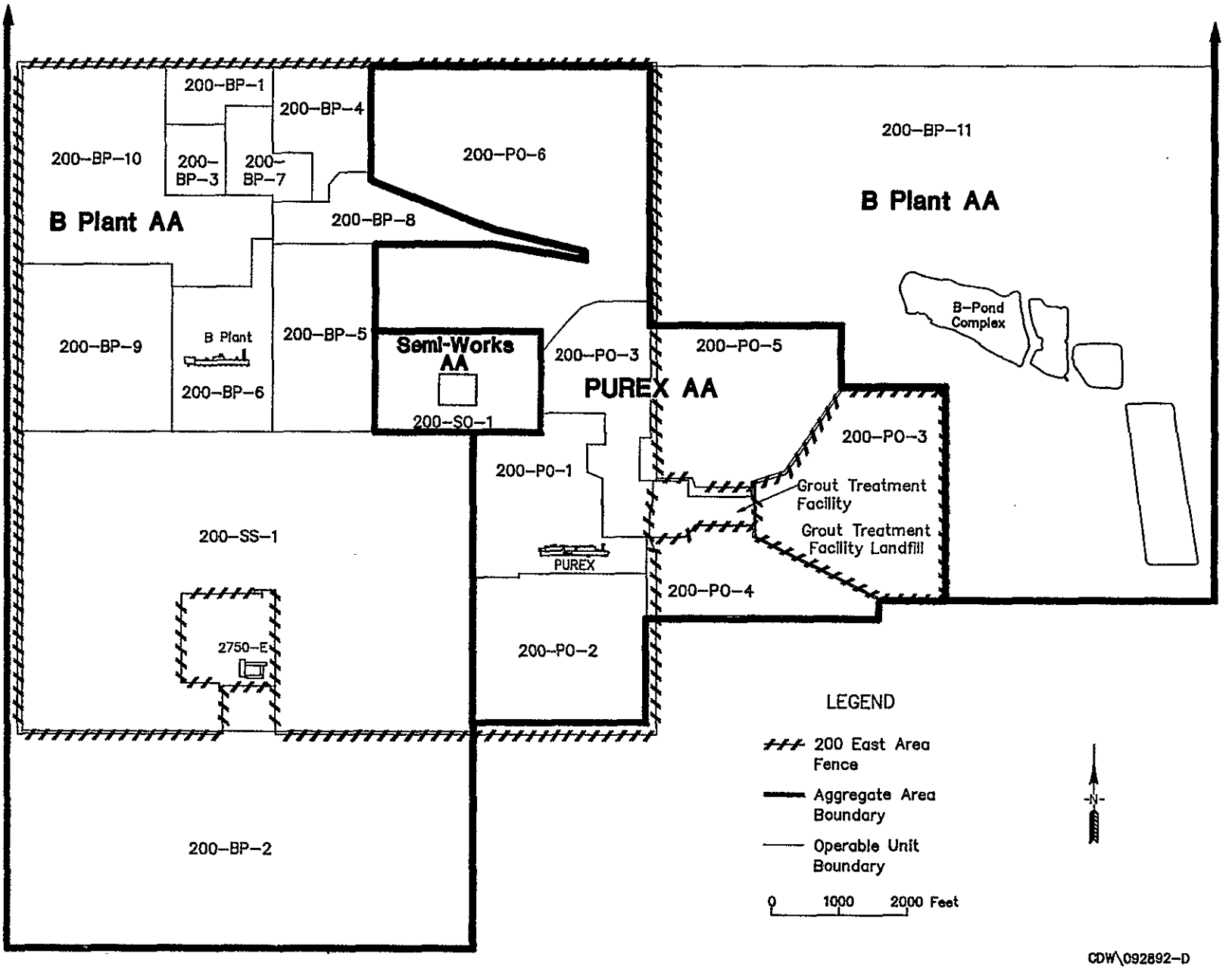


Figure 1-3. 200 East Aggregate Areas.

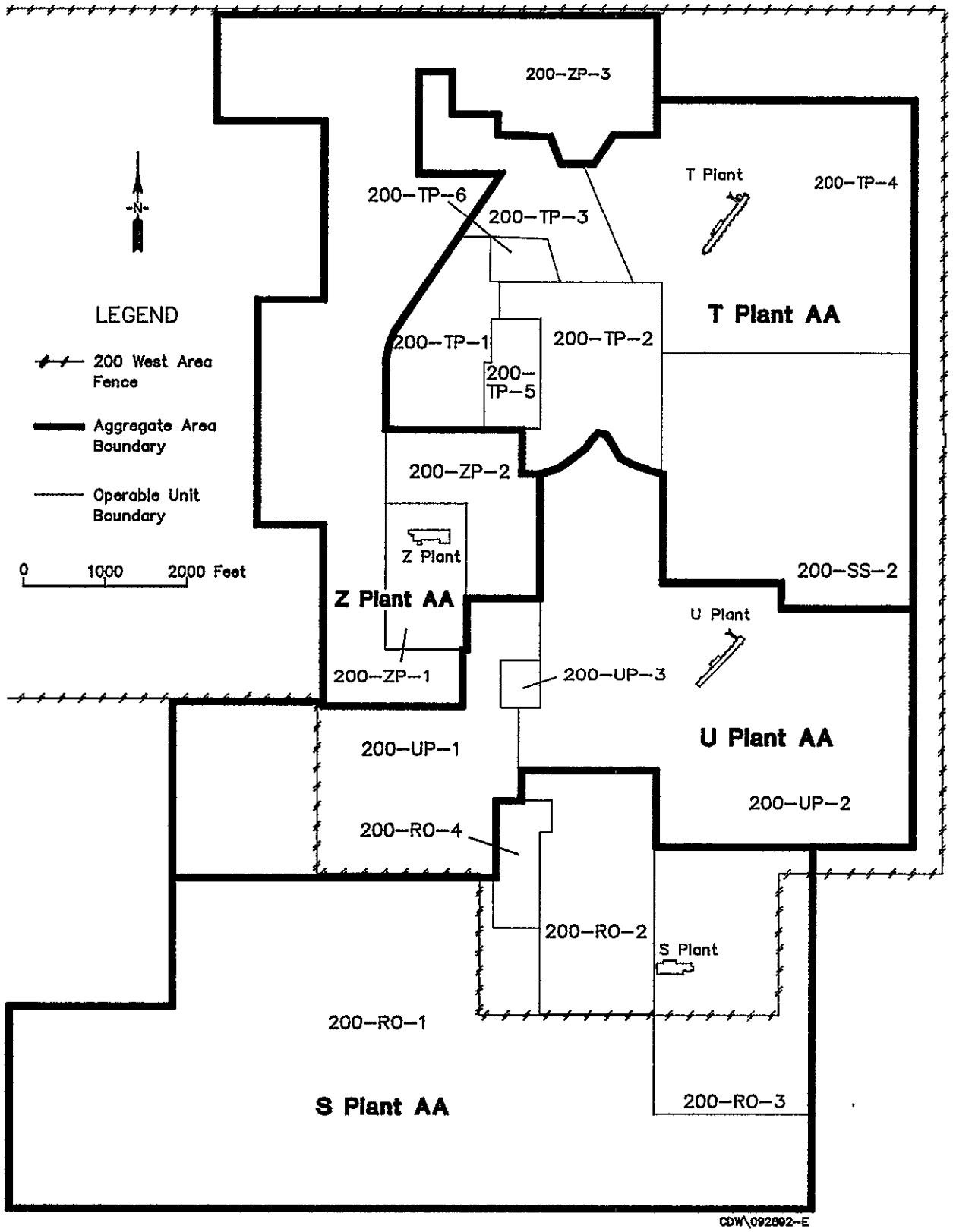


Figure 1-4. 200 West Aggregate Areas.

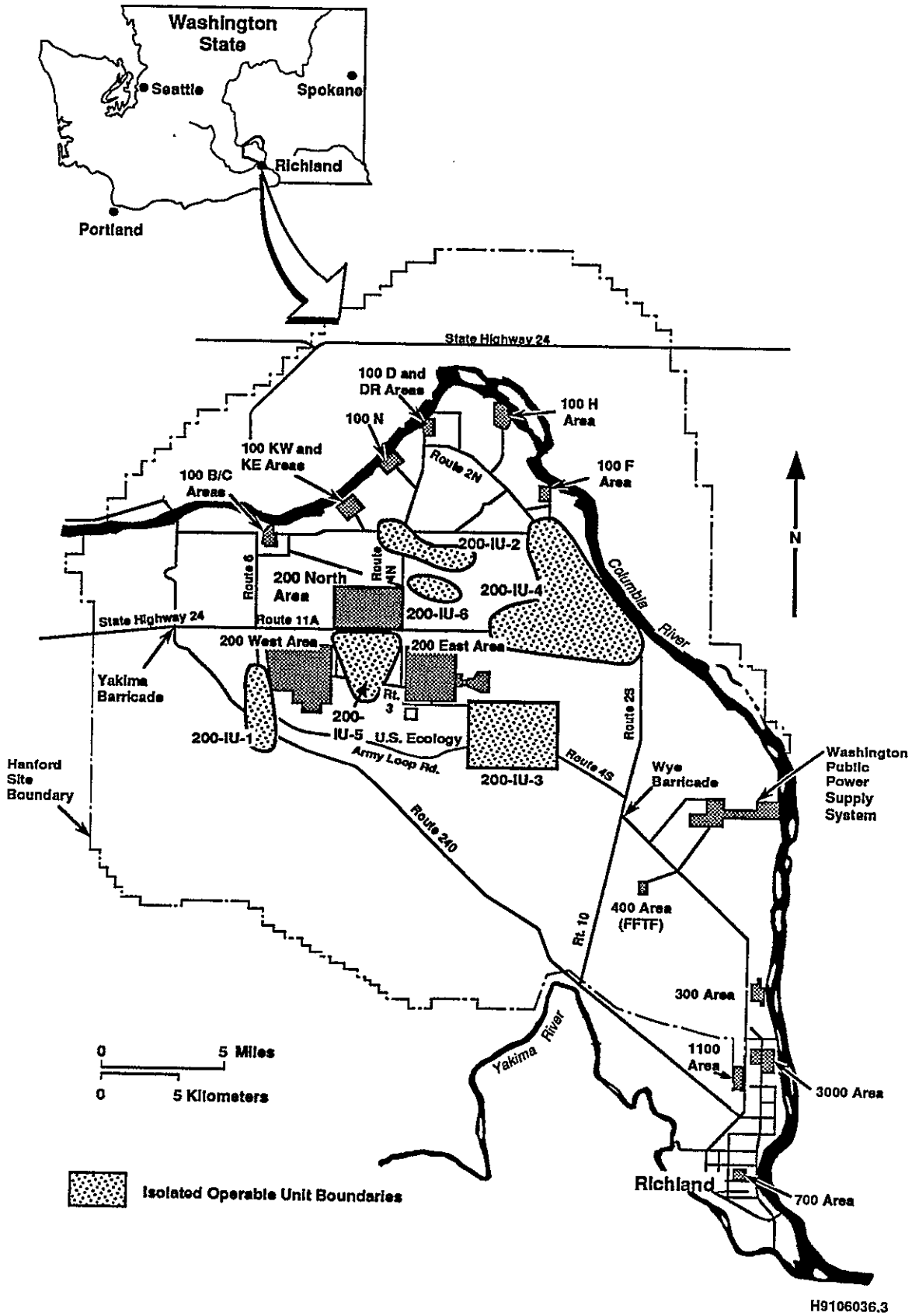


Figure 1-5. 200 NPL Site Isolated Operable Units.

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

2.0 FACILITY, PROCESS AND OPERATIONAL HISTORY DESCRIPTIONS

Section 2.0 of the aggregate area management study (AAMS) presents historical data on the Z 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 Z Plant Aggregate Area (Section 2.1), summarizes the history of operations (Section 2.2), describes the facilities, buildings, and structures of the Z Plant Aggregate Area (Section 2.3), and describes Z 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 km^2 (560 mi^2) 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 km^2 (3.2 mi^2) 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 Z Plant Aggregate Area (consisting of operable units 200-ZP-1, 200-ZP-2, and 200-ZP-3) lies in the northwest portion of the 200 West Area (Figure 1-4). Plate 1 shows the topography of the Z Plant Aggregate Area. The media sampling locations are depicted on Plate 2.

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.

Irradiated fuel rods from the 100 Areas were shipped to separations facilities in the 200 Areas for initial processing to separate plutonium and uranium. Between 1945 and 1949, the primary output of this process, a plutonium nitrate solution, was concentrated into a plutonium nitrate paste in Z Plant before being shipped to Los Alamos for refinement into metallic plutonium. Beginning in 1949, plutonium finishing was conducted at the Z Plant Aggregate Area.

The major processes conducted in the Z Plant Aggregate Area included producing metallic plutonium, and recovering plutonium and americium from plutonium scrap solutions. A Z Plant Aggregate Area timeline is schematically illustrated on Figure 2-1.

The Plutonium Isolation Facility operated within the Z Plant Aggregate Area from approximately 1945 to 1949 in the 231-Z Building. The primary Z Plant Aggregate Area facility is the 234-5Z Building. This building housed the Plutonium Finishing Plant (PFP) and operated continuously from 1949 to 1973 and intermittently between 1985 and 1988.

Beginning in 1955, additional process equipment was installed at the Z Plant Aggregate Area to recover plutonium from PFP liquid waste streams. Two separate types of

plutonium separation operations occurred within the Z Plant Aggregate Area. They included RECUPLEX and the Plutonium Reclamation Facility (PRF). The RECUPLEX plutonium recovery process operated inside the 234-5Z Building from 1955 to 1962, at which time it was terminated after a criticality event (uncontrolled nuclear reaction within the PFP). In 1964, a replacement scrap solution recovery facility, the PRF, was brought on line in the 236-Z Building. The PRF operated from 1964 to 1979 and from 1984 to 1987. The PRF was scheduled to reactivate in 1991.

An additional Z Plant Aggregate Area recovery process operated in the 242-Z Building between 1964 and 1976 to recover americium from the PFP waste stream. The americium recovery process was shut down in 1976 after an explosion occurred in one of the recovery units.

Operations of the PFP Remote Mechanical C (RMC) line and the PRF are currently suspended. Pending completion of the PRF readiness review and regulatory approval of the PFP Wastewater Sampling and Analysis Plan, operation of the PRF will resume to process plutonium solution now held in storage in the PFP. These solutions will then be processed through the RMC line to produce stable Plutonium Oxide for long-term storage. Future operations at PFP will be evaluated via National Environmental Policy Act documentation to be prepared after the stabilization campaigns.

2.3 FACILITIES, BUILDINGS, AND STRUCTURES

The Z Plant Aggregate Area contains a large variety of waste disposal and storage units in addition to its plutonium finishing and recovery facilities and support facilities. 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 TRU waste and fission products in concentrations as to require permanent isolation.

- Transuranic 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 Z 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. The locations of these waste management units are shown on separate figures for each waste management group (Figures 2-2 through 2-4 and 2-7 through 2-13) (WHC 1991a, DOE-RL 1991a). Figure 2-1 summarizes the operational history of each of the waste management units. Tables 2-2 and 2-3 summarize data identified regarding the quantity and types of waste 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.

Prior to 1977, liquid wastes generated in Z Plant Aggregate Area were generally disposed of to the soil column via various cribs, french drains, reverse wells, trenches, and tile fields. After 1977, high-level and mixed liquid wastes were generally routed to the tank farms. Process condensates have not been discharged to cribs since 1972, and are currently transferred to 200 Areas tank farms for storage following treatment in the 241-Z Treatment Tank (Section 2.3.2.3). Non-process wastewater, e.g., non-contact cooling water and sanitary wastewater from standby activities is discharged to the soil column via the 216-Z-20 Crib and the 216-Z-21 Seepage Basin. The 216-Z-21 Seepage Basin is discussed in Section 2.3.8.2, and the 216-Z-20 Crib is discussed as part of the U Plant AAMSR. The Tri-Party Agreement specifies that the 216-Z-20 Crib is to be addressed in the U Plant AAMS. However, the U Plant AAMSR recommends that the 216-Z-20 Crib be addressed in the Z Plant AAMS. Beginning in September 1991, the discharge of PFP wastewater to the 216-Z-20 Crib was limited to 606 L (160 gal) per minute or less, averaged over the calendar month. This discharge limit was set in accordance with Tri-Party Agreement milestone M-17-16A. Another Tri-Party Agreement milestone, M-17, requires cessation of all discharge to the crib by June 1995 (Ecology et al. 1991).

Sanitary wastes generated in the Z Plant complex are also disposed of to the soil column through septic tanks and associated drain fields. Solid wastes generated within Z Plant Aggregate Area and at other Hanford Site facilities are disposed of in the 218-W Burial Grounds. Accidental spills or releases (e.g., resulting from pipe leaks, overflows, or fires) of waste materials also occurred at various times and locations and are noted as unplanned releases.

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 interactions of the Hanford programs. Some plants and buildings are or contain RCRA TSD facilities; a description of such facilities is provided in Section 2.6.

The main Z Plant complex, the PFP, consists of four major facilities and a number of ancillary structures which are located as shown on Figure 2-2. The major facilities include the RMC line located in the 234-5Z Building, finished product inspection and testing laboratories located in the 231-Z Building, the PRF located in the 236-Z Building, and the Americium Recovery Facility located in the 242-Z Building. Other Z-Plant Aggregate Area facilities include the 291-Z Building, the 2736-ZB Building, the 232-Z Incinerator, and a waste treatment tank inside the 241-Z Building (241-Z Treatment Tank). The latter two are AAMS waste management units. The 231-Z Building, the 242-Z Building, and the 232-Z Building are inactive facilities. The 241-Z Treatment Tank is described in Section 2.3.2.3; the 232-Z Incinerator is described in Section 2.3.1.6. Z Plant building and facilities which are not AAMS waste management units are described in Sections 2.3.1.1 through 2.3.1.5.

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 the Decommissioning and RCRA Closure Program. These structures include:

- 234-5Z Hazardous Waste Staging Area (HWSA) (active hazardous waste and process chemical storage area)
- Radioactive Mixed Waste Storage Facility (RMWSF) (active RCRA TSD)
- Waste Receiving and Processing (WRAP) Facility (proposed drummed waste reprocessing facility).

2.3.1.1 234-5Z Building. The 234-5Z Building is the site of the primary plutonium finishing facility, the PFP. First constructed in 1949, the concrete and sheet metal multi-story building was later expanded to occupy 18,580 m^2 (200,000 ft^2). The 234-5Z Building housed the RECUPLEX process line which purified and converted plutonium nitrate solutions to other usable plutonium forms or compounds. The RECUPLEX operated from 1955 through 1962 to reclaim additional plutonium from the PFP liquid and solid wastes and scraps. The RECUPLEX process wastes included mixtures of tributylphosphate with carbon

tetrachloride and acidic aqueous wastes. The 216-Z-8 French Drain, the 216-Z-9 Trench, and a structure designated the 216-Z-8 Settling Tank for the purpose of this study received RECUPLEX waste.

Three plutonium processing lines operated inside the 234-5Z Building. They included the RG-RB line (1949-1953), the RMA line (1953-1979), and the RMC line (1969-1973 and 1985-1988). Section 2.4 provides a detailed description of wastes generated from these process lines. Historically, liquid wastes generated from these operations contained traces of plutonium and other TRU elements which were routed to the following waste sites:

- 216-Z-1 & 216-Z-2 Cribs
- 216-Z-3 Crib
- 216-Z-12 Crib
- 216-Z-1A Tile Field
- 216-Z-19 Ditch.

Wastes discharged to the 216-Z-1 and 216-Z-2 Cribs, 216-Z-1A Tile Field, 216-Z-3 Crib, and 216-Z-12 Crib were routed through the 241-Z-361 Settling Tank prior to discharge. Some of the process waste was also routed through the 241-Z Treatment Tank (241-Z Building) prior to disposal.

The 216-Z-19 Ditch is an inactive facility discussed in the U Plant AAMSR. The Tri-Party Agreement specifies that the 216-Z-19 Ditch is to be addressed in the U Plant AAMS.

In addition to the plutonium processing lines, the 234-5Z Building houses office space, analytical and development laboratories, workshops, storerooms, and locker rooms.

Currently, there are 80 potential non-process contributors to the liquid effluent waste stream (Jensen 1990). Potential contributors include equipment cooling water drains; heating, ventilation, and air conditioning (HVAC) drains (condensate). This wastewater is disposed of to the 216-Z-20 Crib, which is an active unit covered in the U Plant AAMSR. The U Plant AAMSR describes the composition of the wastewater.

2.3.1.2 231-Z Building. The 231-Z Building is the site of the Plutonium Isolation Facility (PIF). The PIF operated from approximately 1945 to 1949 to condense the plutonium nitrate solution from the separation process facilities into plutonium paste prior to additional off-site processing. Several waste management units including the 216-Z-4 Trench, 216-Z-5 and 216-Z-6 Cribs, and the 216-Z-10 Reverse Well began receiving liquid waste from the 231-Z Building in 1945.

After 1949, the 231-Z Building was used for metallurgical labs and offices for research on plutonium and alloys. It is a 1,860 m^2 (20,000 ft^2) structure which currently

houses inactive process cells and occupied office space. It is located approximately 30 m (98 ft) north of the PFP Complex Protected Areas exclusion fence. Liquid process wastes containing radioisotopes, dissolved metals, and other compounds were disposed of from this facility via the 231-Z-151 Sump to the following waste units:

- 216-Z-4 Trench
- 216-Z-5 Cribs
- 216-Z-6 Crib
- 216-Z-7 Cribs
- 216-Z-16 Crib
- 216-Z-10 Reverse Well
- 216-Z-17 Trench.

Process wastes from the 231-Z Building were previously discharged to the 216-Z-1(D) Ditch, now abandoned and backfilled. The ditch was located east of the 231-Z Building and ran south to the 216-U-10 Pond via the 216-Z-19 Ditch (now abandoned and backfilled) (Figure 2-8). The 216-U-10 Pond, discussed in the U Plant AAMSR 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 216-Z-1(D) Ditch and 216-Z-19 Ditch are discussed in the U Plant AAMSR.

Currently, the 231-Z Building houses office space, a carpenter's shop, a sign painter's shop, and a number of laboratories. Routine effluents from the building include cooling water and condensate from the HVAC systems. There are four potential contributors to the effluent waste stream from these sources which comprise 8 individual contributors. These wastes are discharged to the 216-Z-20 Crib.

Sanitary wastewaters from the 231-Z Building (5,500 L [1,500 gal] per day) discharge through the 2607-W-8 Septic Tank to a sanitary drainfield northeast of the 231-Z Building (Figure 2-9).

2.3.1.3 236-Z Building. The 236-Z Building houses the PRF process lines. The purpose of this operation is to recover plutonium from scrap solutions within the PFP and other DOE facilities. The 236-Z Building is a six-story 520 m^2 (5,600 ft^2) reinforced concrete structure. Multiple floor levels house process and supporting facilities used for the plutonium reclamation operations.

PRF process wastes were similar to the RECUPLEX wastes; in addition, dibutyl butyl phosphonate (DBBP) was used in the PRF process. Plutonium recovery process wastes were routed to the 241-Z-361 Settling Tank before being discharged to cribs and trenches in the Z Plant Aggregate Area. The 216-Z-1A Tile Field, the 216-Z-1 and 216-Z-2 Cribs, and the 216-Z-18 Crib received PRF process waste.

The plutonium recovery facilities are currently idle. Low-level wastewater including equipment cooling water, HVAC condensate, process cooling water, and steam condensate discharge to three piping drain headers which route the effluents to the 216-Z-20 Crib. There are currently 41 potential non-process contributors to the effluent waste stream. Potential contributors include equipment cooling water drains and HVAC drains.

2.3.1.4 242-Z Building. The 242-Z Building housed the Americium Recovery process line. The 93 m^2 (1,000 ft^2) building was used from 1964 to 1976 to recover americium from the PFP process line.

Liquid wastes from the Americium Recovery process line consisted of concentrated nitric acid with traces of TRU elements and metals. The DBBP was also used in the americium recovery process. This waste stream was routed to the 241-Z-361 Settling Tank and then discharged to the 216-Z-1A Tile Field and the 216-Z-18 Crib. Beginning in 1973, these wastes were routed to the 242-T Evaporator. The 242-T Evaporator, located in the T Plant Aggregate Area, is discussed in the T Plant AAMSR.

Currently, there are no routine process effluent contributors from this building. A single piping drain header carries condensate effluent from this building to the 216-Z-20 Crib.

2.3.1.5 241-Z Building. The 241-Z Building is located south of the 234-5Z Building (Figure 2-2). The 241-Z Building houses equipment used to temporarily store and treat process effluents from the PFP. The facility includes five 15,900 L (4,200 gal) below-grade tanks housed in concrete sumps and two above-grade tanks. One of the below-grade tanks, the 241-Z Treatment Tank, also called Tank D-5 and TK-5, is an active RCRA TSD (see Section 2.3.2.3). Another below-grade tank, Tank D-6, has been declared not fit for use and consequently has been deactivated. The two above-grade tanks, D-10 and D-11, are used to mix chemical additives for the D-5 Tank. The 241-Z Building structure is also referred to as a storage tank pit. A General Electric Company drawing shows the 241-Z Building as a subsurface structure with a concrete floor, side walls, and internal walls separating each tank compartment. The structure has a ground-level concrete cover, and above-ground sheet-metal housing for utility piping and electrical components. The 241-Z (D-5) Treatment Tank is the easternmost of the tanks within the building.

2.3.1.6 Other Buildings and Facilities.

2.3.1.6.1 232-Z Incinerator. The 232-Z Incinerator is an inactive Z Plant Aggregate Area waste management unit located on the southwest side of the 234-5Z Building (Figure 2-2). The 186 m^2 (2,000 ft^2) building housed the dry waste incinerator from 1959 to 1973 which incinerated plutonium-contaminated solid wastes in preparation for plutonium recovery. The building also housed equipment used for supporting operations such as offgas treatment and leaching. The first floor contained a storage room, electrical equipment room,

a process room containing waste handling equipment, a chemical mixing room, and a change room. The second story housed the building heating and ventilation equipment. The building has been inactive since 1973 and there are currently no routine contributors to the effluent waste stream. The 232-Z Incinerator Building is scheduled for decommissioning in Fiscal Year 1999 under the Decommissioning and RCRA Closure Program. Historically, the 216-Z-1A Tile Field received aqueous wastes from the 232-Z Incinerator, but the nature and quantity of these wastes is unknown.

A piping drain header leads from this building to the 216-Z-20 Crib. There is no process solution contact with the 216-Z-20 Crib effluents under normal operating conditions. The drain header is a condensate drain header.

No releases to the soil column have been reported at this waste management unit.

2.3.1.6.2 234-5Z Hazardous Waste Staging Area (HWSA). The HWSA facility is an active RCRA generator waste accumulation area. Also called the Hazardous Waste Storage Area, this asphalt pad is located on the east side of the 234-5Z Building (Figure 2-2). The eastern pad is located about 15.3 m (50 ft) east of the eastern wall of the building, along the inner security fence line and has stored containerized wastes. Wastes typically contained in the staging area over the course of a year included waste nitrates and oxidizers, polychlorinated biphenyls (PCBs), process chemicals, and carbon tetrachloride. No releases are known to have occurred at this unit.

2.3.1.6.3 Radioactive Mixed Waste Storage Facility (RMWSF). The RMWSF is an active RCRA TSD facility which consists of twelve small buildings used to temporarily store designated mixed waste (Figure 2-2). The unit was started in 1988 on the west side of Dayton Avenue, west of the 218-W-2 Burial Ground.

No spills or releases have been reported at this facility.

2.3.1.6.4 291-Z Building. The 291-Z Building houses the ventilation exhaust fans, instrument air compressors, and vacuum pumps to handle all ventilation exhaust from the 234-5Z, 236-Z, and 242-Z Buildings and formerly the 232-Z Building. It is a 1,300 m^2 (14,000 ft^2) building.

Routine effluents from the 291-Z Building include non-contact cooling and condensate wastewater from HVAC equipment, cooling water for the compressors, and vacuum-pump seal water. These wastes were discharged to the following units:

- 216-Z-13 French Drain
- 216-Z-14 French Drain
- 216-Z-15 French Drain
- 216-Z-1(D) Ditch.

Currently, there is one drain header which discharges effluents from the 291-Z Building to the 216-Z-20 Crib. There are 12 potential contributors to the waste stream including floor drains and sinks (WHC 1990b).

2.3.1.6.5 2736-ZB Building. The 2736-ZB Building, constructed in 1983, is used for plutonium product handling operations. The 1,950 m^2 (21,000 ft^2) building is separated into a front section and a back section. The front section consists of administrative areas. The back section is where storage and handling of the finished plutonium product occurs. This process includes the storage and handling of radioactive solid waste product material.

Routine effluents from the building currently are limited to cooling and condensation wastewater from HVAC equipment and air compressors.

2.3.1.6.6 Waste Receiving and Processing (WRAP) Facility. The proposed WRAP will be a permitted RCRA TSD facility designed to process existing drummed mixed waste. The first phase of the project, drum recovery and repackaging is expected to come online in mid-1993. A second phase of the project will include constructing a mixed waste incinerator and incinerating the repackaged drums. The proposed WRAP facility will be located in the general vicinity of the Radioactive Mixed Waste Storage Facility, west of the 218-W-2 Burial Ground (Figure 2-2).

No wastes are currently associated with this proposed facility.

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 Z Plant Aggregate Area including settling tanks, septic tanks, and a treatment tank. Settling tanks were used for settling suspended solids in fluid wastes prior to transfer to cribs or drains. Treatment tanks were used to raise the pH of fluid wastes prior to transfer to cribs, storage tanks, or tilefields. Septic tanks are discussed in Section 2.3.6. No vaults or single-shell tanks were identified within the Z Plant Aggregate Area.

Two liquid waste holding tanks within the Z Plant Aggregate Area, the 241-Z-361 Settling Tank and the 241-Z Treatment Tank are identified in WHC (1991a). A review of Hanford drawings identified a third tank, commonly referred to as the Silica Gel Settling Tank which has been designated as the 216-Z-8 Settling Tank for the purposes of this report.

Sections 2.3.2.1 through 2.3.2.3 describe the history, construction, and operation of each of these facilities.

2.3.2.1 216-Z-8 Settling Tank. The 216-Z-8 Settling Tank is an inactive waste management unit located on the east side of the 234-5Z Building, 6.1 m (20 ft) west of the 216-Z-8 French Drain (Figure 2-3). The 57,000 L (15,000 gal) carbon steel tank was used as a solids settling tank for a backflush of the feed filters for the RECUPLEX process. Liquid waste overflowed from the 216-Z-8 Settling Tank to the 216-Z-8 French Drain where it was disposed of to the soil column. The tank operated from 1955 to April 1962, when the RECUPLEX process line was shut down.

No releases are associated with this tank. Fluid level measurements in April 1974, indicated that the tank contained 29,081 L (7,653 gal) of liquid and 1,888 L (497 gal) of sludge. The plutonium content of the tank was estimated to be 1.6 kg (3.5 lb) in 1974.

The 216-Z-8 Settling Tank has also been identified as the Silica Gel Settling Tank.

2.3.2.2 241-Z-361 Settling Tank. The 241-Z-361 Settling Tank is an inactive waste management unit located approximately 106.8 m (350 ft) south of the 234-5Z Building (Figure 2-3). The underground, steel-lined, concrete tank is 4.6 m (15 ft) wide x 8.5 m (28 ft) long with a sloping bottom. The height of the tank varies between 5.8 m (19 ft) and 6.1 m (20 ft). The 241-Z-361 Settling Tank served as a settling tank for liquid wastes routed to the 216-Z-1A Tile Field and the 216-Z-1, 216-Z-2, 216-Z-3, 216-Z-12, and 216-Z-18 Cribs from the PFP (234-5Z Building), PRF (236-Z Building), and 242-Z Building. The 241-Z-361 Settling Tank was used between 1949 and 1976 (Figure 2-1).

No releases are associated with this tank. This unit received liquid waste estimated to contain 30 to 75 kg (65 to 165 lb) of plutonium (1 mrem/hr gamma; 0.8 mrem/hr neutron) (WHC 1991a). However, information as to what part of that waste was retained in the settling tank was not found.

The 241-Z-361 Settling Tank has also been identified as 207-Z Settling Tank.

2.3.2.3 241-Z Treatment Tank. The 241-Z Treatment Tank (Tank D-5) is a RCRA TSD facility. The Treatment Tank receives and treats corrosive liquid waste from the 234-5Z Building. Additional information regarding the layout of the 241-Z Building and additional tanks in the building is presented in Section 2.3.1.5. The corrosive liquid waste is treated by addition of caustic soda, to increase the pH of the liquid. The 241-Z Treatment Tank is designed to treat a maximum of 20,140 L (5,300 gal) per day (WHC 1991a). The nominal outflow from the tank is approximately 58,900 L (10,200 gal) per week. After treatment, the liquid wastes are transferred via pipeline to the 244-TX Receiver Tank north of Z Plant PFP Complex. The wastes are then rerouted to various Hanford Site tank farms. Currently, when accumulated, scrubber water and other non-contact wastewater from standby operation of the PFP are routed to the 241-SY-102 Tank which is an S Plant Aggregate Area waste management unit.

Unplanned releases UN-200-W-74, UN-200-W-75, and UN-200-W-79 are associated with the 241-Z Building treatment tanks. Unplanned release UN-200-W-79 occurred when an influent pH line (D-6 transfer line) failed adjacent to the 241-Z Treatment Tank. Table 2-6 describes the unplanned releases in more detail.

2.3.3 Cribs and Drains

The cribs and drains were designed to inject or percolate wastewater into the ground without exposing it to the open air. The locations of cribs and drains in the Z Plant Aggregate Area are shown on Figure 2-4. 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. Wastewater flows directly into the backfilled material or covered open space and percolates into the vadose zone soils. A typical crib is illustrated on Figure 2-5. 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 on Figure 2-6. The 216-Z-1A Tile Field is similar in design and operation to the cribs and is thus also discussed in this section.

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 Z Plant Aggregate Area.

Nine cribs, four french drains, and one tile field were identified within the Z Plant Aggregate Area (WHC 1990a). The cribs, drains, and tile fields identified include the following:

- 216-Z-1 and 216-Z-2 Cribs
- 216-Z-3 Crib
- 216-Z-5 Crib
- 216-Z-6 Crib
- 216-Z-7 Crib
- 216-Z-12 Crib
- 216-Z-16 Crib
- 216-Z-18 Crib

- 216-Z-8 French Drain
- 216-Z-13 French Drain
- 216-Z-14 French Drain
- 216-Z-15 French Drain
- 216-Z-1A Tile Field.

Sections 2.3.3.1 through 2.3.3.14 describe the history, construction, and operation of each of these facilities. Tables 2-1, 2-2, 2-3, and 2-4 present available information regarding sources of and inventories of wastes disposed of to these waste management units. Locations of these waste management units are identified on Figure 2-4.

2.3.3.1 216-Z-1 and 216-Z-2 Cribs. The 216-Z-1 and 216-Z-2 Cribs are inactive waste management units located approximately 122 m (400 ft) south of the 234-5Z Building. Each crib consists of a wood-lined box 3.7 by 3.7 by 4.3 m (12 by 12 by 14 ft) high set and backfilled with gravel in a 6.4 m (21 ft) deep excavation.

The cribs received liquid process wastes from the 234-5Z Building from June 1949 until June 1952. The cribs received aqueous and organic wastes from the PRF for one month in 1966 and one month in 1967. The cribs received PRF process waste and americium recovery line wastes from the 236-Z and 242-Z Buildings from March 1968 to April 1969. From March 1968 to April 1969, the cribs received uranium wastes from 236-Z Building (Stenner et al. 1988).

Figure 2-10 shows the location of the pipeline which carried process wastes from the 234-5Z Building to the 216-Z-2 Crib via the 216-Z-361 Settling Tank. The 216-Z-2 Crib overflowed into the 216-Z-1 Crib which then overflowed into the 216-Z-1A Tile Field.

No unplanned releases were associated with these cribs.

The 216-Z-1 and 216-Z-2 Cribs have also been identified as the 234-5 No. 2 Crib and the "216-Z-7."

2.3.3.2 216-Z-3 Crib. The 216-Z-3 Crib is an inactive waste management unit located approximately 122 m (400 ft) south of the 234-5Z Building, due east of the 216-Z-1 and 216-Z-2 Cribs. The 216-Z-3 Crib consists of three 1.2 m diameter (4 ft) by 6.7 m (22 ft) long perforated corrugated culverts laid end to end in a 7.6 m (25 ft) deep excavation. The culverts were laid horizontally on gravel fill 4.6 m (15 ft) above the crib bottom. The excavation was then backfilled to surrounding grade.

The 216-Z-3 Crib received neutral/basic process waste and analytical and development laboratory wastes from the 234-5Z Building via the 241-Z-361 Settling Tank from June 1952 to March 1959.

No unplanned releases were associated with this crib.

The 216-Z-3 Crib has also been identified as the 216-Z-3 Culvert, the 234-5 No. 3 and No. 4 Cribs, and the 216-Z-8 Crib.

2.3.3.3 216-Z-5 Crib. The 216-Z-5 Crib is an inactive waste management unit located approximately 660 m (200 ft) northeast of the 231-Z Building. The 216-Z-5 Crib consists of two wooden boxes, each 3.7 by 3.7 by 1.2 m (12 by 12 by 4 ft) high, placed in 5.6 m (18 ft) deep excavations constructed with 1:1 side slopes.

The 216-Z-5 Crib received 231-Z Building process waste via the 231-Z-151 Sump. The 216-Z-5 Crib was used to dispose of liquid waste to the soil column from June 1945 until February 1947. Use of the 216-Z-5 Crib was discontinued when sludge in the waste plugged the soil. The cap on the 216-Z-5 Crib has reportedly weakened (WHC 1991a) creating a cave-in potential.

No unplanned releases were associated with this crib.

The 216-Z-5 Crib has also been identified as the 231-W-1 and 231-W-2 Cribs and the 231-W Sumps.

2.3.3.4 216-Z-6 Crib. The 216-Z-6 Crib is an inactive waste management unit located approximately 91.5 m (300 ft) east of the 231-Z Building and 61 m (200 ft) north of 19th Street. The Crib consists of a wooden box 15.3 m (50 ft) long by 2.0 m (6.5 ft) wide by 0.6 m (2 ft) high, placed in a 2.4 m (8 ft) deep excavation.

The 216-Z-6 Crib received process waste from the 231-Z Building via the 231-Z-151 Sump for one month in June 1945. Use of the crib was discontinued due to plugging of the surrounding soil by process sludge and precipitates. The cap on the 216-Z-6 Crib has reportedly weakened (WHC 1991a) creating a cave-in potential.

No unplanned releases were associated with this crib.

The 216-Z-6 Crib has also been identified as the 231-W-4 Crib, the 226-W-4 Crib, and the 231-Z-6 Crib.

2.3.3.5 216-Z-7 Crib. The 216-Z-7 Crib is an inactive waste management unit located approximately 152.5 m (500 ft) east of the 231-Z Building and about 137.3 m (450 ft) north of 19th Street. The 216-Z-7 Crib consists of two parallel wooden structures 45.7 m (150 ft) long by 1.5 m (5 ft) wide by 0.6 m (2 ft) high, placed in a 1.5 m (5 ft) deep excavation. Each wooden structure was constructed of three overlapping tiers. A 45.8 m (150 ft) long,

7.5 or 10 cm (3 or 4 inch) diameter perforated distribution pipe runs above the second tier. Each of the two trenches is covered by 503 m (1,650 ft) of 5 cm (2 inch) planking, then tar paper. The excavation was backfilled with gravel.

The 216-Z-7 Crib received process waste from the 231-Z Building via the 231-W-151 Sump from February 1947 to February 1967. The 216-Z-7 Crib replaced the 216-Z-5 Crib. It also received Hanford Laboratory waste from the 231-Z Building, via the 231-W-151 Sump. In addition, the site received waste from PNL operations in 231-Z Building, and 300 Area laboratory waste from the 340 Facility (WHC 1991a). In total, the site received an estimated 79,900,000 L (21,100,000 gal) of liquid waste.

No unplanned releases were associated with this crib.

The 216-Z-7 Crib has also been identified as the 231-W Trench, the 231-W Crib, and the 231-Z-6 Crib.

2.3.3.6 216-Z-12 Crib. The 216-Z-12 Crib is an inactive waste management unit located approximately 122 m (400 ft) southwest of the 234-5Z Building. The 216-Z-12 Crib consists of a 91.5 by 6.1 by 6.1 m (300 by 20 by 20 ft) deep excavation with 1.5 m (5 ft) of gravel in the bottom backfilled to grade. A 30 cm (12 inch) diameter, perforated, vitrified clay pipe runs the length of the crib, 1.2 m (4 ft) above the crib bottom. In July 1968, a 15 cm (6 inch) diameter schedule 10 pipe was run parallel to and 9.2 m (30 ft) west of the original line. The new line bypassed 30.5 m (100 ft) of the original line. The original line was plugged upstream from the junction of the two lines.

The site received PFP process waste and analytical and development laboratory waste from the 234-5Z Building via the 241-Z-361 Settling Tank. The crib's active life was from 1959 to 1973. The slightly acidic, low-salt waste was adjusted to a pH range of 8 to 10 before disposal. The 216-Z-12 Crib reportedly received 281,000,000 liters (72,250,000 gal) of liquid waste which included 25 kg (55 lb) of plutonium (WHC 1991a).

No unplanned releases were associated with this crib.

The 216-Z-12 Crib has also been identified as the 207-Z-12 Crib.

2.3.3.7 216-Z-16 Crib. The 216-Z-16 Crib is an inactive waste management unit located about 76.3 m (250 ft) northwest of the 231-Z Building. The 216-Z-16 Crib consists of an excavation 54.9 by 3.1 by 4.6 m (180 by 10 by 15 ft) deep with 1.5 m (5 ft) of gravel in the bottom. A perforated 10 cm (4 inch) diameter PVC pipe runs down the crib center, 1.2 m (4 ft) above the bottom of the excavation. A polyethylene vapor barrier was placed over the gravel, then covered with 10 cm (4 inches) of sand, and earth backfill to grade.

The 216-Z-16 Crib received 231-Z Building laboratory waste from PNL operations from March 1968 to January 1977. The 216-Z-16 Crib received 102,000,000 L (27,000,000 gal) of neutral/basic liquid waste containing approximately 0.072 kg (0.16 lb) of plutonium (WHC 1991a).

No unplanned releases are associated with this crib.

This waste management unit has not been identified by any other designation than the 216-Z-16 Crib.

2.3.3.8 216-Z-18 Crib. The 216-Z-18 Crib is an inactive waste management unit located approximately 183 m (600 ft) south of the 234-5Z Building which received wastes via the 241-Z-361 Settling Tank. The 216-Z-18 Crib consists of five parallel excavations, each 63.1 m (207 ft) by 3.1 m (10 ft) with depths ranging from 4.6 to 5.5 m (15 to 18 ft). A 91.5 m (300 ft) long, 7.5 cm (3 inch) diameter steel pipe runs east and west, bisecting the length of each excavation. Two 30.5 m (100 ft) long, 7.5 cm (3 inch) diameter, perforated, fiberglass-reinforced epoxy pipes exit each side of the steel pipe in each excavation (2 lines north, 2 lines south). The distribution pipes are 0.3 m (1 ft) above the crib bottom in a 0.6 m (2 ft) thick bed of 3.8 to 7.5 cm (1.5 to 3 inch) gravel. Each excavation was backfilled to grade.

From April 1969 to May 1973, the 216-Z-18 Crib received both extraction column solvent and acidic aqueous waste from the PRF in the 236-Z Building. The 216-Z-18 Crib received 3.86 million L (1,020,000 gal) of high salt, acidic, organic liquid waste (WHC 1991a). The wastes disposed of to the crib included approximately 175,000 kg (386,000 lb) of carbon tetrachloride, 22,000 kg (48,500 lb) of tributylphosphate, and 15,000 kg (33,000 lb) of DBBP (Stenner et al. 1988). Approximately 23 kg (55.7 lb) of plutonium were disposed of to the 216-Z-18 Crib.

No unplanned releases are associated with this crib.

This waste management unit has not been identified by any other designation than the 216-Z-18 Crib.

2.3.3.9 216-Z-8 French Drain. The 216-Z-8 French Drain is an inactive liquid waste management unit located 41.5 m (300 ft) east of the 234-5Z Building and 61 m (200 ft) south of 19th street. The 216-Z-8 French Drain consists of two 90 cm (36 inch) diameter tile culverts stacked on end in a 5.2 m (17 ft) deep gravel-backfilled excavation. The unit received neutral to basic RECUPLEX process waste via the adjacent 216-Z-8 Settling Tank (Silica Gel Tank) between July 1955 and April 1962.

No unplanned releases are associated with the 216-Z-8 French Drain.

The 216-Z-8 French Drain has also been identified as the 234-5 RECUPLEX French Drain, "216-Z-9," and the 216-Z-8 Crib.

2.3.3.10 216-Z-13 French Drain. The 216-Z-13 French Drain is an active non-contact wastewater management unit located 58.0 m (190 ft) south of the 234-5Z Building on the southeast side of the 291-Z Building. The 216-Z-13 French Drain consists of two 90 cm (36 inch) diameter tile culverts stacked on end in a 4.6 m (15 ft) deep gravel-backfilled excavation. The unit has operated continuously from 1949 to the present (Figure 2-1). The 216-Z-13 French Drain receives steam condensate from the ET-8 Exhaust fan turbine and floor drainage from the 291-Z Building.

No releases of hazardous materials or radionuclides have been reported for this unit. However, due to accidents or unusual events in the process areas, Owens (1981) reports that low level contamination can be assumed.

This waste management unit has not been identified by any other designation than the 216-Z-13 French Drain.

2.3.3.11 216-Z-14 French Drain. The 216-Z-14 French Drain is an active non-contact wastewater management unit located 58 m (190 ft) south of the 234-5Z Building on the southwest side of the 291-Z ventilation equipment building. The 216-Z-14 French Drain consists of two 90 cm (36 inch) diameter tile culverts stacked on end in a 4.6 m (15 ft) deep gravel-backfilled excavation. The unit has operated continuously from 1949 to the present (Figure 2-1). The 216-Z-14 French Drain receives steam condensate from the ET-9 Exhaust fan turbine and floor drainage from the 291-Z Building.

No releases of hazardous materials or radionuclides have been reported for this unit. However, due to accidents or unusual events in the process areas, Owens (1981) reports that low-level contamination can be assumed.

This waste management unit has not been identified by any other designation than the 216-Z-14 French Drain.

2.3.3.12 216-Z-15 French Drain. The 216-Z-15 French Drain is an active non-contact wastewater disposal unit located 15.3 m (50 ft) south of the 234-5Z Building on the north side of the 291-Z ventilation equipment building. The 216-Z-15 French Drain consists of two 90 cm (36 inch) diameter tile culverts stacked on end in a 4.9 m (16 ft) deep gravel-backfilled excavation. The unit has operated continuously from 1949 to the present (Figure 2-1). The 216-Z-15 French Drain receives drainage from the S-12 evaporator cooler.

No releases of hazardous materials or radionuclides have been reported for this unit. However, due to accidents or unusual events in the process areas, Owens (1981) low-level contamination can be assumed.

This waste management unit has not been identified by any other designation than the 216-Z-15 French Drain.

2.3.3.13 216-Z-1A Tile Field. The 216-Z-1A Tile Field is an inactive waste management unit located about 152.5 m (500 ft) south of the 234-5Z Building and immediately south of the 216-Z-1 and 216-Z-2 Cribs. The 216-Z-1A Tile Field consists of a 85.4 m (280 ft) long north-south running trunk with seven pairs of 21.4 m (70 ft) laterals spaced at 10.7 m (35 ft) intervals in a herring-bone pattern (WHC 1991a). The tile field piping consists of 20 cm (8 inch) diameter perforated vitrified clay pipe placed on a 1.5 m (5 ft) deep gravel bed, 5.8 m (19 ft) below ground surface (Figure 2-10).

The 216-Z-1A Tile Field's active life was from June 1949 to April 1969. As originally constructed, the 216-Z-1A Tile Field received liquid waste as overflow from the 216-Z-1 and 216-Z-2 Cribs. In later years, liquid waste was routed directly to the tile field. Available information indicates that the service history of the 216-Z-1A Tile Field proceeded roughly as shown in Table 2-4.

The 216-Z-1A Tile Field received approximately 6.2 million L (1,640,000 gal) of liquid waste. Other sources report only 5.21 million L (1. 38 million gal) of fluid disposed of to the 216-Z-1A Tile Field and WHC (1991a) reports only 1 million L (264,000 gal) of fluid disposal. Material discharged to the tile field reportedly included 268,000 kg (591,000 lb) of carbon tetrachloride, 30,000 kg (66,000 lb) of tributylphosphate, and 20,300 kg (44,800 lb) of DBBP.

No unplanned releases were associated with the 216-Z-1A Tile Field.

The 216-Z-1A Tile Field has also been identified as the 234-5 Tile Field and the "216-Z-7."

2.3.4 Reverse Wells

Reverse wells are buried or covered encased drilled holes with the lower end perforated or open to allow liquid to seep to the ground. These units injected waste water into the ground at depths greater than the cribs and drains described above. Reverse wells are generally constructed of steel or concrete pipe and may either be open or filled with gravel.

Reverse wells were used for the disposal of low-level liquid wastes in the early phases of Hanford Site (and PFP) operations, but proved unsatisfactory because they plugged easily and introduced the waste into the ground at or near the water table (Brown and Ruppert 1948). Therefore, by 1954, all reverse wells at the Hanford Site had been removed from service; associated wastes were re-routed to cribs and other types of ground disposal units (Fecht et al. 1977).

2.3.4.1 216-Z-10 Reverse Well. One reverse well, the 216-Z-10 Reverse Well, is located within the Z Plant Aggregate Area (Figure 2-7). Sources of waste disposed of to the reverse well are summarized in Table 2-1. Tables 2-2 and 2-3 summarize available information regarding quantities and types of radionuclide and chemical constituents disposed of to this waste management unit.

The 216-Z-10 Reverse Well is an inactive, wastewater management unit. It is a 145.8 m (50 ft) deep underground injection well constructed of 15.2 cm (6 inch) diameter schedule 50 steel pipe. The 216-Z-10 Reverse Well is located 30.5 m (100 ft) east of the 231-Z Building and 122 m (400 ft) north of 19th Street. The reverse well received 231-Z Building process and laboratory waste via the 231-Z-151 Sump for four months between February and June 1945 (Figure 2-1). Brown and Ruppert (1948) reported that the well received about 1,000,000 L (264,000 gal) of TRU-contaminated process waste at the rate of about 75 L (20 gal) per minute. The well was deactivated after it became plugged with sludge. The pipeline to the well was capped west of the 231-Z-151 Sump.

No unplanned releases are associated with the 216-Z-10 Reverse Well.

The 216-Z-10 Reverse Well has also been identified as "216-Z-2," 231-W Reverse Well, and 231-W-150 Dry Well or Reverse Well.

2.3.5 Ponds, Ditches, and Trenches

The Z Plant Aggregate Area includes three trenches as shown on Figure 2-8. There are no ponds within the Z Plant Aggregate Area. Table 2-1 lists salient features of each of the trenches, which are Z Plant Aggregate Area waste management units. Tables 2-2 and 2-3 summarize information identified with respect to radionuclide and chemical wastes received by each unit.

2.3.5.1 216-Z-4 Trench. The 216-Z-4 Trench is an inactive waste management unit located 152 m (500 ft) north of the 2704-Z Building. The 216-Z-4 Trench consisted of a 3.1 by 3.1 by 4.6 m (10 by 10 by 15 ft) deep unlined excavation.

The 216-Z-4 Trench received process and laboratory waste from the 231-Z Building for one month in June 1945. The unit was deactivated and backfilled when the effluent flow exceeded the infiltration capacity of the trench. The pipeline from the 231-Z Building to the trench was capped west of the 231-Z-151 Sump.

The WHC (1991a) indicates that the 216-Z-4 Trench received approximately 11,000 L (2,900 gal) of neutral/basic liquid waste containing approximately 0.002 kg (0.004 lb) of plutonium and small amounts of other TRU elements.

No unplanned releases are associated with this trench.

The 216-Z-4 Trench has also been identified as the 231-W-3 Pit, Sump, or Crib; the 216-Z-4 Crib; and the 231-W-Sump.

2.3.5.2 216-Z-9 Trench. The 216-Z-9 Trench is an inactive waste management unit located about 213 m (700 ft) east of the 234-5Z Building, and 152 m (500 ft) south of 19th Street. The 216-Z-9 Trench consists of a 6.4 m (21 ft) deep excavation with a 36.6 m (120 ft) by 22.5 m (90 ft) concrete cover. The walls of the trench slope inward and downward to the 18.3 m (60 ft) by 9.2 m (30 ft) floor space. The sloping walls of the trench were paved with acid-resistant brick. The cover of the trench is supported by six concrete columns.

The 216-Z-9 Trench operated from July 1955 to June 1962, receiving all solvent and aqueous wastes from the RECUPLEX facility in the 234-5Z Building. Reportedly the 216-Z-9 Trench received 4.05 million L (1.07 million gal) of low salt, acidic, aqueous, and organic liquid waste from the RECUPLEX facility. It is estimated that 83,000 to 300,000 L (21,912 to 79,200 gal) or 132,000 to 477,000 kg (291,060 to 1,051,785 lb) of carbon tetrachloride may have been disposed of to the soil column at this location. The waste stream included plutonium and other TRU elements. The total volume of liquid wastes disposed of to the soil was 4,090,000 L (1,080,000 gal).

By the time the 216-Z-9 Trench was retired in 1962, it had received 50 to 150 kg (110 to 330 lb) of plutonium. The bulk of this material was expected to be bound up in the upper few inches of sediments and sludge in the bottom of the trench. In 1963 and 1969, the reactivity of the material at the bottom of the trench was measured using the pulsed neutron source technique. Based on these measurements and other data, it was decided in 1973 to actively mine the 216-Z-9 Trench to remove plutonium. This measure was intended to reduce the risk of environmental contamination and to reduce the criticality potential (e.g., the potential for uncontrolled nuclear reactions). The 216-Z-9 Trench was mined with remote mechanical equipment between August 1976 and January 1977. The mining operation removed an estimated 58 kg (128 lb) of plutonium. Based on new data acquired during the mining operation, an estimated 38 to 48 kg (84 to 106 lb) of plutonium remained

in the 216-Z-9 Trench after the mining operation. The plutonium-contaminated sediment and sludge recovered during the mining operation was drummed and disposed of in Trench No. 1 of the 218-W-4C Burial Ground.

No unplanned releases were associated with this trench.

The 216-Z-9 Trench has also been identified as the 216-Z-9 Crib, the 216-Z-9 Cavern, the 234-5 RECUPLEX Cavern, and the 216-Z-10 Crib.

2.3.5.3 216-Z-17 Trench. The 216-Z-17 Trench is an inactive waste management unit located about 76.3 m (250 ft) north of 19th Street and 91.5 m (300 ft) east of the 231-Z Building. The 216-Z-17 Trench consisted of a 61 by 3.1 by 2.4 m (200 by 10 by 8 ft) deep excavation with 1:1 side slopes. It was parallel to and 12.2 m (40 ft) west of the 216-Z-1 Ditch. The 216-Z-1 Ditch is an inactive waste management unit associated with the U Plant Aggregate Area. The trench was deactivated and backfilled when the effluent flow exceeded the infiltration capacity of the pit.

The 216-Z-17 Trench received laboratory waste from PNL operations in the 231-Z Building for a one-year period between February 1967 and February 1968. The 216-Z-17 Trench received 36.8 million L (9.72 million gal) of neutral/basic liquid waste which contained 0.05 kg (0.11 lb) of plutonium (WHC 1991a). The trench remained open for about seven years before being backfilled in 1975. Field surveys measured in the 216-Z-17 Trench before backfilling indicated 2,000 dis/min of alpha activity.

No unplanned releases were associated with this trench.

The 216-Z-17 Trench has also been identified as the 216-Z-17 Ditch.

2.3.6 Septic Tanks and Associated Drain Fields

Five septic tanks and their associated drain fields were identified within the Z Plant Aggregate Area.

- 2607-Z Septic Tank
- 2607-Z-1 Septic Tank
- 2607-WA Septic Tank
- 2607-WB Septic Tank
- 2607-W-8 Septic Tank.

The locations of these waste management units are shown on Figure 2-9.

2.3.6.1 2607-Z Septic Tank and Drain Field. The 2607-Z Septic Tank and Drain Field is an active waste management unit located about 33.6 m (110 ft) east of the 236-Z Building. The unit receives sanitary wastewater and septic waste from 234-5Z and 2704-Z Buildings at a nominal rate of 23,000 L (6,000 gal) per day. The drain field is located 18.6 m (61 ft) east of the septic tank. The 2607-Z Septic Tank is an 11 by 3.4 by 7 m (36 by 11 by 23 ft) deep concrete box with a 95,000 L (25,000 gal) capacity two-chamber tank. The drain field consists of 36 rows of 15 cm (6 inch) drain tile spaced at 2.4 m (8 ft) intervals. It lies in a gravel bed which extends a minimum of 46 cm (18 inches) below the drain pipe. The excavation is backfilled forming a surface that is below original grade. The drainfield is therefore identifiable as a large rectangular recess in an otherwise flat field. This waste management unit began operating in 1949.

No radionuclides or hazardous chemicals have been associated with this unit.

2.3.6.2 2607-Z-1 Septic Tank and Drain Field. The 2607-Z-1 Septic Tank and Drain Field is an active waste management unit located on the west side of the 234-5Z Building (Figure 2-9). The source of the sanitary waste was not specified. This waste management unit began operating in 1965.

No radionuclides or hazardous chemicals have been associated with this waste management unit.

2.3.6.3 2607-WA Septic Tank and Drain Field. The 2607-WA Septic Tank and Drain Field is an active waste management unit located immediately south of the Z Plant mobile office complex (WHC 1991a). The unit receives sanitary wastes from the mobile office trailers at a nominal rate of 6,000 L (1,600 gal) per day. The unit includes two 3,800 L (1,000 gal) septic tanks and an abandoned septic tank plus one active and one abandoned drain field. The unit began operating in 1968.

No radionuclides or hazardous chemicals have been associated with this waste management unit.

2.3.6.4 2607-WB Septic Tank and Drain Field. The 2607-WB Septic Tank and Drain Field is an active waste management unit located approximately 200 m (600 ft) south and east of the PFP mobile office complex. The unit receives sanitary wastewater and septic waste from the mobile office complex. This waste management unit began operating in 1955.

No radionuclides or hazardous chemicals have been associated with this waste management unit.

2.3.6.5 2607-W-8 Septic Tank and Drain Field. The 2607-W-8 Septic Tank and Drain Field is an active waste management unit located northeast of the 231-Z Building. The unit

receives sanitary wastewater and septic waste from the 231-Z Building at a nominal rate of 5,500 L (1,500 gal) per day. The reinforced concrete septic tank has a capacity of 19,266 L (5,070 gal). The waste management unit began operating in 1959.

No radionuclides or hazardous chemicals have been associated with this waste management unit.

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 inch) 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 Z Plant Aggregate Area, and the facilities that they connect are shown on Figure 2-10. 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 Z Plant past practice investigations (see Section 8.3.3.8) to determine if the high-level lines are leaking and if they have contaminated 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.

The PFP pipelines are concentrated in the vicinity of PFP processing buildings (e.g., the 231-Z and 234-5Z Buildings). As shown on Figure 2-10, a process waste discharge line exited the east side of the 231-Z Building, running due east to the 231-Z-151 Sump. Stainless steel and, in later years, PVC pipe, connected the sump to the 216-Z-4 Trench; the 216-Z-5, 216-Z-6, and 216-Z-7 Cribs; the 216-Z-10 Reverse Well; the 216-Z-16 Crib; and to the 216-Z-17 Trench.

Also as shown on Figure 2-10, various process waste lines ran from the 234-5Z Building to the 216-Z-1 and 216-Z-2 Cribs; the 216-Z-1A Tile Field, the 216-Z-3 Crib; the 216-Z-9 Trench; the 216-Z-12 Crib; and the 216-Z-18 Crib. The process line discharging to the 216-Z-9 Trench also discharged to the 216-Z-8 Settling Tank and the 216-Z-8 French Drain (Figure 2-10).

Non-contact wastewater exited the 231-Z Building and 234-5Z Building through vitrified clay pipes which initially discharged to the 216-Z-1/216-Z-11 Ditch system. The 216-Z-1 and 216-Z-11 Ditches are U Plant Aggregate Area waste management units. Near

the 234-5Z Building, additional non-contact wastewater was discharged to the ground through french drains (216-Z-13, 216-Z-14, and 216-Z-15) located around the 291-Z Building (Figure 2-10).

Diversion boxes or sumps 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 two diversion boxes and one sump in the Z Plant Aggregate Area:.

- 241-Z Diversion Box No. 1
- 241-Z Diversion Box No. 2
- 231-Z-151 Sump.

2.3.7.1 241-Z Diversion Box No. 1. The 241-Z Diversion Box No. 1 is an inactive waste management unit associated with the 234-5Z Building liquid waste disposal cribs. It is located about 100 m (328 ft) south of the 234-5Z Building and approximately 10 m (33 ft) north of the 216-Z-1A Tile Field. This unit is a 2.1 by 2.1 by 2.8 m (7 by 7 by 9.1 ft) high concrete box with a floor drain which apparently discharges to the soil column approximately 15 m (50 ft) southeast of the unit. It is buried to a depth of 2.7 m (9 ft) with the upper surface of its 0.15 m (0.5 ft) thick lid slightly above 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. Process wastes from the 234-5Z Building were routed through this diversion box via the 241-Z-361 Settling Tank.

Two 15 cm (6 inch) stainless steel transfer lines connect the unit to the 216-Z-1 Crib and the 216-Z-3 Crib. A third 15 cm (6 inch) stainless steel transfer line runs to the 241-Z Diversion Box No. 2.

No unplanned releases are associated with this unit.

2.3.7.2 241-Z Diversion Box No. 2. The 241-Z Diversion Box No. 2 is an inactive waste management unit associated with the 234-5Z Building liquid waste disposal cribs. It is located about 100 m (328 ft) southwest of the 234-5Z Building and approximately 10 m (33 ft) north of the 216-Z-12 Crib. This unit is a 2.1 by 2.1 by 5.2 m (7 by 7 by 17 ft) high concrete box with a floor drain which apparently discharges to the soil column approximately 15 m (50 ft) northwest of the unit. It is buried to a depth of 5.2 m (17 ft) with the upper surface of its 0.15 m (0.5 ft) thick lid slightly above ground level. Multiple encased liquid waste transfer lines enter the box through its east wall. Liquid waste routing is made possible through the use of changeable jumper assemblies that connect pairs of waste transfer lines. Process wastes from the 234-5Z Building were routed through this diversion box via the 241-Z-361 Settling Tank.

Two 15 cm (6 inch) stainless steel transfer lines connect the unit to the 216-Z-12 Crib.

No unplanned releases are associated with this unit.

2.3.7.3 231-Z-151 Sump. The 231-Z-151 Sump is an inactive waste management unit associated with the 231-Z Building. It is located approximately 30 m (98 ft) east of the 231-Z Building. The 231-Z-151 Sump is a 5.2 by 5.2 by 5.3 m (17 by 17 by 17.5 ft) deep reinforced concrete structure. The sump was built in 1944 with a central 16,000 L (4,200 gal) agitator tank and modified in 1948 with piping changes and the addition of a second 2,650 L (700 gal) agitator tank. The sump was used to transfer waste solutions from processing and laboratory operations in the 231-Z Building to cribs and trenches north and east of that building. Further details regarding the use and operating history of the sump were not found.

One unplanned release, UN-200-W-130, is associated with this unit. In January 1967, an excavation uncovered a leaking flange on a waste line on the east side of the sump. Alpha, beta, and gamma readings of up to 40,000 d/m alpha, 100 mrem/hr beta, and 500 mrem/hr gamma was reported. The waste line was repaired and covered with 15 cm (6 inch) of clean soil.

The 231-Z-151 Sump has also been identified as the 231-Z-151 Sump Tank, the 231-Z-151 Diversion Box, and the 231-W-151 Sump.

2.3.8 Basins

Two basins, the 207-Z Retention Basin and the 216-Z-21 Seepage Basin were identified in the Z Plant Aggregate Area (Figure 2-11). The 216-Z-21 Seepage Basin was not identified as a Z Plant Aggregate Area waste management unit by the Tri-Party Agreement, but is recommended for inclusion in the AAMS.

2.3.8.1 207-Z Retention Basin. The 207-Z Retention Basin is an inactive waste unit located approximately 60 m (197 ft) southeast of the 236-Z Building. The 15.3 by 12.2 by 3.1 m (50 by 40 by 10 ft) concrete structure is divided into two cells separated by a 0.3 m (1 ft) thick concrete wall. There is a 1.8 m (6 ft) woven wire fence around the top of the basins. Each cell contains a sump and a pump.

The 207-Z Retention Basin operated from 1949 to 1959 (Figure 2-1) receiving potentially contaminated liquid waste including steam condensate and cooling water from the 234-5Z Building via the D-3 piping system. Waste sent to this holding facility was then released to the 216-Z-1(D) and 216-Z-11 Ditch systems. This ditch system is an inactive wastewater conveyance ditch which is a U Plant Aggregate Area waste management unit.

No releases are associated with this waste management unit.

The 207-Z Retention Basin has also been identified as the 207-Z Sump, 207-Z Pond, and 207-Z Retention Pond. Hanford drawings also identify the 207-Z Retention Basin as the 241-Z Retention Basin.

2.3.8.2 216-Z-21 Seepage Basin. The 216-Z-21 Seepage Basin is an active waste management unit located approximately 100 m (328 ft) east of the 234-5Z Building and 40 m (131 ft) south of the 216-Z-9 Trench (Figure 2-11). The 216-Z-21 Seepage Basin was constructed in the 1980s for discharge of non-contact condensate from the 234-5Z HVAC system and storm water runoff. It also received wastewater from inlet air washing. The seepage basin was constructed following backfilling of the 216-Z-19 Ditch system and construction of the 216-Z-20 Crib. The seepage basin was constructed to alleviate backup of the 216-Z-20 Crib from HVAC condensate and storm water runoff originally routed to the latter crib. Storm drain lines connecting to the seepage basin run from catch basins on the north side of the 234-5Z Building, and from an overflow line from the water tank north of the 234-5Z Building. A storm drain connection from the east side of the 234-5Z Building is also present. The draft Carbon Tetrachloride ERA Proposal (DOE-RL 1991b) indicated that wastewater is discharged to the unit at a rate of approximately 9.8×10^7 L (2.6×10^7 gal) per year. The draft ERA proposal concluded that seepage from this basin could have an impact on groundwater levels in the underlying unconfined aquifer.

Historical information indicative of radionuclide or hazardous chemical waste discharges to this waste management unit was not found in our review of available documents. No unplanned releases are associated with the seepage basin.

The 216-Z-21 Seepage Basin has also been identified as Seepage Basin 207-Z.

2.3.9 Burial Sites

The 200 West Area Burial Grounds were established independently of the main Z Plant process facilities and have operated from approximately 1944 to present. The location of the burial grounds are shown on Figure 2-12. The burial sites have received wastes from various sources throughout the Hanford Site, including the PFP. Solid waste disposal facilities include caissons and various types of burial trenches. Burial grounds generally consist of one or more of these solid waste disposal facilities. Caissons consist of concrete/steel chambers set below ground surface with an associated steel riser pipe through which waste packages were dropped into the caisson. Caissons are typically ventilated to reduce exposures to personnel depositing waste packages. Caissons were also constructed of vertical steel casing or open-ended 55-gallon drums welded end-to-end set vertically in an excavation. After filling with solid waste packages, the caissons were backfilled and capped with concrete.

The following solid waste burial grounds are located within the Z Plant Aggregate Area. These include:

- 218-W-1 Burial Ground
- 218-W-1A Burial Ground
- 218-W-2 Burial Ground
- 218-W-2A Burial Ground
- 218-W-3 Burial Ground
- 218-W-3A Burial Ground
- 218-W-3AE Burial Ground
- 218-W-4A Burial Ground
- 218-W-4B Burial Ground
- 218-W-4C Burial Ground
- 218-W-5 Burial Ground
- 218-W-6 Burial Ground
- 218-W-11 Burial Ground
- Z Plant Burn Pit.

Several of the above units, including the 218-W-2A, 218-W-3A, 218-W-3AE, 218-W-4B, 218-W-4C, 218-W-5, and 218-W-6 Burial Grounds, are currently being permitted under a RCRA Part B permit. The 218-W-3A, 218-W-3AE, and 218-W-5 Burial Grounds are part of the Low-Level Waste Management Area (LLWMA) 3. The 218-W-4B Burial Ground is part of the LLWMA 4. The 218-W-6 Burial Ground is part of the LLWMA 5 (Barton et al. 1990). Although solid wastes generated in the PFP facilities (e.g., the analytical laboratories) are disposed of in the burial grounds, and LLWMA 3, LLWMA 4, and LLWMA 5 are located within the Z Plant Aggregate Area, the LLWMAs and the PFP are administered under separate programs. The burial grounds are administered by Westinghouse Hanford under the Waste Management Program whereas the PFP is administered under the Chemical Processing Program.

Many of the TRU wastes disposed of in the burial grounds were placed in Radioactive Retrievable Storage Units which were facilities used to store 55-gallon drums or boxes containing radioactive mixed wastes. Waste containers were stored on underground asphalt pads and polyethylene-lined underground trenches. An earthen cover over the trenches provided radiological protection. The wastes were packaged in steel, concrete, or wood containers and then placed into burial trenches.

Monthly or semiannual physical and radiological surveys are made of the 200 Areas burial grounds. The monitoring includes investigating for undesirable weed growth, burial ground cave-ins, soil erosion, damaged radiation postings, boundary markers and fencing, damage caused by wildlife, and any other undesirable changes that may have occurred since the previous survey. The radiological survey includes burial ground monitoring or activity

level monitoring to identify loose contamination, contamination spread, and radioactivity uptake in plant life. These monitoring programs are described in Section 4.0.

Sections 2.3.9.1 through 2.3.9.14 describe available data regarding the use and operational history of each of these facilities. Tables 2-2 and 2-3 summarize available information regarding the inventory of radioisotopes and other chemical compounds disposed of at the burial ground facilities. Table 2-5 presents a partial inventory of hazardous constituents disposed of to the 218-W-3A, 218-W-3AE, 218-W-4C, and 218-W-5 Burial Grounds.

2.3.9.1 218-W-1 Burial Ground. The 218-W-1 Burial Ground is an inactive waste management unit located on the east side of Dayton Avenue opposite the Radioactive Mixed Waste Storage Facility. The 158.9 by 139.7 m (521 by 458 ft) unit consists of 15 trenches running in an east-west direction. Twelve of these trenches are 2.4 m (8 ft) deep, 1.5 m (5 ft) wide at the bottom, and 4.9 m (16 ft) wide at ground level. The other three are 2.7 m (9 ft) deep flat bottom trenches with a 7.3 m (24 ft) surface width. There are two gravel roads running east-west through the burial ground. The unit has been retired and stabilized.

The 218-W-1 Burial Ground received TRU and mixed solid waste from 1944 to 1953.

Three unplanned releases, UN-200-W-11, UPR-200-W-84, and UPR-200-W-134, are associated with this waste management unit (Table 2-6). In 1952, a fire released plutonium contamination to 200,000 dis/min inside and 30,000 dis/min outside the burial ground (WHC 1991a). In 1980, a liquid spill during burial operations resulted in contamination of the floor of a burial trench (UPR-200-W-84). Radiation survey readings at the time of the spill ranged up to 2,000 mrem/hr. For remediation, the contaminated soil was picked up and placed in the burial trench. In 1975, a waste drum labeled "transuranic" was inappropriately buried in the 218-W-1 Burial Ground (UPR-200-W-134). The drum was left in place.

The 218-W-1 Burial Ground has also been identified as the Dry Waste Burial Ground No. 001 (Elder et al. 1987).

2.3.9.2 218-W-1A Burial Ground. The 218-W-1A Burial Ground is an inactive waste management unit located in the northeast part of the Z Plant Aggregate Area, near the 218-W-6 Burial Ground. This unit contains approximately 10 trenches. There are also several areas used as individual burial holes, but definite locations are not known. Total reported depths are only available for Trench 6, which is 1.5 m (5 ft) deep, and Trench 7, which is 6.1 m (20 ft) deep.

The 218-W-1A Burial Ground received industrial wastes including some radioisotopes from 1944 to 1954. This burial ground was the first large equipment burial unit used in the 200 West Area. Most of the equipment was buried in wooden boxes which eventually rotted and caused settling of the ground surface. Most of these depressions were filled in 1975.

In 1960, a burial box collapsed during burial in the 218-W-1A Burial Ground causing spotty ground contamination at several locations (see UPR-200-W-158, Figure 2-13 and Table 2-6).

The 218-W-1A Burial Ground has also been identified as the Industrial Waste Burial Ground No. 1.

2.3.9.3 218-W-2 Burial Ground. The 218-W-2 Burial Ground is an inactive waste management unit located east of Dayton Avenue and 610 m (2,000 ft) north of 19th Street. The 218-W-2 Burial Ground consists of 20 miscellaneous dry waste trenches, running east-west with bottom widths of 1.5 m (5 ft) and lengths ranging from 141.2 to 143.7 m (463 to 471 ft).

The 218-W-2 Burial Ground received miscellaneous unsegregated dry waste from 1953 to 1956. The unit has been retired and stabilized.

No releases were reported for this waste management unit in the literature reviewed.

The 218-W-2 Burial Ground has been identified as the Dry Waste Burial Ground No. 002.

2.3.9.4 218-W-2A Burial Ground. The 218-W-2A Burial Ground is an inactive waste management unit located about 457.5 m (1,500 ft) north of 23rd Street and 457.5 m (1,500 ft) east of Dayton Avenue. The 218-W-2A Burial Ground consists of 19 trenches of various lengths, numbered 1 through 11, and 20 through 27. Trenches numbered 11 through 15 were used to bury construction cell blocks. The trenches were 4.6 m (15 ft) deep and 4.9 m (16 ft) wide at the bottom.

The 218-W-2A Burial Ground received mixed solid waste between 1954 and 1986. Conflicting accounts of the total volume of waste disposed of to the unit included: 19,000 m^3 (671,000 ft^3) and 25,000 m^3 (33,000 ft^3) by WHC (1991a). The burial ground contains miscellaneous radioactive solid waste from facilities in the 200 West Area, including tanks, concrete blocks, facility wastes, and process equipment. Sixteen trenches were filled with dry industrial waste. Trench 27 contains contaminated soil scraped from the 216-T-4-1 Pond. No records indicate that hazardous waste has been deposited in these waste units after 1980 (Elder et al. 1987). Of the 25,000 m^3 (833,00 ft^3) of waste contained in the unit, only 340 m^3 (12,000 ft^3) were disposed of after November 1980 (WHC 1991a). The waste disposed of before November 1980 is both low-level and byproduct, while the waste disposed of since that date is strictly low-level.

In 1957, the collapse of a burial box caused 648 hectares (1,600 acres) of TRU contamination to the area (Elder et al. 1987). Remedial actions for this unplanned release (UPR-200-W-45) are discussed in Table 2-6.

The 218-W-2A Burial Ground has also been identified as the Industrial Waste Burial Ground No. 2, the 218-W-02A Burial Ground, and the 200-W Industrial Waste No. 02A.

This burial ground has been identified in a RCRA Part B permit application as a TSD facility and will undergo RCRA closure. A final cap and cover in accordance with the RCRA landfill standards have been proposed.

2.3.9.5 218-W-3 Burial Ground. The 218-W-3 Burial Ground is an inactive waste management unit located on the northeast corner of the intersection of Dayton Avenue and 23rd Street. The 218.4 by 155.6 m (716 by 510 ft) unit consists of 20 dry waste trenches. Trenches 1 through 3 are 122 m (400 ft) in length; Trenches 4 through 20 are 144.9 m (475 ft) in length. Each trench is identified by a permanent concrete post with brass name plate. This unit is now retired and has been stabilized.

The 218-W-3 Burial Ground received TRU/mixed solid waste from 1957 to 1960 or 1961. The site received almost 11,000 m^3 (388,000 ft^3) of miscellaneous unsegregated mixed TRU and non-TRU waste from various Hanford Site operations.

No releases were reported for this waste management unit in the literature reviewed.

The 218-W-3 Burial Ground has also been identified as the Dry Waste Burial Ground No. 003.

2.3.9.6 218-W-3A Burial Ground. The 218-W-3A Burial Ground is an active waste management unit located immediately southeast of the intersection of Dayton Avenue and 27th Street. The 381.3 m (1,250 ft) long, irregularly shaped unit consists of 61 dry and industrial waste trenches which run in an east-west direction. Seven of the trenches are 163.2 m (535 ft) long, thirty-five are 283.7 m (930 ft) long, and ten are 274.5 m (900 ft) long. The remaining trenches range in length from 122.9 to 156.1 m (403 to 512 ft). Trench depths range from 3.7 to 5.8 m (12 to 19 ft). Each trench location is identified by a permanent concrete post with a brass name plate. Seven of the 61 trenches have been fully backfilled and the surface has been stabilized. Table 2-5 summarizes available inventory information for the 218-W-3A Burial Ground.

Since 1970, the 218-W-3A Burial Ground site has received over 99,000 m^3 (3,500,000 ft^3) of TRU/mixed solid waste from various Hanford Site operations.

No releases were reported for this waste management unit in the literature reviewed.

The 218-W-3A Burial Ground has also been identified as the Dry Waste Burial Ground No. 03A.

This burial ground has been identified in a RCRA Part B permit application as a TSD facility and will undergo RCRA closure. A final cap and cover in accordance with the RCRA landfill standards have been proposed.

2.3.9.7 218-W-3AE Burial Ground. The 218-W-3AE Burial Ground is an active waste management unit bordered on the north by 27th Street and on the west by Dayton Avenue. The irregularly shaped unit consists of 28 trenches of varying sizes. Trench 2E is 380 by 5.5 m (1,246 by 18 ft) (bottom), 405.7 by 14 m (1,330 by 46 ft) (surface), and 14.9 m (6 ft) deep with a minimum of 2.4 m (8 ft) of backfill. Trench 5E is 327.9 by 14.6 m (1,075 by 48 ft) (bottom), 422.4 by 32.9 m (1,385 by 108 ft) (surface), and 6.1 m (20 ft) deep with a minimum of 2.4 m (8 ft) of backfill. Trench 10 E is 364.5 by 12.2 m (1,195 by 40 ft) (bottom), 459 by 28.7 m (1,505 by 94 ft) (surface), and 5.5 m (18 ft) deep, with a minimum of 2.4 m (8 ft) of backfill. Each trench location is identified with a concrete post with brass name plate. Table 2-5 summarizes available inventory information for the burial ground.

Since 1981, the 218-W-3AE Burial Ground has received 21,390 m^3 (755,390 ft^3) mixed solid waste. Wastes disposed of to the unit include miscellaneous wastes such as rags, paper, rubber gloves, disposal supplies, broken tools, and industrial waste such as failed equipment, tanks, pumps, ovens, agitators, heaters, hoods, jumpers, and accessories.

No releases were reported for this waste management unit in the literature reviewed.

The 218-W-3AE Burial Ground has also been identified as the Industrial Waste Burial Ground No. 3AE and Dry Waste Burial Ground No. 3AE.

This burial ground has been identified in a RCRA Part B permit application as a TSD facility and will undergo RCRA closure. A final cap and cover in accordance with the RCRA landfill standards have been proposed.

2.3.9.8 218-W-4A Burial Ground. The 218-W-4A Burial Ground is an inactive waste management unit located near the southeast corner of the intersection of 27th Avenue and Dayton Avenue. The unit consists of 21 filled trenches which run east-west and eight drop chutes. A small miscellaneous trench runs north-south at the east end of Trench 11. All trenches are 9.2 m (30 ft) wide and 4.9 m (16 ft) deep and range in length from 149.5 to 295.5 m (490 to 969 ft). Each trench location is identified by a permanent concrete post with a brass name plate.

Two caissons are located between Trenches 17, 18, and 19 at their east end. Both consist of 6.5 cm (26 inch) diameter, 12 gauge well casing extended 14.6 m (48 ft) below grade. Both have 82.5 cm (33 inch) thick concrete cover blocks. Six 4.6 m (15 ft) deep caissons were installed in Trench 16. These are made of 55-gallon steel drums welded

together with the ends cut out (except the bottom of the lower drum) and placed on end with the upper surface at ground level. After use, soil was shoveled into these wells to absorb the high gamma radiation given off by the wastes deposited.

The 218-W-4A Burial Ground received TRU/mixed solid waste from 1958 to 1968. The site received almost 18,000 m^3 (636,000 ft^3) of miscellaneous dry, unsegregated mixed TRU and non-TRU waste.

Four unplanned releases are associated with this burial ground: UPR-200-W-16, UPR-200-W-26, UPR-200-W-53, and UPR-200-W-72 (see Table 2-6 for discussion).

This waste management unit has not been identified by any other designation than the 218-W-4A Burial Ground.

2.3.9.9 218-W-4B Burial Ground. The 218-W-4B Burial Ground is an active waste management unit for TRU/mixed waste located near the northeast corner of the intersection of Dayton Avenue and 19th Street. The 218-W-4B Burial Ground consists of 13 trenches and 12 caissons. Caissons which received TRU waste consist of concrete and steel covered vaults. Caissons which received low level waste were constructed of corrugated pipe with a concrete bottom and top. Both types of caissons were used for the disposal of solid wastes from hot cell operations. Two trenches and four caissons (contained in a third trench) contain retrievable stored TRU waste. Of the remaining eleven trenches, ten contain unsegregated low-level and TRU waste and one contains low-level waste. Within the trench containing the four transuranic caissons are an additional seven low-level caissons. Trenches 1 through 6 and 8 contain unsegregated mixed TRU and non-TRU waste. Trench 9 contains unsegregated TRU waste. Trenches 10, 12, and 13 contain non-TRU waste. No information was available concerning Trenches 7 and 11.

The row of 12 caissons includes 5 alpha caissons for TRU waste, one UNI silo type caisson (for high activity waste from N Reactor), and six MFP caissons (for non-TRU and nonsegregated waste). The six MFP caissons consist of 1 silo type, 1 alpha type, and 4 dry waste caissons. The alpha type caissons weigh 11,804 kg (26,000 lb). They have an 2.7 m (8.75 ft) diameter and are 3.1 m (10 ft) high, constructed primarily of concrete and have a steel cover fitted with lifting lugs. The silo type caissons are 9.2 m (30 ft) tall with a 3.1 m (10 ft) diameter and have a concrete base. Waste is placed beneath a concrete slab 4.6 m (15 ft) below grade. Dry waste caissons are 2.4 m (8 ft) in diameter and 3.1 m (10 ft) high, constructed of corrugated metal with a concrete top and bottom. Caissons are ventilated with electric blowers. Caisson air is exhausted through filters to prevent contamination from occurring when wastes are dropped into the caissons. The caisson trench is the only active area of the unit. All caissons are inactive except Caisson 6 and Alpha Caissons 4 and 5.

The 218-W-4B Burial Ground began operations in 1967 and has received an estimated 10,000 m^3 (353,000 ft^3) of waste. Of this amount, approximately 3,250 m^3 (115,770 ft^3)

consists of retrievable stored TRU waste. The unit receives miscellaneous radioactive solid waste, the majority of which is from facilities located in the 200 West Area. The solid waste consists of rags, paper, cardboard, plastic, pumps, tanks, process equipment, and other miscellaneous dry waste. The only nonsegregated waste received by this site was deposited between January 1, 1967 and May 1, 1970. Records prior to May 1968 are incomplete.

Radiation monitoring readings of 12,000 dis/min (WHC 1991a) have been reported in a small area of mulch (presumably placed to enhance revegetation of the area). No other releases have been identified at this waste management unit.

The 218-W-4B Burial Ground has also been identified as the Dry Waste Burial Ground No. 04B.

This burial ground has been identified in a RCRA Part B permit application as a TSD facility and will undergo RCRA closure. A final cap and cover in accordance with the RCRA landfill standards have been proposed.

2.3.9.10 218-W-4C Burial Ground. The 218-W-4C Burial Ground is an active waste management unit located east of Dayton Avenue between 16th Street and 19th Street. Hanford drawings indicate that the unit consists of 65 trenches with space allocated for several more. Forty-eight of the trenches run east-west. Twenty-four of these are 183.6 m (602 ft) long, nineteen are 219.3 m (719 ft) long, four are 181.2 m, (594 ft) long, and one trench is 91.2 m (299 ft) long. Seventeen trenches run north-south. Of these, fourteen are 202.8 m (665 ft) long and three are 154.96 m (508 ft) long. The average trench depth is about 7.6 m (25 ft).

Beginning in 1974, the 218-W-4C Burial Ground has received over 16,000 m^3 (565,000 ft^3) of TRU and mixed solid waste from Hanford Site facilities and several off-site sources. The northernmost trench is the Naval Reactor Core Trench and also contains a number of core barrels from Bettis Naval Station. Trench No. 1 contains drums with plutonium-contaminated soil from the 216-Z-9 Trench mining operation and noncombustible TRU waste. Trench No. 4 contains drums of assorted combustible TRU waste and one module of noncombustible TRU waste. Trenches No. 1, 4, 7, 20, 24, and 25 and the easterly end of No. 19 contain retrievable waste. Trenches No. 23, 28, 48, 53, and 58 and the remainder of No. 19 receive low-level waste. Table 2-5 summarizes available inventory information for the burial ground.

No releases are associated with this waste management unit.

The 218-W-4C Burial Ground has also been identified as the Dry Waste Burial Ground No. 01C.

This burial ground has been identified in a RCRA Part B permit application as a TSD facility and will undergo RCRA closure. A final cap and cover in accordance with the RCRA landfill standards have been proposed.

2.3.9.11 218-W-5 Burial Ground. The 218-W-5 Burial Ground is an active waste management unit for low-level/mixed solid waste located at the southwest corner of the intersection of 27th Street and Dayton Avenues. The unit consists of 56 active or planned trenches, all oriented east-west. Twenty-seven of the trenches are 4.6 m (15 ft) wide at the bottom and 5.2 m (17 ft) deep. Of these, eighteen are 353.8 m (1,160 ft) long, four are 131.2 m (430 ft) long, three are 161.65 m (530 ft) long, and two are 323.3 m (1,060 ft) long. Seven trenches are 353.8 m (1,160 ft) long, 12.2 m (40 ft) wide (bottom), and 5.185 to 6.1 m (17 to 20 ft) deep. Each trench location is identified by a permanent concrete post with a brass name plate.

The 218-W-5 Burial Ground has operated since 1986, receiving 32,500 m^3 (1,147,000 ft^3) of mixed and retrievable TRU wastes. A reported 204 kg (450 lb) of lead are buried in Trench 21 and 1,684 kg (3,710 lb) in Trench 9 (WHC 1991a). The 218-W-5 Burial Ground may also receive defueled, decommissioned nuclear submarine reactor compartments in the future, each of which contains approximately 83,536 kg (184,000 lb) of lead. Table 2-5 summarizes available inventory information for the landfill.

No releases are associated with this waste management unit.

This waste management unit has not been identified by any other designation than the 218-W-5 Burial Ground.

This burial ground has been identified in a RCRA Part B permit application as a TSD facility and will undergo RCRA closure. A final cap and cover in accordance with the RCRA landfill standards have been proposed.

2.3.9.12 218-W-6 Burial Ground. The 218-W-6 Burial Ground is a proposed waste management unit for low-level/mixed solid waste which will include 28 trenches. It will be located north of the 218-W-1A Burial Ground. No wastes have been disposed of at this unit. In 1960, an unplanned release at the adjacent 218-W-1A Burial Ground resulted in ground contamination in the 218-W-6 Burial Ground. Remedial actions and current radiation survey readings were not identified.

This burial ground has been identified in a RCRA Part B permit application as a TSD facility. When it begins operating, it will be subject to RCRA landfill and closure standards.

2.3.9.13 218-W-11 Burial Ground. The 218-W-11 Burial Ground is an inactive waste management unit located immediately north of the 218-W-1 Burial Ground. The unit

consists of two filled burial trenches running east-west. Trench 1 is 78.69 m (258 ft) long. Trench 2 is 45.75 m (150 ft) long. The unit has been stabilized and reseeded with grass.

The 218-W-11 Burial Ground received low-level and mixed solid waste in 1960 (Elder et al. 1987). The unit received an estimated 1,160 m^3 (41,000 ft^3) of low-level/mixed waste (WHC 1991a). The waste disposed of to this unit includes low-level contaminated sluicing equipment that had been used for the uranium recovery program at the 221-U Building.

Radiation monitoring readings of 12,000 dis/min (WHC 1991a) have been reported in a small area of mulch (presumably placed to enhance revegetation of the area). No other releases have been identified at this waste management unit.

This waste management unit has not been identified by any other designation than the 218-W-11 Burial Ground.

2.3.9.14 Z Plant Burn Pit. The Z Plant Burn Pit is an inactive facility used between 1950 and 1960 to burn miscellaneous nonradioactive waste material. Such materials included office and non-hazardous laboratory waste. The burn pit was reportedly 15.3 by 12.2 by 3.1 m (50 by 40 by 10 ft) deep. Reportedly the unit received 2,000 m^3 (70,000 ft^3) of waste material of which less than 1,000 m^3 (35,000 ft^3) was chemical waste. The former Z Plant Burn Pit is believed to be located approximately 50 m (164 ft) south of 19th Street and 150 m (492 ft) east of the 231-Z Building.

2.3.10 Unplanned Releases

Twenty-one distinct unplanned releases were identified in the Z Plant Aggregate Area. Twenty of the unplanned releases (including two locations of UN-200-W-23 and four locations of UPR-200-W-158) are shown on Figure 2-13. The Hanford coordinates of unplanned release UN-200-W-44 were not identified. Unplanned releases designated with a "UPR" are releases from or within the operations of specific waste management units, and are considered part of that waste management unit for remediation purposes. Releases designated with a "UN" are considered a distinct waste management unit for remediation purposes.

UPRs are not included as independent sites in the Tri-Party Agreement, however, because they are closely associated with existing waste management units. Therefore, UPRs and their associated waste management units will be addressed together in this study.

With one exception, UN-200-W-103, no waste inventory information was identified for the unplanned releases. Table 2-6 summarizes the known information regarding 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 WHC (1991a).

2.4 WASTE GENERATING PROCESSES

This section describes the primary waste generating process areas and the associated building locations at the Z Plant Aggregate Area which include:

- The Plutonium Isolation Facility (PIF) (231-Z Building)
- The Plutonium Finishing Plant (PFP) (234-5Z Building)
- The RECUPLEX plutonium recovery process (234-5Z Building)
- The Plutonium Reclamation Facility (PRF) (236-Z Building)
- The Americium Recovery facility (242-Z Building)
- The Analytical and Development Laboratory.

Table 2-7 summarizes available information regarding the chemical characteristics of each of the waste streams produced by Z Plant Aggregate Area. The process history of the Z Plant Aggregate Area is illustrated on Figure 2-14. The chemicals and radionuclides that have been detected or which are known to be present in Z Plant Aggregate Area waste streams are summarized in Table 2-8. Table 2-9 lists chemicals used or stored in the Z Plant Aggregate Area laboratory. The chemicals identified in Table 2-9 represent potential contributors to the Z Plant Aggregate Area waste stream if they are spilled or otherwise enter effluents, but most cannot be considered routine waste stream components. Table 2-10 lists radionuclides, organic, and inorganic chemicals disposed of at Z Plant Aggregate Area waste management units based on several sources listed at the bottom of the table. Sections 2.4.1 through 2.4.6 describe the Z Plant Aggregate Area process facilities identified above.

2.4.1 Plutonium Isolation Facility (PIF)

2.4.1.1 Process Description. The 231-Z Building (described in Section 2.3.1.2) was the primary location of the PIF process line. The 231-Z Building is also known as the Concentration Building. The exact dates of PIF operation are unclear, but are thought to be from 1945 to 1949. The PIF was described as being a seventh production step where concentrated plutonium nitrate solution was further reduced to a paste. This process consisted of the following steps:

- Ammonium nitrate was added to the plutonium nitrate solution, reducing the plutonium to the +4 valence state

- Sulfates and peroxide were added to the mixture, causing plutonium to precipitate as plutonium peroxide

- Nitric acid was added to this precipitate, forming a purer more concentrated plutonium nitrate solution

- This product was placed in small shipping containers and boiled using hot air to form a wet plutonium nitrate paste.

Until 1949, the plutonium nitrate paste was shipped to Los Alamos, New Mexico, for final processing into plutonium metal. Apparently, after 1949 this concentration step was moved to the 234-5Z Building. The wet plutonium paste output by PFP was then processed as discussed in the following subsection.

2.4.1.2 PIF Waste Streams. Little information was identified regarding PIF waste streams. PIF waste streams probably included process wastes and non-contact wastewater. The process wastes can be characterized as acidic and corrosive, high in salts, and low in organic content. The PIF process wastes likely contained minor amounts of fission products, plutonium, and other TRU elements. Process wastes were discharged through the 231-Z-151 Sump to various waste management units including:

- 216-Z-4 Trench
- 216-Z-5 Crib
- 216-Z-6 Crib
- 216-Z-7 Crib
- 216-Z-10 Reverse Well.

2.4.2 Plutonium Finishing Plant (PFP)

2.4.2.1 Process Description. The 234-5Z Building (described in Section 2.3.1.1) is the primary location of the PFP process lines. The DOE operated three successive PFP process lines to convert plutonium nitrate to plutonium metal:

- The RG-RB line which operated from 1949 to 1953
- The Remote Mechanical A line which operated from 1953 to 1979
- The Remote Mechanical C line which operated from 1960 to 1973 and from 1985 to 1988.

The PFP facility is currently in a standby mode.

Each of these process lines created waste streams which contained detectable quantities of plutonium and other TRU elements (Jensen 1990).

The PFP facility contains chemical processing equipment used to convert plutonium nitrate to plutonium oxide and then to the metal, if metal was the desired product. During periods of operation, plutonium oxide is produced by precipitating plutonium as plutonium oxalate, and then filtering and calcining the precipitate. To produce the metal, plutonium oxide is first converted to plutonium fluoride by reacting it with hydrofluoric acid. The fluoride is placed in a container, which is placed in a magnesium oxide crucible with calcium. A reducing charge is then applied to the crucible to convert the plutonium fluoride to plutonium metal, which is then molded into a button. Sometimes the buttons are remelted and cast into a finished shape. Cast forms are coated with nickel and polished to enable them to be handled without spreading plutonium contamination.

2.4.2.2 PFP Liquid Waste Streams. Wastes produced by the PFP fall into two categories:

- Process wastes and condensates
- Non-contact wastewater.

2.4.2.2.1 Process Wastes. The PFP liquid process wastes can be characterized as acidic and corrosive (pH 2), high in salts, and low in organic content. The wastes contain only minor amounts of fission products and low concentrations of plutonium and other TRU elements (Jensen 1990). The waste is high in nitrates in the form of nitric acid, aluminum nitrate, magnesium nitrate, ferric nitrate, and calcium nitrate. Other components are aluminum fluoride, potassium hydroxide, potassium fluoride, chromium, lead, and other trace metal ions.

Process wastes, including process condensates, are discharged through the 241-Z Treatment Tank (Tank D-5) where they undergo addition of sodium hydroxide, ferric nitrate, and sodium nitrite for solubilization and neutralization purposes. Corrosion inhibitors such as sodium nitrite and aluminum compounds for solubilization were also added in this tank. The effluent from this tank has a neutral pH. The treated wastes are currently transferred by pipeline to 241-SY-102 Tank at the 241-SY Tank Farm via the 241-TX Receiver Tank located in the 241-TX Tank Farm.

Prior to 1973, the waste was discharged via cribs to the soil column. The 216-Z-3 and 216-Z-12 Cribs were used to dispose of PFP process waste. Beginning in 1973, the ultimate destination of these treated wastes was originally in single-shell, then later in double-shell tanks.

2.4.2.2.2 Non-Contact Wastewater. Non-contact wastewater, e.g., wastewater which does not come into direct contact with any of the plutonium separation processes, is characterized as low salt, low organic, neutral to basic aqueous waste. Jensen (1990) identified 80 inputs to the wastewater stream, including sanitary wastewater from drinking fountains, sinks, and toilets; cooling water; steam condensate; air conditioning condensate; and wastes from chemical laboratory sinks, nonradiological laboratory sinks in radiation

zones, wound flushing stations, eyewash stations, safety showers, floor drains, roof drains, and storm sewers. The bulk of the wastewater is equipment cooling water and HVAC steam condensate.

Jensen (1990) did not identify any routine contributors of chemicals to the wastewater effluent and concludes that concentrations will depend on plant operations, possible chemicals spills, and water quality of the river water used in the plant. Direct measurement of effluent concentrations is not feasible because there is no access for sampling before the wastewater exiting PFP enters the common sanitary/stormwater drain system. Sampling and analysis of the combined effluent during periods of PFP operation has identified a number of constituents that are elevated above background (i.e., river water); however, many of these constituents are also elevated during periods when PFP is not in operation (Jensen 1990). Chemicals and surrogate parameters that are consistently elevated include the following:

- barium
- calcium
- fluoride
- magnesium
- potassium
- sodium
- strontium
- sulfate
- uranium
- zinc
- alpha activity
- beta activity
- conductivity
- total dissolved solids
- TOC
- TOX (as Cl^-).

In addition, the organic compounds acetone, methylene chloride, and chloroform have been detected in plant effluent.

Non-contact wastewater is currently discharged to the 216-Z-21 Seepage Basin and the 216-Z-20 Ditch. The 216-Z-20 Ditch is an active waste management unit which is not currently a Z Plant Aggregate Area waste management unit. Prior to September 1981, the wastewater flowed to the 216-U-10 Pond through the 216-Z-19 Ditch. Prior to the construction of the 216-Z-19 Ditch, wastewater was discharged to the 216-Z-1 and 216-Z-11 Ditches. The 216-Z-1, 216-Z-11, and 216-Z-19 Ditches are inactive waste management units discussed in the U Plant AAMSR.

2.4.3 RECUPLEX Plutonium Recovery Process

2.4.3.1 Process Description. The DOE recovered plutonium from PFP waste streams using the RECUPLEX process from 1955 to 1962. The process used solvent extraction column technology to remove plutonium from the PFP waste streams. The RECUPLEX facility was housed in the 234-5Z Building.

The RECUPLEX solvent extraction technology is based on the formation of an organic-plutonium complex which is preferentially soluble in an organic solvent. This process used nitric acid and hydrofluoric acid to convert plutonium solids to plutonium nitrate and a tributylphosphate-carbon tetrachloride solvent to recover plutonium from the purified plutonium nitrate solutions. An 85:15 ratio by volume of carbon tetrachloride to tributylphosphate was used. Other ratios were tested during the pilot plant treatability tests, but the ratio of 85:15 gave the most satisfactory results for plutonium recovery.

Silica gel was used as a settling agent on the dissolved feed for the RECUPLEX process. A silica gel waste settling tank (the 216-Z-8 Settling Tank), was used to hold the backflush solution from the filters.

2.4.3.2 RECUPLEX Waste Streams. The RECUPLEX process produced three primary waste streams:

- Spent aqueous extractant
- Spent organic solvents
- Waste silica gel.

Other waste streams produced by RECUPLEX include fabrication oil and non-contact wastewater from the building sinks and equipment wash areas.

2.4.3.2.1 Spent Aqueous Extractant. The aqueous process waste is characterized as acidic, high-salt, low-level radioactive liquid waste containing low levels of plutonium and other TRU elements. Major components of the waste are nitric acid, fluoride, and phosphate. Carbon tetrachloride was used in combination with DBBP to remove residual plutonium from the aqueous solution prior to its discharge.

2.4.3.2.2 Spent Organic Solvent. The organic process waste is characterized as slightly acidic, low salt, high organic, radioactive liquid waste with intermediate levels of plutonium and other TRU elements. Major components of the waste are carbon tetrachloride/tributylphosphate, and DBBP.

With continued use, the carbon tetrachloride/tributylphosphate extraction solvent would gradually degrade into carbon tetrachloride/dibutyl phosphate and lose its capacity as an extractant. The mixture was periodically replaced with fresh solvent and the degraded solvent discharged to the 216-Z-9 Trench. This trench was the only waste site used for solvent disposal during RECUPLEX operation. The 216-Z-9 Trench received approximately 4 million L (1,000,000 gal) of waste from RECUPLEX (WHC 1991a). The quantity of carbon tetrachloride discharged to the trench is estimated to be approximately 83,000 to 300,000 L (22,000 to 79,000 gal).

2.4.3.2.3 Spent Silica Gel. The disposal history of the settled solids in the 216-Z-8 Settling Tank is not known. Available information suggests that the tank has never been pumped out. A reported 1.6 kg (3.5 lb) of plutonium were present in the tank as of 1974 (WHC 1991a). Historically, liquid overflow from the 216-Z-8 Settling Tank was discharged to the 216-Z-8 French Drain. Both units have been idle since RECUPLEX shut down in 1962.

2.4.3.2.4 Other RECUPLEX Waste Streams. Other RECUPLEX waste streams include fabrication oil and non-contact wastewater. Non-contact wastewater is currently discharged to the 216-Z-20 Ditch. Prior to September 1981, the wastewater flowed to the 216-U-10 Pond through the 216-Z-19 Ditch. Prior to the construction of the 216-Z-19 Ditch, wastewater was discharged to the 216-Z-1 and 216-Z-11 Ditches.

2.4.4 Plutonium Reclamation Facility (PRF)

2.4.4.1 Process Description. The PRF replaced the RECUPLEX process line after a criticality accident forced the closure of the RECUPLEX unit in April 1962. The PRF operated from 1964 to 1979 and again from 1984 to May 1991 in the 236-Z Building. This facility is currently idle but is planned to restart operation in the near future. The PRF was designed to reclaim plutonium from solutions and solids from PFP waste streams. The recoverable material is treated to produce soluble plutonium as plutonium nitrate. The PRF has essentially the same mission as RECUPLEX and utilizes a similar solvent extraction column technology. The extraction solvent used is carbon tetrachloride/tributylphosphate in a 80:20 ratio by volume, whereas the ratio in the RECUPLEX process was 85:15.

2.4.4.2 PRF Waste Streams. The primary waste streams generated by the PRF were similar to those produced by RECUPLEX:

- Spent aqueous solutions
- Spent organic wastes
- Non-contact wastewater.

The characteristics of these wastes are essentially the same as those of the RECUPLEX wastes described in Section 2.4.3.2.

Spent aqueous and organic wastes from the PRF were disposed of to the soil column through a series of cribs until 1973. Cribs that are known to have received PRF wastes include:

- 216-Z-1A Tile Field - 5/64 to 5/66, 6/66 to 10/67, 10/67 to 4/69
- 216-Z-1 & 216-Z-2 Cribs - 5/66 to 6/66, 10/67
- 216-Z-18 Crib - 4/69 to 5/73.

Organic wastes from PRF processing operations in the 1980s have been containerized and shipped to the RMW storage complex. The organic wastes containers are currently awaiting disposal. The carbon tetrachloride ERA proposal (DOE-RL 1991b) estimated the total volume of all types of PRF liquid waste deposited to PRF waste management unit as follows:

• 216-Z-1 & 216-Z-2 Cribs	211,000 L	(56,000 gal)
• 216-Z-1A Tile Field	5,260,000 L	(1,389,000 gal)
• 216-Z-18 Crib	3,860,000 L	(1,019,000 gal).

The total amount of spent carbon tetrachloride disposed of from the PRF facility to soil was approximately 280,000 L (74,000 gal).

2.4.5 Americium Recovery

2.4.5.1 Americium Recovery Process Description. The recovery of americium from PRF waste streams started in 1964 in the 242-Z Building. After a chemical explosion in an ion-exchange column, this facility was shut down in 1976. The explosion reportedly could have released up to 1 mCi of alpha activity to the atmosphere through the Z Plant stack (ERDA 1976).

The process used an ion exchange technique to recover americium from the waste streams. Elution and regeneration of the ion exchange resin was done with nitric acid.

Americium was also recovered in the PRF using DBBP in a carbon tetrachloride diluent as an extractant solvent. The DBBP was subsequently replaced with tributylphosphate in the process.

2.4.5.2 Americium Recovery Waste Streams. Information on wastes generated from the americium recovery process was not available. Presumably, these waste streams would have included spent ion exchange resins, waste organic solvent, and unrecovered americium.

2.4.6 Analytical and Development Laboratories

The Z Plant analytical and development laboratories are currently housed in the 234-5Z Building. Historically, analytical and development laboratories are also reported to have been housed in the 231-Z Building (Stenner et al. 1988).

2.4.6.1 Laboratory Processes. The Z Plant laboratory currently provides analytical services and supports research and development activities for the Plutonium Finishing Operations. Historically, the laboratory provided the same services for the PFP. This support was provided in the following ways:

- Quality assurance/quality control (QA/QC) for the plutonium processing lines
- Liquid scintillation counting
- Preparation work for solvent extraction tests.

Present activities of this unit are limited to research and development, and associated analyses needed to support production processing operations (Jensen 1990). Table 2-9 lists all the chemicals and reagents known to have been used or stored in the laboratory area. Exact quantities of these chemicals and reagents stored or used is not known.

2.4.6.2 Laboratory Waste Streams. There are three types of wastes produced in the laboratory area:

- Laboratory process wastes
- Used or discarded analytical reagents and chemicals
- Wastewater from laboratory sinks and emergency showers.

2.4.6.2.1 Laboratory Process Wastes. Laboratory process wastes were characterized as slightly acidic, low salt radioactive wastes. These wastes were routed through the 241-Z-361 Settling Tank to various cribs. The 216-Z-3 and 216-Z-12 Cribs received laboratory process wastes. The pH of these wastes were adjusted to between 8 and 10 in the 241-Z Treatment Tank prior to disposal.

2.4.6.2.2 Analytical Reagents and Chemicals. Information on the disposition of used or discarded analytical reagents is not available. A large number of chemicals are in use or are stored in the laboratory, as listed in Table 2-9. Laboratory chemicals are known to have been stored in the 234-5Z Hazardous Waste Staging Area (HWSA) prior to disposal.

2.4.6.2.3 Laboratory Wastewater. Nonradiological laboratory sinks and emergency showers in the laboratory area drain to the main sanitary wastewater system in the 234-5Z Building. The contents of this wastewater have not been determined, but are likely to contain intermittent releases from laboratory procedures, cleaning glassware, and chemical spills. Wastewater containing hazardous chemicals is routed to the 241-Z Building. This wastewater is combined with non-process wastewater and roof drain runoff from other buildings at Z Plant. The combined effluent is currently discharged to the 216-Z-20 Crib. Formerly, wastewater was discharged in sequence to the 216-Z-1, 216-Z-11, and 216-Z-19 Ditches.

2.5 INTERACTION WITH OTHER AGGREGATE AREAS OR OPERABLE UNITS

This part of the report discusses the interaction of the Z Plant Aggregate Area with other 200 Areas facilities and the disposal of the wastes generated. The 200 Areas has two distinct operational areas, 200 East and 200 West (Figures 1-3 and 1-4). These are dedicated to chemical separations and waste management.

- The B Plant, one of the original fuel separation facilities was in operation from 1945 to 1952. The bismuth phosphate process was used to separate plutonium from irradiated uranium fuel. The plutonium was precipitated on a bismuth-phosphate carrier in B Plant and later converted to plutonium nitrate; this took place in the 231-Z Building and 234-5Z Building of the Z Plant Aggregate Area (Rai et al. 1981).

- The PUREX facility separates uranium, plutonium, and neptunium from fission products found in the production reactors' irradiated uranium fuel. The plutonium stream after a series of purification steps, is concentrated and sent to the PFP as plutonium nitrate to be converted to metal form. This facility was in operation from 1956 to 1972, and was placed in a standby mode until 1983. Operations were resumed in 1983 and then shutdown in 1988. From December 1989 to the spring of 1990, a stabilization run was operated at PUREX. Currently, the PUREX facility is in standby mode.

The 200 West Area Plants consists of the U Plant, S Plant, T Plant, and Z Plant. The interaction of the U Plant, S Plant, and T Plants with Z Plant Aggregate Area are as follows:

- The U Plant was used to recover uranium from stored radioactive waste from 1952 to 1958. A major waste management unit in the U Plant Aggregate Area is the 216-U-10 Pond which is located south of the PFP. The 216-U-10 Pond served as a sink for wastes, both nonradioactive and radioactive, from other units (Rai et al. 1981). The following is a summary of these releases into the 216-U-10 Pond from the PFP:

  - Effluents from the 231-Z Building containing cooling water and condensation from HVAC equipment, and inactive operation cells. This building also sent laboratory wastes to this pond.

  - Wastewater from the overflow 261-Z-19 Ditch and its predecessors 216-Z-1 and Z-11 Ditches was sent to 216-U Pond. This wastewater came from the 231-Z and 234-5Z Buildings (main processing facility of the Z Plant Aggregate Area). The 216-Z-1 Ditch received cooling water and steam condensate from 231-Z, 234-5Z, and 291-Z Buildings.

The 216-Z-19 Ditch also received uncontaminated water from the 200 West Area High Tank Overflow. This water eventually was sent to the 216-U Pond. Long-term use of the 216-Z-19 Ditch resulted in localized accumulation of TRU and fission products due to sorption and filtration into the upper sediments. These products included plutonium 239, 240, and 241 and americium 241 discharges from 234-5Z and 231-Z facilities. Process waste containing small quantities of plutonium was also released to the 216-U-10 Pond from the 236-Z Building (PRF).

- The T Plant was one of the original bismuth phosphate fuel separation facilities and was in operation from 1944 to 1956. The final concentration processing to final plutonium product was done in the 234-5Z Building and the 231-Z Building (Rai et al. 1981).

- The REDOX process (S Plant) succeeded the bismuth-phosphate process 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 in the Z Plant Aggregate Area for processing (Rai et al. 1981).

Solid wastes from Hanford Site-wide sources were routed to 200 West Area Burial Grounds within the Z Plant Aggregate Area for disposal.

2.6 INTERACTION WITH RESOURCE CONSERVATION RECOVERY ACT PROGRAM

Several waste management units located within the Z Plant Aggregate Area boundaries are subject to RCRA (and corresponding Washington State) regulations. These include:

- The 241-Z Treatment Tank is a TSD facility subject to a RCRA Part B permit. Currently, only Tank D-5 is identified in the facility Part A, but Tanks D-4, D-7, and D-8 are expected to be added.

- Solid Waste Burial Grounds 218-W-2A, 218-W-3A, 218-W-3AE, 218-W-4B, 218-W-4C, 218-W-5, and 218-W-6 are included in a RCRA Part B permit application and will be closed in accordance with the TSD facility closure requirements.

Three unplanned releases are located within the boundaries of waste management units that are TSD facilities regulated under RCRA:

- UPR-200-W-45 resulted in contamination in Solid Waste Burial Ground 218-W-2A
- UPR-200-158 resulted in contamination in Solid Waste Burial Grounds 218-W-3A and 218-W-6
- UN-200-132 resulted in contamination in Solid Waste Burial Ground 218-W-4C.

Three unplanned releases are indirectly associated with the 241-Z Treatment Tank system and could be considered relevant for purposes of RCRA corrective action:

- UN-200-W-74
- UN-200-W-75
- UN-200-W-79.

Remediation actions recommended later in this report for the waste management units and unplanned releases identified above will consider necessary interactions with RCRA program requirements and activities.

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 Z 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 Z Plant Aggregate Area are covered under this program. These facilities include the 232-Z Incinerator. This program is also responsible for managing the RCRA closure and RARA activities. The program 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 Z 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, none of which are located in the Z Plant Aggregate Area. 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 Z Plant Aggregate Area. These facilities include the 241-Z Treatment Tank; the 216-Z-13, 216-Z-14, and 216-Z-15 French Drains; 2607-Z, 2607-Z-1, 2607-WA, 2607-WB, 2607-W-8 Septic Tanks and Drain Fields; 216-Z-21 Seepage Basin; the 218-W-3A, 218-W-3AE, 218-W-4B, 218-W-4C, and 218-W-5 Burial Grounds; and all high-level waste process lines and their associated diversion boxes and catch tanks.

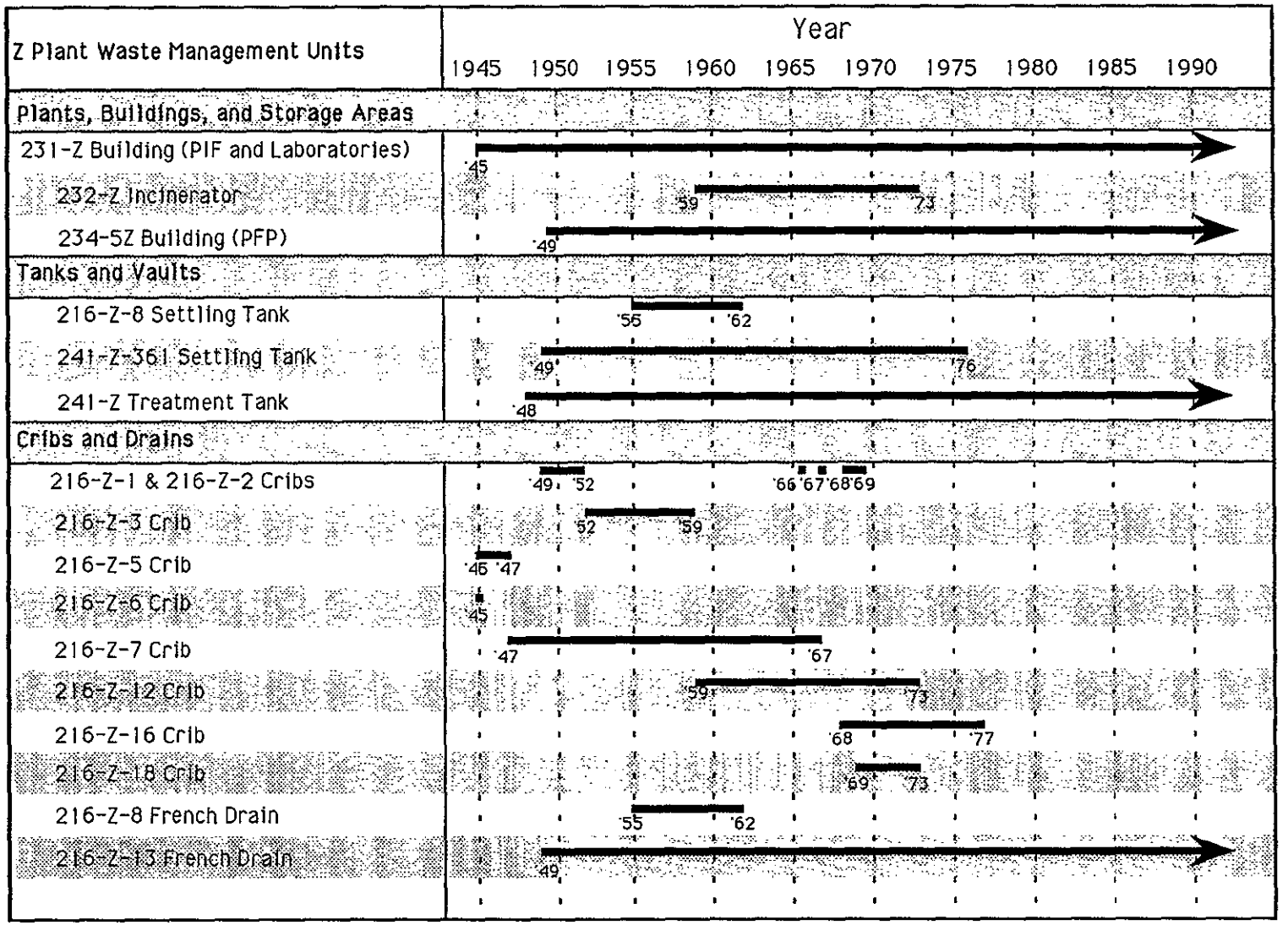


Figure 2-1. Z Plant Aggregate Area Timeline. (Sheet 1 of 4)

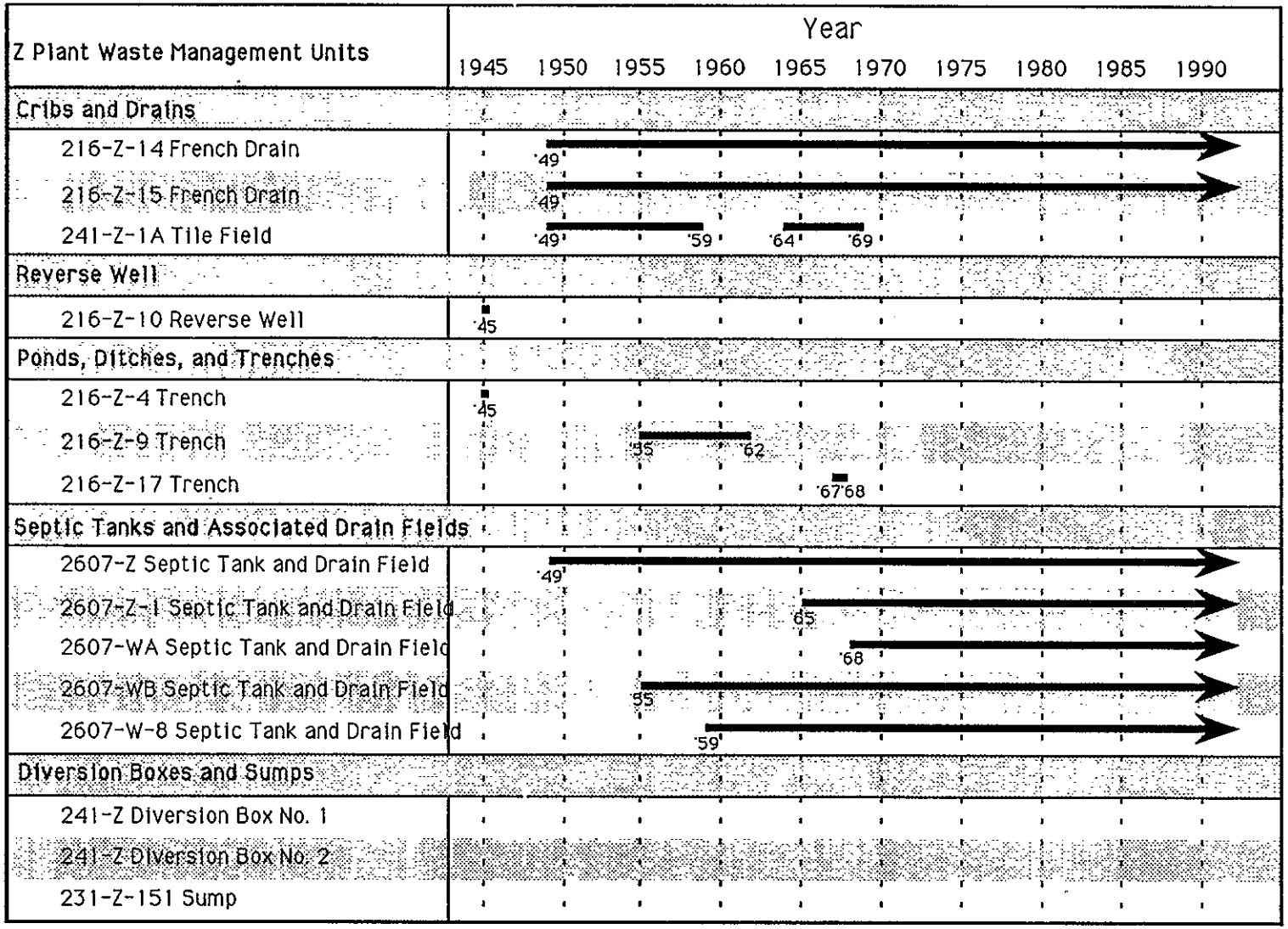


Figure 2-1. Z Plant Aggregate Area Timeline. (Sheet 2 of 4)

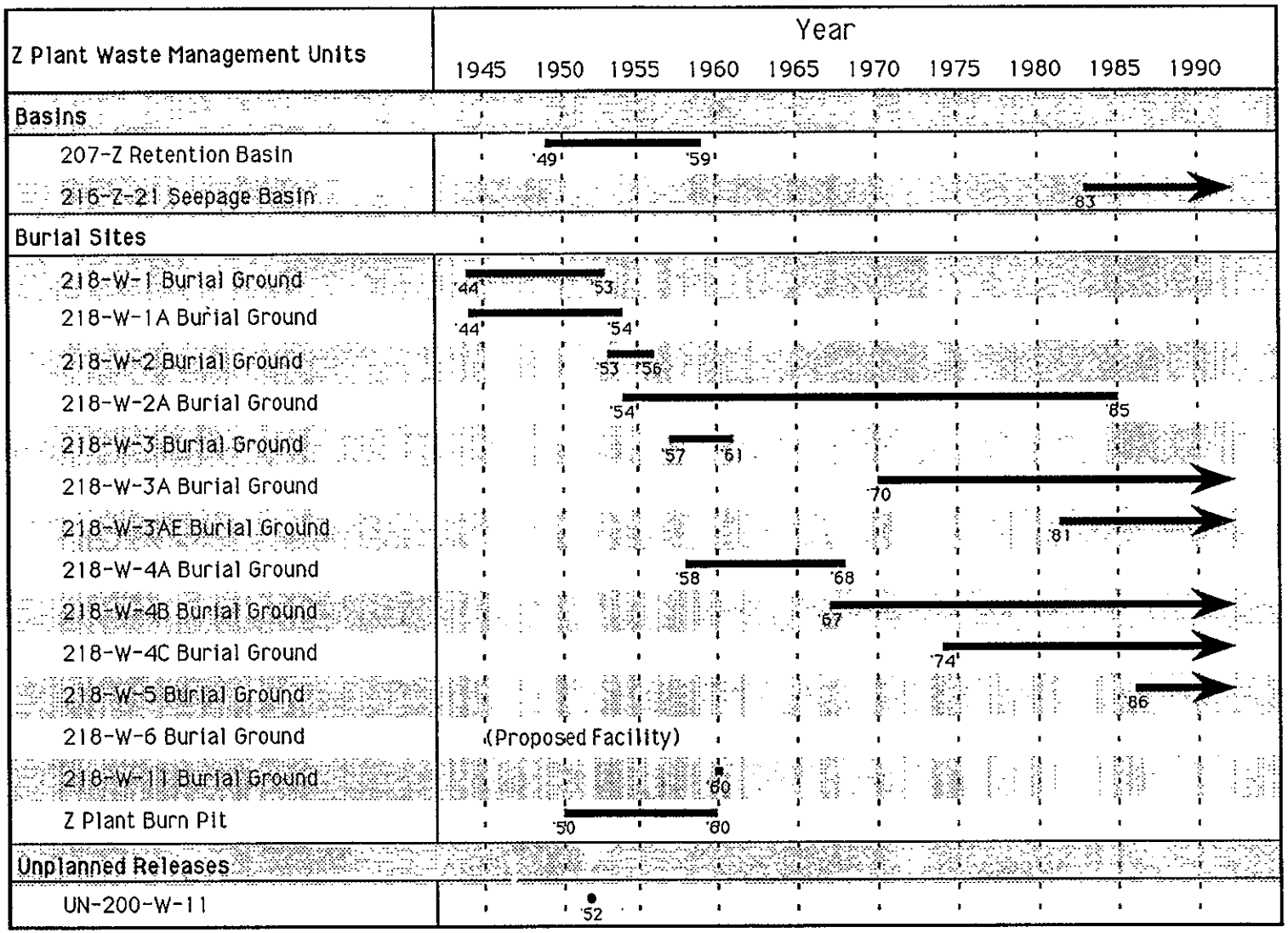


Figure 2-1. Z Plant Aggregate Area Timeline. (Sheet 3 of 4)

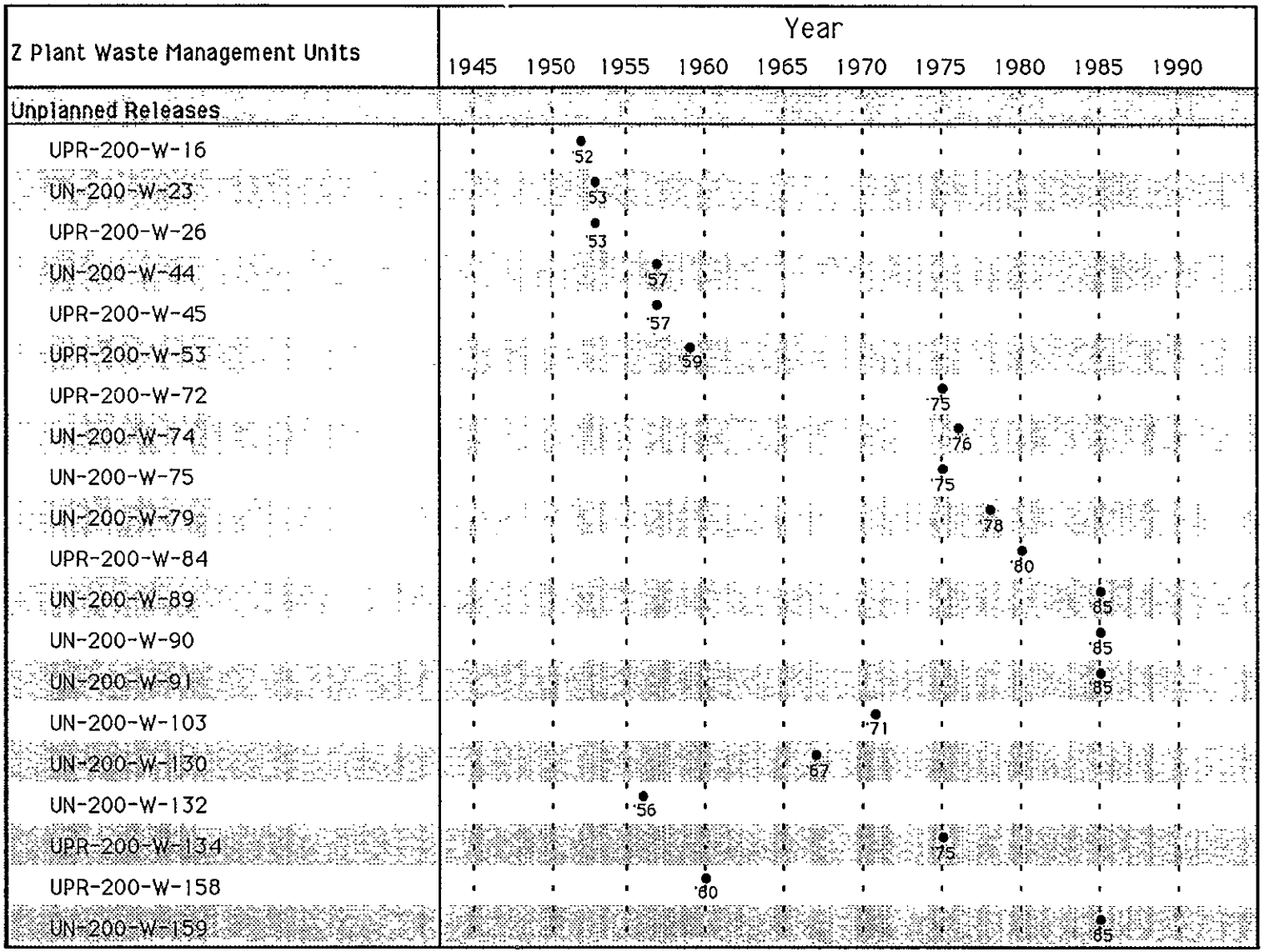


Figure 2-1. Z Plant Aggregate Area Timeline. (Sheet 4 of 4)

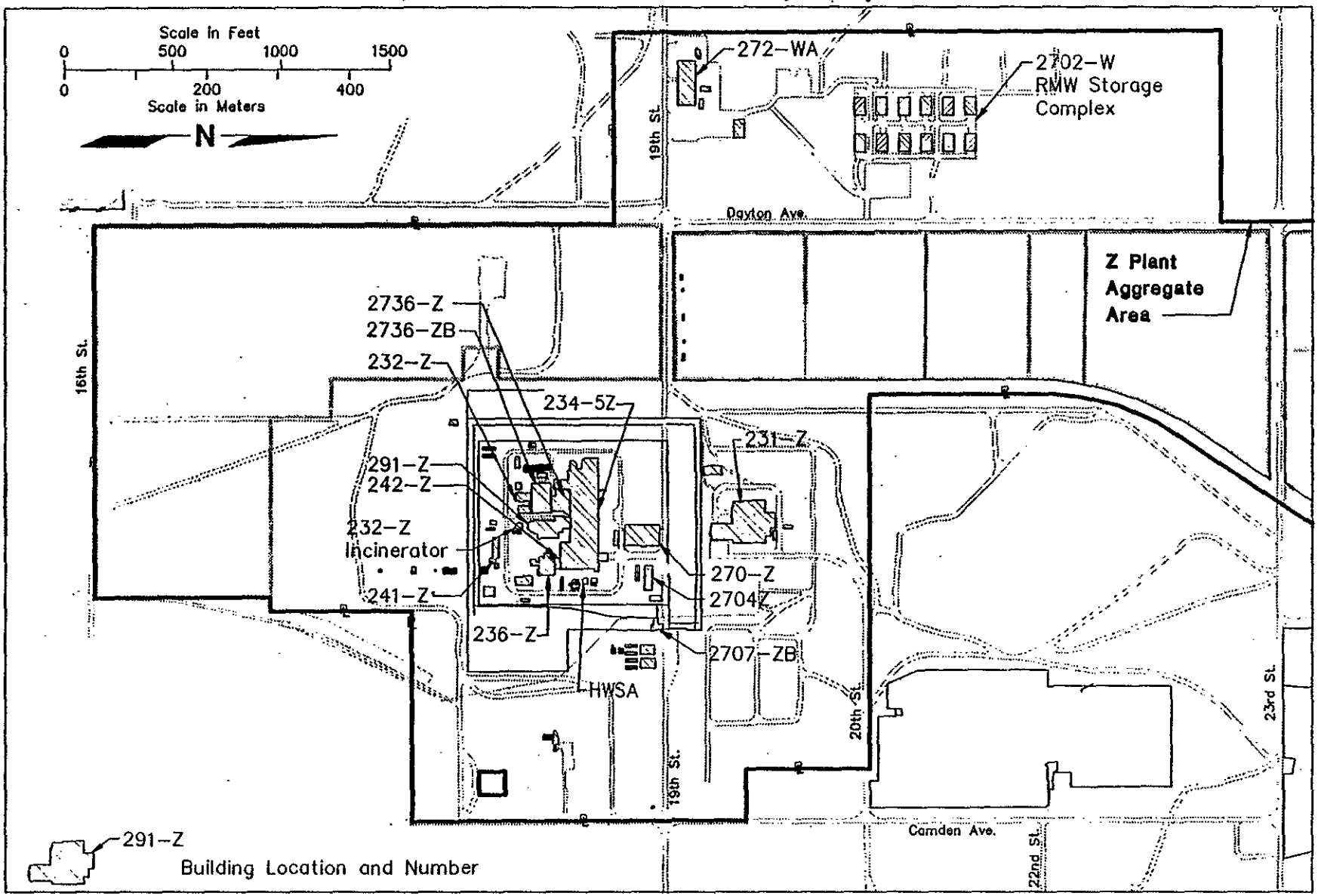


Figure 2-2. Location of Plants, Buildings, and Storage Areas.

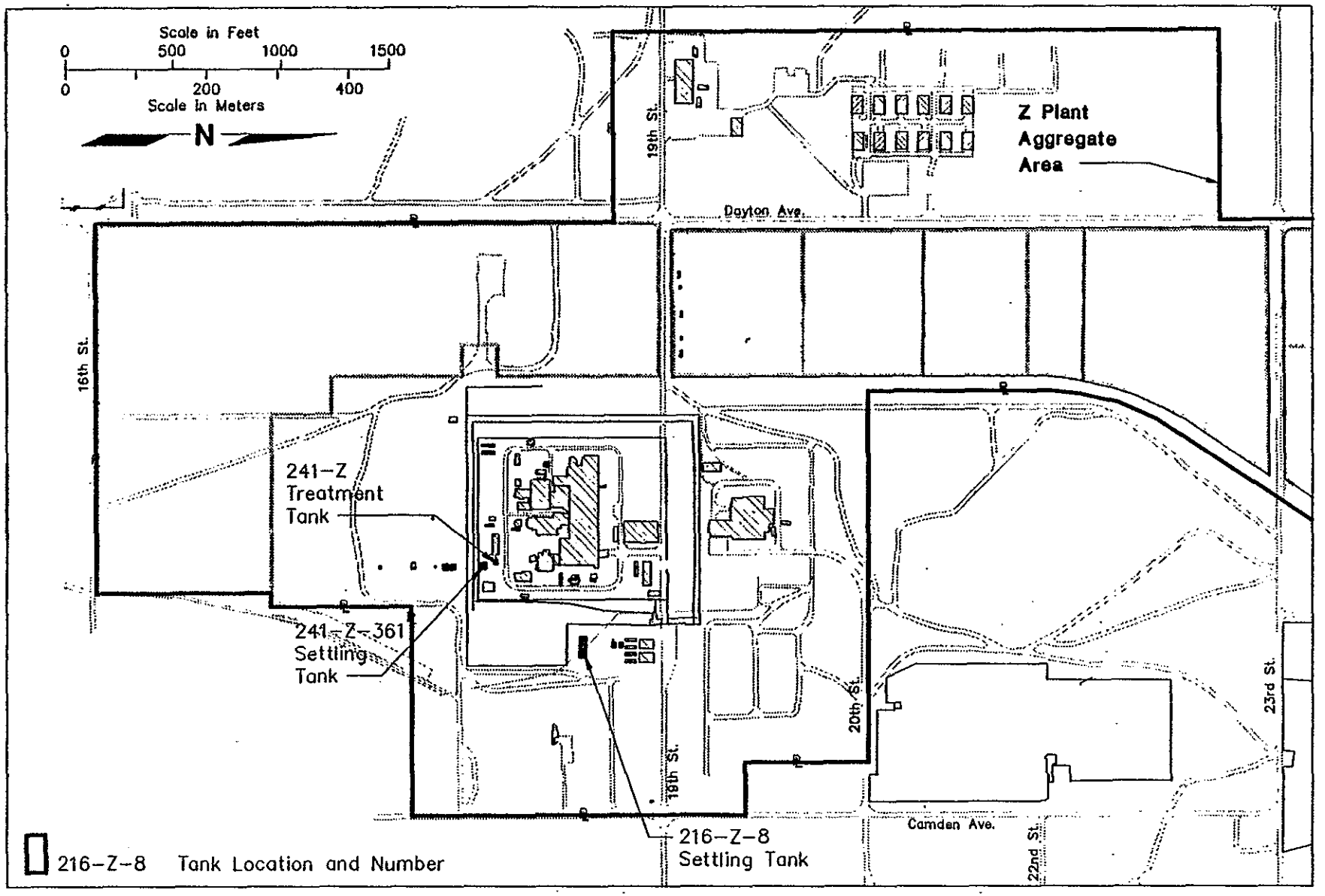


Figure 2-3. Location of Tanks and Vaults.

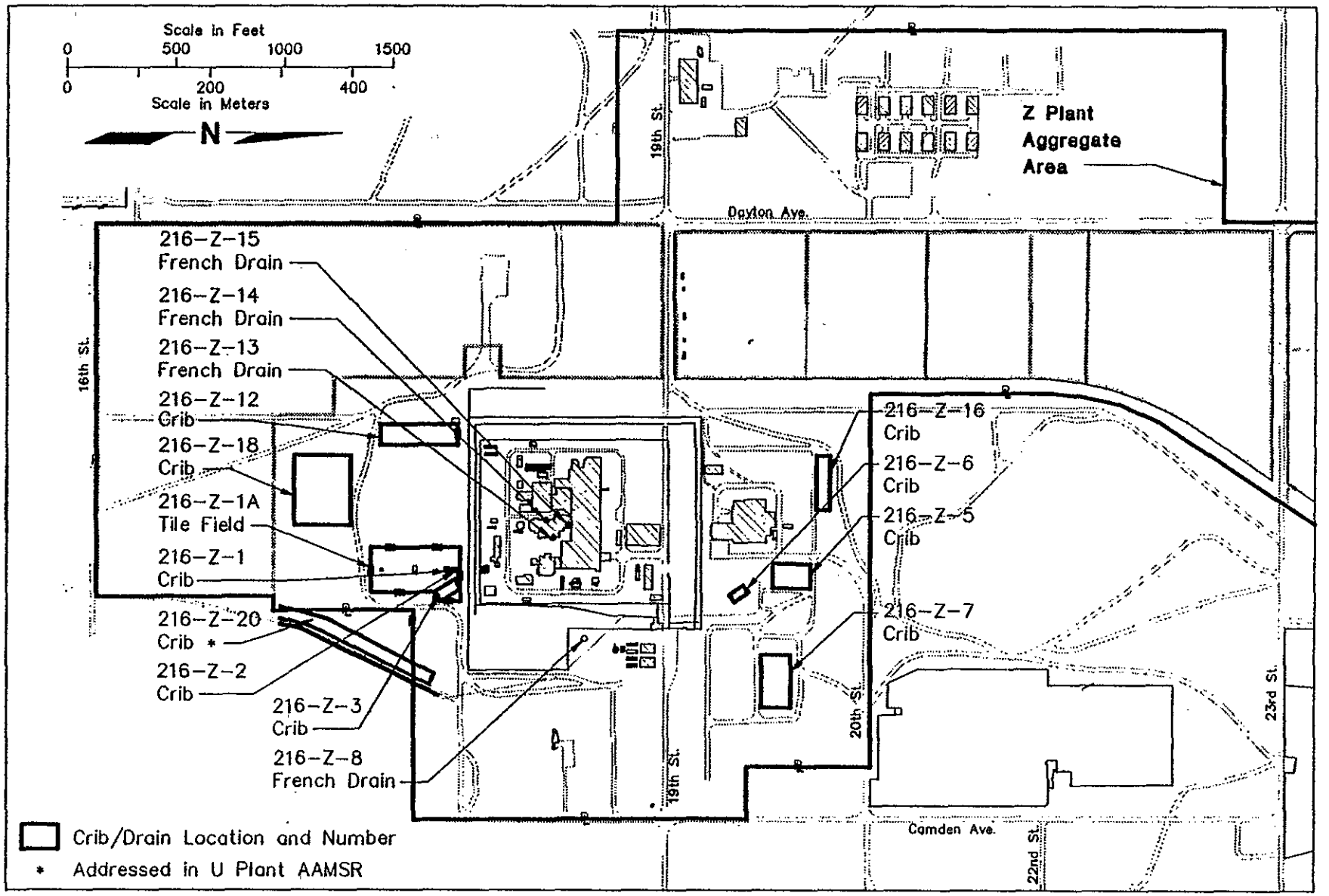


Figure 2-4. Location of Cribs and Drains.

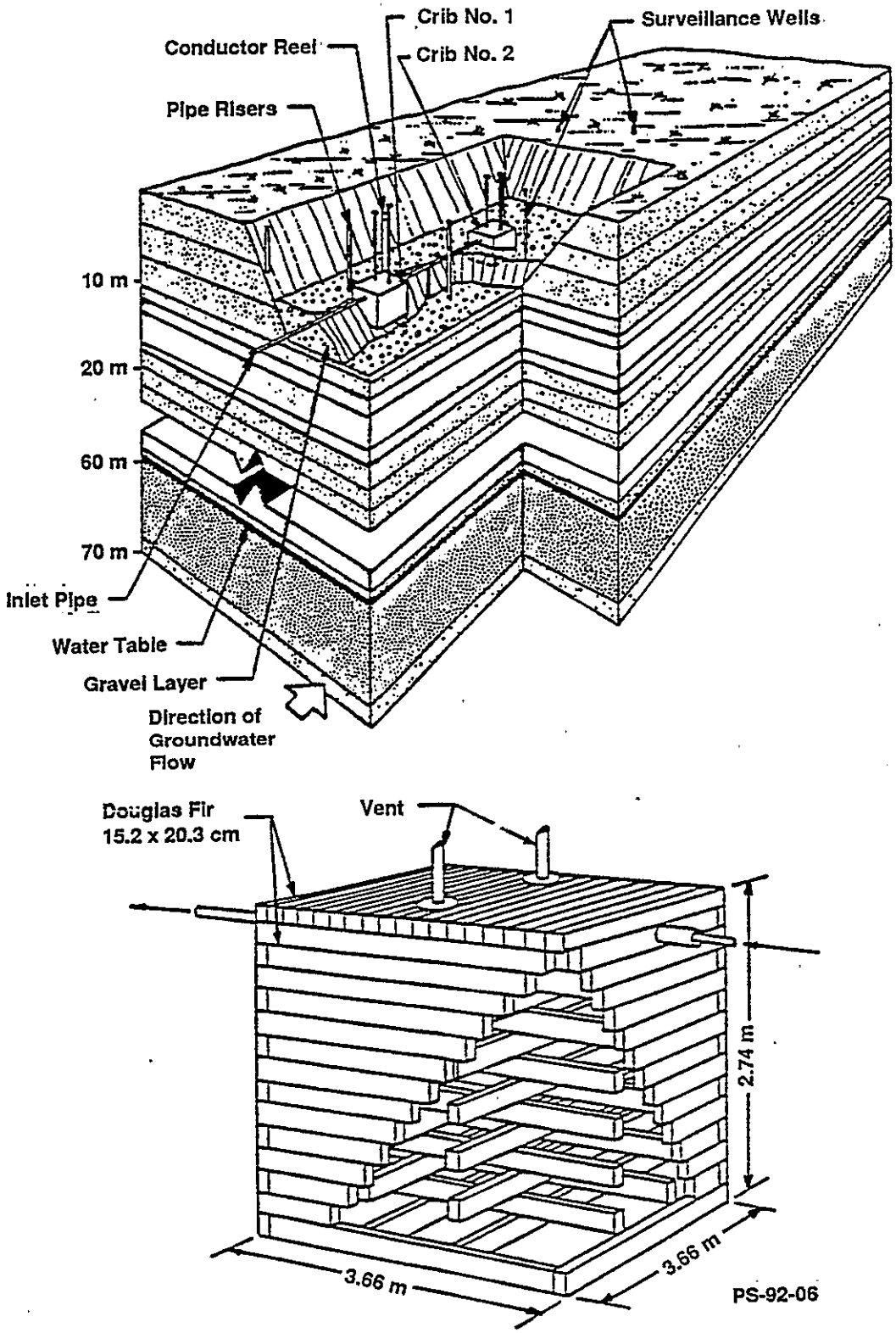


Figure 2-5. Typical Crib.

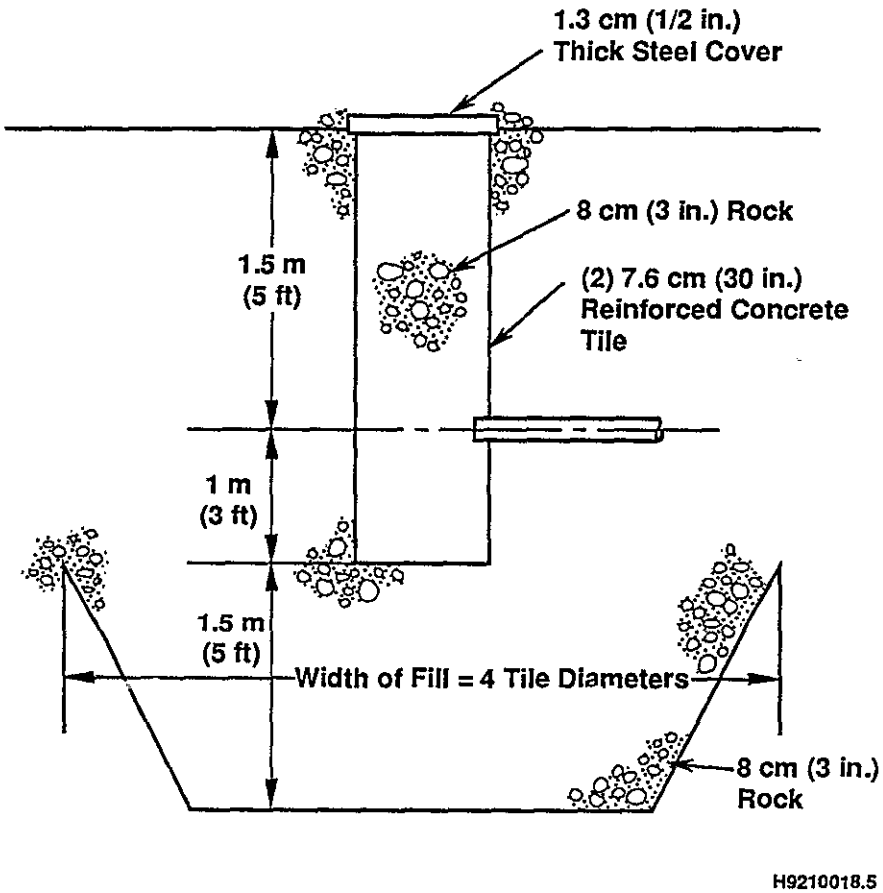


Figure 2-6. Typical French Drain.

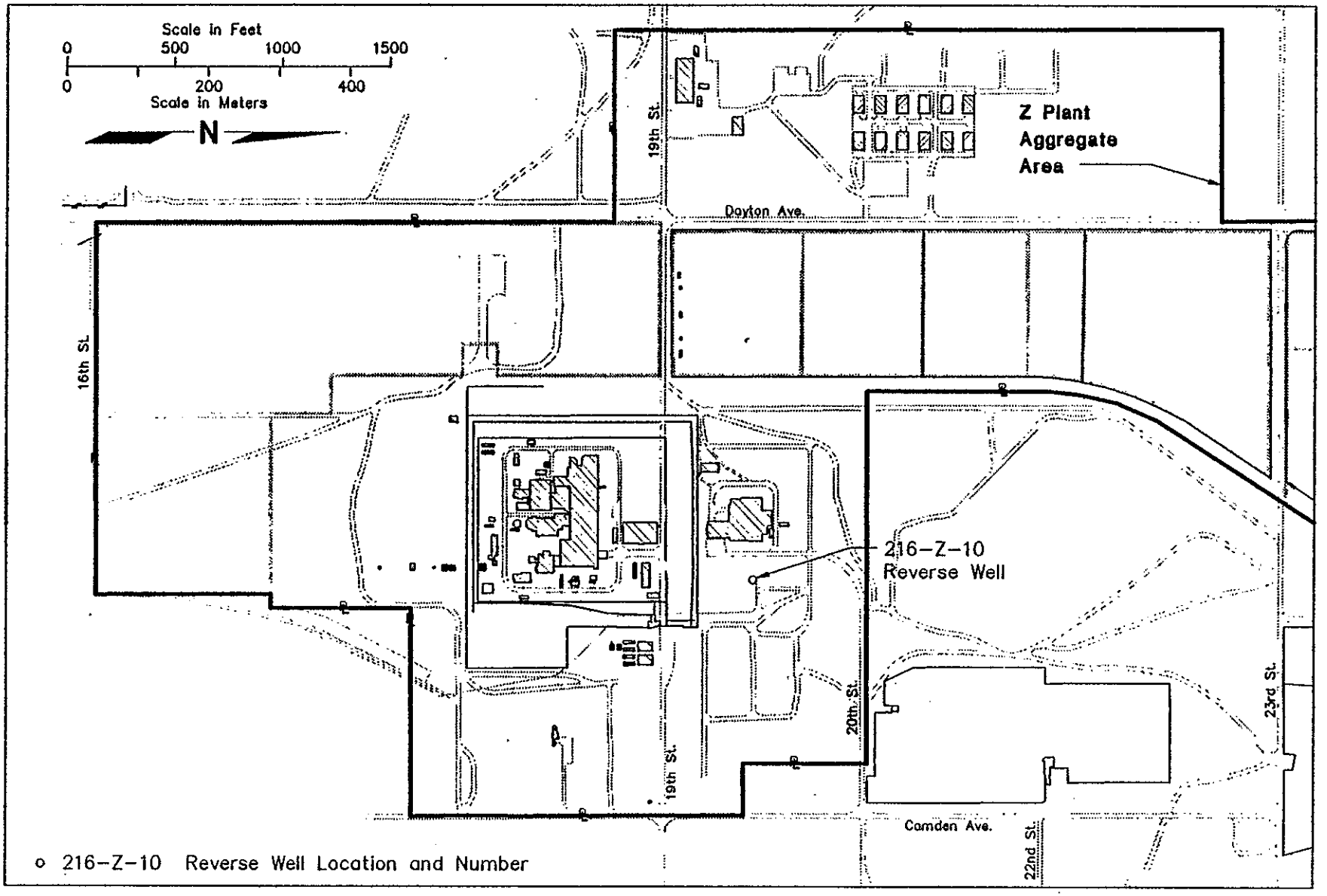


Figure 2-7. Location of Reverse Wells.

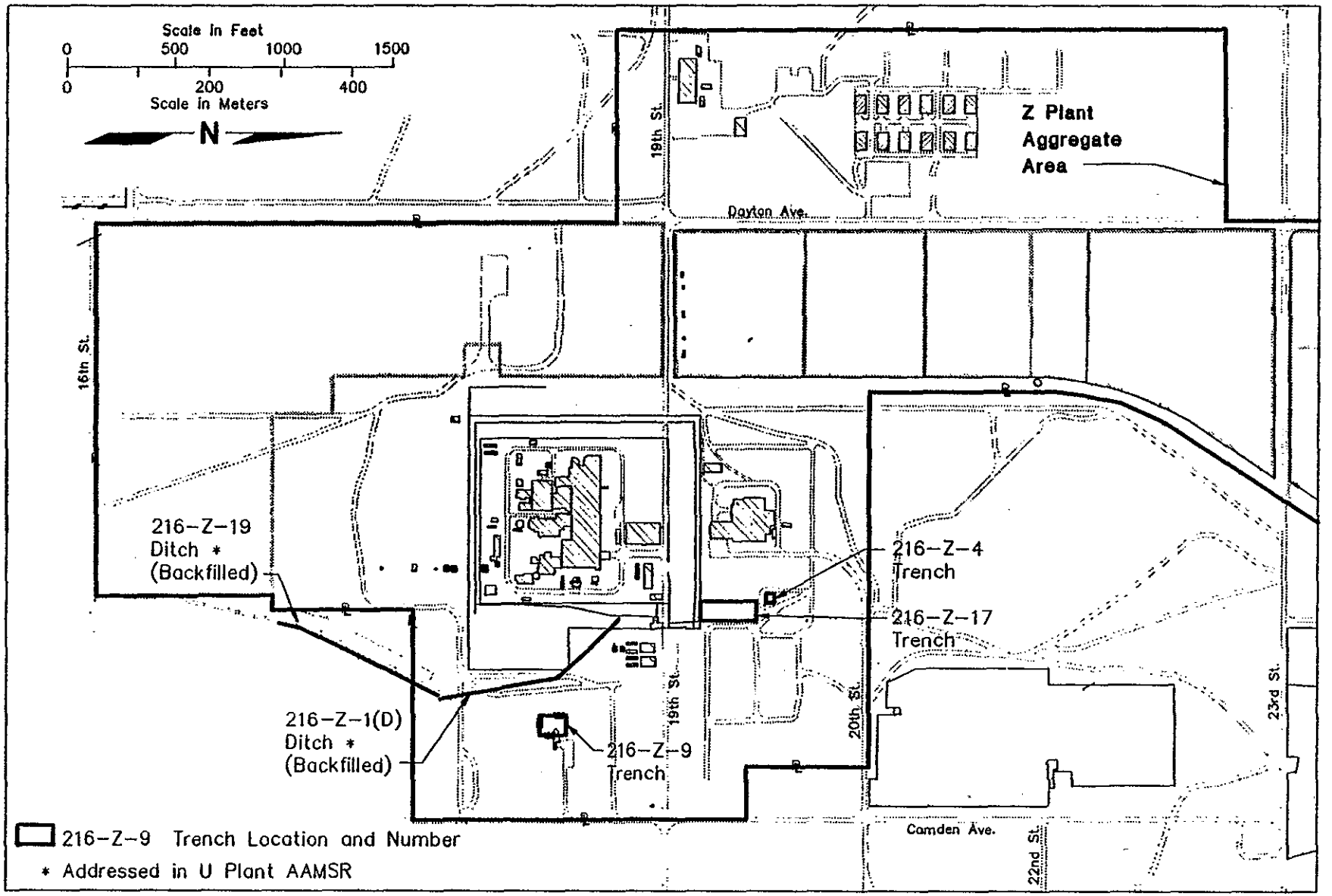


Figure 2-8. Location of Ponds, Ditches, and Trenches.

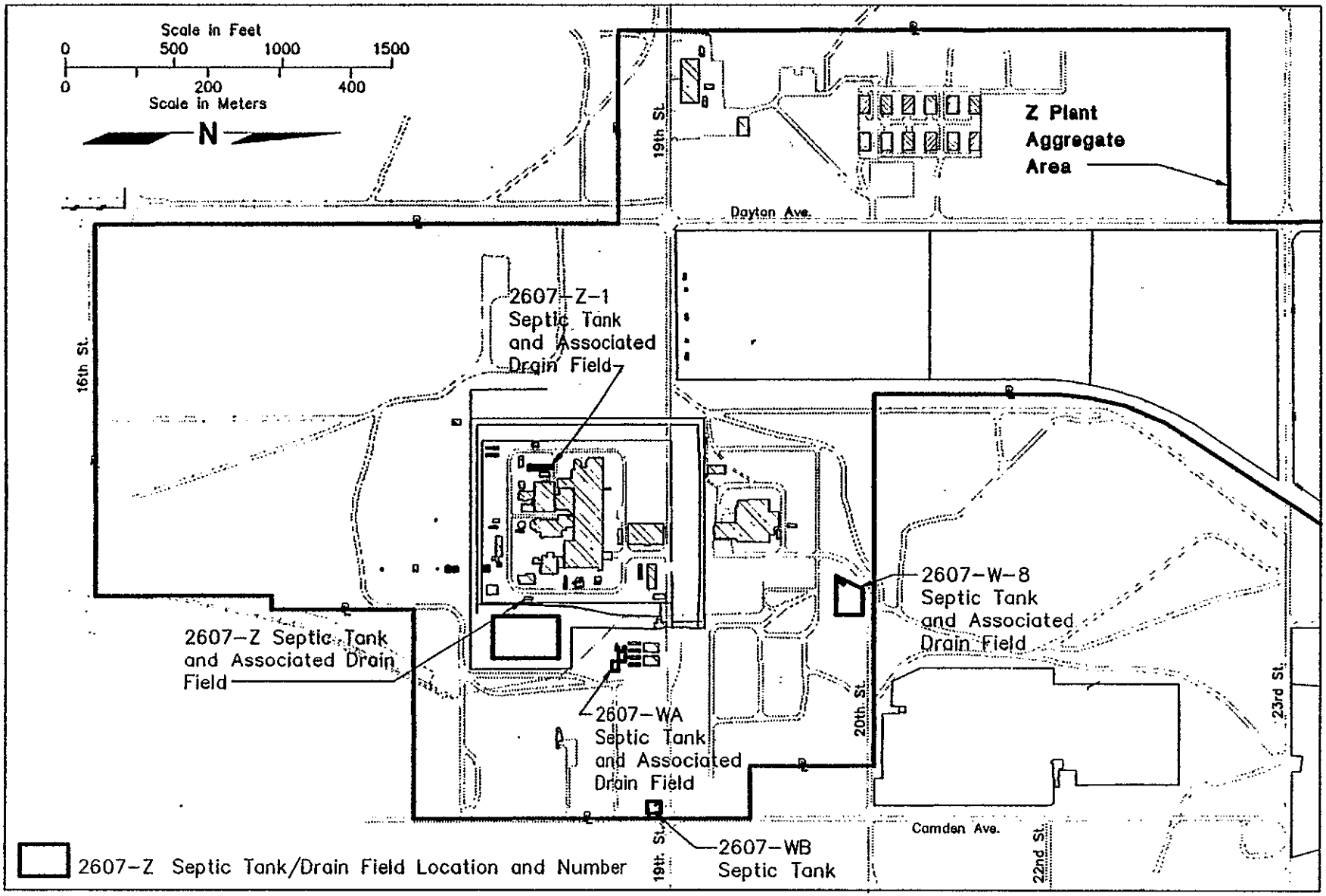


Figure 2-9. Location of Septic Tanks and Associated Drain Fields.

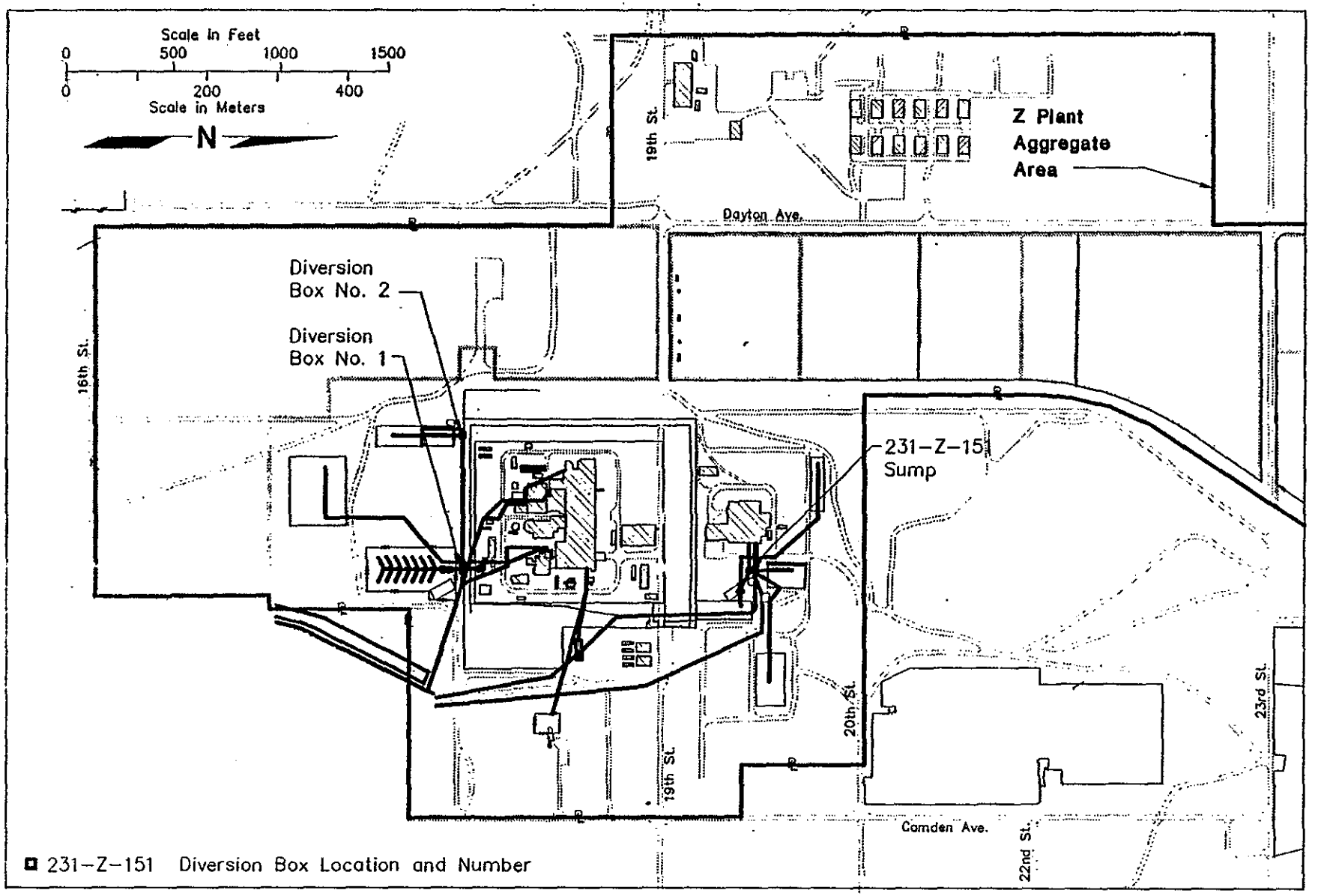


Figure 2-10. Location of Transfer Facilities, Diversion Boxes, and Pipelines.

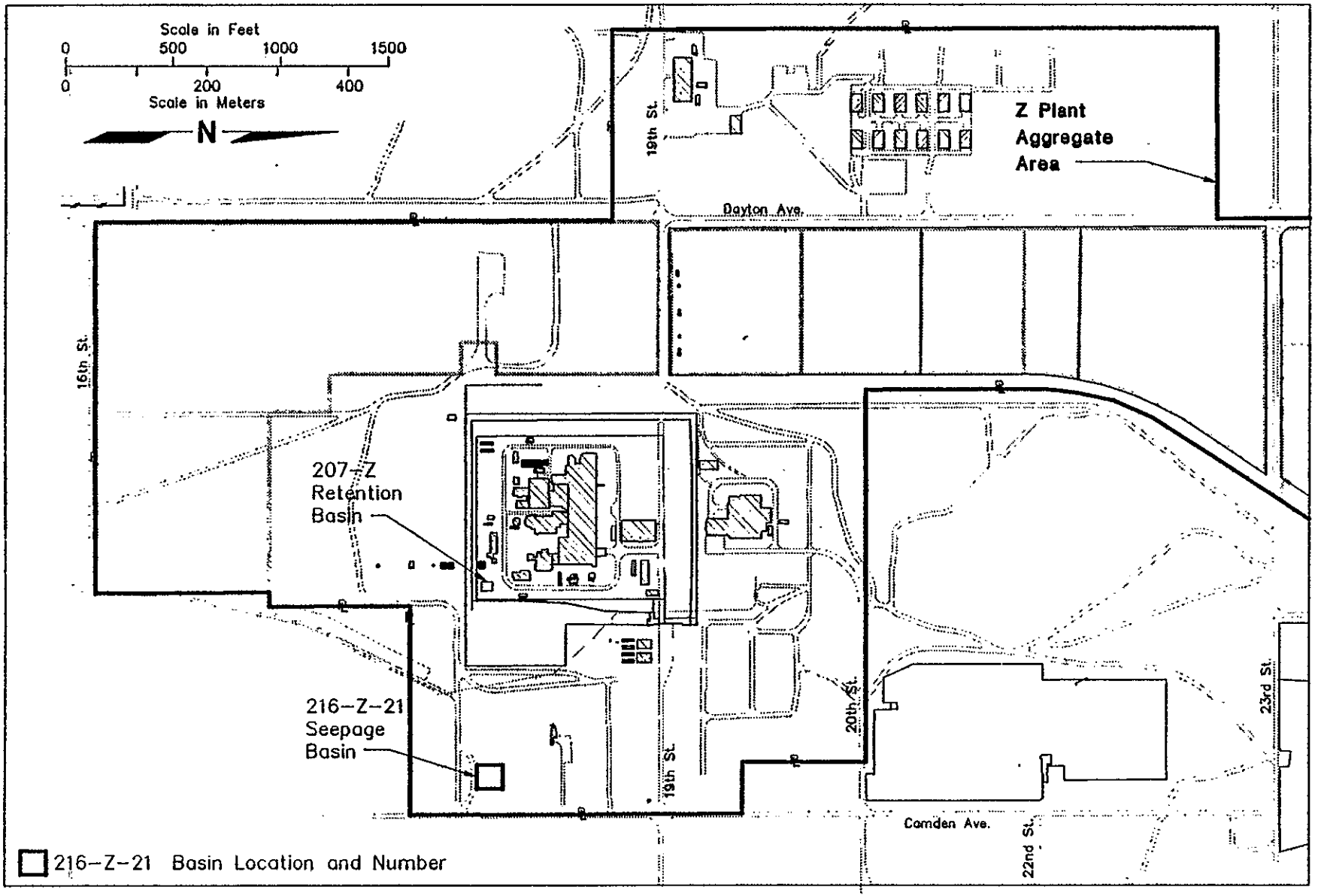


Figure 2-11. Location of Basins.

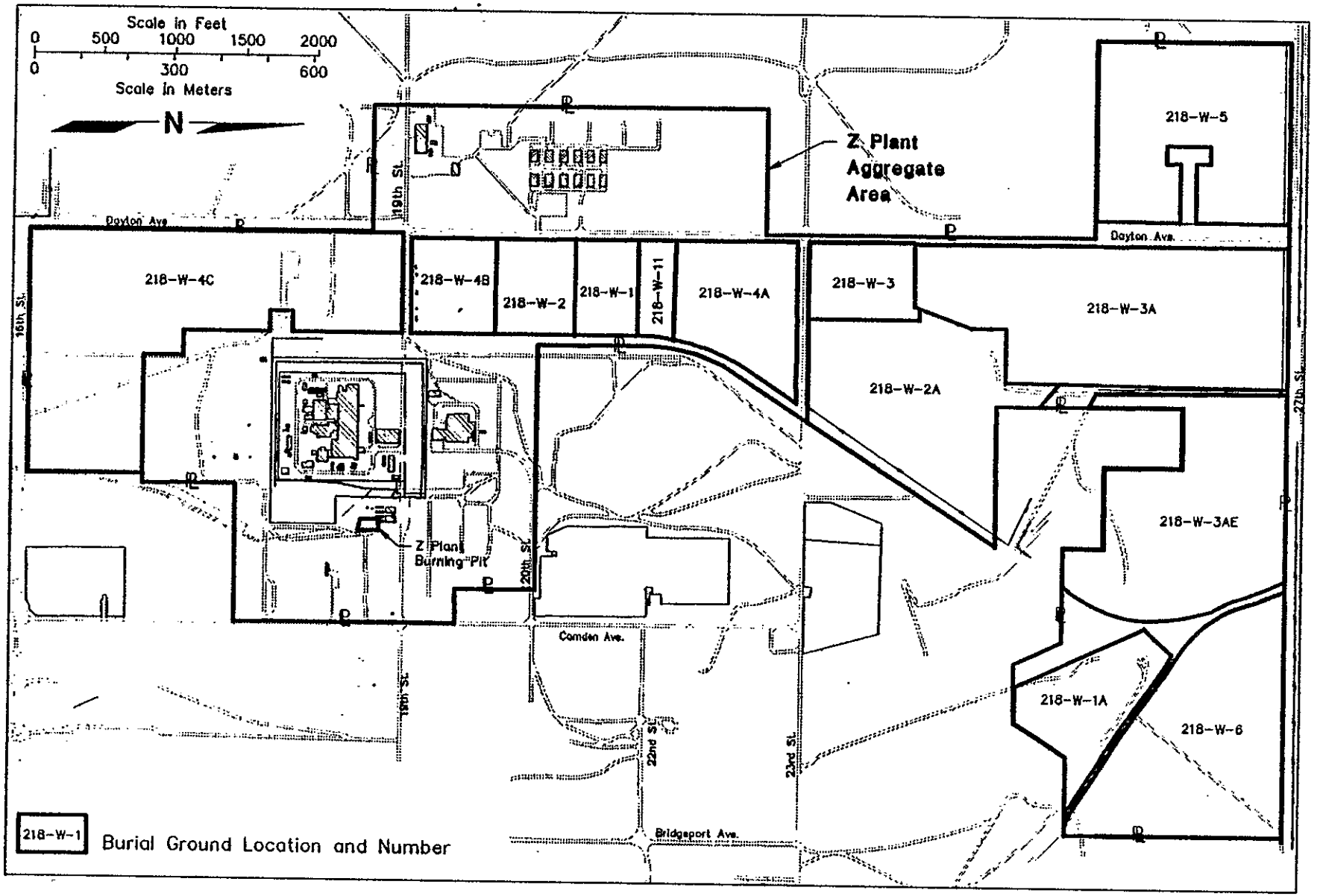


Figure 2-12. Location of Burial Sites.

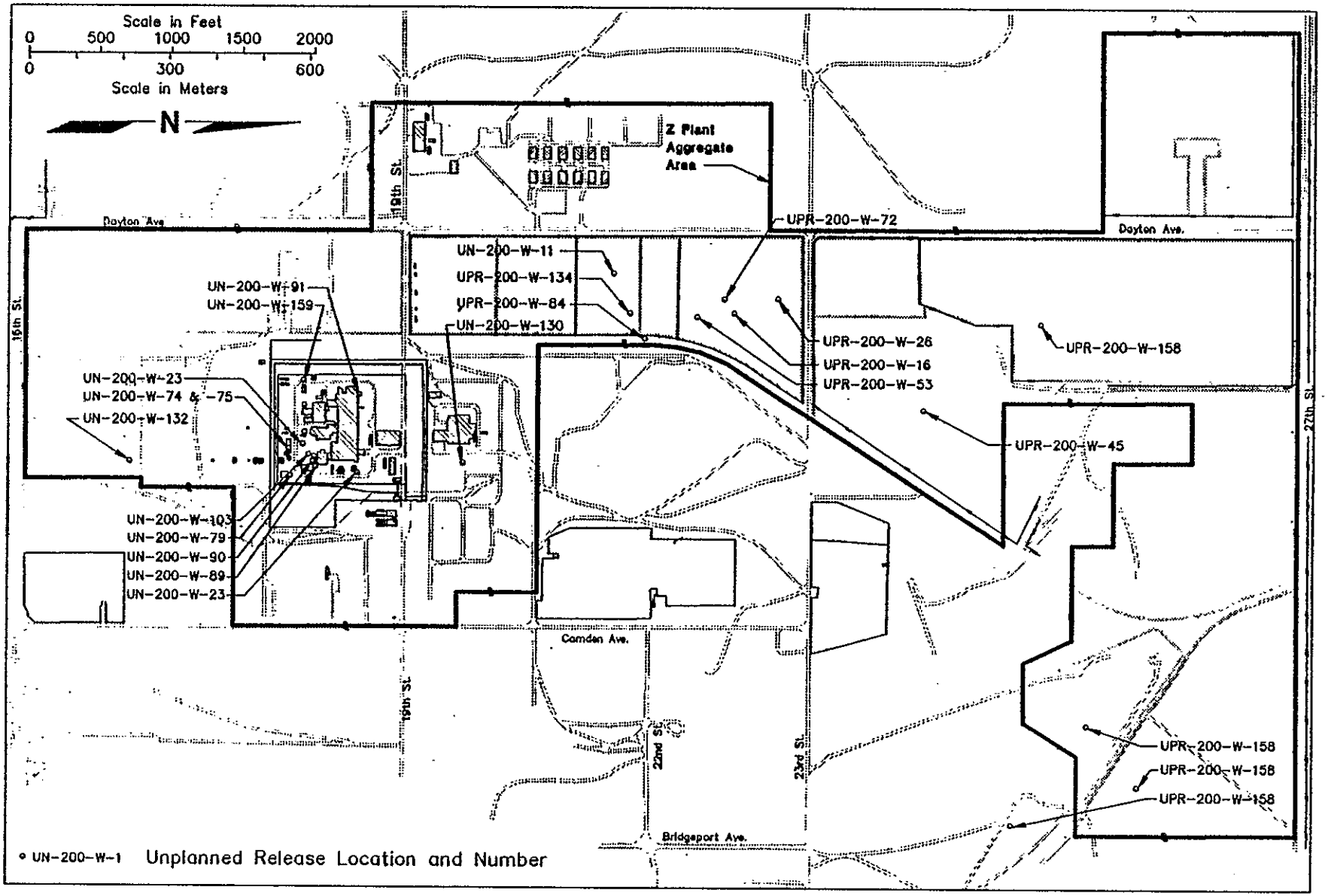
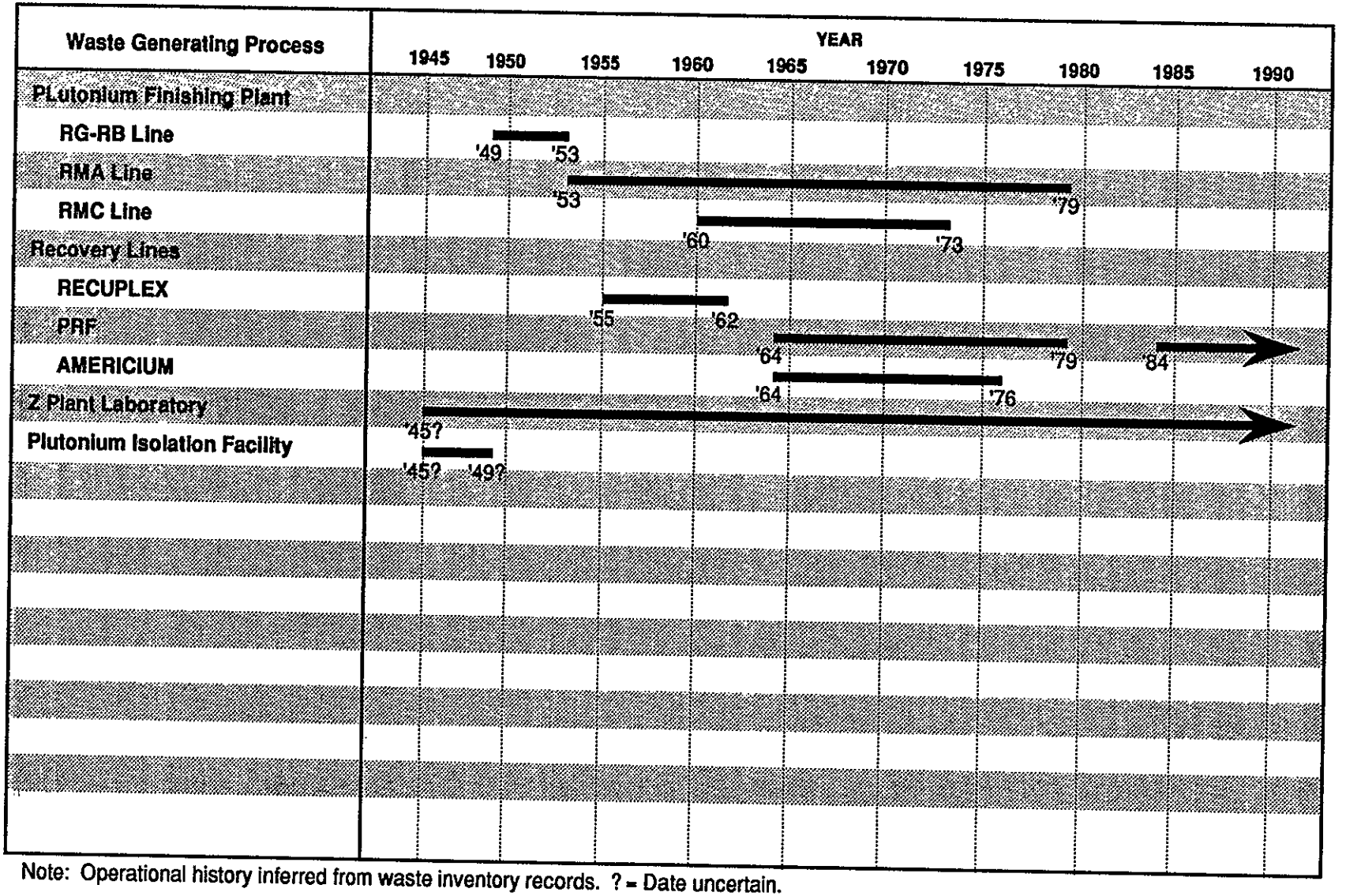


Figure 2-13. Location of Unplanned Releases.



Note: Operational history inferred from waste inventory records. ? = Date uncertain.

Figure 2-14. Z Plant Process History.

Table 2-1. Summary of Z Plant Aggregate Area Waste Management Units. (Sheet 1 of 5)

Waste Management Unit (Aliases)	Source Description/Type	Total Fluid Volume Received in Liters	Solid Waste Volume Received in m^3	Contaminated Soil Volume in m^3	Operable Unit
Plants, Buildings, and Storage Areas					
232-Z Incinerator	Low level radioactive waste and TRU waste/LLW	na	na	nr	200-ZP-1
Tanks and Vaults					
216-Z-8 Settling Tank (Silica Gel Settling Tank)	Organic, radioactive waste from RECUPLEX process (234-5Z) Building)/HLW	nr	na	nr	200-ZP-2
241-Z-361 Settling Tank (207-Z Settling Tank)	Acidic, organic, radioactive waste from PFP and plutonium recovery processes (234-5Z Building, RECUPLEX process, and 242-Z Building)/HLW	nr	nr	nr	200-ZP-1
241-Z Treatment Tank (Tank D-5)	Corrosive aqueous waste from 234-5Z PFP/HLW	nr	na	nr	200-ZP-2
Cribs and Drains					
216-Z-1 & 216-Z-2 Cribs (234-5 No. 2 Crib, 216-Z-7)	PRF (236-Z) and 242-Z process waste 234-5Z lab wastes/HLW	33,700,000 (38,900,000)	na	8,300	200-ZP-1
216-Z-3 Crib (216-Z-3 Culvert, 234-5 No. 3 and No. 4 Cribs, 216-Z-8 Crib)	234-5Z process, analytical, and development wastes via 241-Z-361 Settling Tank/HLW	178,000,000	na	1,500	200-ZP-1
216-Z-5 Crib (231-W-1 and 231-W-2 Cribs, 231-W Sumps)	Process waste from 231-Z Building via 231-Z-151 sump/HLW	31,000,000 (30,000,000)	na	210	200-ZP-2
216-Z-6 Crib (231-W-4 Crib, 226-W-4 Crib, 231-Z-6 Crib)	Process waste from 231-Z Building via 231-Z-151 sump/HLW	98,000	na	44	200-ZP-2
216-Z-7 Crib (231-W Trench, 231-W Crib, 231-Z-6 Crib)	Laboratory waste from 231-Z Building and 340 laboratory/HLW	79,900,000	na	590	200-ZP-2
216-Z-12 Crib (207-Z-12 Crib)	234-5Z process, analytical, and development wastes via 241-Z-361 Settling Tank/HLW	281,000,000	na	5,400	200-ZP-1

Table 2-1. Summary of Z Plant Aggregate Area Waste Management Units. (Sheet 2 of 5)

Waste Management Unit (Aliases)	Source Description/Type	Total Fluid Volume Received in Liters	Solid Waste Volume Received in m^3	Contaminated Soil Volume in m^3	Operable Unit
216-Z-16 Crib	Radioactive process waste from 231-Z Building/HLW	102,000,000	na	460	200-ZP-2
216-Z-18 Crib	High salt, acidic, organic waste from 236-Z Building/HLW	3,860,000	na	5,700	200-ZP-1
216-Z-8 French Drain (234-5 RECUPLEX French Drain, 231-W-150 Dry Well, 231-W-150 Reverse Well)	Overflow from Z-8 Settling Tank/HLW	9,590	na	58	200-ZP-2
216-Z-13 French Drain	ET-8 turbine steam condensate and 291-Z Building floor drain/LLW	nr	na	nr	200-ZP-1
216-Z-14 French Drain	ET-9 turbine steam condensate and 291-Z Building floor drain/LLW	nr	na	nr	200-ZP-1
216-Z-15 French Drain	Aqueous waste from S-12 evaporative cooler (291-Z Building)/LLW	nr	na	nr	200-ZP-1
216-Z-1A Tile Field (234-5 Tile Field, "216-Z-7")	Overflow from 216-Z-1, 216-Z-2, or 216-Z-3 Cribs, PFP process wastes (234-5Z Building), PRF process waste (236-Z Building), and 242-Z process wastes/HLW	5,210,000 6,200,000	na	nr	200-ZP-1
Reverse Well					
216-Z-10 Reverse Well ("216-Z-2," 231-W Reverse Well, "216-Z-9," 216-Z-8 Crib)	Process and laboratory waste from 231-Z Building via 231-Z-151 sump/HLW	1,000,000	na	0.17	200-ZP-2
Ponds, Ditches, and Trenches					
216-Z-4 Trench (231-W-3 Pit, Sump, or Crib, 216-Z-4 Crib, 231-W Sump)	Process and laboratory waste from 231-Z Building/HLW	11,000		56	200-ZP-2
216-Z-9 Trench (216-Z-9 Crib, 216-Z-9 Cavern, 234-5 RECUPLEX Cavern, 216-Z-10 Crib)	Radioactive, acidic, organic wastes from RECUPLEX process (234-5Z Building), and 242-Z Building inorganic process wastes/HLW	4,090,000	na	5,100	200-ZP-2
216-Z-17 Trench (216-Z-17 Ditch)	Process waste from 231-Z Building via 231-W-151 sump/HLW	36,800,000 (36,700,000)	na	200	200-ZP-2

Table 2-1. Summary of Z Plant Aggregate Area Waste Management Units. (Sheet 3 of 5)

Waste Management Unit (Aliases)	Source Description/Type	Total Fluid Volume Received in Liters	Solid Waste Volume Received in m^3	Contaminated Soil Volume in m^3	Operable Unit
Septic Tanks and Associated Drain Fields					
2607-Z Septic Tank and Drain Field	Sanitary wastewater for 234-5Z and 2704-Z Buildings/NRH	nr	na	nr	200-ZP-2
2607-Z-1 Septic Tank and Drain Field	Sanitary wastewater/NRH	nr	na	nr	200-ZP-2
2607-WA Septic Tank and Drain Field	Sanitary wastewater/NRH	nr	na	nr	200-ZP-2
2607-WB Septic Tank and Drain Field	Sanitary wastewater from 272-WA Building/NRH	nr	na		200-ZP-2
2607-W-8 Septic Tank and Drain Field	Sanitary wastewater from 231-Z Building/NRH	nr	na	nr	200-ZP-2
Transfer Facilities, Diversion Boxes, and Pipelines					
241-Z Diversion Box No. 1	Process waste from 234-5Z Building/HLW	nr	na	nr	200-ZP-1
241-Z Diversion Box No. 2	Process waste from 234-5Z Building/HLW	nr	na	nr	200-ZP-1
231-Z-151 Sump (231-Z-151 Sump Tank, or 231-W-151 Sump)	Process and laboratory waste from 231-Z Building/HLW	nr	na	nr	200-ZP-1
Basins					
207-Z Retention Basin (207-Z Sump, 207-Z Pond, 207-Z Retention Pond, 241-Z Retention Basin)	May have received contaminated waste, steam condensate, and/or cooling water/LLW	nr	na	nr	200-ZP-2
216-Z-21 Seepage Basin (Seepage Basin 207-Z)	Storm water runoff from north of 234-5Z building/NRH	10^6 liters/yr	na	nr	200-ZP-2

Table 2-1. Summary of Z Plant Aggregate Area Waste Management Units. (Sheet 4 of 5)

Waste Management Unit (Aliases)	Source Description/Type	Total Fluid Volume Received in Liters	Solid Waste Volume Received in m^3	Contaminated Soil Volume in m^3	Operable Unit
Burial Sites					
218-W-1 Burial Ground (Dry Waste Burial Ground No. 001)	Transuranic mixed solid waste/LLW	na	7,000	8,983	200-ZP-3
218-W-1A Burial Ground (Industrial Waste Burial Ground No. 1)	Mixed industrial solid waste/LLW	na	16,000	20,398	200-ZP-3
218-W-2 Burial Ground (Dry Waste Burial Ground No. 002)	Transuranic mixed solid waste/LLW	na	8,200	22,927	200-ZP-3
218-W-2A Burial Ground (Industrial Waste Burial Ground No. 2, 218-W-02A Burial Ground, 200-W Industrial Waste No. 02A)	Mixed industrial solid waste/LLW	na	19,000	94,777	200-ZP-3
218-W-3 Burial Ground (Dry Waste Burial Ground No. 003)	Transuranic mixed solid waste/LLW	na	11,000	25,292	200-ZP-3
218-W-3A Burial Ground (Dry Waste Burial Ground No. 03A)	Transuranic mixed solid waste/LLW	na	24,000	51,144	200-ZP-3
218-W-3AE Burial Ground (Industrial Waste Burial Ground No. 3AE, Dry Waste Burial Ground No. 3AE)	Mixed industrial solid waste/LLW	na	21,390	nr	200-ZP-3
218-W-4A Burial Ground	Transuranic mixed solid waste/LLW	na	18,000	26,486	200-ZP-3
218-W-4B Burial Ground (Dry Waste Burial Ground No. 4B)	Transuranic mixed solid waste/LLW	na	10,000	20,630	200-ZP-3
218-W-4C Burial Ground (Dry Waste Burial Ground No. 1C)	Transuranic mixed solid waste/LLW	na	16,000	9,110	200-ZP-3
218-W-5 Burial Ground	Low level/mixed solid waste/LLW	na	32,500	nr	200-ZP-3
218-W-6 Burial Ground	Low level/mixed solid waste (Proposed Facility)/LLW	none	none	nr	200-ZP-3

Table 2-1. Summary of Z Plant Aggregate Area Waste Management Units. (Sheet 5 of 5)

Waste Management Unit (Aliases)	Source Description/Type	Total Fluid Volume Received in Liters	Solid Waste Volume Received in m^3	Contaminated Soil Volume in m^3	Operable Unit
218-W-11 Burial Ground	Low level/mixed solid waste/LLW	na	1,160	309	200-ZP-3
Z Plant Burn Pit	Office and non-hazardous waste/NRH	na	2,000	nr	200-ZP-2

Notes:

[a] Volume data derived from Waste Information Data System - WHC 1991a. Waste Type: (30,000,000) Parenthetical data from Stenner et al. 1988.
na Not applicable.
nr No value reported.

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

Table 2-2. Z Plant Aggregate Area Waste Management Unit Radionuclide Waste Inventory Summary. (Sheet 1 of 4)

Waste Management Unit	Total Pu in gm	Quantity of Reported Radionuclides in Unit in Ci[a]											
		^{238}U	^{137}Cs	^{106}Ru	^{90}Sr	^{60}Co	^{3}H	^{14}C	^{154}Eu	Other[c] Radionuclides	^{238}Pu	^{239}Pu	^{240}Pu
Plants, Buildings, and Storage Areas													
232-Z Incinerator	—	—	—	—	—	—	—	—	—	—	—	—	—
Tanks and Vaults													
216-Z-8 Settling Tank	1,600	—	—	—	—	—	—	—	—	—	—	—	—
241-Z-361 Settling Tank	30,000 to 75,000[b]	—	—	—	—	—	—	—	—	—	—	—	—
241-Z Treatment Tank	—	—	—	—	—	—	—	—	—	—	—	—	—
Cribs and Drains													
216-Z-1 & 216-Z-2 Cribs	7,000	0.027	0.04 (0.165)	1.6×10^{-11}	0.037 (0.0159)	0.0171	—	—	—	—	—	2,680	992
216-Z-3 Crib	5,700	1.7×10^{-5}	0.048	6.0×10^{-9} (16.9)	0.045 (0.097)	—	—	—	—	—	—	325	87.8
216-Z-5 Crib	340	1.7×10^{-5} 2.0×10^{-5}	3.6 (3.92)	5.2×10^{-12}	1.7 1.83	0.0026	—	—	—	—	—	19.4	5.24
216-Z-6 Crib	5	1.7×10^{-5} 2.0×10^{-5}	0.035	2.7×10^{-14}	0.033 (0.0361)	0.00048	—	—	—	0.0385	—	0.28	0.077
216-Z-7 Crib	2,000	0.0015	200 (224)	5.1×10^{-6}	200 (223)	0.0765	—	—	—	—	—	114	30.8
216-Z-12 Crib	25,000	1.7×10^{-5}	0.053 (0.0528)	9.3×10^{-7}	0.051 0.0562)	0.00515	—	—	—	—	—	1,430	386
216-Z-16 Crib	72	—	—	—	—	—	—	—	—	—	—	4.09	1.1
216-Z-18 Crib	23,000	—	—	—	—	—	—	—	—	—	—	1,310	353

Table 2-2. Z Plant Aggregate Area Waste Management Unit Radionuclide Waste Inventory Summary. (Sheet 2 of 4)

Waste Management Unit	Total Pu in gm	Quantity of Reported Radionuclides in Unit in Ci[a]											
		^{238}U	^{137}Cs	^{106}Ru	^{90}Sr	^{60}Co	^{3}H	^{14}C	^{154}Eu	Other[aa] Radionuclides	^{238}Pu	^{239}Pu	^{240}Pu
216-Z-8 French Drain	2	—	—	—	—	—	—	—	—	1,373 (^{241}Am)	0.13	2.76	0.745
216-Z-13 French Drain	—	—	—	—	—	—	—	—	—	—	—	—	—
216-Z-14 French Drain	—	—	—	—	—	—	—	—	—	—	—	—	—
216-Z-15 French Drain	—	—	—	—	—	—	—	—	—	—	—	—	—
216-Z-1A Tile Field	57,000	—	0.16	5.2×10^{-6}	0.15	—	—	—	—	3,432 (^{241}Am)	—	137	37
Reverse Well													
216-Z-10 Reverse Well	50	—	—	—	—	—	—	—	—	bb	0.14	2.85	0.77
Ponds, Ditches, and Trenches													
216-Z-4 Trench	2	1.7×10^{-5}	0.035	2.7×10^{-14}	0.033	—	—	—	—	—	—	—	—
216-Z-9 Trench	48,000	1.7×10^{-5} 2.0×10^{-5}	0.052 (0.0556)	1.9×10^{-8}	0.049 (0.0535)	0.00395	—	—	—	8,580 (^{241}Am)	—	2,190	590
216-Z-17 Trench	50	5.0×10^{-5}	—	—	—	—	—	—	—	—	—	2.87	0.225
Septic Tanks and Associated Drain Fields													
2607-Z Septic Tank and Drain Field	—	—	—	—	—	—	—	—	—	—	—	—	—
2607-Z-1 Septic Tank and Drain Field	—	—	—	—	—	—	—	—	—	—	—	—	—
2607-WA Septic Tank and Drain Field	—	—	—	—	—	—	—	—	—	—	—	—	—
2607-WB Septic Tank and Drain Field	—	—	—	—	—	—	—	—	—	—	—	—	—

Table 2-2. Z Plant Aggregate Area Waste Management Unit Radionuclide Waste Inventory Summary. (Sheet 3 of 4)

Waste Management Unit	Total Pu in gm	Quantity of Reported Radionuclides in Unit in Ci[a]											
		^{238}U	^{137}Cs	^{106}Ru	^{90}Sr	^{60}Co	^{3}H	^{14}C	^{154}Eu	Other[e] Radionuclides	^{238}Pu	^{239}Pu	^{240}Pu
2607-W-8 Septic Tank and Drain Field	—	—	—	—	—	—	—	—	—	—	—	—	—
Transfer Facilities, Diversion Boxes, and Pipelines													
241-Z Diversion Box No. 1	—	—	—	—	—	—	—	—	—	—	—	—	—
241-Z Diversion Box No. 2	—	—	—	—	—	—	—	—	—	—	—	—	—
231-Z-151 Sump	—	—	—	—	—	—	—	—	—	—	—	—	—
Basins													
207-Z Retention Basin	—	—	—	—	—	—	—	—	—	—	—	—	—
216-Z-21 Seepage Basin	—	—	—	—	—	—	—	—	—	—	—	—	—
Burial Sites													
218-W-1 Burial Ground	94,000	0.0235	1.63 (4.15)	8.83×10^{12} (4.3)	1.44 (3.88)	—	—	—	—	—	—	5,370	1,450
218-W-1A Burial Ground	2,000	0.302	359 (997)	5.23×10^{9} (1,030)	359 (932)	—	—	—	—	—	—	114	30.8
218-W-2 Burial Ground	126,000	46.9	4.86 (10.4)	5.72×10^{10} (10.8)	4.1 (9.7)	—	—	—	—	—	—	7,190	1,940
218-W-2A Burial Ground	—	—	2,766	0.0025	2,467	0.33	—	—	—	—	—	—	—
218-W-3 Burial Ground	68,000	23.5	9.15 (18.7)	1.31×10^{8} (19.3)	8.15 (17.5)	—	—	—	—	—	—	3,880	1,050
218-W-3A Burial Ground	29,300	—	302,000	12.7	101,000	9,840	178,000	1.74	0.145	3,960	—	—	—
218-W-3AE Burial Ground	122	—	14,300	0.0268	4,240	299	19,500	0.321	0.141	10.5	—	—	—
218-W-4A Burial Ground	35,400	—	39.3	8.42×10^{-6}	35.4	—	—	—	—	1.18	—	—	—

Table 2-2. Z Plant Aggregate Area Waste Management Unit Radionuclide Waste Inventory Summary. (Sheet 4 of 4)

		Quantity of Reported Radionuclides in Unit in Ci[a]											
Waste Management Unit	Total Pu in gm	^{238}U	^{137}Cs	^{106}Ru	^{90}Sr	^{60}Co	^{3}H	^{14}C	^{154}Eu	Other** Radionuclides	^{238}Pu	^{239}Pu	^{240}Pu
218-W-4B Trenches	48,800 [2089.74]	—	6,410	390	89,700	—	68,500	—	—	60	—	—	—
218-W-4B Caissons	7,290	—	12,340	216	11,000	76,000	786	—	0.211	—	—	—	—
218-W-4C Burial Ground	383,000 [3613.80]	—	165,000	927	111,000	221,000	25.1	7.85	288	11,600	—	—	—
218-W-5 Burial Ground	154	—	1,500	1.58	1,350	3,410	15,200	4.29	108	67.7	—	—	—
218-W-6 Burial Ground	—	—	—	—	—	—	—	—	—	—	—	—	—
218-W-11 Burial Ground	—	—	0.0020	1.6×10^{-9}	0.0009	—	—	—	—	—	—	—	—
Z Plant Burn Pit	—	—	—	—	—	—	—	—	—	—	—	—	—

Notes:

a Curies decayed through 1989, except burial ground waste units, which are decayed through December 31, 1990.
b Estimated quantity present in waste stream, amount retained in settling tank is unknown.
Data obtained from WHC 1991a and Anderson et al. 1991.
Data presented in parentheses obtained from Stenner et al. 1988.
Data presented in brackets obtained from Jensen 1990.
aa Also received 1.0 Ci of ^{241}Am, 1.9 Ci of ^{241}Pu, and 0.00004 Ci of ^{242}Pu.
bb Also received 1.0 Ci of ^{241}Am, 2.0 Ci of ^{241}Pu, and 0.00004 Ci of ^{242}Pu.
** Other radionuclides are discussed in Section 2.3.9.
— indicates no applicable data found during document review.
Waste inventories indicate materials disposed of at waste management units indicated. Not all facilities listed released radionuclides to the environment.

Table 2-3. Z Plant Aggregate Area Waste Management Unit Chemical Waste Inventory Summary. (Sheet 1 of 3)

Waste Management Unit	Quantity of Reported Chemical in Unit in kg[a]													
	Carbon tetra chloride	Tributyl-phosphate	DBBP	Nitrate	Sodium	Fluoride	Calcium Nitrate	Magnesium Nitrate	Nitric Acid	Aluminum Fluoride Nitrate	Aluminum Nitrate	Ferric Nitrate	Sulfate	Sodium Hydroxide
Plant, Buildings, and Storage Areas														
232-Z Incinerator	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Tanks and Vaults														
216-Z-8 Settling Tank	–	–	–	–	–	–	–	–	–	–	–	–	–	–
241-Z-361 Settling Tank	–	–	–	–	–	–	–	–	–	–	–	–	–	1,000
241-Z Treatment Tank	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Cribs and Drains														
216-Z-1 & 216-Z-2 Cribs	–	–	–	100,000	80,000	30,000	–	–	–	–	–	–	–	–
216-Z-3 Crib	–	–	–	600,000	400,000	160,000	–	–	–	–	–	–	–	–
216-Z-5 Crib	–	–	–	100,000	100,000	–	–	–	–	–	–	–	–	–
216-Z-6 Crib	–	–	–	130	50	–	–	–	–	–	–	–	–	–
216-Z-7 Crib	–	–	–	20,000	–	–	–	–	–	–	–	–	–	–
216-Z-12 Crib	–	–	–	900,000	600,000	300,000	–	–	–	–	–	–	–	–
216-Z-16 Crib	–	–	–	–	–	–	–	–	–	–	–	–	–	–
216-Z-18 Crib	173,800	22,000	15,000	500,000	200,000	–	130,000	170,000	37,000	200,000	170,000	37,000	10,000	–
216-Z-8 French Drain	–	–	–	–	–	–	–	–	–	–	–	–	–	–
216-Z-13 French Drain	–	–	–	–	–	–	–	–	–	–	–	–	–	–
216-Z-14 French Drain(b)	–	–	–	–	–	–	–	–	–	–	–	–	–	–
216-Z-15 French Drain(b)	–	–	–	–	–	–	–	–	–	–	–	–	–	–
216-Z-1A Tile Field	268,000	30,000	20,300	3,000	900	900	–	–	–	–	–	–	–	–

Table 2-3. Z Plant Aggregate Area Waste Management Unit Chemical Waste Inventory Summary. (Sheet 2 of 3)

	Quantity of Reported Chemical in Unit in kg[a]													
Waste Management Unit	Carbon tetra chloride	Tributyl-phosphate	DBBP	Nitrate	Sodium	Fluoride	Calcium Nitrate	Magnesium Nitrate	Nitric Acid	Aluminum Fluoride Nitrate	Aluminum Nitrate	Ferric Nitrate	Sulfate	Sodium Hydroxide
Reverse Well														
216-Z-10 Reverse Well	–	–	–	100	30	–	–	–	–	–	–	–	–	–
Ponds, Ditches, and Trenches														
216-Z-4 Trench	–	–	–	–	–	–	–	–	–	–	–	–	–	–
216-Z-9 Trench	131,140 471,000	–	–	500,000	200,000	–	130,000	180,000	39,000	210,000	190,000	40,000	10,000	–
216-Z-17 Trench	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Septic Tanks and Associated Drain Fields														
2607-Z Septic Tank and Drain Field	–	–	–	–	–	–	–	–	–	–	–	–	–	–
2607-Z-1 Septic Tank and Drain Field	–	–	–	–	–	–	–	–	–	–	–	–	–	–
2607-WA Septic Tank and Drain Field	–	–	–	–	–	–	–	–	–	–	–	–	–	–
2607-WB Septic Tank and Drain Field	–	–	–	–	–	–	–	–	–	–	–	–	–	–
2607-W-8 Septic Tank and Drain Field	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Transfer Facilities, Diversion Boxes, and Pipelines														
241-Z Diversion Box No. 1	–	–	–	–	–	–	–	–	–	–	–	–	–	–
241-Z Diversion Box No. 2	–	–	–	–	–	–	–	–	–	–	–	–	–	–
231-Z-151 Sump	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Basins														
241-Z Retention Basin	–	–	–	–	–	–	–	–	–	–	–	–	–	–
216-Z-21 Seepage Basin	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Burial Sites														
218-W-1 Burial Ground	–	–	–	–	–	–	–	–	–	–	–	–	–	–
218-W-1A Burial Ground	–	–	–	–	–	–	–	–	–	–	–	–	–	–
218-W-2 Burial Ground	–	–	–	–	–	–	–	–	–	–	–	–	–	–

Table 2-3. Z Plant Aggregate Area Waste Management Unit Chemical Waste Inventory Summary. (Sheet 3 of 3)

	Quantity of Reported Chemical in Unit in kg[d]													
Waste Management Unit	Carbon tetra chloride	Tributyl-phosphate	DBBP	Nitrate	Sodium	Fluoride	Calcium Nitrate	Magnesium Nitrate	Nitric Acid	Aluminum Fluoride Nitrate	Aluminum Nitrate	Ferric Nitrate	Sulfate	Sodium Hydroxide
218-W-2A Burial Ground	–	–	–	–	–	–	–	–	–	–	–	–	–	–
218-W-3 Burial Ground	–	–	–	–	–	–	–	–	–	–	–	–	–	–
218-W-3A Burial Ground	–	–	–	–	–	–	–	–	–	–	–	–	–	–
218-W-3AE Burial Ground	–	–	–	–	–	–	–	–	–	–	–	–	–	–
218-W-4A Burial Ground	–	–	–	–	–	–	–	–	–	–	–	–	–	–
218-W-4B Burial Ground	–	–	–	–	–	–	–	–	–	–	–	–	–	–
218-W-4C Burial Ground	–	–	–	–	–	–	–	–	–	–	–	–	–	–
218-W-5 Burial Ground	–	–	–	–	–	–	–	–	–	–	–	–	–	–
218-W-6 Burial Ground	–	–	–	–	–	–	–	–	–	–	–	–	–	–
218-W-11 Burial Ground	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Z Plant Burn Pit	–	–	–	–	–	–	–	–	–	–	–	–	–	–

Notes:

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

b Additional organics received
65 kg benzenes and halobenzenes
840 kg toxic process chemicals
437 kg acids
14.06 kg poison lab chemicals
7.51 kg misc. and lab chem
127 kg paints, thinners, resins, asphalt
280 kg nonflammable refrigerant gas
Amounts indicated are units that have been stored on the 234-5Z-1/WSA.
They do not represent a release or disposal to the unit.

c Additional inorganics received
50 kg $NaCr_3$
100 kg $Na_2C_2O_4$
100 kg $NaNH_2SO_3$

d Maximum of range estimated in DOE/RL 1991b.

- indicates no applicable data found during document review.

Waste inventories indicate materials disposed of at waste management units. Not all facilities listed released radionuclides to the environment.

* Value obtained using density of CCl_4 = 1.58 kg/L

Data obtained from WHC 1991a.

Table 2-4. Service History of the 216-Z-1A Tile Field.

SERVCE DATES		
FROM	TO	FUNCTION
6/49	6/52	216-Z-1 and 216-Z-2 Cribs and the 216-Z-1A Tile Field received process, analytical, and development lab wastes from 234-5Z Building via the 241-Z-361 Settling Tank.
6/52	3/59	216-Z-1 and 216-Z-2 Cribs were bypassed. 216-Z-1A Tile Field received the above wastes via overflow from 216-Z-3 Crib.
3/59	5/64	All portions of this site were inactive.
5/64	8/64	216-Z-1 and 216-Z-2 Cribs were still inactive. 216-Z-1A Tile Field received aqueous and organic waste from PRF (236-Z Building).
8/64	5/66	Same as above plus received 242-Z Building Waste and Americium Recovery (242-Z) waste.
5/66	6/66	216-Z-1 and 216-Z-2 Cribs and 216-Z-1A Tile Field received 236-Z Building aqueous and organic waste and 242-Z Building waste while the distribution point in 216-Z-1A Tile Field was moved from the A section 30.5 m (100 ft) down the main trunk to the B section.
6/66	10/67	216-Z-1 and 216-Z-2 Cribs were inactive; section B of the 216-Z-1A Tile Field received aqueous and organic waste from 236-Z Building and from the 242-Z Building, while the discharge point on 216-Z-1A was moved 23 m (75 ft) further down the main trunk.
10/67	10/67	216-Z-1 and 216-Z-2 Cribs received 236-Z and 242-Z Building wastes while the discharge point in the 216-Z-1A Tile Field was moved 23 m (75 ft) further down the main trunk from the B section to the C section.
10/67	3/68	216-Z-1 and 216-Z-2 Cribs were inactive; 216-Z-1A Tile Field received 236-Z and 242-Z Building wastes.
3/68	4/69	216-Z-1A Tile Field continued to receive the above wastes; 216-Z-1 and 216-Z-2 Cribs received uranium wastes from 236-Z Building.
4/69	-	All portions of the 216-Z-1, 216-Z-2, 216-Z-3 Cribs and 216-Z-1A Tile Field were retired.

Table 2-5. Partial Inventory of Hazardous Constituents Disposed of to the 218-W-3A, 218-W-3AE, 218-W-4C, and 218-W-5 Burial Grounds. (Sheet 1 of 3)

218-W-3A	
Constituent	Minimum Inventory in kg (lb)
Lead	6,764.10 (14,899.0)
Beryllium	0.16 (0.36)
Mercury	0.95 (2.09)
Oil	4.99 (11.00)
Xylene-toluene	213.38 (470.00)
Slaked lime	14.07 (31.00)
Tar	124.85 (275.00)
Copper	18.43 (40.60)
Uranium hexafluoride	0.09 (0.20)
Hexanol	317.80 (700.00)
Toluene	2,236.86 (4,927.00)
Polyurethane	22.70 (50.00)
Cadmium	1.11 (2.44)
Naphthylamine tritium	102.15 (225.00)
Xylene/pseudocumene	13.62 (30.00)
Naphthalene	135.29 (298.00)
Pseudocumene	150.27 (331.00)
Ethylene glycol	4.99 (11.00)
Glycerine	9.99 (22.00)
Isopropanol	8.76 (19.30)
Tributylphosphate	19.02 (41.90)
Xylene	281.03 (619.00)
Dibutyl phosphate	4.20 (9.26)
Isopropyl alcohol	30.15 (66.40)
Tetrahydro furan	0.90 (1.98)
Hexane	4.99 (11.00)
Normal parafin hydrocarbons	7.40 (16.30)
Trioctyl phosphine	5.86 (12.90)
Acetonitrile	75.36 (166.00)
Carbon tetrachloride	7.49 (16.50)
Kerosene	3.75 (8.27)
Barium	9.08 (20.00)
Chromium	3.63 (8.00)
Silver	2.27 (5.00)
Aliquat 336	0.81 (1.79)
Butyl acetate	2.36 (5.20)
Ethanol	0.83 (1.83)
Methanol	23.84 (52.50)

Table 2-5. Partial Inventory of Hazardous Constituents Disposed of to the 218-W-3A, 218-W-3AE, 218-W-4C, and 218-W-5 Burial Grounds. (Sheet 2 of 3)

218-W-3A	
Constituent	Minimum Inventory in kg (lb)
Cyclohexane	1.02 (2.29)
Cyclohexanone	4.34 (9.57)
Ethanolamine	1.02 (2.29)
Amalgamated Mercury	0.45 (1.00)
Lead shielding	8,006.74 (17,636.00)
218-W-3A-E	
Constituent	Minimum Inventory in kg (lb)
Lead	7,028.37 (15,481.00)
Asbestos	1.36 (3.00)
Copper	2,464.31 (5,428.00)
Freon II	127.12 (280.00)
Mercury	98.06 (216.00)
Charcoal	2,179.20 (4,800.00)
Sulfuric acid	0.23 (0.50)
Chromium	202.03 (445.00)
Sodium fluoride	24,836.07 (54,705.00)
Sodium hydroxide	3,250.19 (7,159.00)
Sodium nitrate	16,612.77 (36,592.00)
Beryllium	301.91 (665.00)
Potassium chloride	3,704.64 (8,160.00)
Potassium nitrate	2,288.16 (5,040.00)
Sodium chloride	3,704.64 (8,160.00)
Sodium nitrite	1,797.84 (3,960.00)
Perchloroethylene	3,622.92 (7,980.00)
Trichloroethene	905.73 (1,995.00)
Tar	5,059.38 (11,144.00)
Aluminum nitrate	9.08 (20.00)
Silver	0.90 (1.98)
Zirconium	2,304.50 (5,076.00)

Table 2-5. Partial Inventory of Hazardous Constituents Disposed of to the 218-W-3A, 218-W-3AE, 218-W-4C, and 218-W-5 Burial Grounds. (Sheet 3 of 3)

218-W-4C	
Constituent	Minimum Inventory in kg (lb)
Lead	265,775.23 (585,408.00)
Zirconium	136.2 (300.00)
Sodium	0.0045 (0.01)
Uranium hexafluoride	123.03 (271.00)
Nitric acid	0.67 (1.48)
Chromium	0.91 (2.00)
Mercury	0.91 (2.00)
Vinyl chloride	0.91 (2.00)
Paint thinner	4.54 (10.00)
Lead shielding	2,727.18 (6,007.00)
Sodium hydroxide	0.10 (0.22)
Slaked lime	8.17 (18.00)
Copper sulfate	26,395.56 (58,140.00)
Sodium diuranate	2,928.3 (6,450.00)
Sodium fluoride	17,597.04 (38,760.00)
Sodium nitrate	216,476.28 (476,820.00)
218-W-5	
Constituent	Minimum Inventory in kg (lb)
Oil	113.50 (250.00)
Lead	181.60 (400.00)
Lead brick	1,480.04 (3,260.00)
Lead shielding	227.00 (500.00)

Source: Solid Waste Information Management System.
Westinghouse Hanford Company, Richland, Washington.

Table 2-6. Summary of Unplanned Releases at the Z Plant Aggregate Area. (Sheet 1 of 6)

Unplanned Release No.	Location (Operable Unit)	Date	Associated Waste Management Unit	Reported Waste-Related History
UN-200-W-11	218-W-1 Burial Ground (200-ZP-3)	1952	218-W-1 Burial Ground	• A fire in the Burial Ground spread plutonium contamination in the vicinity of Z Plant (Stenner et al. 1988). • Remedial actions, if any, were not identified. • PNL Hazard Ranking: Potentially low scoring; insufficient information to score.
UN-200-W-23	234-5Z Building (200-ZP-1)	June 1953	na	• Waste box fire resulted in plutonium contamination of up to 10,000 d/m affecting 27.9 m^2 (300 ft^2) (Stenner et al. 1988). • Area was covered with black top and posted with access control signs. • PNL Hazard Ranking: 0.86
UN-200-W-44	Between REDOX facility and T Plant (200-ZP-3)	October 25, 1957	na	• Burial box fell from flat car while in transit contaminating area of 6.1 by 7.625 m (20 by 25 ft) along railroad tracks between REDOX facility and T Plant. • Release was of unidentified beta/gamma source with readings of 2 mrem/hr. • Remedial actions were not identified. • Location not indicated. • PNL Hazard Ranking: 0.86
UN-200-W-74	241-Z Building (200-ZP-1)	May 18, 1976	241-Z Treatment Tank	• The line from the effluent header D-3 to the D-8 tank inside the building leaked alpha waste to a small area of approximately 125 cm^2 (20 $in.^2$) below an overground polyethylene line. • Maximum readings of the waste were 8,000 dis/min. • Contaminated soil was picked up and packaged for burial. • PNL Hazard Ranking: 0.98
UN-200-W-75	241-Z Building (200-ZP-1)	January 9, 1975	241-Z Treatment Tank	• Equipment in the D-7 Sample Cabinet contaminated by an unidentified beta/gamma source resulted in contamination of 21.35 m^2 (70 ft^2) near 241-Z Building. • Direct readings ranged from 2,000 to greater than 40,000 dis/min and smearable readings reached 20,000 dis/min. • Contaminated dirt was removed and placed in 55 gallon drums for burial. • PNL Hazard Ranking: 0.82

Table 2-6. Summary of Unplanned Releases at the Z Plant Aggregate Area. (Sheet 2 of 6)

Unplanned Release No.	Location (Operable Unit)	Date	Associated Waste Management Unit	Reported Waste-Related History
UN-200-W-79	pH line leading to 241-Z Treatment Tank (200-ZP-1)	October 6, 1978	241-Z Treatment Tank	• Two 5-foot-square areas were affected by leak in pH line: an area under the pH meter lines and an area north of the D-7 and D-8 sample cabinets (WHC 1991a). • Alpha readings indicated 500 to 2,000 dis/min. • Decontamination at the areas was reportedly completed October 30, 1978 (WHC 1991a). • PNL Hazard Ranking: 1.20
UN-200-W-89	236-Z Building (200-ZP-1)	May 29, 1985	na	• Recycle Container fell from forklift platform spilling onto 0.239 m^2 (3 ft^2) area of asphalt at southeast corner of 236-Z Building. • Alpha readings indicated contamination up to 50,000 dis/min. • The Recycle Container was double-bagged and placed in a burial box. • WHC (1991a) reports that area was decontaminated to background levels and released April 4, 1985. • PNL Hazard Ranking: Not scored
UN-200-W-90	236-Z Building (200-ZP-1)	May 2, 1985	na	• Radioactive material spilled while loading pipe sections into burial boxes affecting about 6.51 m^2 (70 ft^2) of 236-Z Building. • Alpha readings of contamination reached 10,000 dis/min. • Area was decontaminated to background levels (WHC 1991a). • PNL Hazard Ranking: Not scored
UN-200-W-91	234-5Z Building (200-ZP-1)	December 11, 1985	na	• Recycle Container overturned during transport affecting area of unknown size near the 234-5Z Building. • Alpha readings in affected area reached 20,000 dis/min. • Due to snow cover on the ground, the area was covered and contained with plastic. • PNL Hazard Ranking: Insufficient information to score

Table 2-6. Summary of Unplanned Releases at the Z Plant Aggregate Area. (Sheet 3 of 6)

Unplanned Release No.	Location (Operable Unit)	Date	Associated Waste Management Unit	Reported Waste-Related History
UN-200-W-103	236-Z Building (200-ZP-1)	April 1971	na	• Approximately 0.01 kg of plutonium was released from a broken crib line running from the 234-5Z Building to the 216-Z-18 Crib about 3.66 m (12 ft) west and 1.83 m (6 ft) south of the 236-Z Building. • Gross alpha contamination was found to be at 76 million dis/min per 100 cm^3 of ground. • For remedial action, approximately one hundred 55-gallon drums of soil were removed and buried in one of the 200 West burial grounds. • Plutonium contamination may still be present under 1.83 m (6 ft) of clean fill soil. • PNL Hazard Ranking: 1.04
UN-200-W-130	231-Z-151 Sump near 231-Z Building (200-ZP-2)	January 20, 1967	231-Z-151 Sump	• An excavation uncovered a leaking flange. • Extent of contamination limited to soil around the waste line on the east side of the 231-Z-151 Sump. • Alpha, beta, and gamma readings of up to 40,000 dis/min alpha, 100 mrem/hr beta, and 500 mrem/hr gamma were reported. • For remediation, the waste line was repaired and covered with 15 cm (6 in.) of clean soil. • PNL Hazard Ranking: Potentially low scoring; insufficient information to score
UN-200-W-132	218-W-4C Burial Ground (200-ZP-3)	July 6, 1956	241-UR-151 Diversion Box	• An estimated 1,900 liters of uranium feed solution for the TBP process overflowed the 241-UR-151 Diversion Box (WHC 1991a) affecting two areas approximately 11.2 and 41.92 m^2 (120 and 145 ft^2). • Affected area was excavated and backfilled after radiation survey. • PNL Hazard Ranking: 1.04
UN-200-W-159	Near Z Plant (200-ZP-1)	May 1985	na	• Unknown amount of 50 percent aqueous sodium hydroxide spilled to the ground from the PFP process line (WHC 1991a). • The soil was removed, packaged, and disposed of off site. • PNL Hazard Ranking: Not scored

Table 2-6. Summary of Unplanned Releases at the Z Plant Aggregate Area. (Sheet 4 of 6)

Unplanned Release No.	Location (Operable Unit)	Date	Associated Waste Management Unit	Reported Waste-Related History
UPR-200-W-16	218-W-4A Burial Ground (200-ZP-3)	July 9, 1952	218-W-4A Burial Ground	• A dry waste fire in the burial ground spread contamination outside the burial trench (Stenner et al. 1988). • Contamination extended over area in the burial ground and to the east and west of the trench. • Maximum readings for plutonium were 200,000 dis/min inside the burial ground and 30,000 dis/min outside. • Contaminated soil on south side of trench was bulldozed into the trench. Ground on the north side was stabilized with road oil. Nearby roads were washed down with water to remove spotty contamination. • PNL Hazard Ranking: 0.86
UPR-200-W-26	218-W-4A Burial Ground (200-ZP-3)	November 27, 1953	218-W-4A Burial Ground	• Burial operations caused spotty contamination in burial ground (Stenner et al. 1988). Ruthenium affected an area near the burial ground and along the 200 West Area railroad line. • Ruthenium readings in affected area outside burial ground were from 600 mrem/hr to 2 rem/hr. • Remedial actions were not identified. • PNL Hazard Ranking: Not scored
UPR-200-W-45	218-W-2A Burial Ground (200-ZP-3)	November 6, 1957	218-W-2A Burial Ground	• Wooden burial box collapsed during burial (Stenner et al. 1988) affecting an estimated 80 hectares (200 acres) within the 200 West Area and 648 hectares (1,600 acres) outside the 200 West Area with ruthenium contamination. • Maximum ruthenium contamination readings were 1,100 mrem/hr (WHC 1991a). • Most of grossly-contaminated burial ground was restored to normal use by plowing, road grading, and water flushing. Adjacent road surfaces were flushed with water. Uncleaned contaminated areas were posted as radiation zones (WHC 1991a). • PNL Hazard Ranking: Not scored due to radionuclide decay

Table 2-6. Summary of Unplanned Releases at the Z Plant Aggregate Area. (Sheet 5 of 6)

Unplanned Release No.	Location (Operable Unit)	Date	Associated Waste Management Unit	Reported Waste-Related History
UPR-200-W-53	218-W-4A Burial Ground (200-ZP-3)	January 8, 1959	218-W-4A	• Burial box containing REDOX cell jumpers collapsed during backfilling operations in the burial ground affecting about 100 hectares (250 acres), primarily with ruthenium (Stenner et al. 1988). • Readings ranged from 50 mR/hr at the burial site to 60,000 ct/m at T Plant. Readings east of the limited area fence were up to 400 c/m. • Contamination occurred in area extending east from the burial ground to within 274.5 m (300 yd) of the east perimeter fence. • For remediation, contaminated roads were washed down with water from tank truck. Contamination was generally fixed in a 5 cm (2 in.) layer of snow. Burial ground and several hundred yards to the east were plowed to further fix contamination. • PNL Hazard Ranking: Not scored because of radionuclide decay
UPR-200-W-72	218-W-4A Burial Ground (200-ZP-3)	October 21, 1975	218-W-4A Burial Ground	• Buried lab waste described as gross alpha and mixes fission products was accidentally disturbed resulting in contamination of a 15.25 by 15.25 m (50 by 50 ft) area (Stenner et al. 1988). • Beta/gamma readings of 100,000 ct/min and alpha readings of up to 70,000 dis/min were obtained. • For remedial action, the contaminated waste was picked up and the area was covered with 15 cm (6 in.) of sand, a layer of urea bone, a layer of 10 mil plastic, 30 to 35 cm (12 to 14 in.) of dirt, and 7.5 to 10 cm (3 to 4 in.) of rock. • PNL Hazard Ranking: Not scored
UPR-200-W-84	218-W-1 Burial Ground (200-ZP-3)	July 23, 1980	na	• A liquid spill of an unknown beta/gamma source during burial of a pump resulted in contamination of the floor of the burial trench (Stenner et al. 1988). • Readings indicated maximum contamination of 2,000 mrem/hr. • For remediation, contaminated soil was picked up and placed in the burial trench. • Location indicated on Figure 2-13-suspect. • PNL Hazard Ranking: Release disposed to engineering facility - not scored

Table 2-6. Summary of Unplanned Releases at the Z Plant Aggregate Area. (Sheet 6 of 6)

Unplanned Release No.	Location (Operable Unit)	Date	Associated Waste Management Unit	Reported Waste-Related History
UPR-200-W-134	218-W-1 Burial Ground (200-ZP-3)	October 27, 1975	na	• A waste drum labeled "transuranic" was inappropriately buried in the 218-W-1 Burial Ground (WHC 1991a). • Although no release to the environment occurred at this time, the handling and storage of the material did not meet standards. • For remedial actions, Atlantic Richfield Hanford Company (ARHCO) personnel were contacted to assure that the location of the burial was determined as accurately as possible and that no operations would be performed that might make retrieval of the drum move difficult. • PNL Hazard Ranking: Release disposed of to engineering facility - not scored
UPR-200-W-158	218-W-1A Burial Ground (200-ZP-3)	June 10, 1960	na	• A burial box containing solid mixed waste collapsed during burial causing spotty ground contamination (WHC 1991a). Contamination reportedly spread generally east and southeast as far as 4.85 km (3 ml) beyond the limited fence area. • Beta/gamma readings ranged from 60 mrem/hr at the burial site to approximately 1,000 ct/min outside the limited area. • PNL Hazard Ranking: 0.82

Note: na - not available

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

Process	Waste Generated	Major Chemical Constituents	Ionic Strength	pH	Organic Concentration	Radioactivity
Plutonium Finishing Plant (PFP)	Process Waste	Nitric acid, nitrate salts, fluoride	high	acidic (pH 2) neutralized before disposal	low	low (Pu and TRU)
	Wastewater	Sodium, fluoride, sulfate	low	neutral	low	trace alpha
RECUPLEX	Aqueous process waste	Nitric acid, fluorides, nitrates, phosphate	high	acidic	low	low
	Organic solvent waste	CCl_4, TBP, DBBP	low	slightly acidic	high	intermediate (Pu and TRU)
	Spent silica gel	Silica gel, Pu	unknown	unknown	unknown	TRU
Plutonium Reclamation Facility (PRF)	Aqueous process waste	Nitric acid, fluorides, nitrates, phosphate	high	acidic	low	low
	Organic process waste	CCl_4, TBP, DBBP	low	slightly acidic	high	intermediate (Pu and TRU)
Americium Recovery	Spent ion exchange resin	^{241}Am, resin	high	unknown	unknown	unknown (^{241}Am)
Analytical laboratory	Laboratory process wastes	Unknown	low	slightly acidic	unknown	unknown
	Used or discarded reagents	see Table 2-9 for potential contributors	unknown	unknown	moderate to low	unknown
	Wastewater	sanitary and lab water	low	neutral/basic after adjust	unknown	unknown
Plutonium Isolation Facility (PIF)	Process Waste	Nitric acid	unknown	unknown	low	low (Pu and TRU)
	Wastewater	Unknown	unknown	unknown	unknown	unknown

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

Inorganic Constituents	Radionuclides
Aluminum nitrate	Plutonium fluoride
Barium	Plutonium nitrate
Boron	Plutonium oxide
Calcium	Uranium
Chloride	^{241}Am
Chromium	^{137}Cs
Copper	^{238}Pu
Fluoride	^{239}Pu
Hydrofluoric acid	^{240}Pu
Iron	Ra
Magnesium	^{90}Sr
Mercury	^{234}U
Nickel	^{238}U
Nitrate	
Nitrate salts	
Potassium	
Silicon	
Sodium	
Sulfate	
Zinc	
Organic Constituents	
Acetone	
Caffeine	
Carbon tetrachloride	
Chloroform	
Decane	
Dibutyl phosphate (DBP)	
Dibutyl butyl phosphonate (DBBP)	
Monobutyl phosphate	
Tributyl phosphate (TBP)	

Table 2-9. Partial List of Chemicals Used in PFP Laboratories. (Sheet 1 of 2)

Compound Name	Formula
Acetic Acid	CH_3CO_2H
Acetone	$CH_3C_2H_3O$
Alizarin Yellow	$C_{14}H_8O_4$
Aluminum Nitrate Nonahydrate	$Al(NO_3)_3\text{-}9H_2O$
Aluminum Nitrate (Mono Basic)	$Al(OH)(NO_3)_2$
Aluminum Sulfate	$Al(SO_4)_3$
Ammonium Chloride	NH_4Cl
Ammonium Hydroxide	NH_4OH
Ammonium Oxalate	$(NH_4)_2C_2O_4$
Ammonium Sulfate	$(NH_4)_2SO_4$
Arsenazo III	Arsenic compounds
Boric Acid	H_3BO_3
Bromocresol Purple	C_7H_6OHBr
Carbon Tetrachloride	CCl_4
Ceric Ammonium Nitrate	$Ce(NH_4)_2(NO_3)_6$
Dibutylphosphate	$(n\text{-}C_4H_9)_2HPO_4$
Ferric Ammonium Sulfate	$FeNH_4SO_4$
Ferric Nitrate	$Fe(NO_3)_3\text{-}6H_2O$
Ferrous Ammonium Sulfate	$(NH_4)_2SO_4FeSO_4\text{-}6H_2O$
Ferrous Sulfamate	$Fe(SO_3NH_2)_2$
Hydrazine	$N_2H_4\text{-}H_2O$
Hydrobromic Acid	HBr
Hydrochloric Acid	HCl
Hydrofluoric Acid	HF
Hydrogen Peroxide	H_2O_2
Hydroiodic Acid	HI
Hydroxylamine Hydrochloride	$NH_2OH\text{-}HCl$
Hydroxylamine Nitrate	$NH_2OH\text{-}HNO_3$
Methanol	CH_3OH
Naphthylamine	$C_{10}H_9N$

Table 2-9. Partial List of Chemicals Used in PFP Laboratories. (Sheet 2 of 2)

Compound Name	Formula
Nitric Acid	HNO_3
Oxalic Acid	$HO_2CCO_2H\text{-}2H_2O$
Phosphoric Acid	H_3PO_4
Potassium Acetate	$KC_2H_3O_2$
Potassium Dichromate	K_2CrO_7
Potassium Iodate	KIO_3
Potassium Permanganate	$KMnO_4$
Silver Oxide	AgO
Sodium Bisulfate	$NaHSO_4$
Sodium Carbonate	Na_2CO_3
Sodium Fluoride	NaF
Sodium Hydroxide	$NaOH$
Sodium Nitrate	$NaNO_3$
Sodium Nitrite	$NaNO_2$
Sodium Oxalate	$Na_2C_2O_4$
Sodium Tartrate	$Na_2C_2H_4O_6\text{-}2H_2O$
Sulfamic Acid	NH_2SO_3H
Sulfonic Acid (chloro)	$ClHSO_3$
Sulfuric Acid	H_2SO_4
Thenoyltrifluoracetone	$(CH)_3SCOCH_2COCF_3$
Thymolphthalein	$C_{28}H_{30}O_4$
Toluene	$C_6H_5CH_3$
Tributylphosphate	$(C_4H_9)_3PO_4$
Tri-Iso-Octylamine	$C_{24}H_{51}N$
Tris (hydroxymethyl)Amino Methane	$(CH_2OH)_3CNH_2$
Xylene	$C_6H_4(CH_3)_2$

Table 2-10. Radionuclides and Chemicals Disposed of to Z Plant Aggregate Area Waste Management Units. (Sheet 1 of 2)

Radionuclides		
^{108}Ag	^{85}Kr	^{82}Sr
^{110}Ag	^{54}Mn	^{90}Sr
^{28}Al	^{93}Mo	^{182}Ta
^{241}Am	^{22}Na	^{99}Tc
^{243}Am	^{91}Nb	^{125m}Te
^{195}Au	^{93m}Nb	^{127}Te
^{133}Ba	^{94}Nb	^{129m}Te
^{7}Be	^{95}Nb	^{121}Te
^{10}Be	^{59}Ni	^{204}Ti
^{14}C	^{63}Ni	^{232}Th
^{45}Ca	^{237}Np	^{234}Th
^{109}Cd	^{32}P	^{170}Tm
^{141}Ce	^{231}Pa	^{233}U
^{144}Ce	^{212}Pb	^{234}U
^{36}Cl	^{214}Pb	^{235}U
^{243}Cm	^{147}Pm	^{236}U
^{244}Cm	^{210}Po	^{238}U
^{245}Cm	^{236}Pu	^{49}V
^{57}Co	^{239}Pu	^{87}Y
^{58}Co	^{240}Pu	^{88}Y
^{60}Co	^{226}Ra	^{90}Y
^{51}Cr	^{228}Ra	^{65}Zn
^{134}Cs	^{86}Rb	^{95}Zr
^{137}Cs	^{187}Re	
^{254}Es	^{103}Ru	
^{152}Eu	^{106}Ru	
^{154}Eu	^{35}S	
^{155}Eu	^{122}Sb	
^{55}Fe	^{124}Sb	
^{59}Fe	^{125}Sb	
^{153}Gd	^{126}Sb	
^{68}Ge	^{46}SC	
^{3}H	^{75}Se	
^{123}I	^{79}Se	
^{125}I	^{151}Sm	
^{129}I	^{113}Sn	
^{131}I	^{123m}Sn	
^{40}K		

Table 2-10. Radionuclides and Chemicals Disposed of to Z Plant Aggregate Area Waste Management Units. (Sheet 2 of 2)

Inorganic Chemicals	Organic Chemicals
Aluminum	Acetonitrile
Asbestos	Butyl acetate
Beryllium	Carbon tetrachloride
Aluminum fluoride	Charcoal
Aluminum nitrate	Creosote
Cadmium	Cyclohexane
Calcium nitrate	Cyclohexanone
Chromium	DDCP
Copper	Dibutyl butyl phosphonate
Copper sulfate	Dibutyl phosphate
Ferric nitrate	Ethanol
Fluoride	Ethanolamine
Lead	Ethylene glycol
Magnesium nitrate	Freon II
Mercury	Glycerine
Mercury - amalgamated	Graphite
Nitrate	Hexane
Nitric acid	Hexanol
Potassium chloride	Isopropanol
Potassium nitrate	Kerosene
Silver	Methanol
Slaked lime	Naphthylamine tritium
Sodium	Normal paraffins
Sodium chloride	Oil
Sodium diuranate	Paint thinner
Sodium fluoride	Perchloroethylene
Sodium hydroxide	Polychlorinated biphenyls
Sodium nitrate	Polyurethane
Sodium nitrite	Pseudocumene
Sulfate	Tar
Sulfuric acid	Tetrahydrofuran
Uranium hexafluoride	Toluene
Zirconium	Tributyl phosphate
	Trichloroethene
	Trioctyl phosphine
	Vinyl chloride
	Xylenes

Sources:

- WHC 1991a and Anderson et al. 1991

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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 Z 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 Z Plant Aggregate Area ranges from about 218 m (715 ft) along the western edge of the area near the 2702-W RMW storage complex, to about 210 m (690 ft) east of the 231-Z Building. A detailed topographic map of the area is provided in Plate 1. Much of the Aggregate Area slopes gently from west to east, although the northeastern part of the Aggregate Area slopes westward, toward the 216Y-9 Pond west of the T Plant complex. Topography in the southwestern corner of the Aggregate Area, near the 218-W-4C Burial Ground slopes to the west and southwest. There are no natural surface drainage channels within the Z Plant Aggregate 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 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 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 x 10^{11} m^3 (8.7 x 10^7 acre-ft) at the USGS gage and 1.6 x 10^{11} m^3 (1.3 x 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 x 10^7 m^3/yr (2.5 x 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 Z Plant Aggregate Area Surface Hydrology

No natural surface water bodies exist in the Z Plant Aggregate Area, which lies within the Yakima River System. The only existing man-made surface water bodies are the 216-Z-21 Seepage Basin and the 207-Z Retention Basin (Figure 2-11). As discussed in Section 2.3.8, the 216-Z-21 Seepage Basin is an unlined infiltration basin located approximately 100 m (328 ft) southeast of the 234-5Z building. The 207-Z Retention Basin consists of a pair of concrete-lined basins located approximately 60 m (197 ft) southeast of the 236-Z building.

The 200 West Area and specifically, the Z Plant Aggregate Area, is not in a designated floodplain. Calculations of probable maximum floods for the Columbia River and Cold Creek Watershed indicate that the 200 West Area is not expected to be inundated under maximum flood conditions (DOE/RL 1991c). The 216-Z-21 Seepage Basin represents minor, if any, flooding potential due to the permeable nature of the underlying soil which allows for rapid infiltration of surface water into the ground. The 207-Z Retention Basin may present some potential for flooding; no current outlets from the basin were identified. However, the low precipitation potential (0.16 m [0.52 ft] annual average) at the site suggests little likelihood of flooding of the 3.1 m (10 ft) deep basin.

3.4 GEOLOGY

The following subsections provide information pertaining to geologic characteristics of southcentral Washington, the Hanford Site, the 200 West Area, and the Z 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 Z Plant Aggregate Area geology (Section 3.4.3).

The geologic characterization of the Hanford Site, including the 200 West Area and Z 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 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 volcaniclastic 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 km^2 (63,000 mi^2) in Washington, Oregon, and Idaho and have an estimated volume of about 174,356 km^3 (40,800 mi^3) (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: volcaniclastics (Reidel and Fecht 1981; Smith et al. 1989), and siliciclastics (DOE 1988b). The volcaniclastics 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 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-gained 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 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 faces, 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 gniessic 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 rhythmites 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 Z Plant Aggregate Area Geology

The following subsections 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 Z 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 Z Plant Aggregate Area are presented on Figures 3-16 through 3-20. 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 Z 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 13 geologic logs from the Z 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 Z Plant Aggregate Area Management Study. The cross sections depict subsurface geology in the Z Plant Aggregate Area. For each cross section, locations of Z Plant Aggregate Area

waste management units are identified for reference. Figures 3-21 through 3-38 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 Z Plant Aggregate Area. The structure and isopach maps are included from Lindsey et al. (1991). Plate 1 should be consulted to identify locations of Z Plant Aggregate Area buildings 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 3-16). 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 Ridge interbed within the 200 West Area.

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 Z 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, 3-22, and 3-23). The top of unit A is relatively flat in the 200 Areas, 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 3-24 and 3-25). 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 Z Plant Aggregate Area, unit A reaches a thickness of more than 17 m (57 ft) in the southern part of the aggregate area, and apparently pinches out just north of the Z Plant Aggregate Area boundary. The lower mud sequence ranges in thickness from about 3.4 m (11 ft) in the northeast corner of the Z Plant Aggregate Area to about 33 m (110 ft) at the southwest corner of the aggregate area.

Isopach and structure contour maps of fluvial gravel unit E (Figures 3-26 and 3-27) and the upper unit (Figures 3-28 and 3-29) 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. These highs include the northern part of the Z Plant Aggregate Area. Several structural lows in the unit E gravels occur across the 200 West Area, including prominent depressions in the Z Plant Aggregate Area north and east of the main Z Plant building complex. The top of Unit E generally dips to the southeast and climbs to the northeast. Unit E thickness varies from about 109 m (358 ft) at the northern boundary of the Z Plant Aggregate Area to about 73 m (239 ft) at the southern boundary of the aggregate area. Intercalated lenticular beds of sand and silt occur throughout the 200 West Area, although predicting where they will occur is very difficult.

The upper unit of the Ringold Formation is present only in the western, northern, and central portion of the 200 West Area (Figures 3-16, 3-18 through 3-20, 3-28, and 3-29). Where the upper unit is present, the top generally dips to the south-southwest. The upper unit is absent on the west central and southern parts of the Z Plant Aggregate Area. The upper unit reaches of thickness of about 12 to 15 m (40 to 50 ft) at the northwest and northeast corners of the Z Plant Aggregate Area, and just north of the main Z Plant building complex.

3.4.3.3 Plio-Pleistocene Unit. The caliche-rich strata of the Plio-Pleistocene unit largely is restricted to the vicinity of 200 West Area, pinching out near the northern, eastern, and southern boundaries of the area (Figures 3-30 and 3-31). 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 200 West Area while it thins in the south-central and central parts of the area. Relatively thick portions of the unit (up to about 8 m (25 ft)) also occur near the main Z Plant building complex, and near the northern boundary of the aggregate area (about 12 m (39 ft)). Several prominent thin areas (about 1.5 m (5 ft) or less) occur south and west of the main Z Plant building complex. Although no erosional windows through the units have been encountered in boreholes, there is a possibility they exist, especially in areas where the unit thins. The top of the unit generally dips to the south and the southwest, although irregularities occur, especially in the southern part of the Z Plant Aggregate Area. In addition, fracturing in the carbonate is potentially common and interbedded carbonate-poor lithologies are found at many locations.

3.4.3.4 Pre-Missoula Gravels. As discussed in the Regional Stratigraphy section (Section 3.4.2) the Pre-Missoula Gravels are present only in the eastcentral Cold Creek syncline and at the east end of Gable Mountain anticline east and south of the 200 East Area. The gravels have not been identified in the 200 West Area.

3.4.3.5 Early "Palouse" Soil. Like the Plio-Pleistocene unit, the early "Palouse" soil is largely restricted to the vicinity of the 200 West Area (Figures 3-32 and 3-33). The unit pinches out in the west-central part of the 200 West Area and near the southern, eastern, and northern boundaries. Limited data from a small number of boreholes located west of the 200 West Area suggest that the unit extends to the west. The thickness of the unit varies. It is thickest in the southeast and southwest parts of the 200 West Area. Within the Z Plant Aggregate Area, the unit reaches a thickness of about 6 to 5.5 m (15 to 18 ft) in the southern part of the aggregate area. The unit is thinnest immediately adjacent to these thick intervals, and is apparently absent at two locations within the 200 West Area, north and west of the main Z Plant building complex in the Z Plant Aggregate Area. Across the 200 Areas, the top of the unit dips to the south, although it becomes fairly irregular over the southern part of the Z Plant Aggregate Area.

Although carbonate is present in the unit in the 200 Areas, no obvious caliches like those seen in the underlying Plio-Pleistocene unit are documented. The loess-like sediments of the early "Palouse" soil are uncemented.

3.4.3.6 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. 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 3-34 and 3-35). 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 silt-dominated 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 silt-dominated deposits become more common. The lower unit is not present over much of the northern part of the 200 West Area, and an area which includes the central north-south spine of the Z Plant Aggregate Area. Eroded zones through the lower fine unit are present to the east and west of the southern part of the Z Plant Aggregate Area. The eroded zones are elongate in a north-south direction. The lower unit dips irregularly across the 200 West Area. The lower

unit is up to about 19 m (62 ft) thick toward the western edge of the Z Plant Aggregate Area, and generally dips to the north, toward the area where the unit is not present.

The upper coarse-grained unit of the Hanford formation consists of interstratified gravel, sand, and lesser silt. 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 silt-dominated 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 (Figures 3-36 and 3-37). Local areas occur where thickness of the upper coarse unit exceeds 38 m (125 ft), including the southern part of the Z Plant Aggregate Area. The base of the unit is incised into the underlying strata of the lower fine unit where the unit is absent the upper coarse unit fills an erosional window, and fills scour areas. 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. Over most of the Z Plant Aggregate Area the top of the upper coarse-grained unit of the Hanford formation is at the ground surface.

3.4.3.7 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 3-38). Dunes are not generally well developed within the 200 West Area. In the Z Plant Aggregate Area these Holocene deposits are found only in localized areas.

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 Z Plant Aggregate Area are presented. The information presented in these sections is principally taken from the standardized text (Connelly et al. 1992, 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 volcaniclastic 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:

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

where

- $K(\theta)$ is the water-content-dependent unsaturated hydraulic conductivity in cm/s
- $\partial\varphi/\partial\theta$ is the slope of the soil-moisture retention curve $\varphi(\theta)$ 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 3-41.

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

An example of perching conditions is a perched zone that 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. The zone apparently exists because of historical waste water disposal to the 216-U-16 Crib. No wells appear to screen this zone in this portion of the site. The existence of the perched zone was inferred from the detection of contaminants disposed of to the 216-U-1 and 216-U-2 Cribs in a groundwater monitoring well completed downgradient of the 216-U-16 Crib.

Another area of known perched water is below the active portion of the 216-U-14 Ditch approximately 150 m southeast of the 241-U Tank Farm. Wells 299-W19-91, -92, and -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 on 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 299-W19-92 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.

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).

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 of the boreholes that this study used (for moisture content or other parameters) were located in the vicinity of the Z 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 $\pm$ 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 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 km^2 (100 mi^2) 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 m^3/day (3,700 acre-ft/day) versus 1,200,000 m^3/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, 216-Z-20 Crib, and the 216-Z-21 Seepage Basin) located within the U Plant and Z 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 3-42, 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 Z Plant Aggregate Area Hydrogeology

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

3.5.3.1 Hydrostratigraphy. As shown on Figure 3-43, the hydrostratigraphic units of concern beneath the Z 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 Z 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 Z Plant AAMSR Report, 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 is presented in the 200 West Groundwater AAMSR.

3.5.3.1.1 Vadose Zone. The vadose zone beneath the Z Plant Aggregate Area ranges in thickness from about 67 m (220 ft) along the southern part of the western Aggregate Area boundary to 58 m (190 ft) in the vicinity of the 216-Z-9 Crib 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 Z Plant building complex (Figure 3-42). As discussed in Section 3.5.2.4, the mound apparently originated from historical discharges to the U Pond, southwest of the Z Plant.

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 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.

Downward-moving moisture in the vadose zone, whether from precipitation recharge or artificial recharge, may accumulate on or within the Plio-Pleistocene and early "Palouse" soil units beneath the Z Plant Aggregate Area. The top of the Plio-Pleistocene Unit occurs at elevations ranging from 152 to 203 m (500 to 665 feet) (18 to 61 m [60 to 200 ft] below ground surface), or about 20 m (64 ft) above the unconfined aquifer at locations south and west of the main Z Plant building complex, and about 64 m (203 ft) above the unconfined aquifer near the northern corner of the Z Plant Aggregate Area. The early "Palouse" soil horizon is typically encountered at depths of between 35 to 45 m (120 to 140 ft) below ground surface, 15 to 20 m (50 to 70 ft) above the water table in the unconfined aquifer.

As an additional means of evaluating potential perched groundwater zones, soil moisture content data obtained during completion of recent Z Plant Aggregate Area groundwater monitoring wells in the burial ground areas (Goodwin and Bjornstad 1990) were reviewed. These wells include 299-W7-7, 299-W7-8, 299-W7-9, 299-W7-10, 299-W15-19, 299-W15-20, 299-W15-21, 299-W15-23, 299-W15-24, and 299-W15-26, and are identified on Figure 3-14. Soil moisture contents from the wells are presented in Table A-1. Table

A-1 presents the soil sample moisture contents (weight percent H_2O) by depth. Corresponding soil horizons and formation contacts have also been identified in the table to assist in assessing the distribution of soil moisture. Depths of sediment unit contacts for wells 299-W7-9, 299-W7-10, 299-W15-20, 299-W15-23, and 299-W18-26 in Table A-1 were taken from lithologic interpretations by Lindsey et al. (1991) for these wells (Figure 3-16). Depths of sediment unit contacts for wells 299-W7-7, 299-W7-8, 299-W15-19, 299-W15-21, and 299-W15-24 were inferred using well log information in Goodwin and Bjornstad (1990).

Soil moisture contents in Table A-1 range from 1 to 23 percent water by weight. Where the Plio-Pleistocene or Early "Palouse" units were encountered, increased soil moisture contents were associated with these units, compared to moisture contents for units above and below (wells 299-W7-8, 299-W7-9, 299-W15-21, and 299-W15-26). Also, for many of these wells, the moisture content in soil samples collected within or just above these units was 10 percent or greater. Elevated moisture contents (11 to 22 percent) were also noted locally in Hanford formation soils in wells 299-W7-8, 299-W15-20 and 299-W15-21. Conversions of the weight percent moisture data to volume percent, or bulk soil densities to facilitate this conversion were not found in the data and documents reviewed.

The trend toward increased soil moisture contents in the Plio-Pleistocene and Early "Palouse" soil may be an indication of a tendency for water retention within or above these units. Within the Hanford formation, elevated moisture contents may reflect very localized increased fines content of the soils. Additional evaluation of the soil moisture data (such as conversion from weight percent to volume percent moisture) would be needed to further evaluate the potential for moisture transport and to assess the potential for development of perched zones in the wells listed.

Perched water was reportedly encountered during drilling of groundwater monitoring well 299-W18-29. The well is located in the Z Plant Aggregate Area near the southern end of the 216-Z-20 Crib (see Figure 3-14 for location). 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 is likely due to waste disposal practices at the 216-Z-20 Crib.

3.5.3.2 Natural Groundwater Recharge. As discussed in Section 3.3.3, no natural surface water bodies exist within the Z Plant Aggregate Area. Therefore, the potential for natural groundwater recharge within the Z Plant Aggregate Area is limited to precipitation infiltration. No precipitation infiltration data were identified with specific reference to the Z 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 (0 to 4 inch) per year.

As suggested in Section 3.5.2.2, precipitation infiltration rates probably vary with respect to location within the Z 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. In general, however, relatively low to near-zero recharge rates are expected.

3.5.3.3 Groundwater Flow Beneath the Z Plant Aggregate Area. Within the Z Plant Aggregate Area, groundwater flow is generally toward the east, based on December 1990 Hanford wells groundwater elevation data similar to the June 1990 flow data from Kasza et al. (1990) (Figure 3-42). 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. Groundwater elevations across the central and northern portions of the Z Plant Aggregate Area are more or less steady.

3.5.3.4 Historical Effects of Operations. Data identified for this study were not sufficient to quantitatively evaluate the effect of wastewater discharges to the soil column from Z Plant Aggregate Area waste management units on groundwater flow in the unconfined aquifer. Calculations discussed in Section 4.1.8 suggest that wastewater discharged to the 216-Z-1, 216-Z-2, 216-Z-3, 216-Z-5, 216-Z-6, 216-Z-7, 216-Z-12, 216-Z-16, and 216-Z-18 Cribs; 216-Z-4, 216-Z-9, and 216-Z-17 Trenches; 216-Z-1A Tile Field; and 216-Z-10 Reverse Well may have infiltrated to the underlying unconfined aquifer. Although estimates of the total volume of fluid discharged to each of these facilities were found (Table 2-1), discharge rates were not identified. Therefore, estimating the potential water level rise associated with individual waste management units by means of a point source algorithm (e.g., the Theis equation) could not be done.

Comparison of total waste water discharges to the soil column from Z Plant Aggregate Area waste management units (exclusive of the 216-Z-20 Crib and the 216-Z-21 Seepage Basin) to that of U Plant Aggregate Area waste management units over the same period of record (1949 to present) indicates that at least until 1985, discharges to the U Ponds were several orders of magnitude greater than discharges to Z Plant Aggregate Area waste management units. Correspondingly greater historical groundwater impacts would be expected beneath the U Ponds.

Currently, an estimated 1.5×10^7 L/yr (4.0×10^6 gal/yr) of liquid are discharged to sanitary tile fields clustered around the Z Plant complex and approximately 5×10^8 L/yr (1.3×10^8 gal/yr) are discharged to the 216-Z-20 Crib and the 216-Z-21 Seepage Basin east of the Z Plant Building complex. These values may be as much as 15 percent of the annualized discharge rate (approximately 4×10^9 L/yr [1.1×10^9 gal/yr]) to the 216-U-10 Ponds System for the period 1944 to 1985. Therefore, continuing Z Plant complex wastewater discharges may contribute to the maintenance of the groundwater mound identified in the southern part of the Z Plant Aggregate Area.

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 caricinus*, *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 area 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, persistantsepal 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 occassions.

3.6.1.3.2 Birds. Over 235 species of birds have been documented to occur at the Hanford Site (Landeen 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 (*Tyranus 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 sparvarius*), 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 herodius*).

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 (*Phryosoma 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 3-4 as state and/or federal threatened and endangered such as the bald eagle (*Haliaeetus leucocephalus*), peregrine falcon (*Falco peregrinus*), American white pelican (*Pelecanus erythroryhnchos*), 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 Z Plant Aggregate Area is the location of the Z Plant building complex and its attendant facilities (e.g., 234-5Z Building, 231-Z Building, 242-Z Building and other structures) and the 218-W Solid Waste Burial Grounds.

Past activities at the Z Plant included plutonium separation from waste streams generated in other 200 Areas facilities and plutonium and americium recovery from in-plant waste streams. Historically, liquid waste generated in Z Plant was disposed of to various land disposal units. Low-level and mixed waste from Z Plant, other Hanford facilities, and off-site facilities was deposited in the 218-W Burial Grounds. Various storage facilities, offices, and laboratories are also located in Z Plant. Waste management units that remain active are noted in Table 2-1.

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

There are no consumptive use of groundwater within the Z 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, about 32 km (20 mi) to the southeast. The nearest water supply wells are located off site about 15 km (9.4 mi) to the northwest. The latter 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 is located near the 241-AY and 241-AZ Tank Farms in the 200 East Area.

3.7 HUMAN RESOURCES

The environmental conditions at the Z Plant Aggregate Area must be evaluated in relationship to the surrounding population centers and other human resources. A very brief summary of demography, archeology, 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 Z 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 archaeologic 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 Z 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 road which crosses diagonally through the vicinity. 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 Z Plant AAMS. 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.

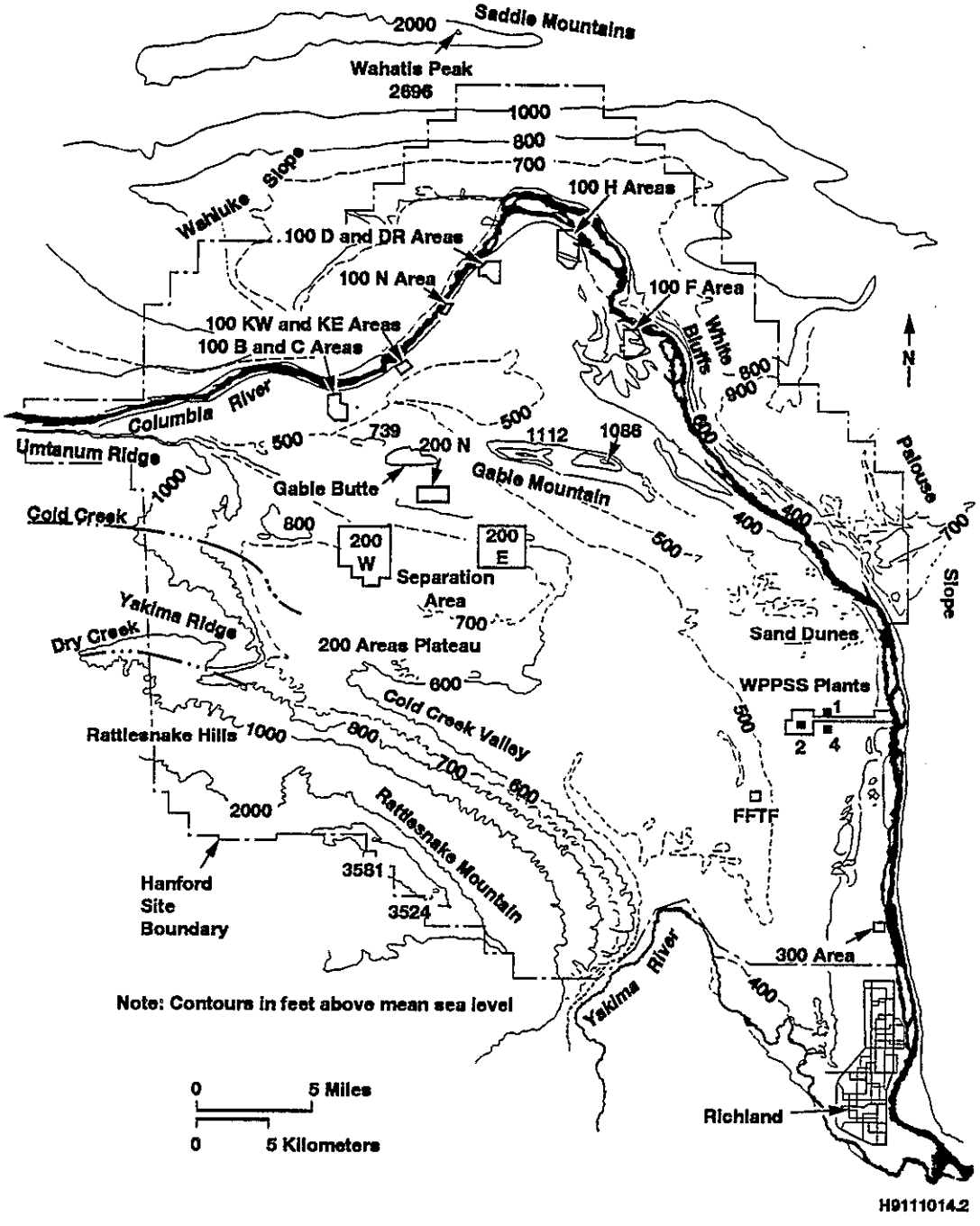

Figure 3-1. Topography and Location Map for the Hanford Site.

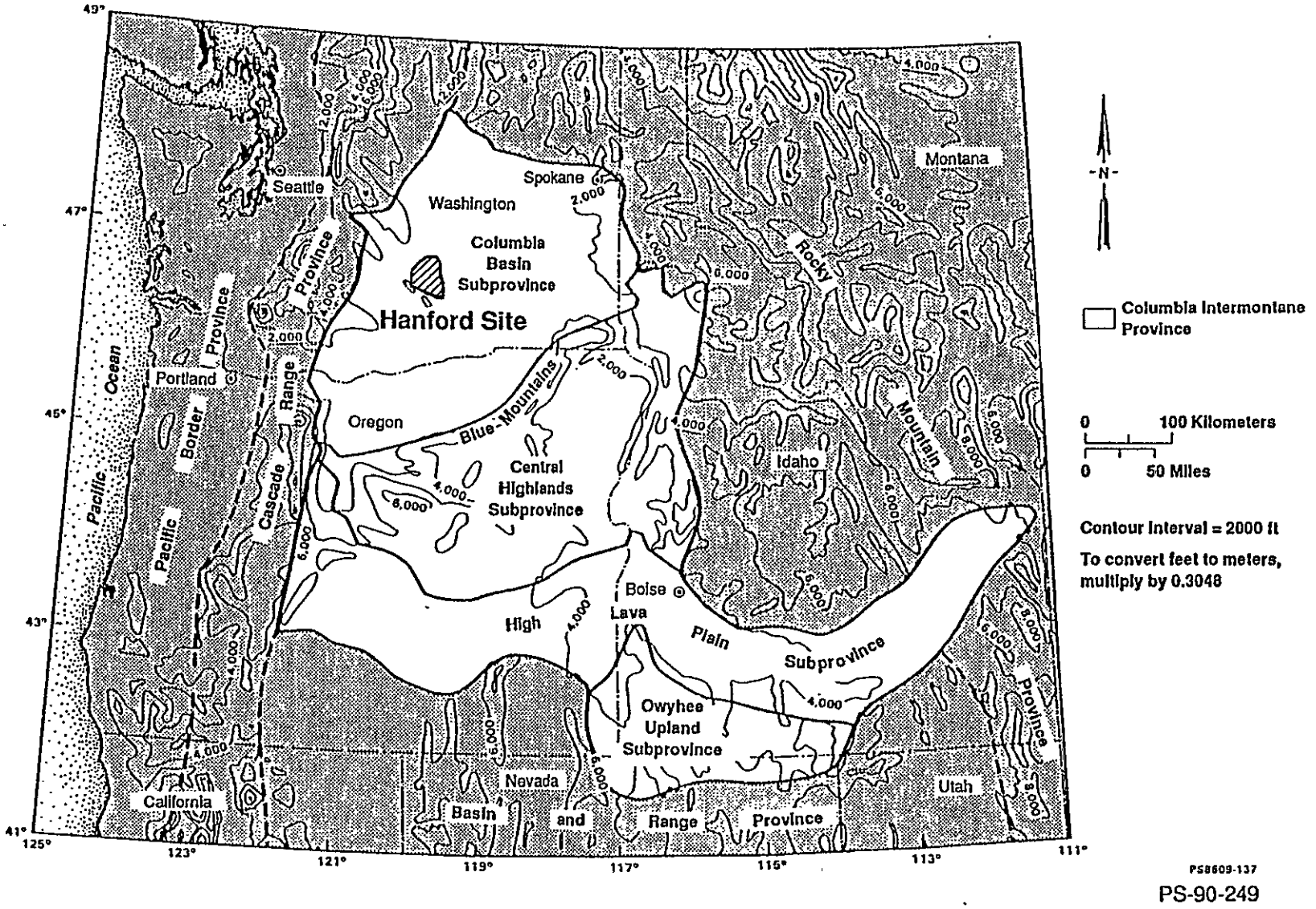

Figure 3-2. Divisions of the Columbia Intermontane Province and Adjacent Snake River Plains Province.

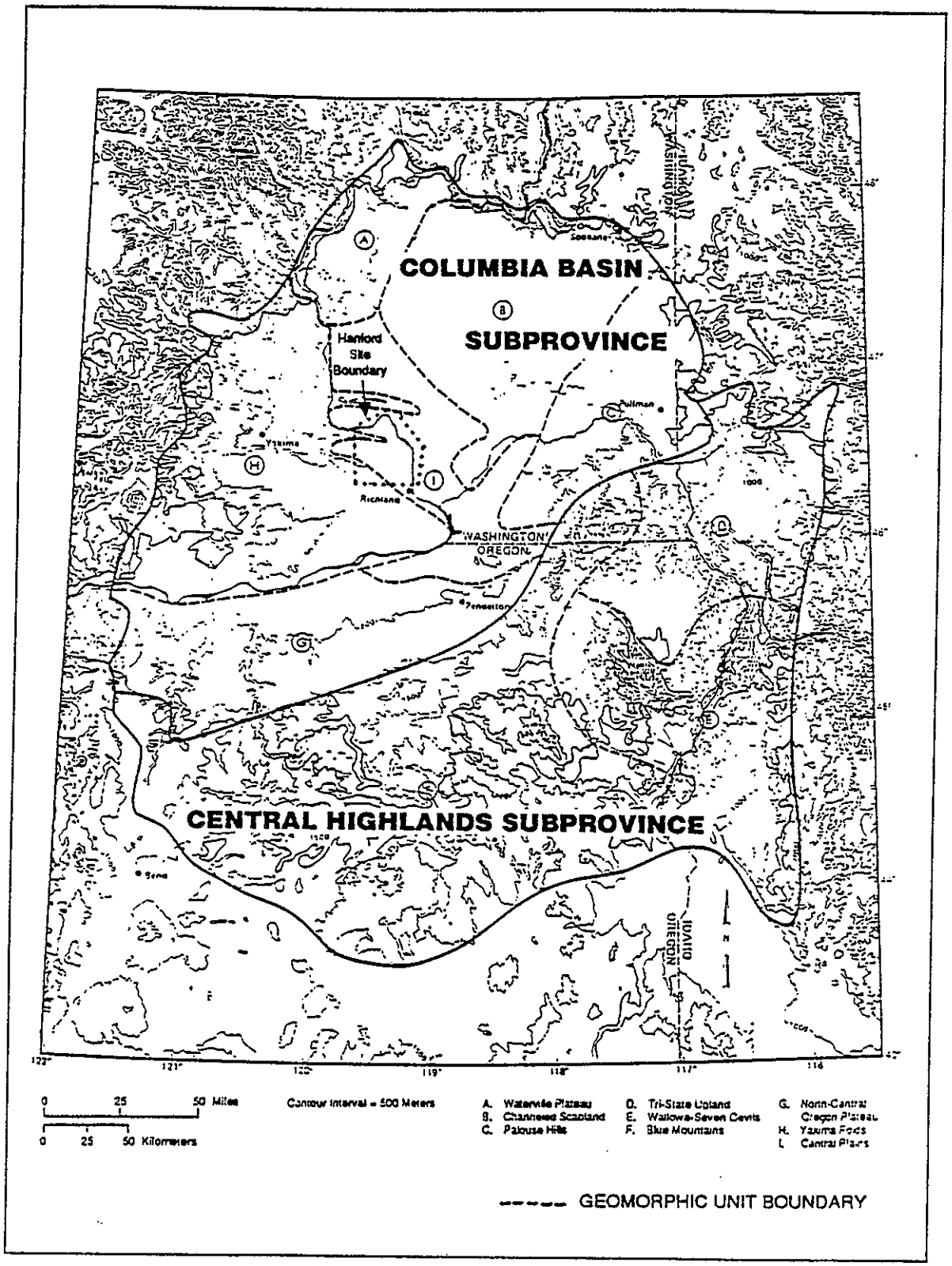

Figure 3-3. Geomorphic Units Within the Central Highlands and Columbia Basin Subprovinces that Contain the Columbia River Basalt Group (DOE 1988b).

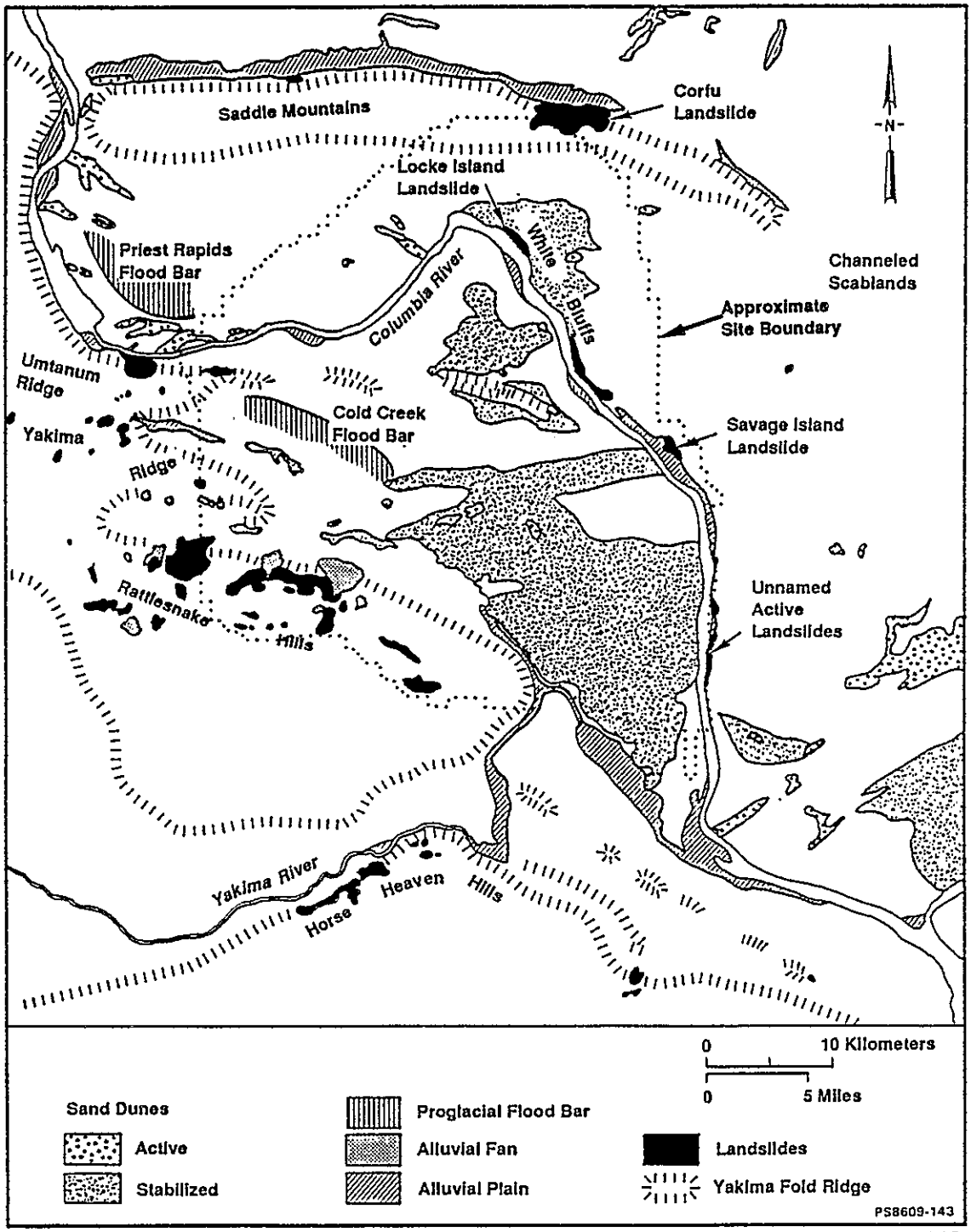

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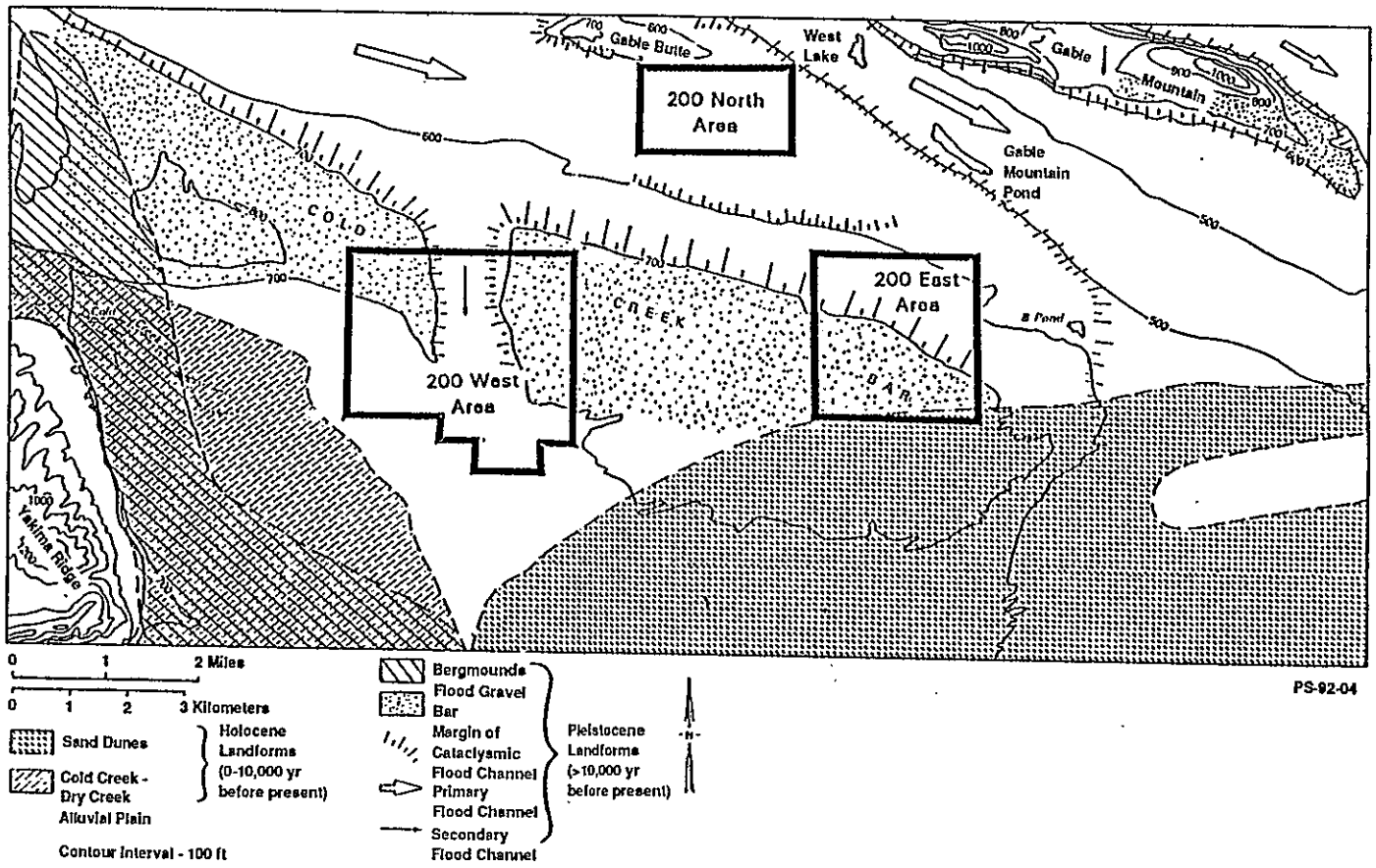
Figure 3-4. Landforms of the Pasco Basin and the Hanford Site.



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

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

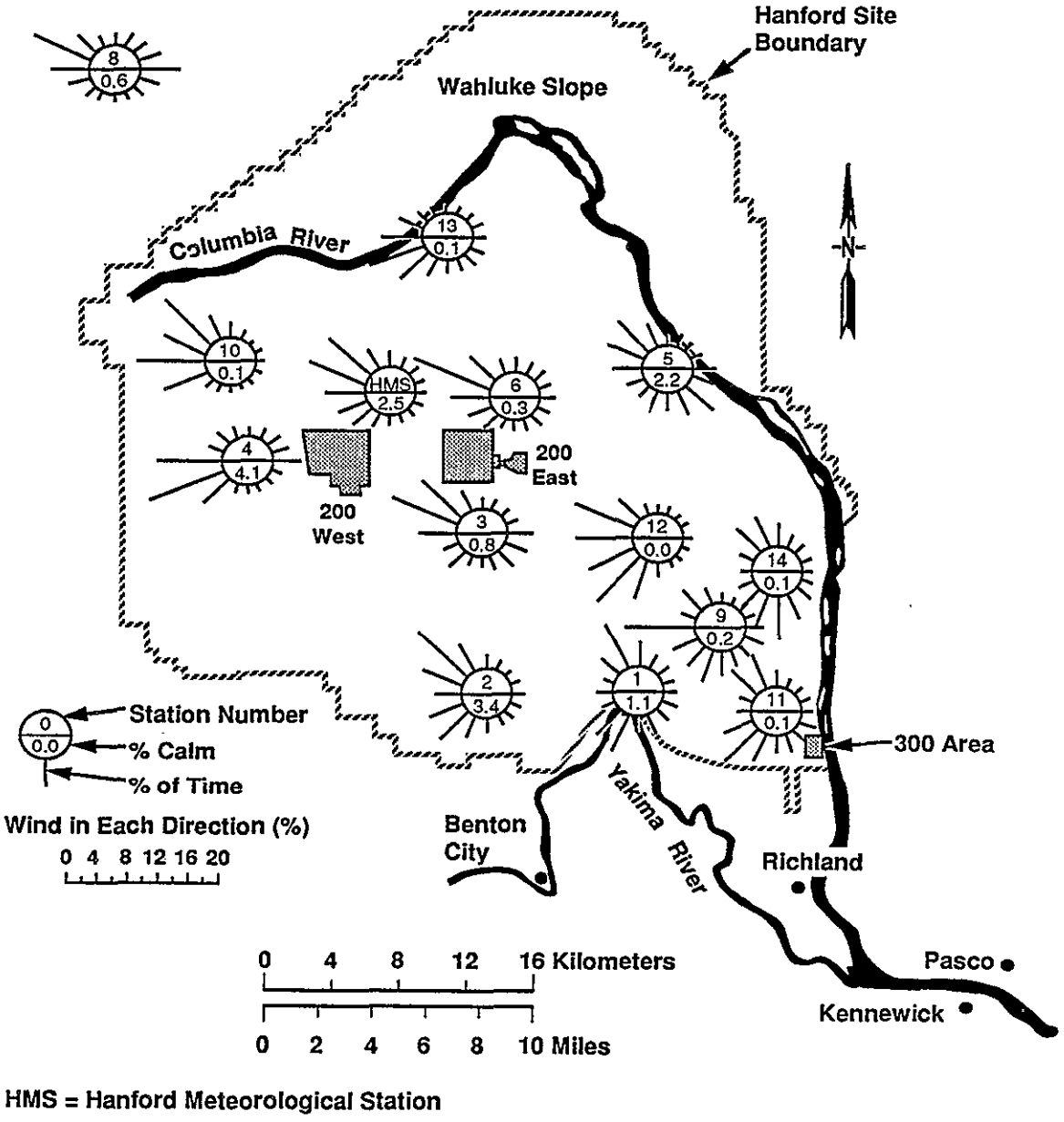


Figure 3-6. Hanford Site Wind Roses, 1979 through 1982 (Stone et al. 1983).

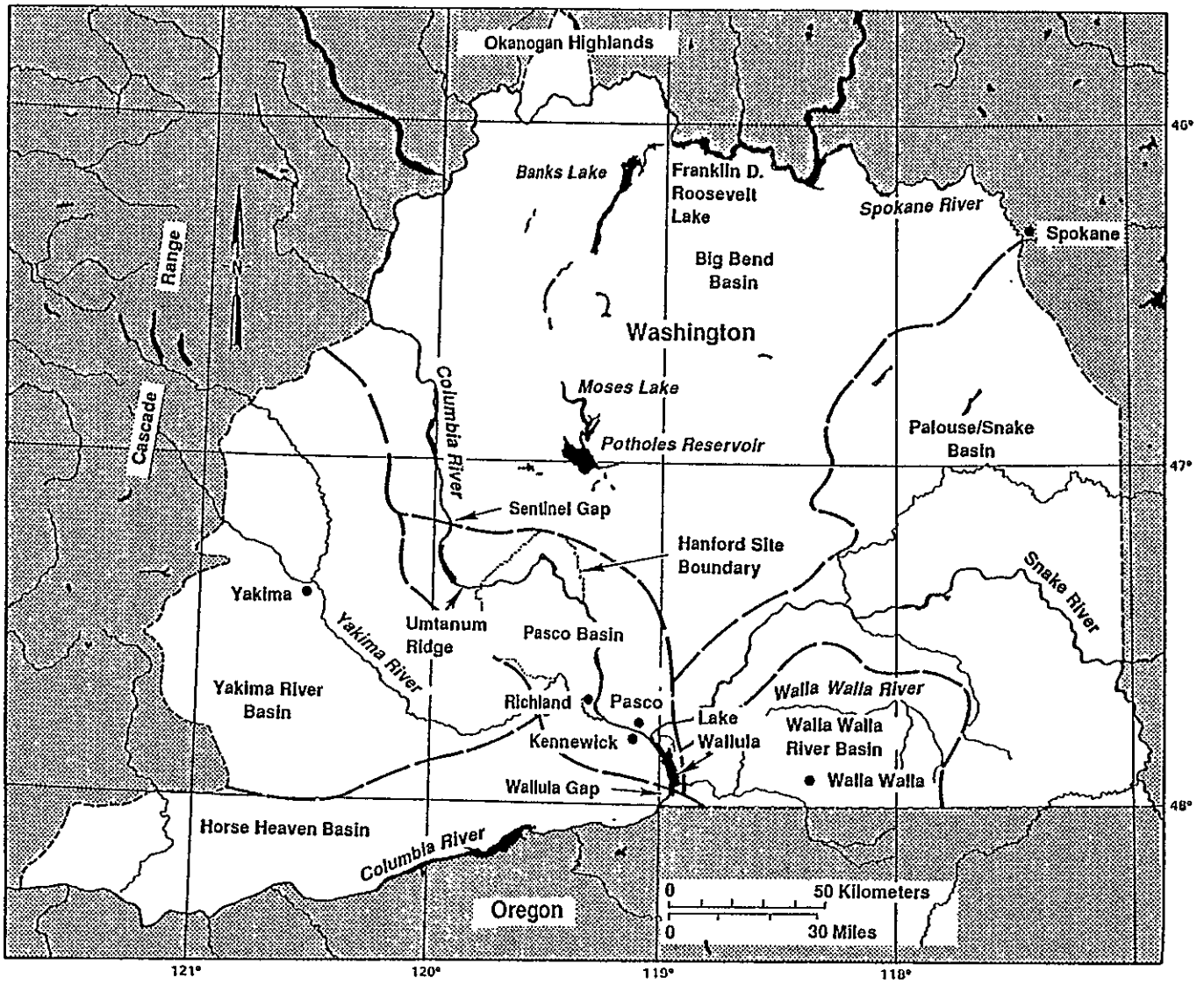


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Figure 3-7. Hydrogeologic Basins Designated for the Washington State Portion of the Columbia Plateau (DOE 1988b).

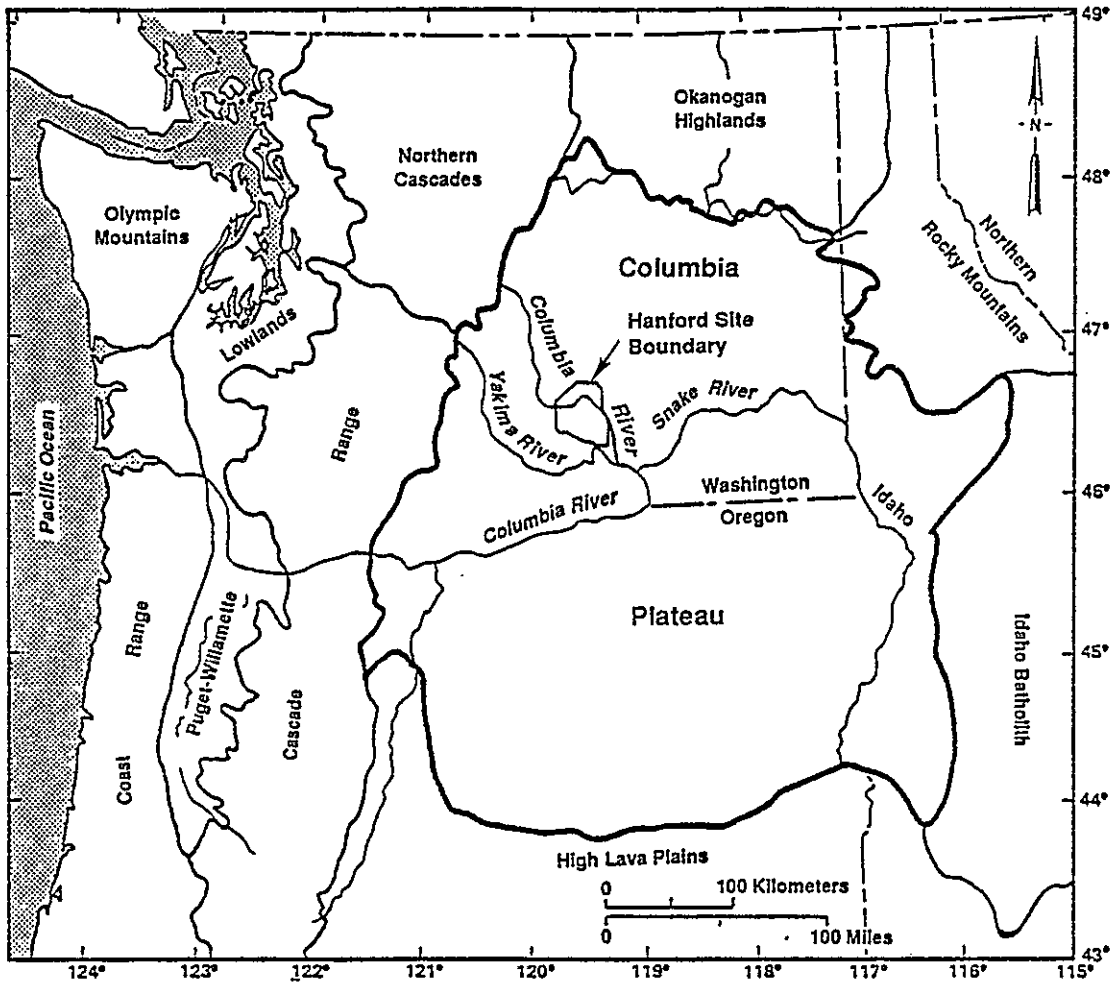

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Figure 3-8. Columbia Plateau and Surrounding Structural Provinces.

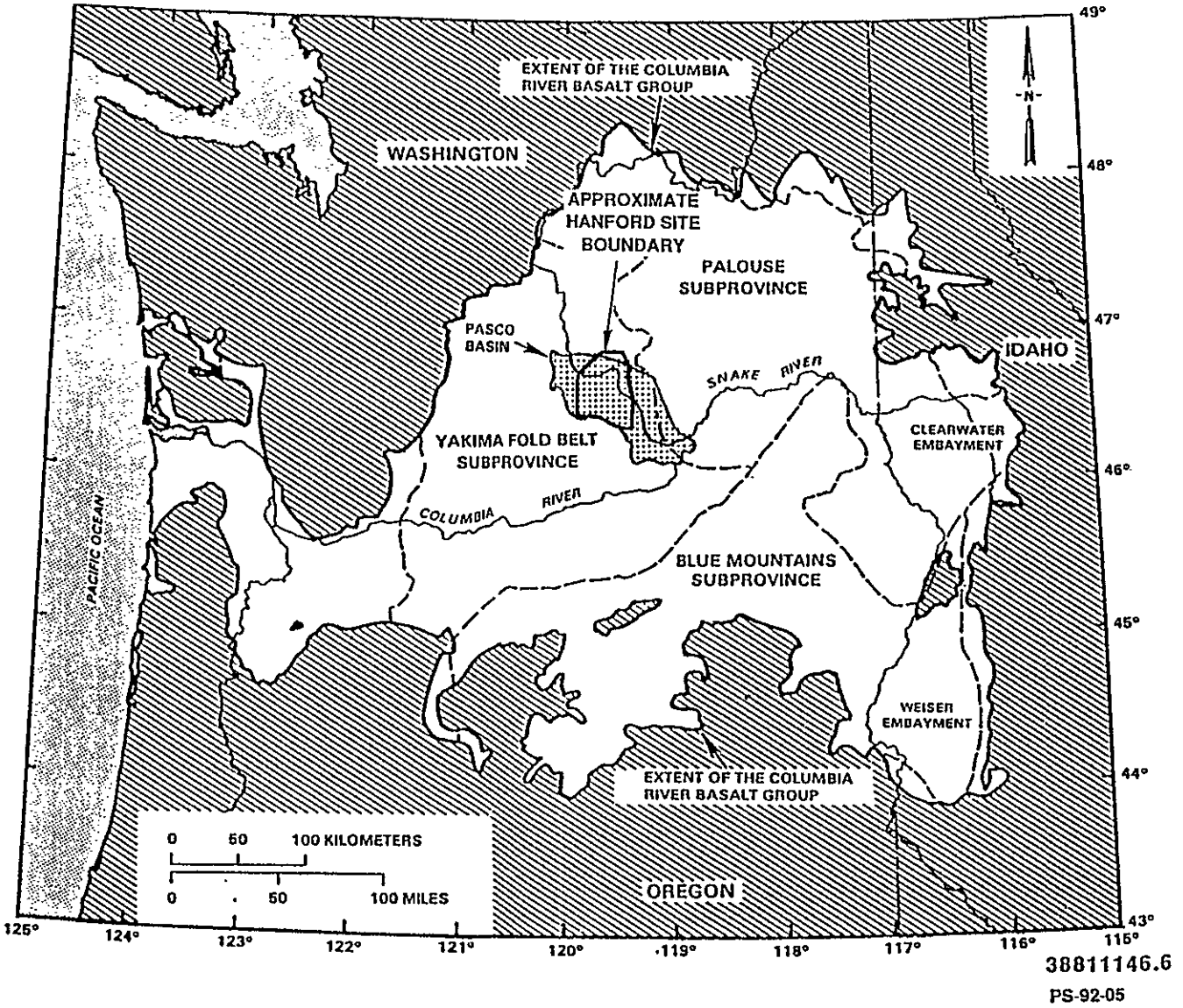

Figure 3-9. Structural Subprovinces of the Columbia Plateau (DOE 1988b).

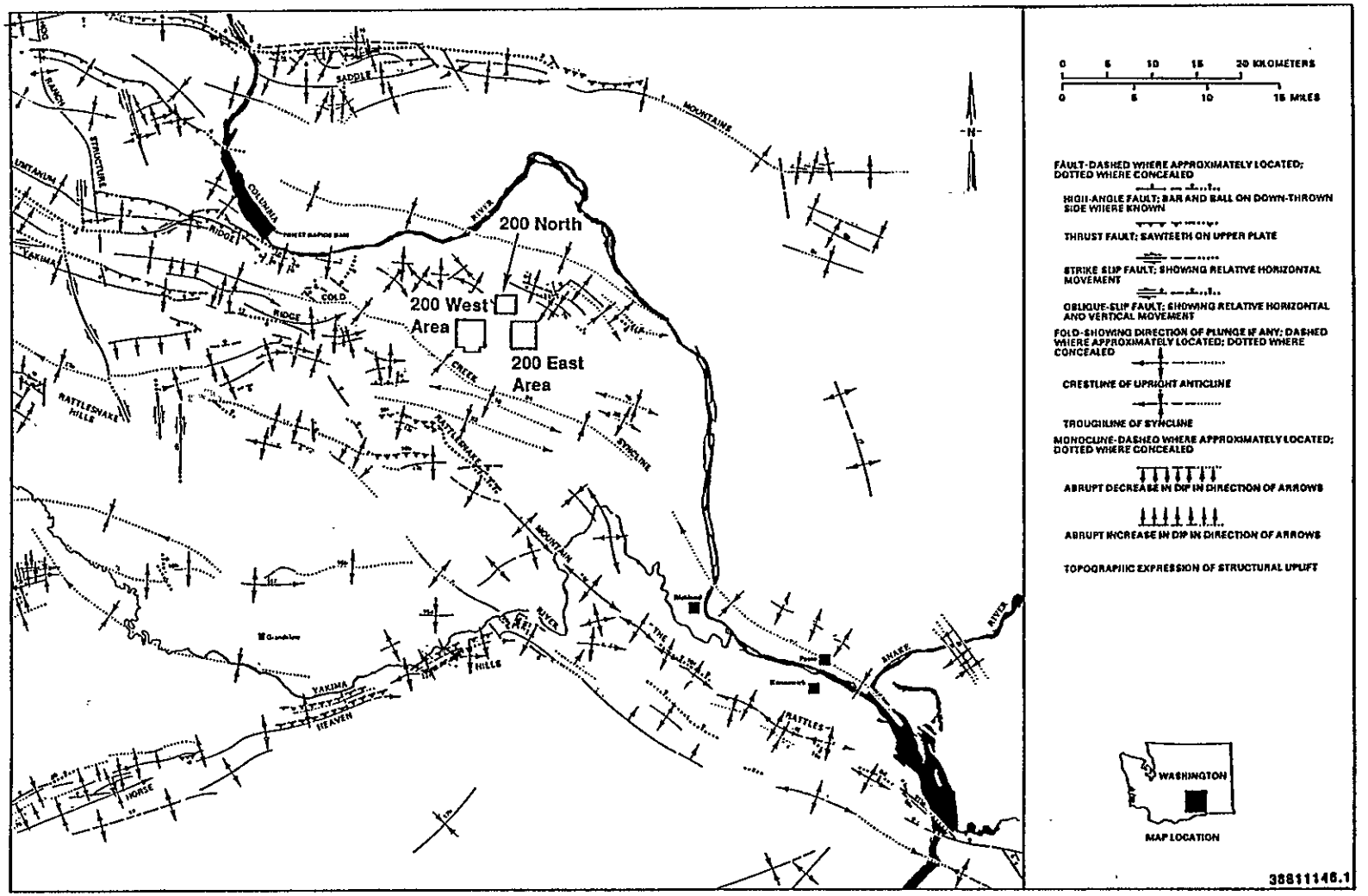

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Figure 3-10. Structured Elements of the Yakima Fold Belt Subprovince (Last et al. 1989).

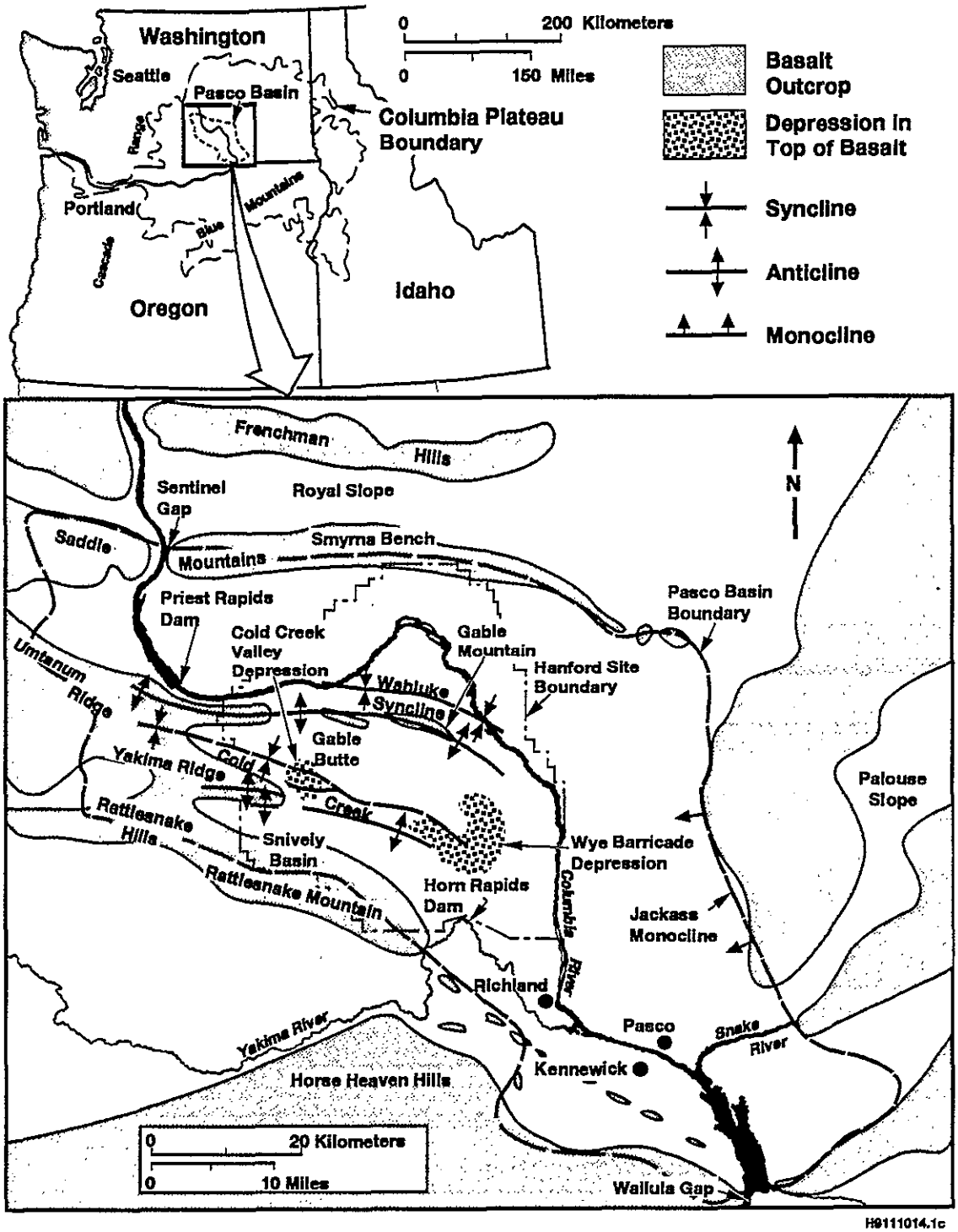
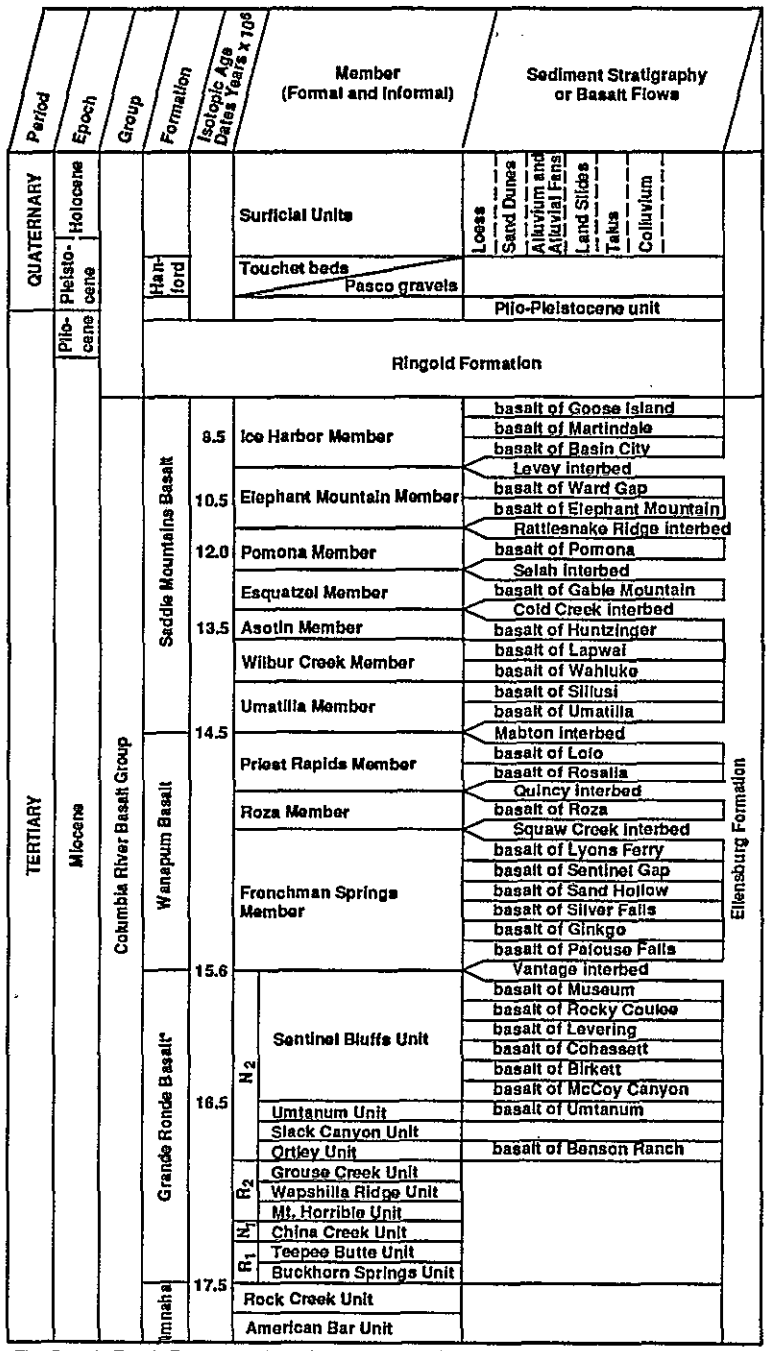


Figure 3-11. Geologic Structures of the Pasco Basin and the Hanford Site.



*The Grande Ronde Basalt consists of at least 120 major basalt flows. Only a few flows have been named. N_2, R_2, N_1 and R_1 are magnetostratigraphic units.

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

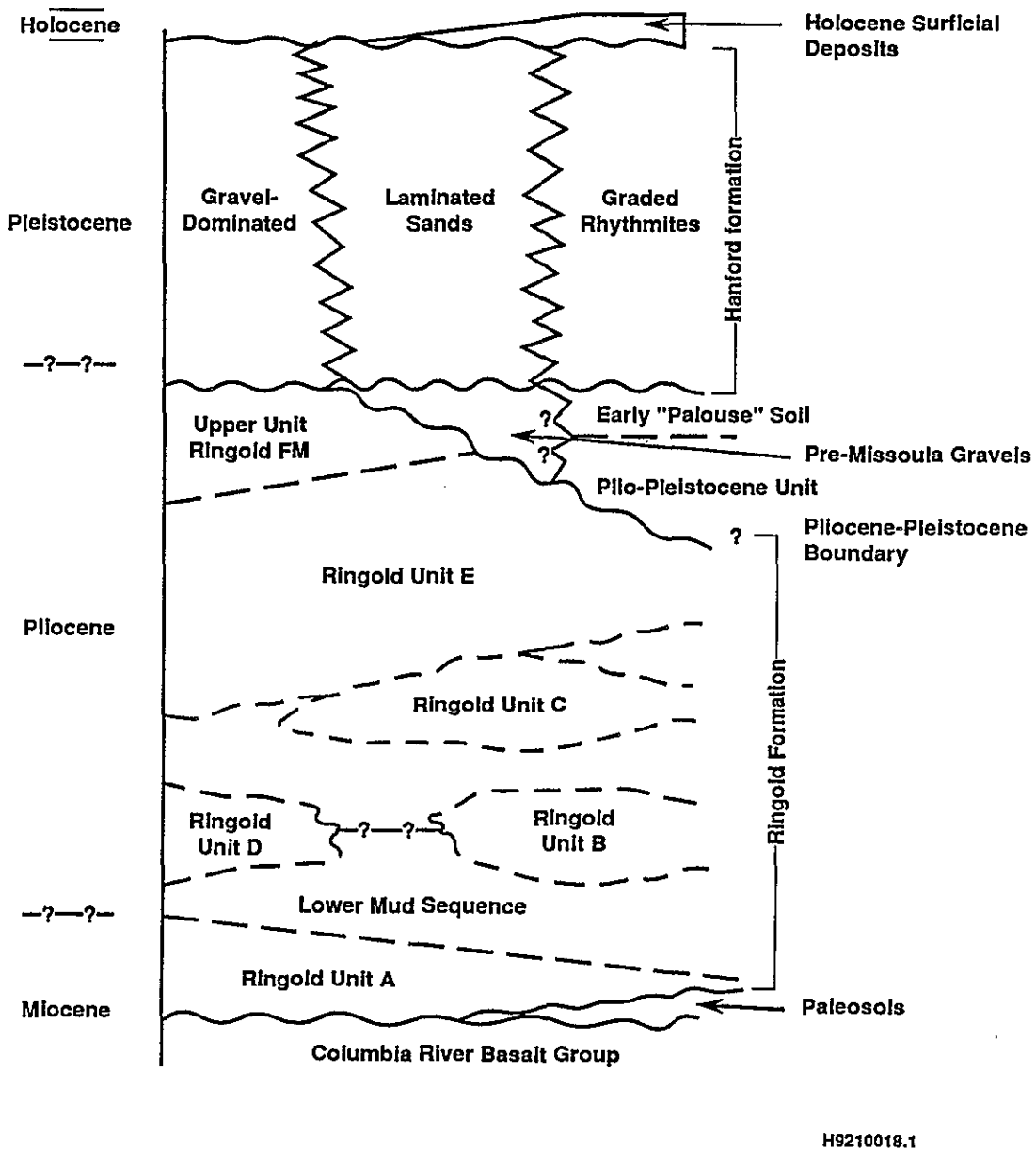

Figure 3-13. Generalized Stratigraphy of the Suprabasalt Sediments Beneath the Hanford Site.

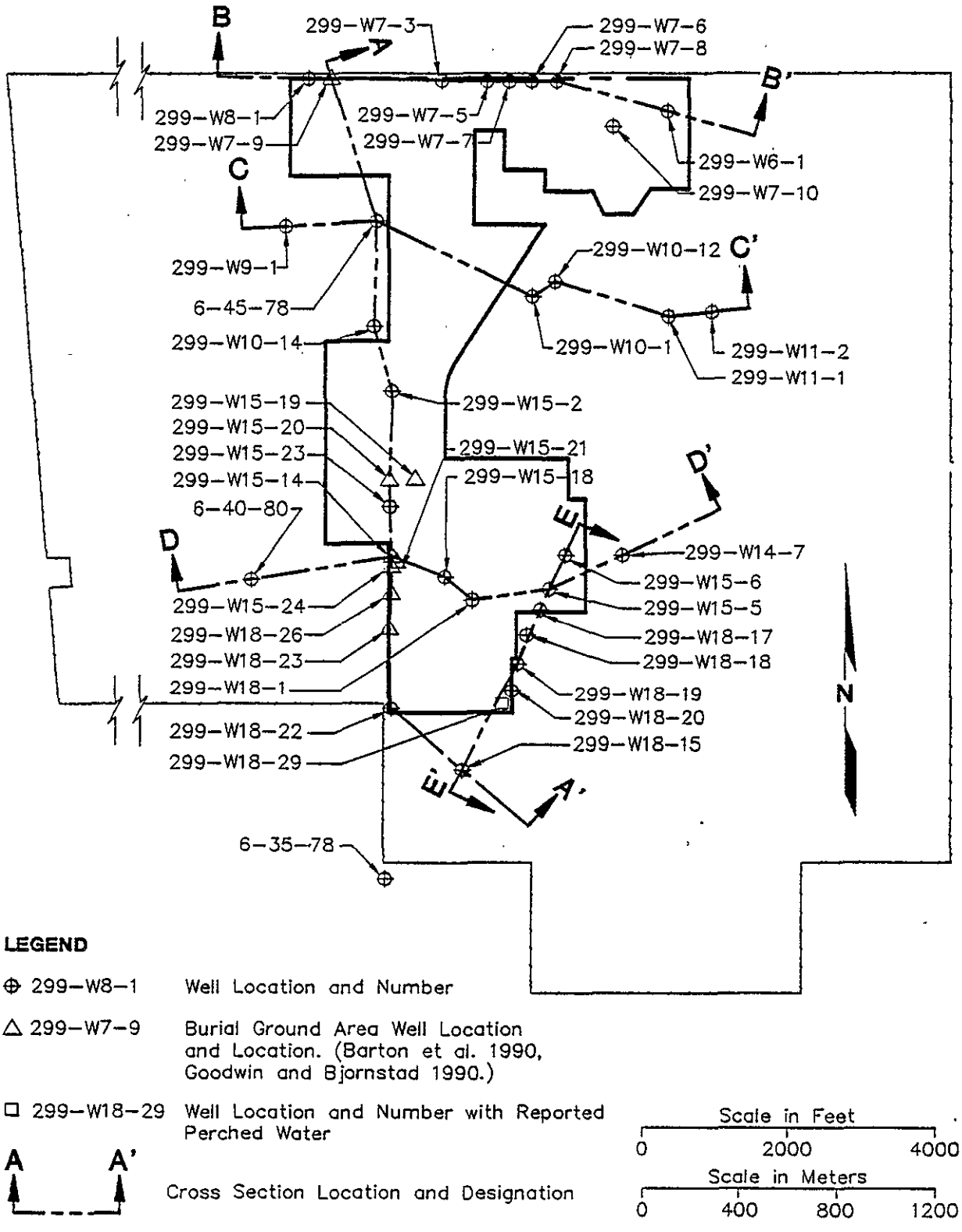

Figure 3-14. Location of Geologic Cross Sections.

UNIT ABREVIATIONS

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

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

Blank portions of cross section well logs represent sediments (dominantly sand) which do not fit into sediment categories depicted by symbols listed above.

NOTES

1. Refer to Figure 3–14 for cross section locations and designation. Cross sections presented on Figures 3–16 through 3–20.

2. Figures based on Lindsey et al. 1991.

Figure 3-15. Legend for Cross Sections.

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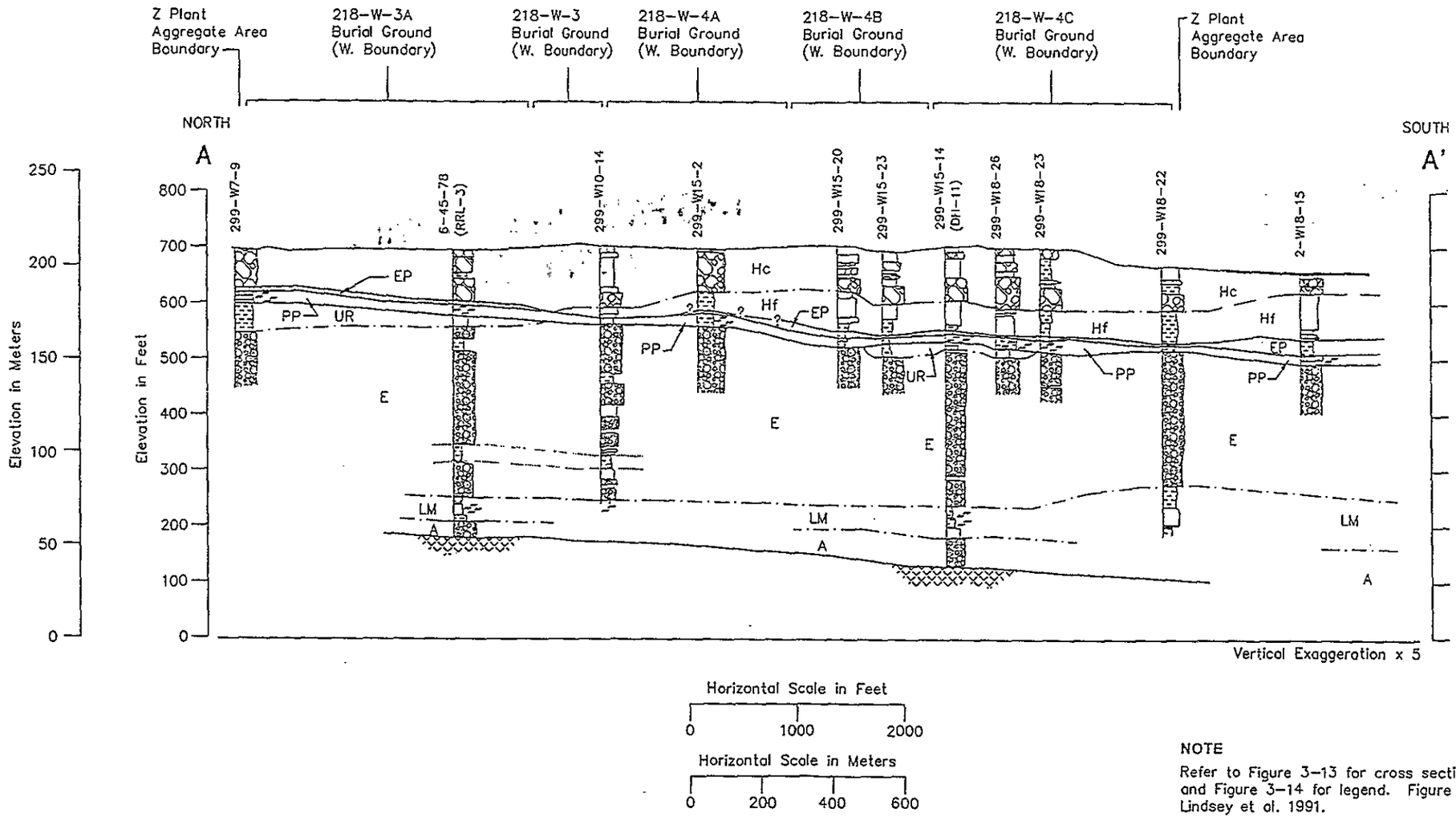

NOTE

Refer to Figure 3-13 for cross section location and Figure 3-14 for legend. Figure based on Lindsey et al. 1991.

Figure 3-16. Z Plant Aggregate Area Geologic Cross Section A-A'.

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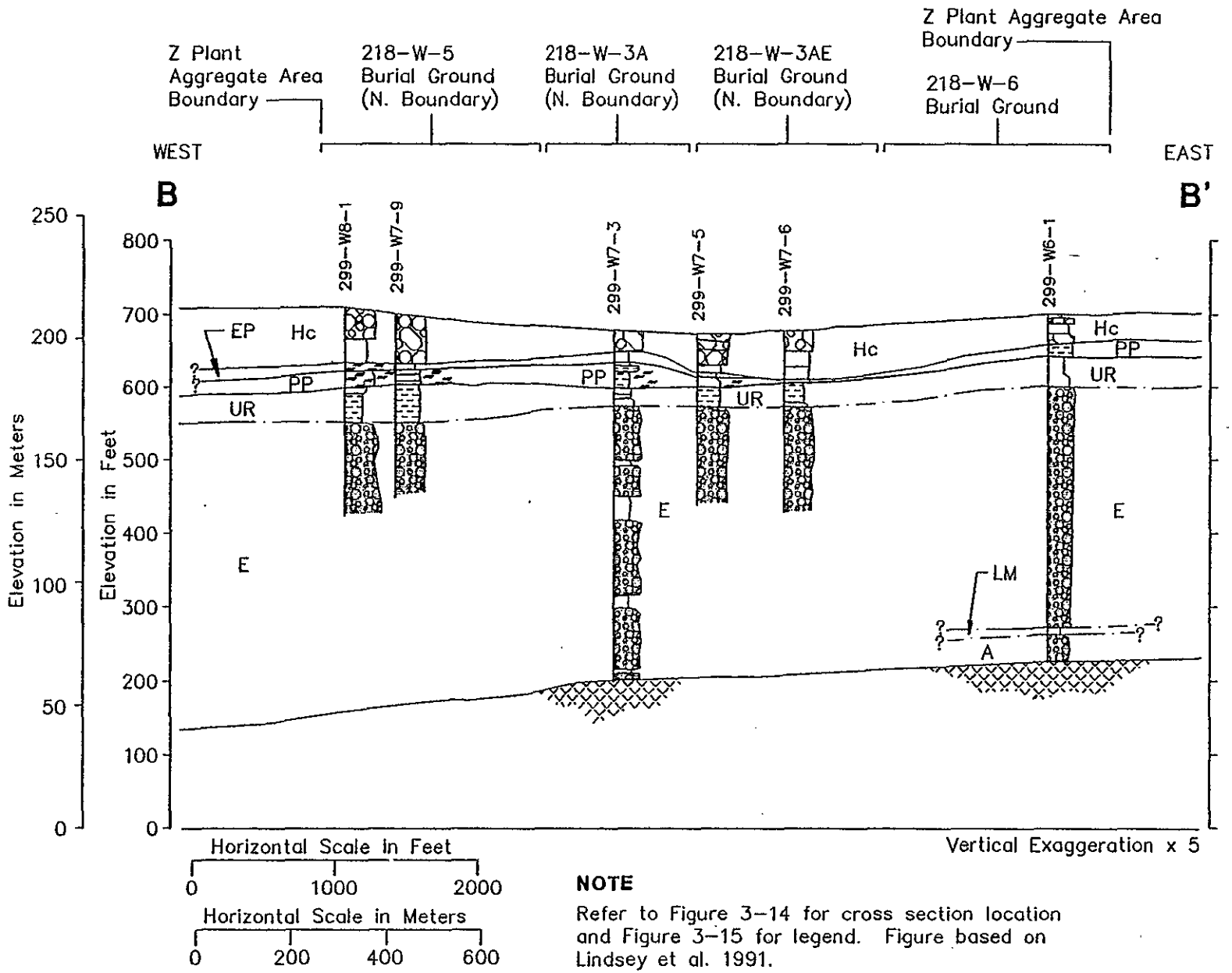
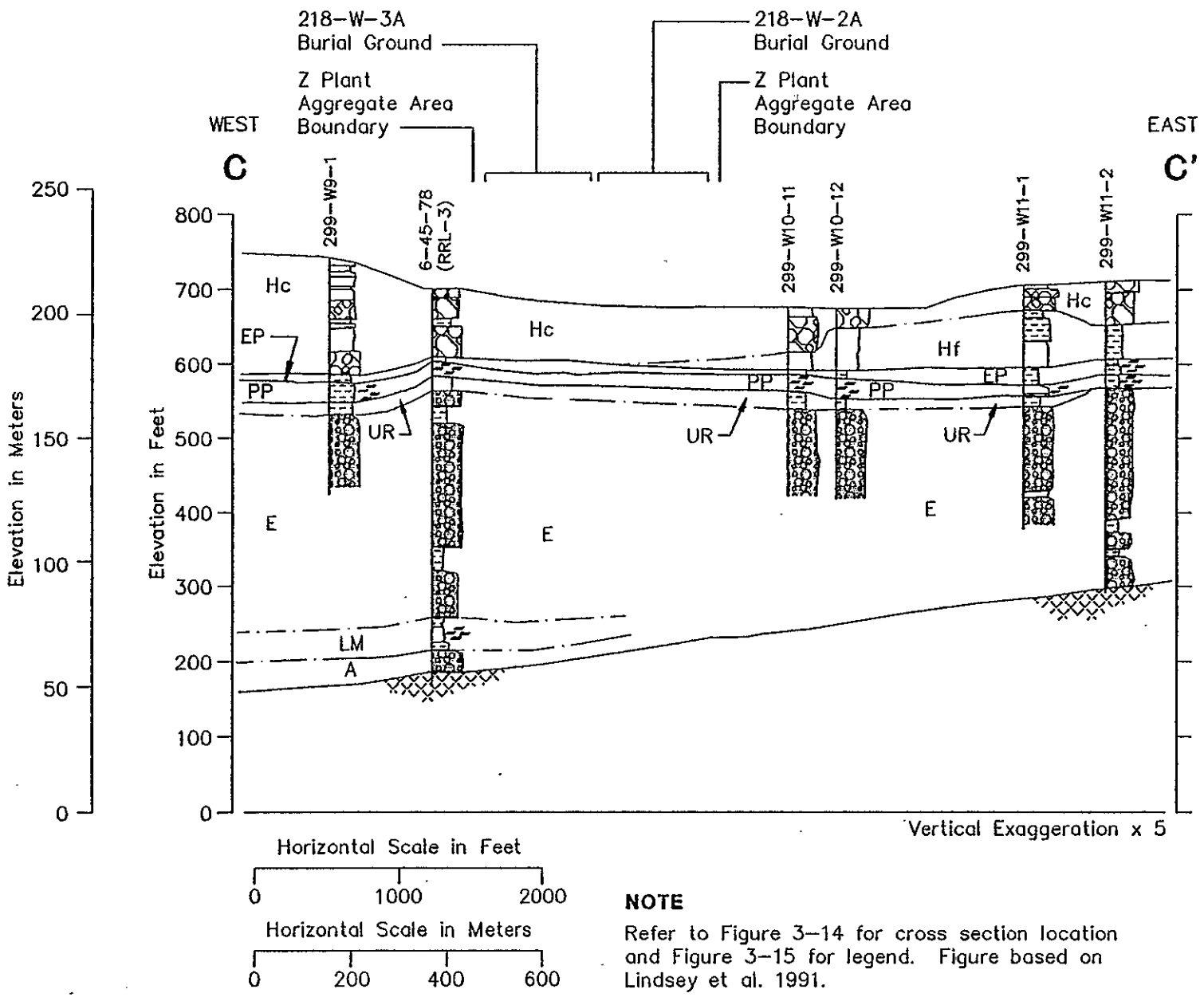


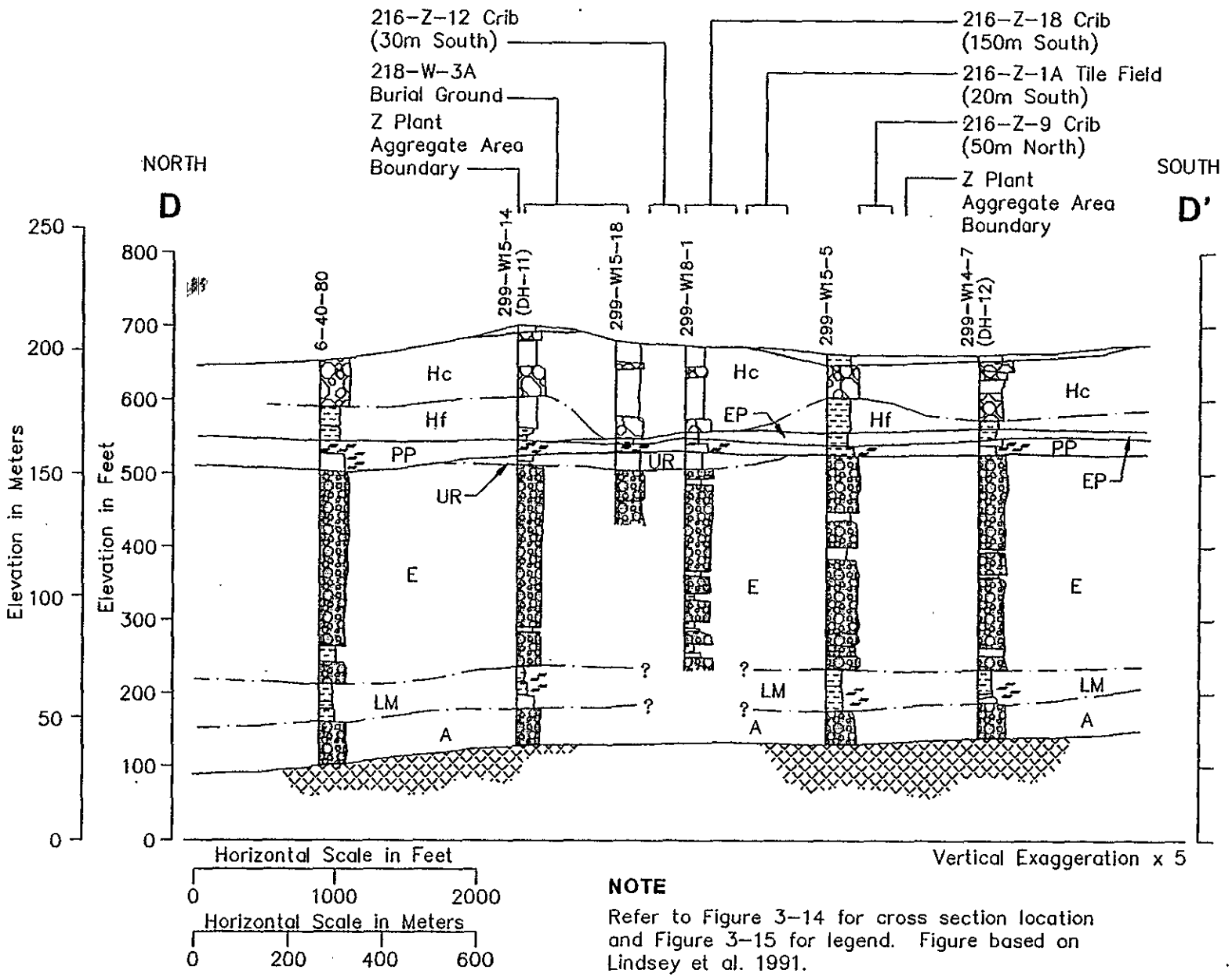
Figure 3-17. Z Plant Aggregate Area Geologic Cross Section B-B'.



NOTE

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

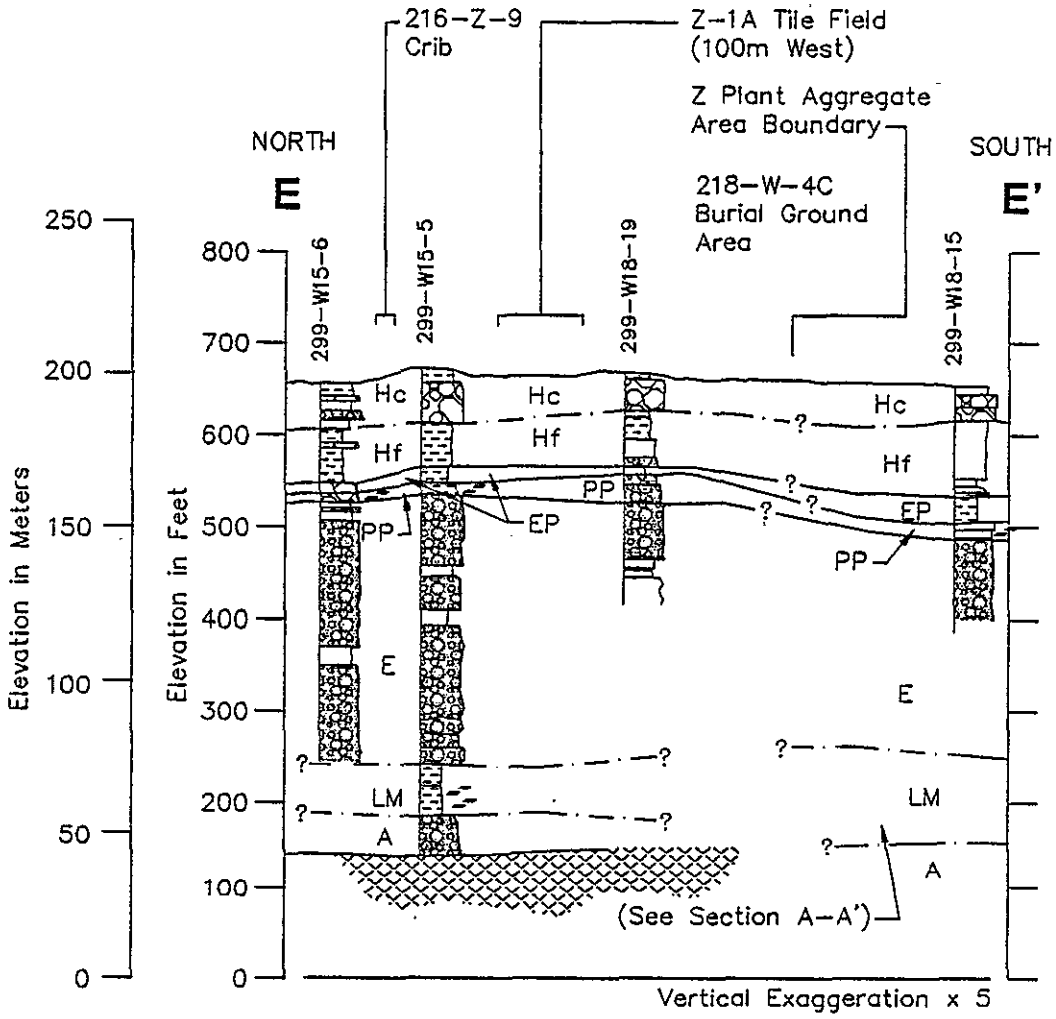
Figure 3-18. Z Plant Aggregate Area Geologic Cross Section C-C'.



NOTE

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

Figure 3-19. Z Plant Aggregate Area Geologic Cross Section D-D'.



NOTE

Refer to Figure 3-14 for Cross Section location and Figure 3-15 for legend. Figure based on Lindsey et al. 1991.

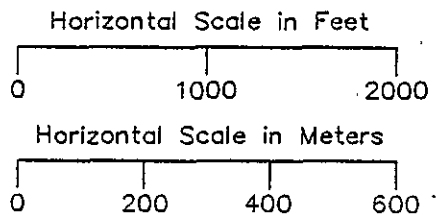


Figure 3-20. Z Plant Aggregate Area Geologic Cross Section E-E'.

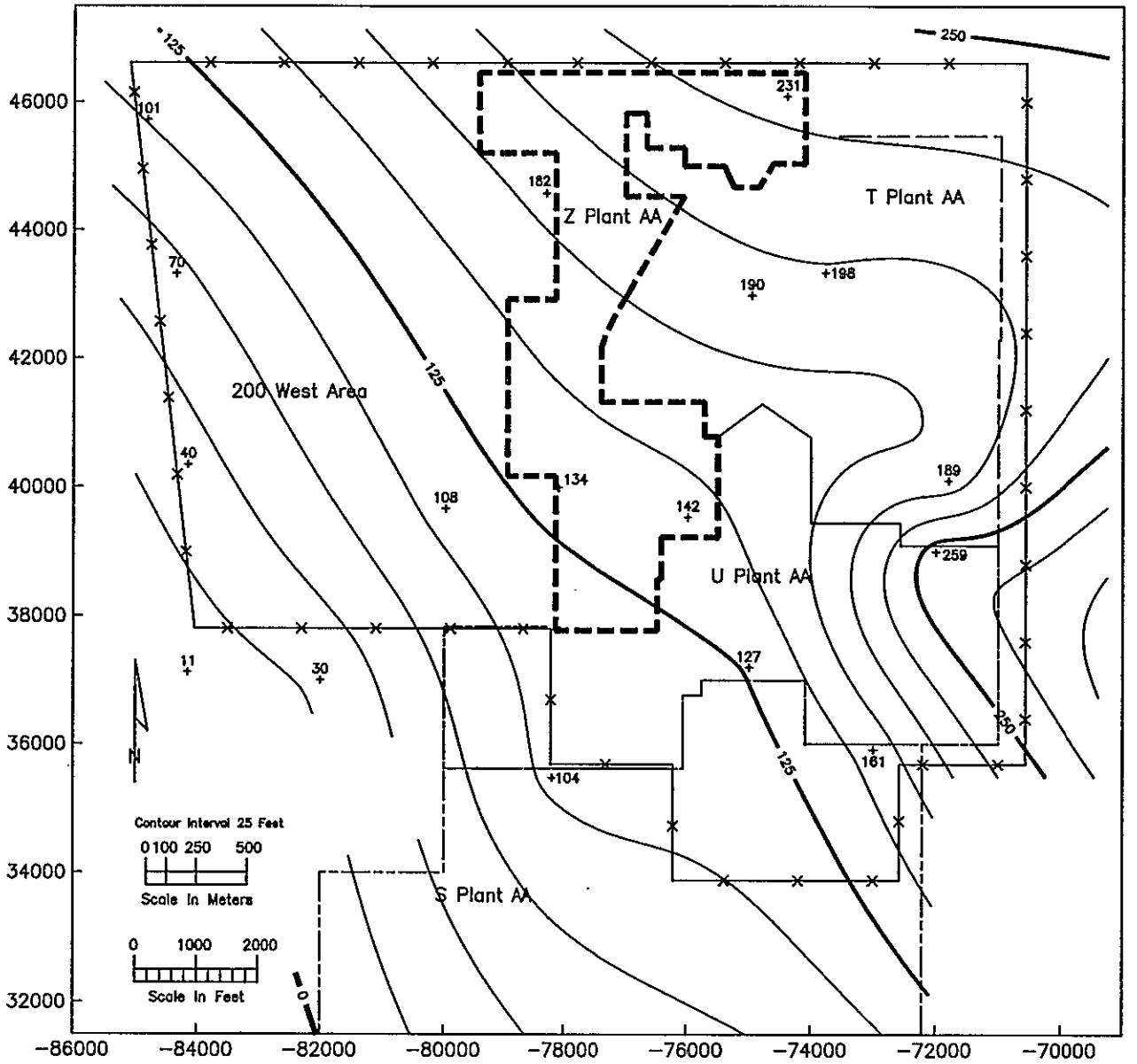


Figure 3-21. Top of the Elephant Mountain Basalt.

3-21

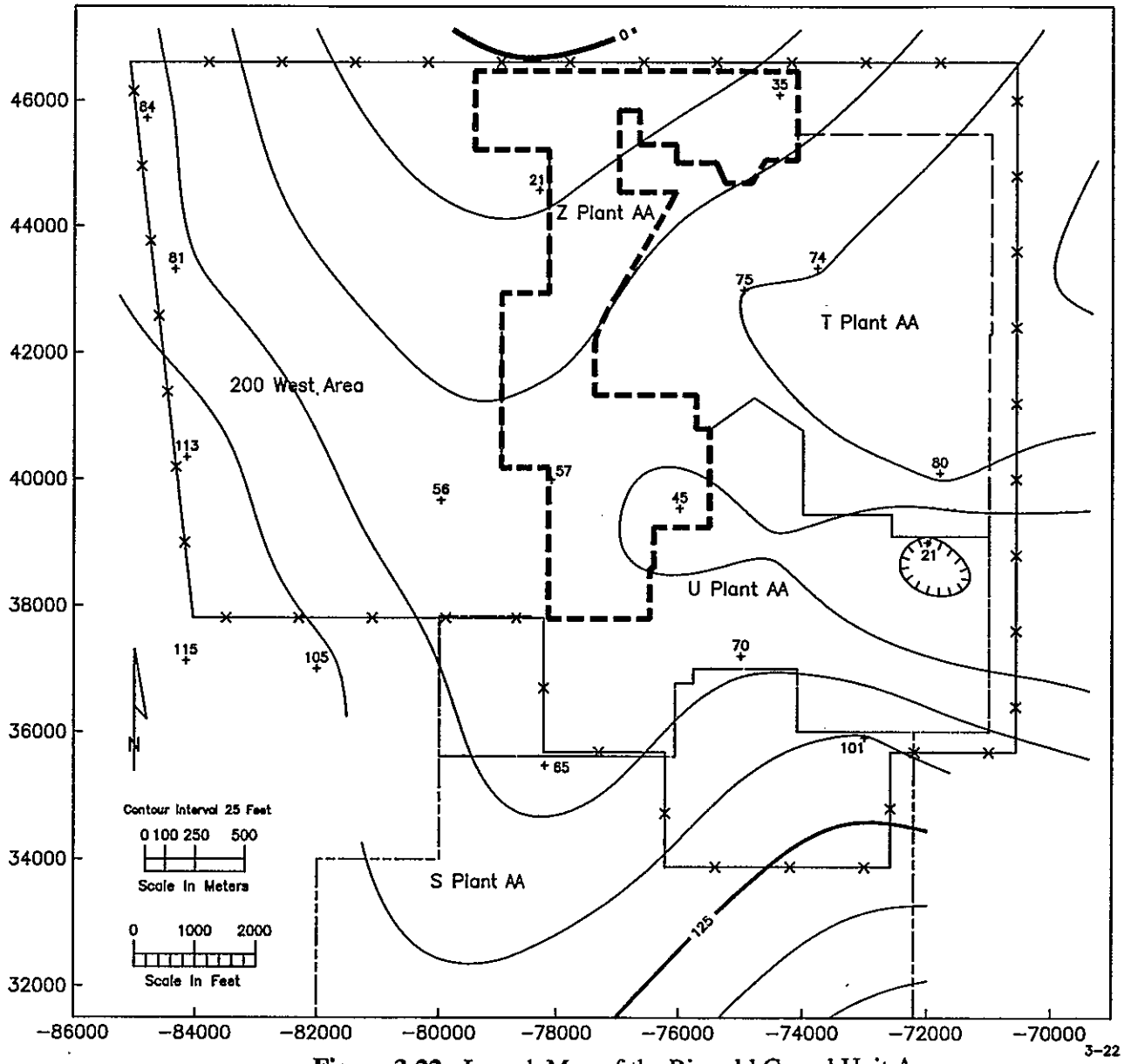


Figure 3-22. Isopach Map of the Ringold Gravel Unit A.

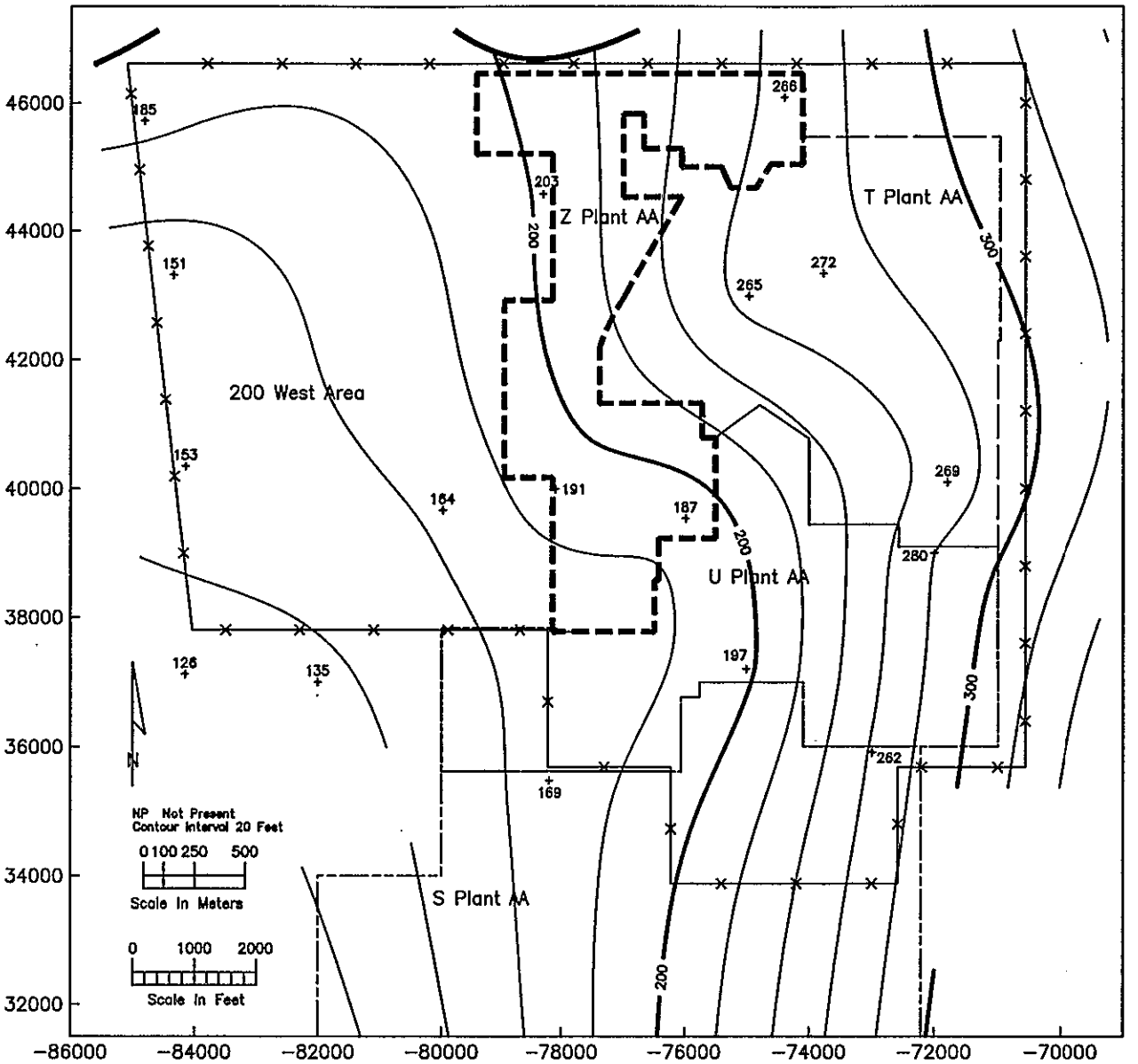


Figure 3-23. Structure Map of the Ringold Gravel Unit A.

3-23

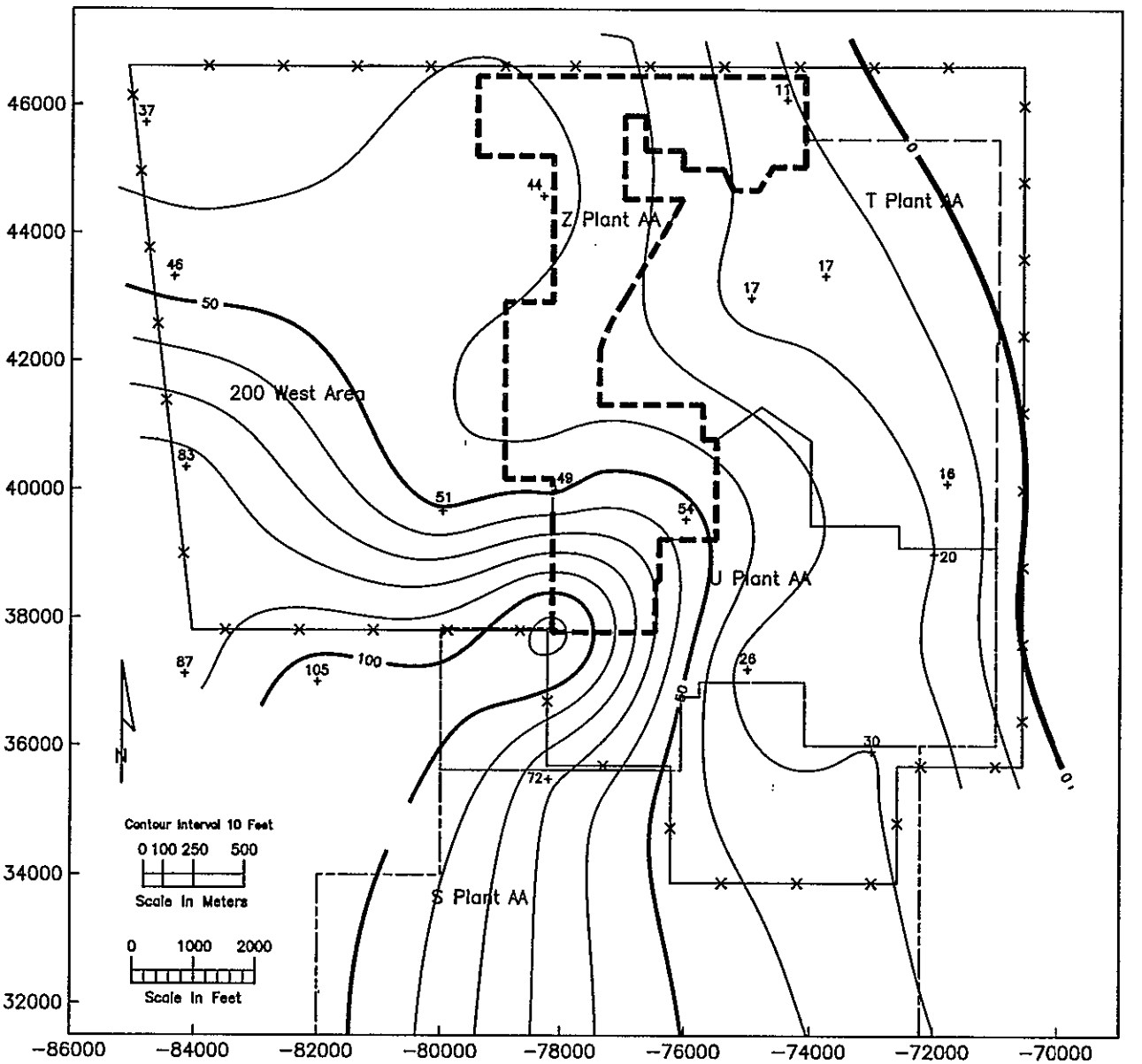


Figure 3-24. Isopach Map of the Ringold Lower Mud Unit.

3-24

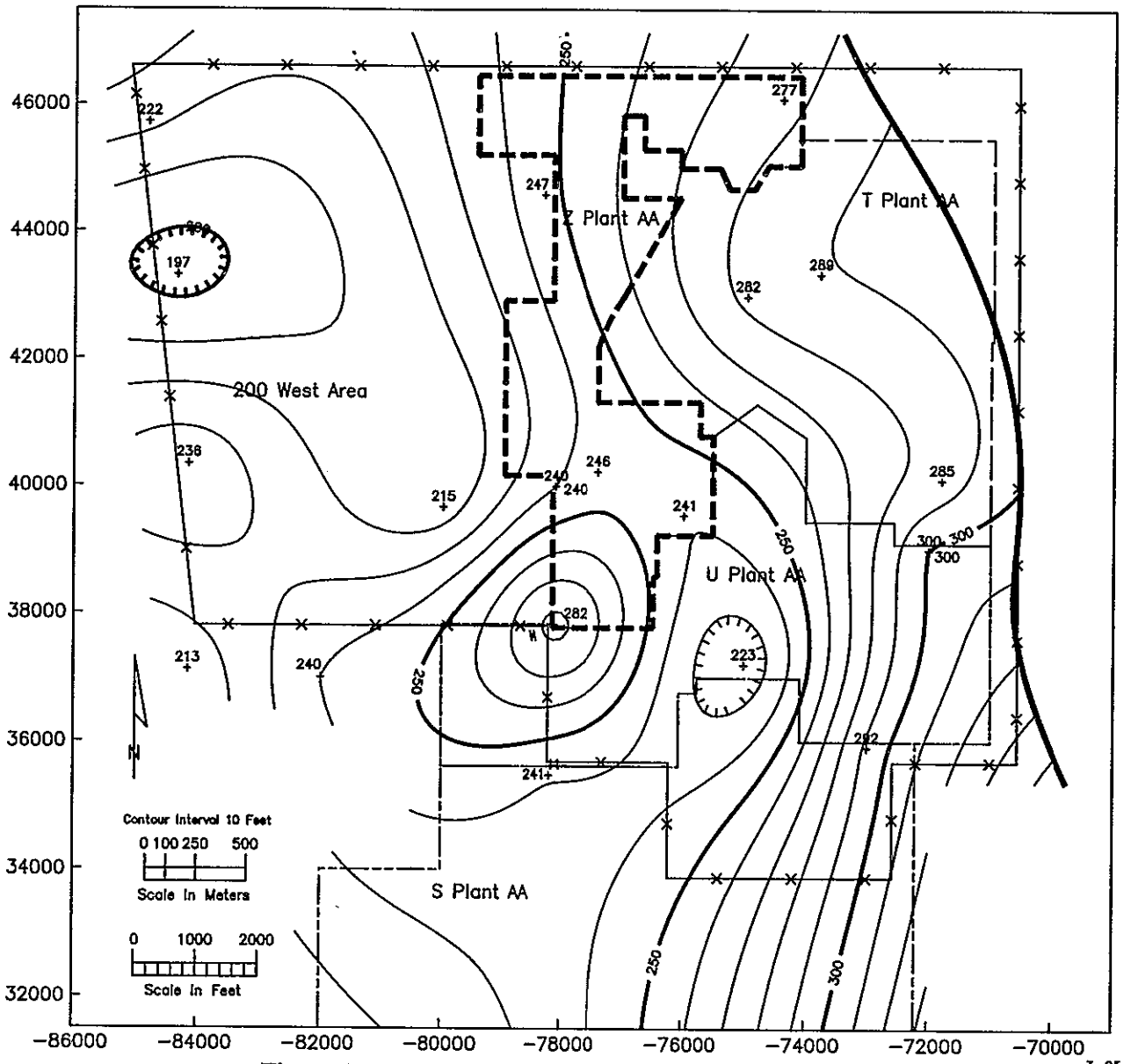


Figure 3-25. Structure Map of the Ringold Lower Mud Unit.

3-25

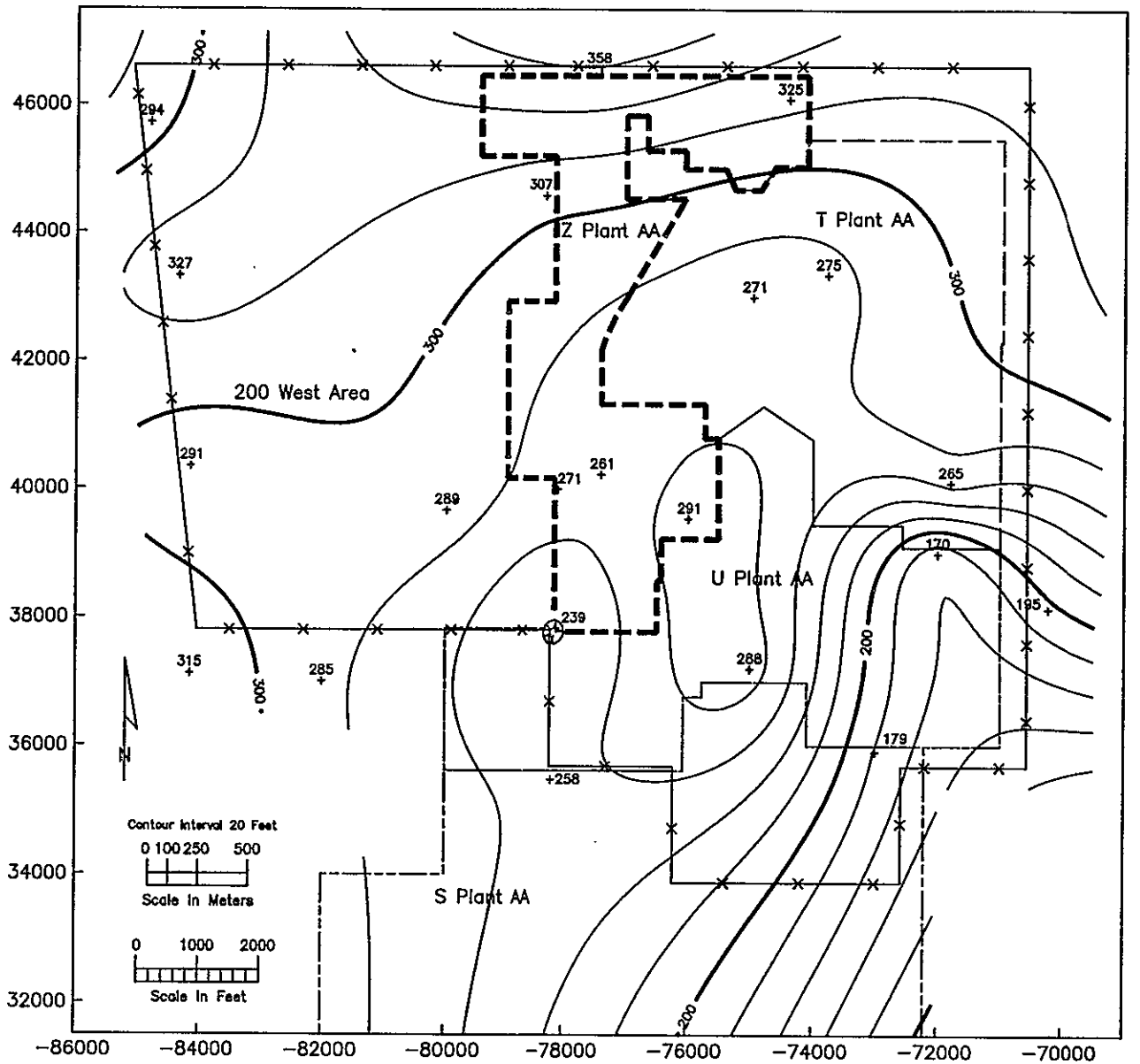


Figure 3-26. Isopach Map of the Ringold Gravel Unit E.

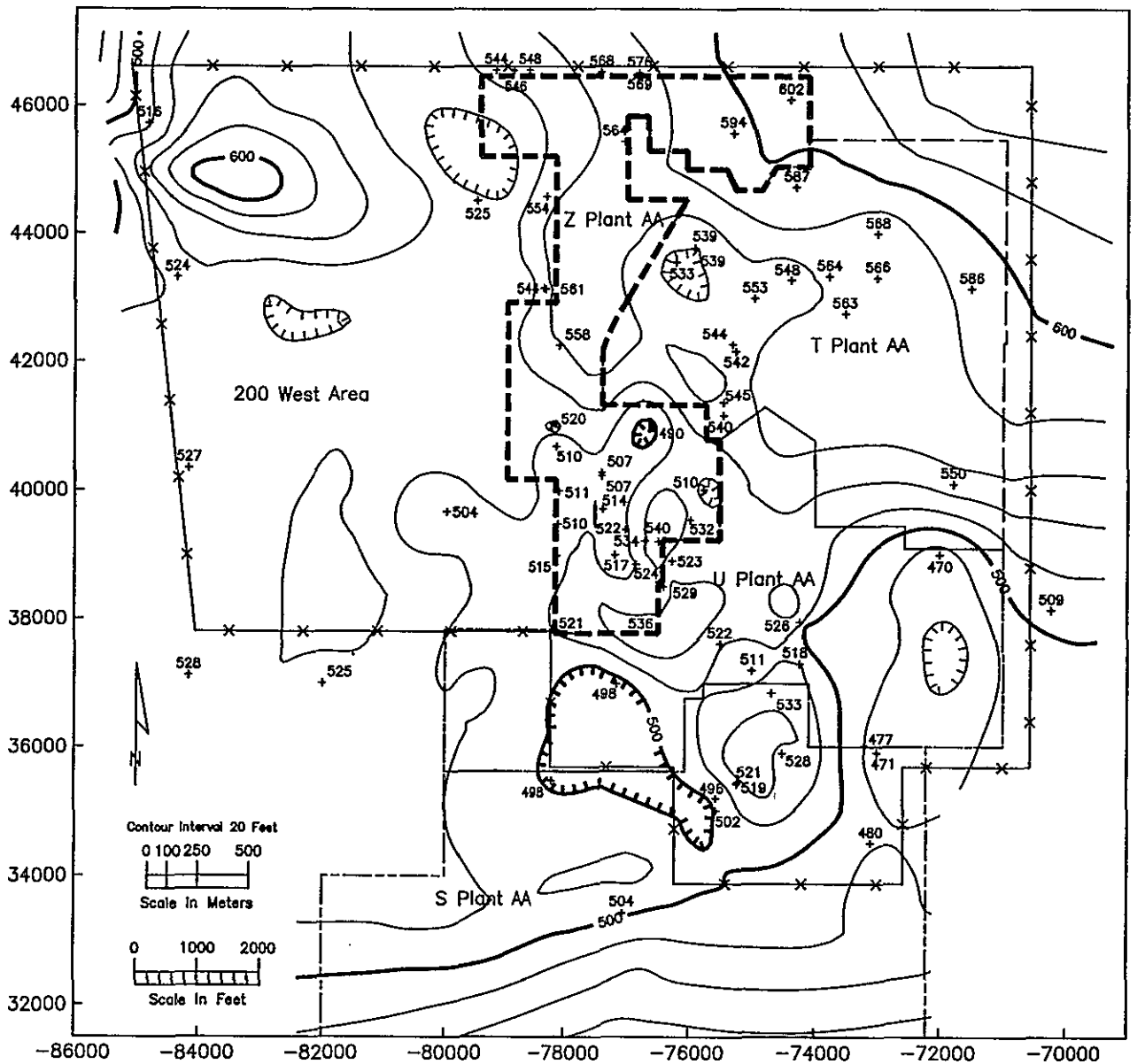


Figure 3-27. Structure Map of the Ringold Gravel Unit E.

3-27

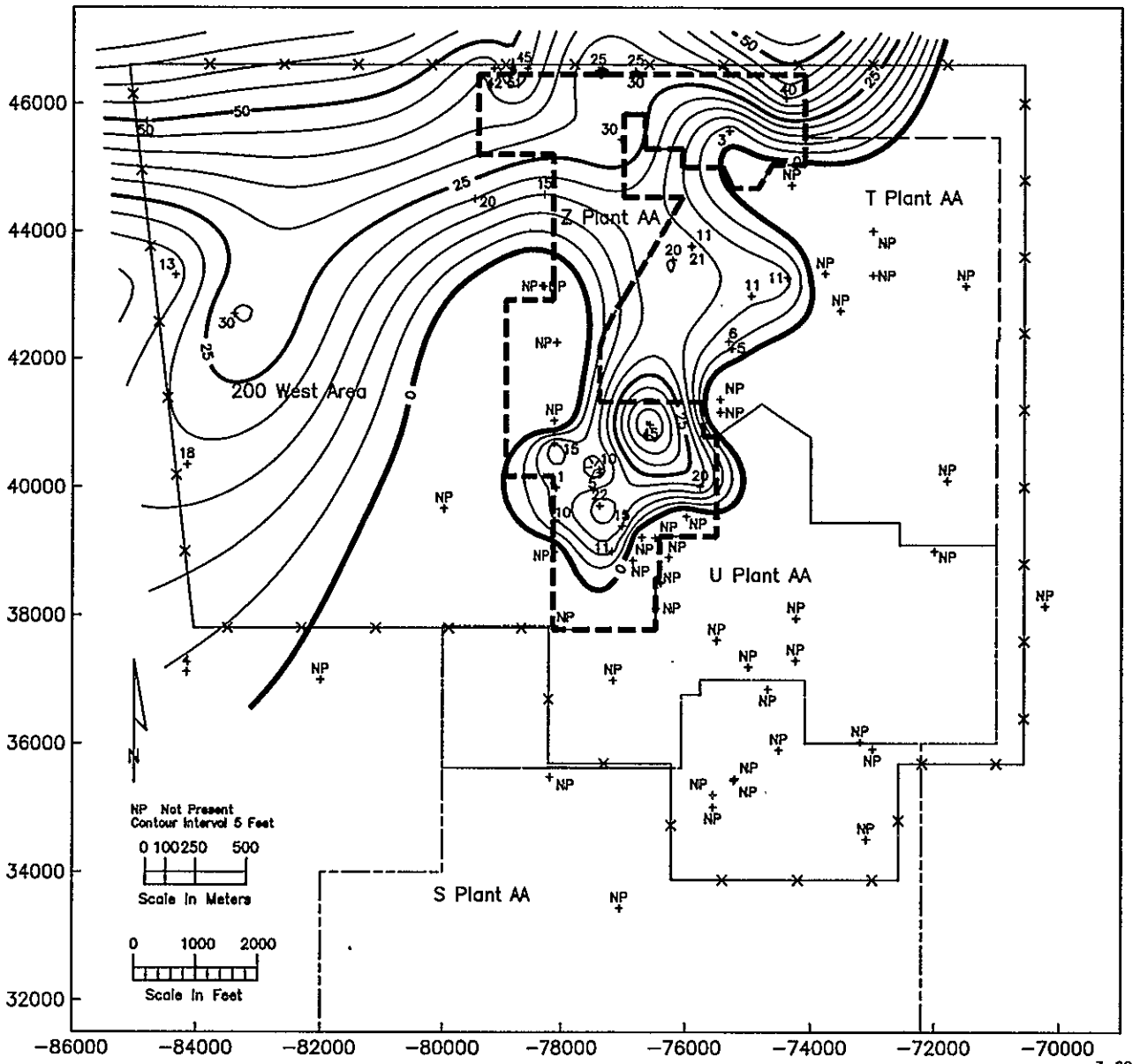


Figure 3-28. Isopach Map of the Upper Ringold.

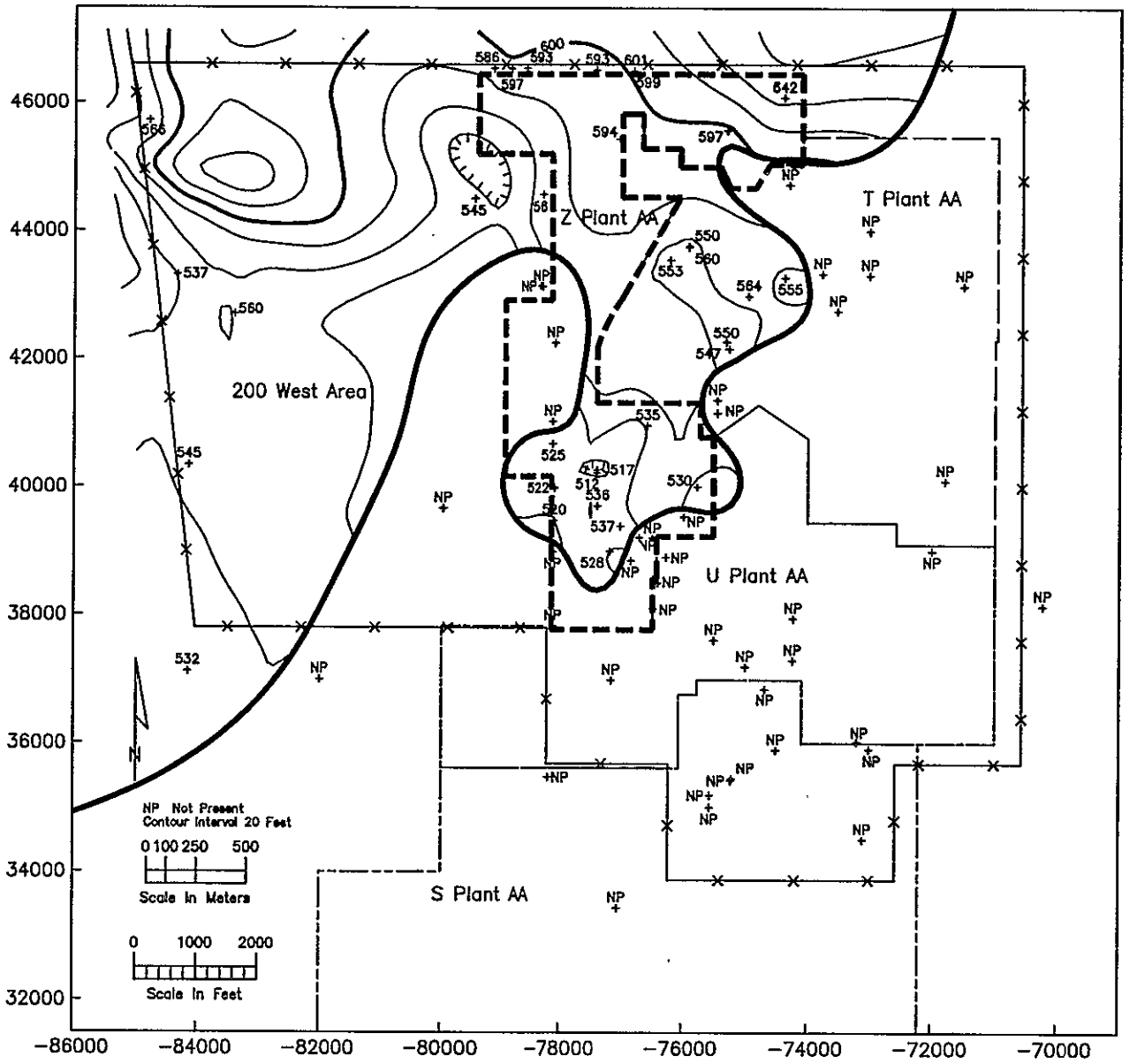


Figure 3-29. Structure Map of the Upper Ringold.

3-29

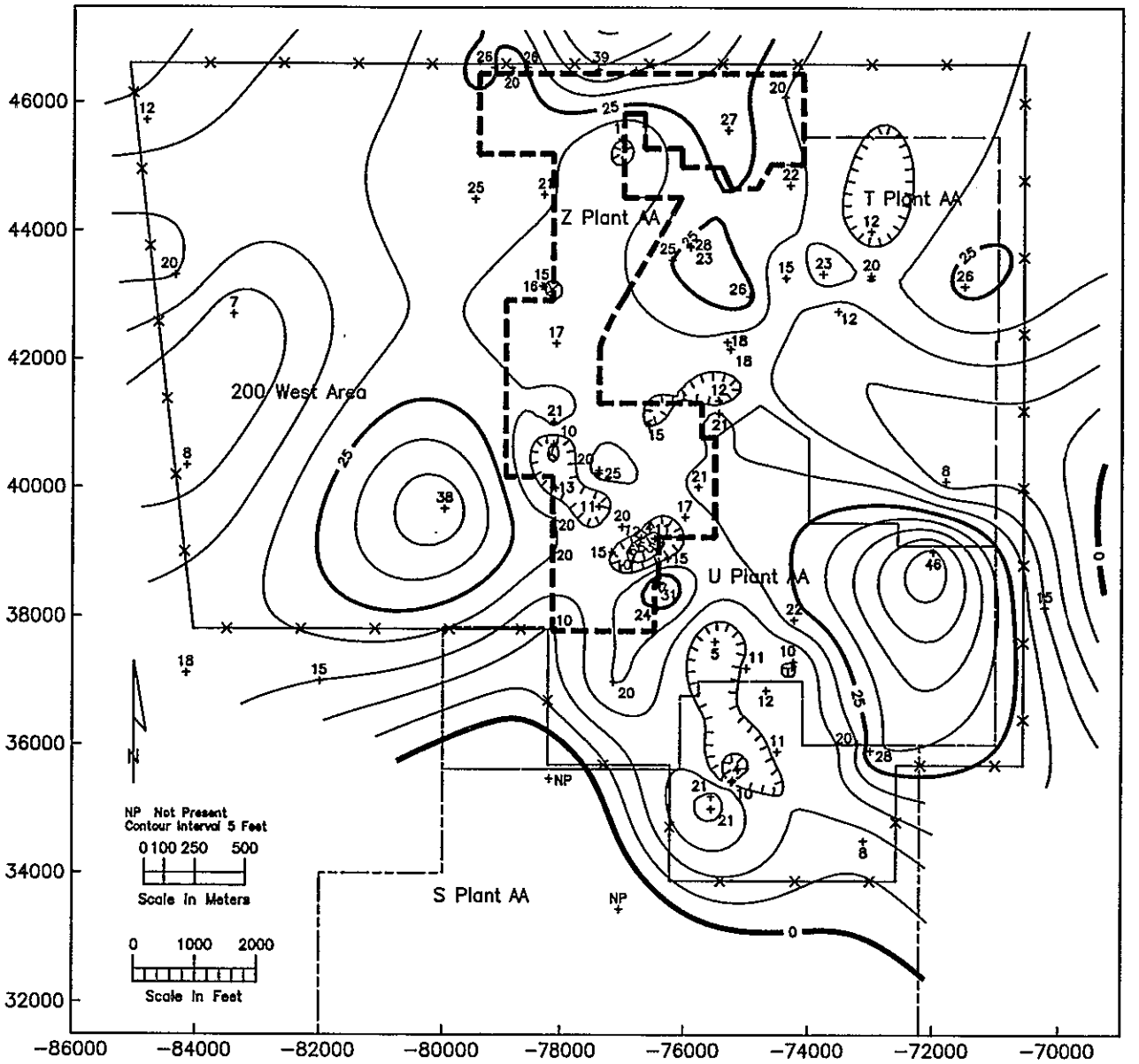


Figure 3-30. Isopach Map of the Plio-Pleistocene Unit.

3-30

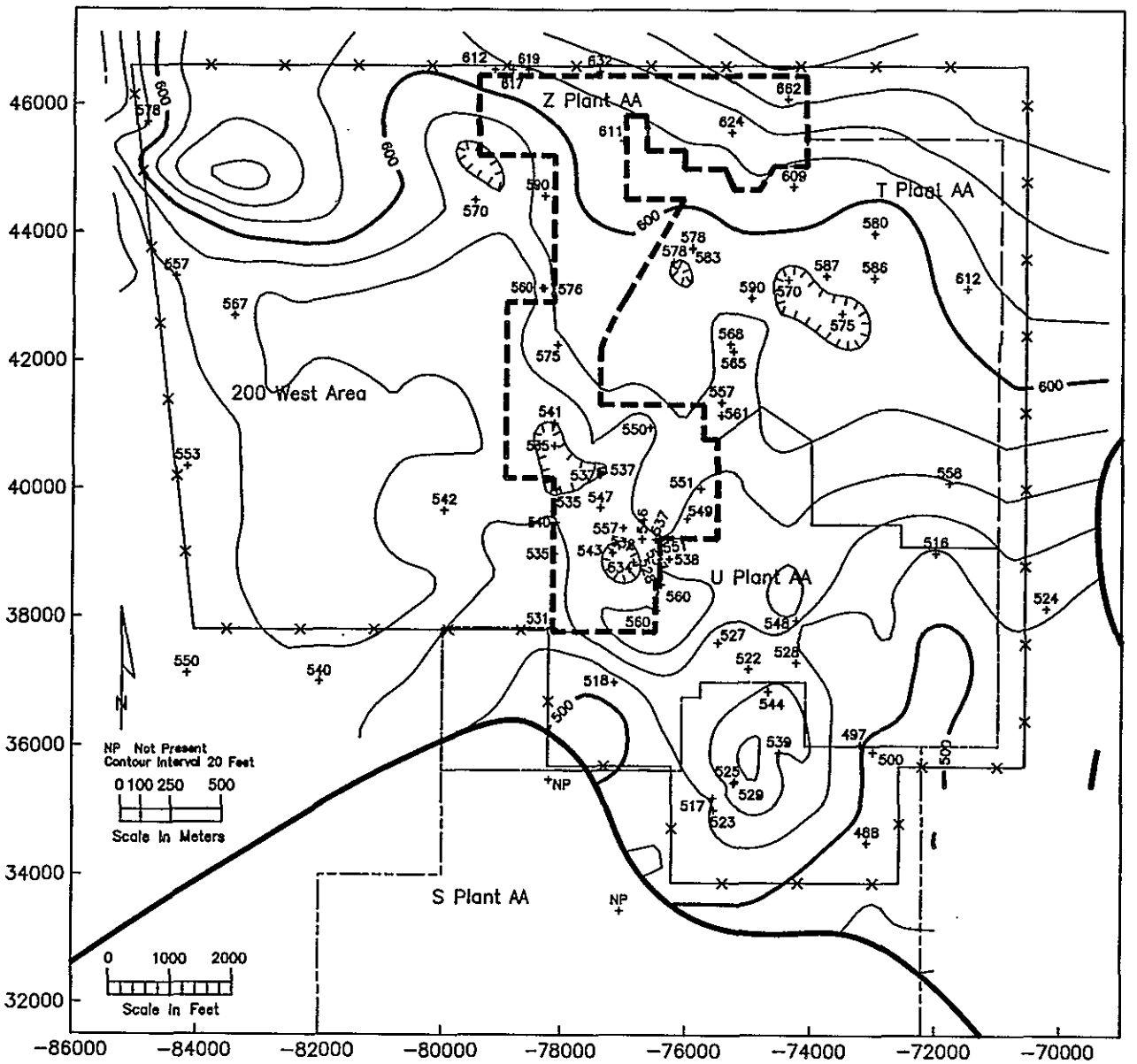


Figure 3-31. Structure Map of the Plio-Pleistocene Unit.

3-31

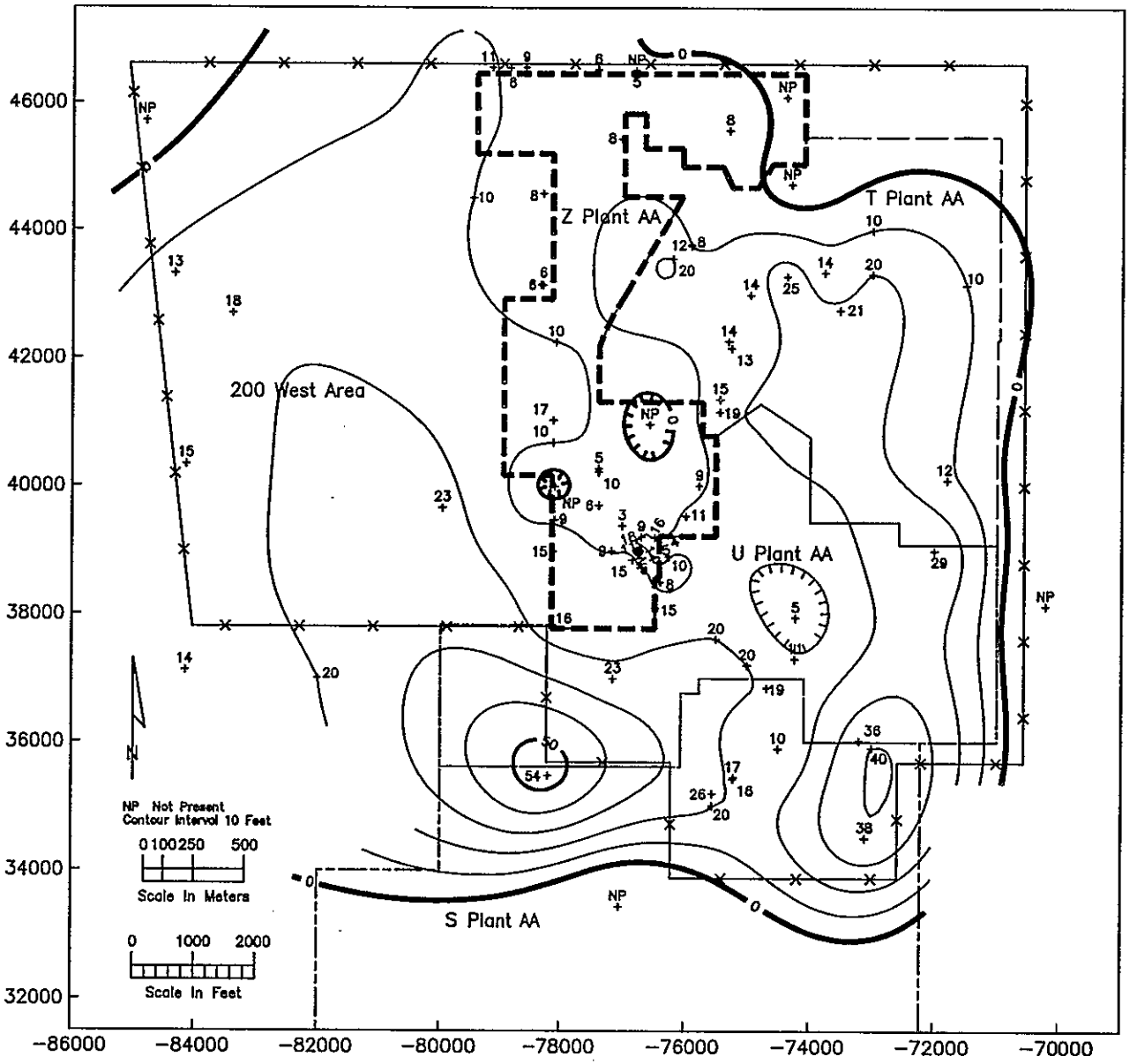


Figure 3-32. Isopach Map of the Early "Palouse" Soil.

3-32

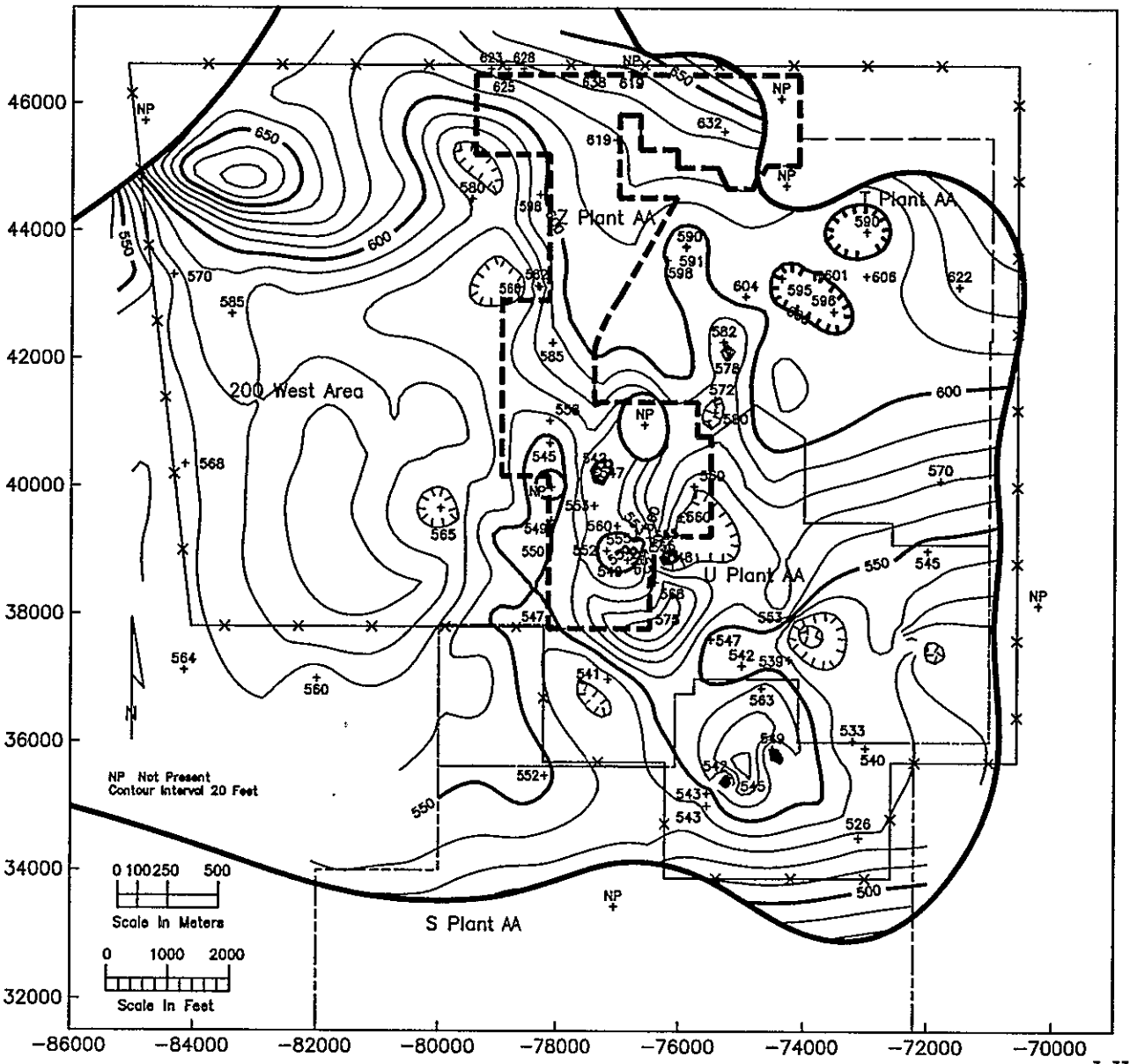


Figure 3-33. Structure Map of the Early "Palouse" Soil.

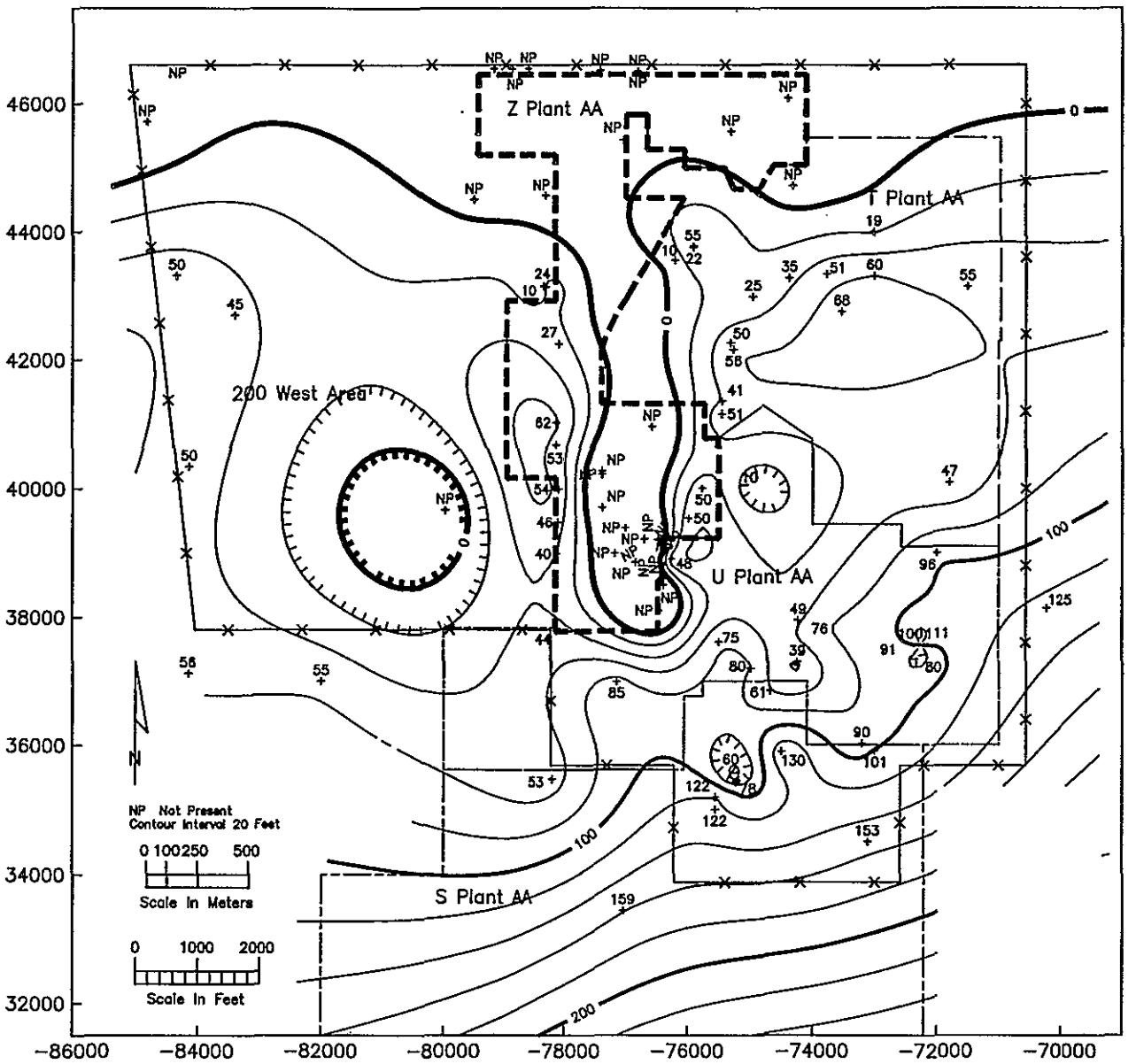


Figure 3-34. Isopach Map of the Lower Fine-Grained Unit of the Hanford Formation.

3-34

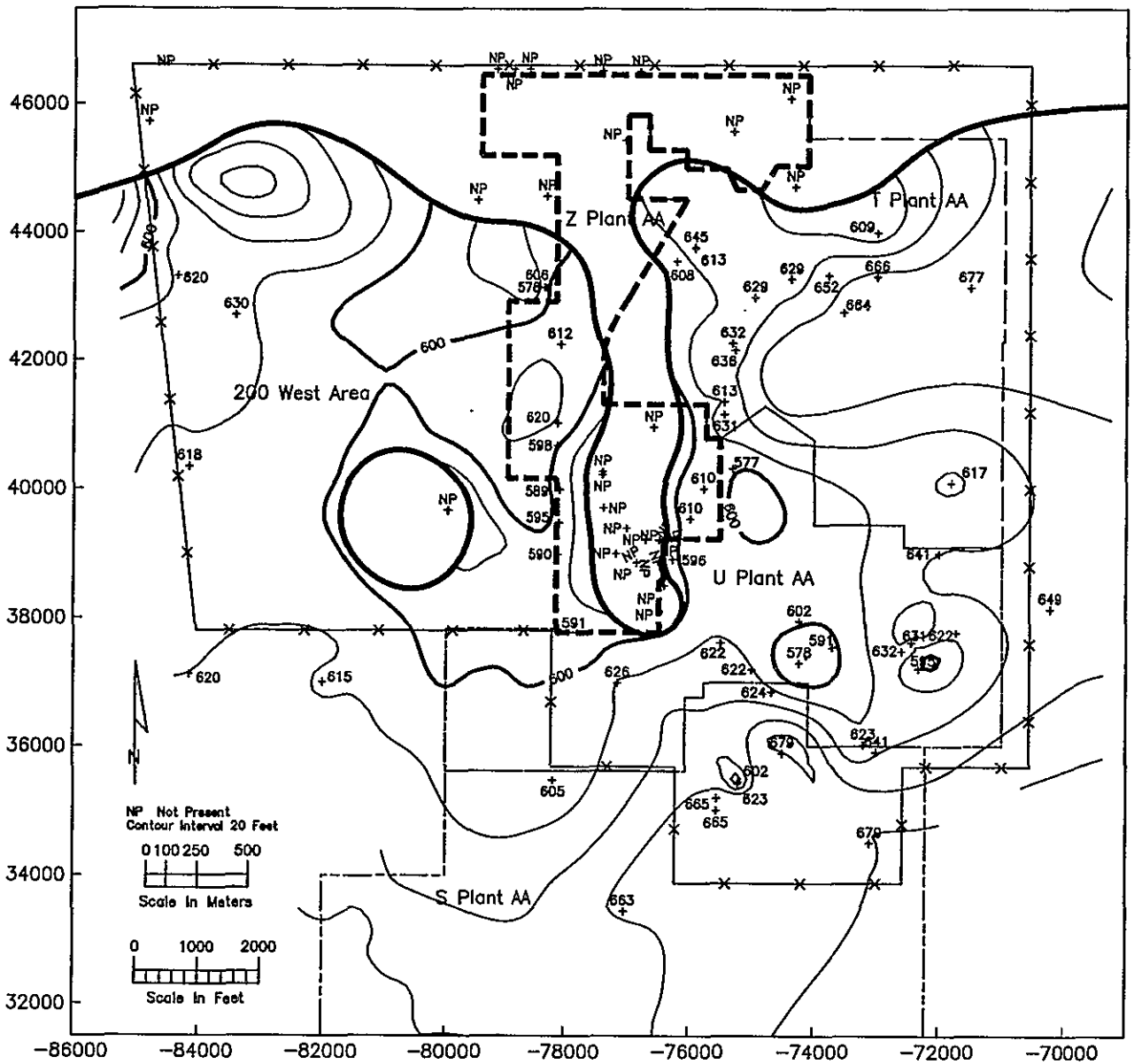


Figure 3-35. Structure Map of the Lower Fine-Grained Unit of the Hanford Formation.

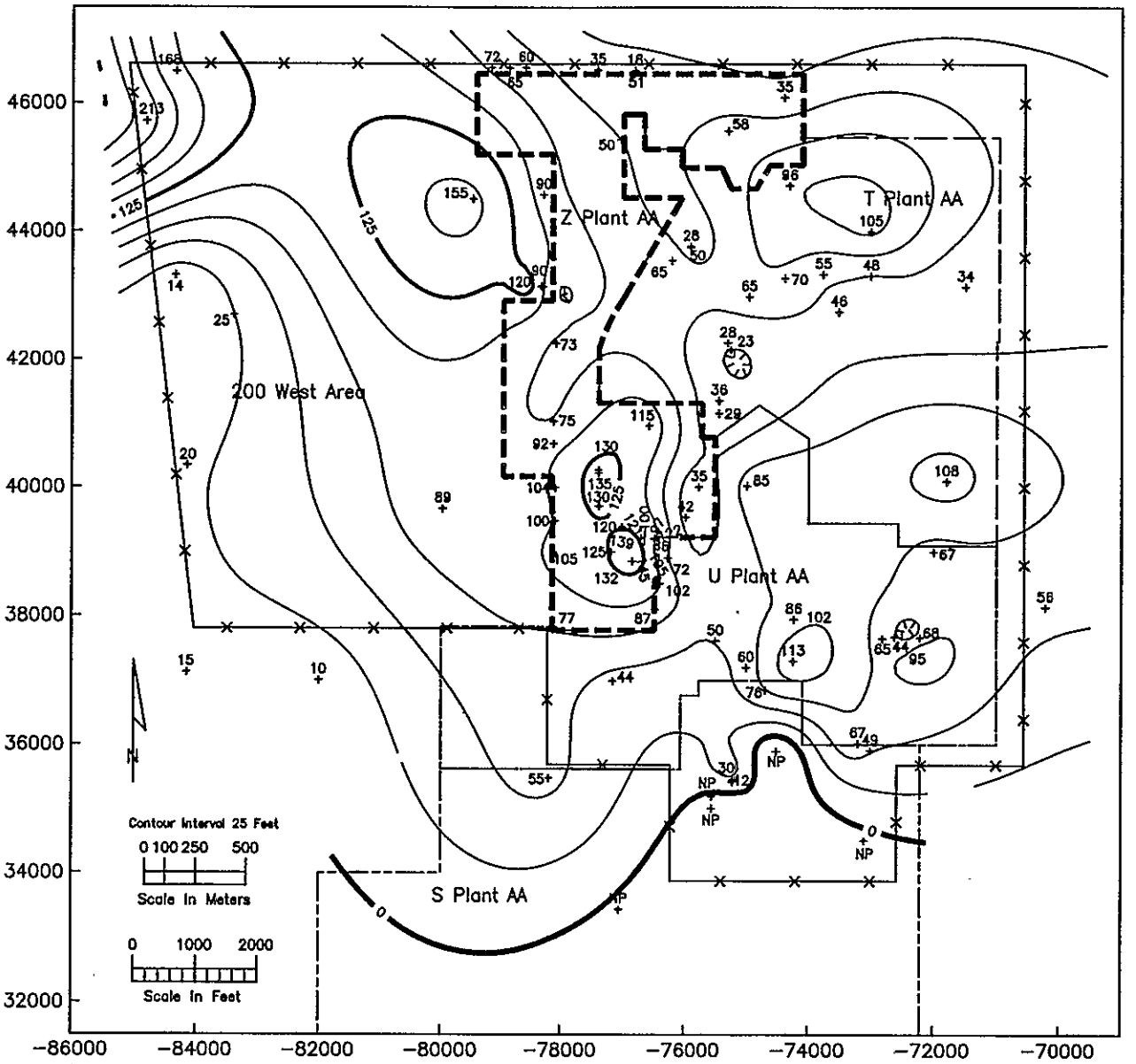


Figure 3-36. Isopach Map of the Upper Coarse-Grained Unit of the Hanford Formation.

3-36

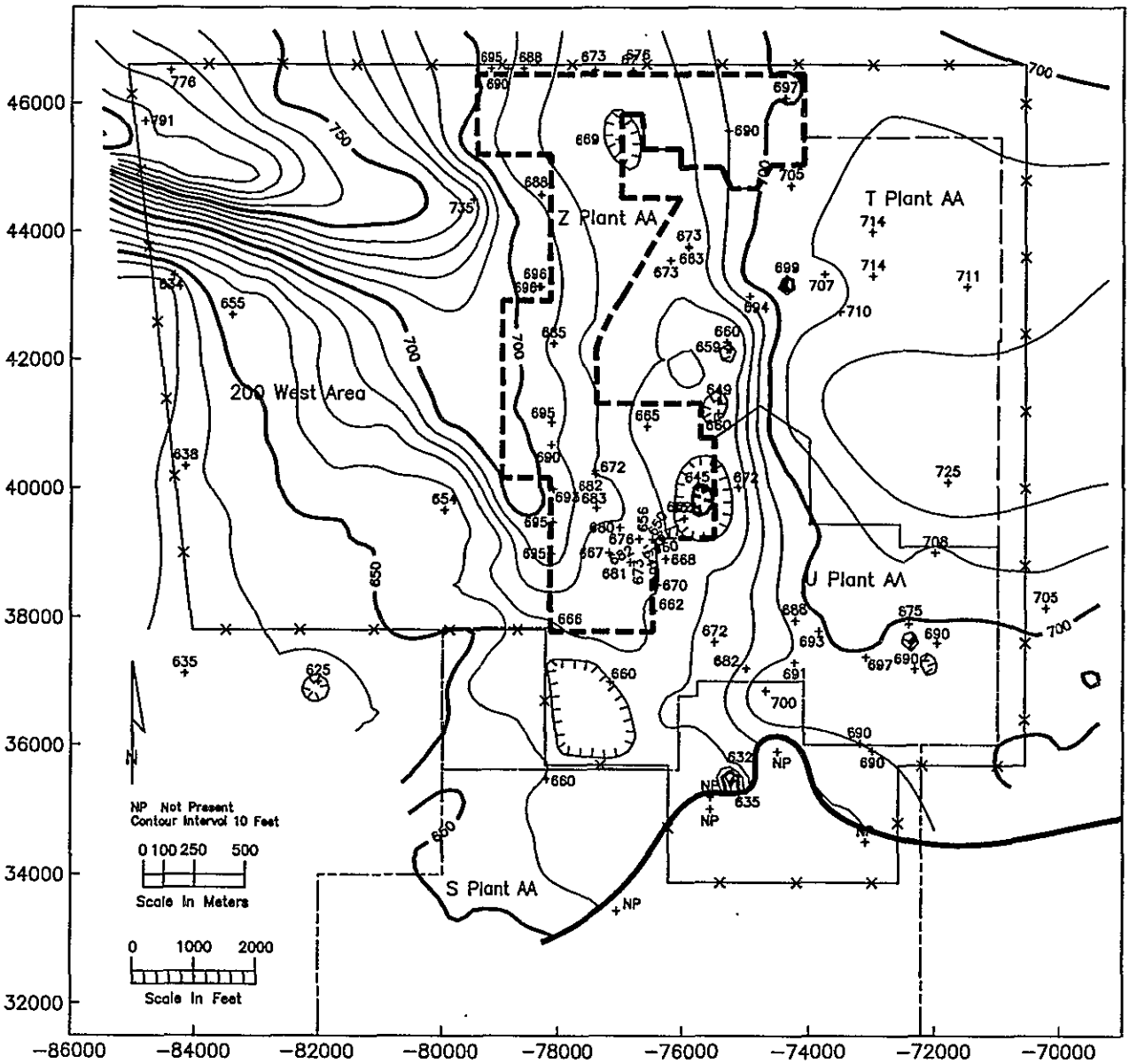


Figure 3-37. Structure Map of the Upper Coarse-Grained Unit of the Hanford Formation. 3-37

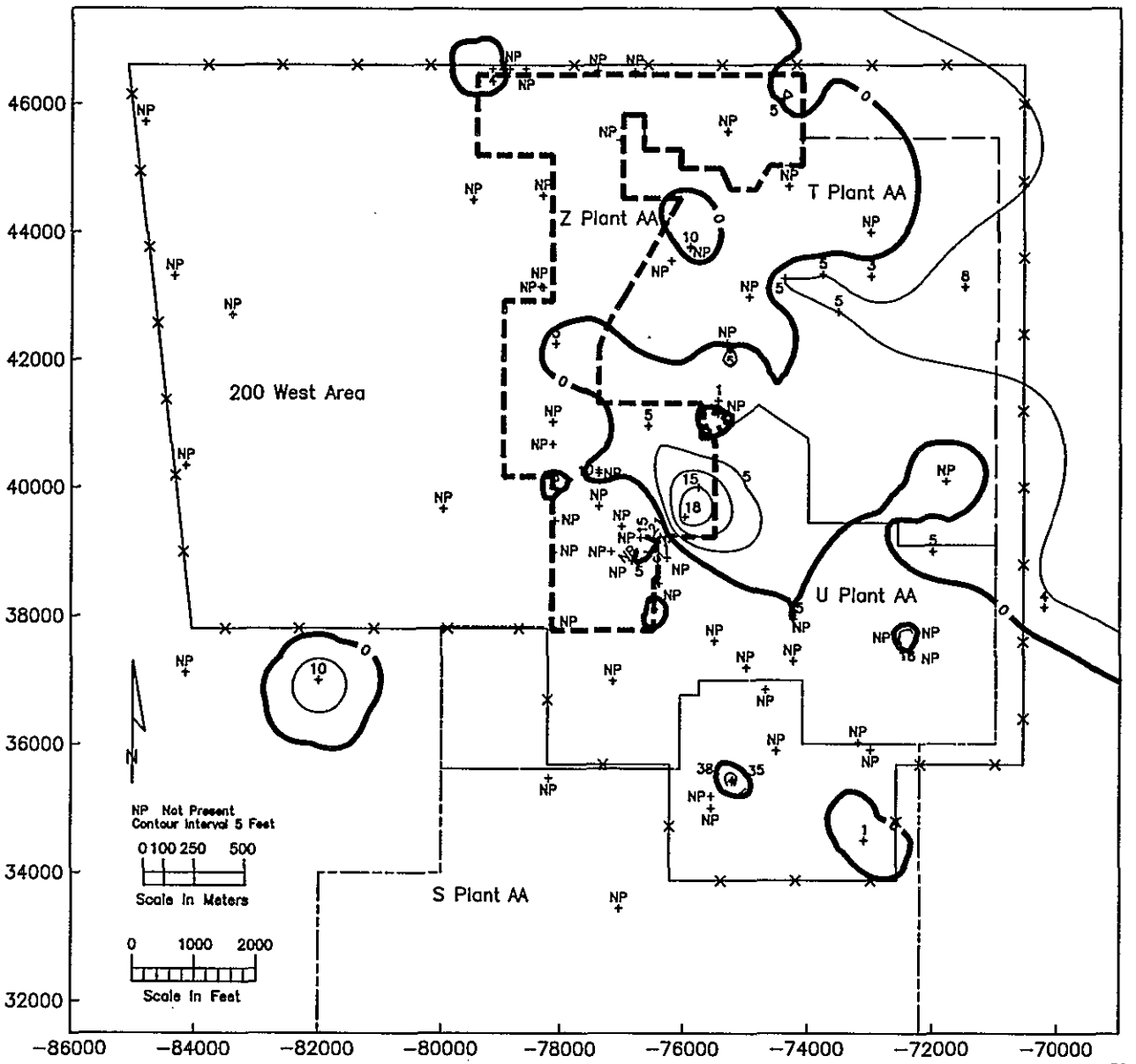


Figure 3-38. Isopach Map of the Backfilled Gravels and Eolian Sands.

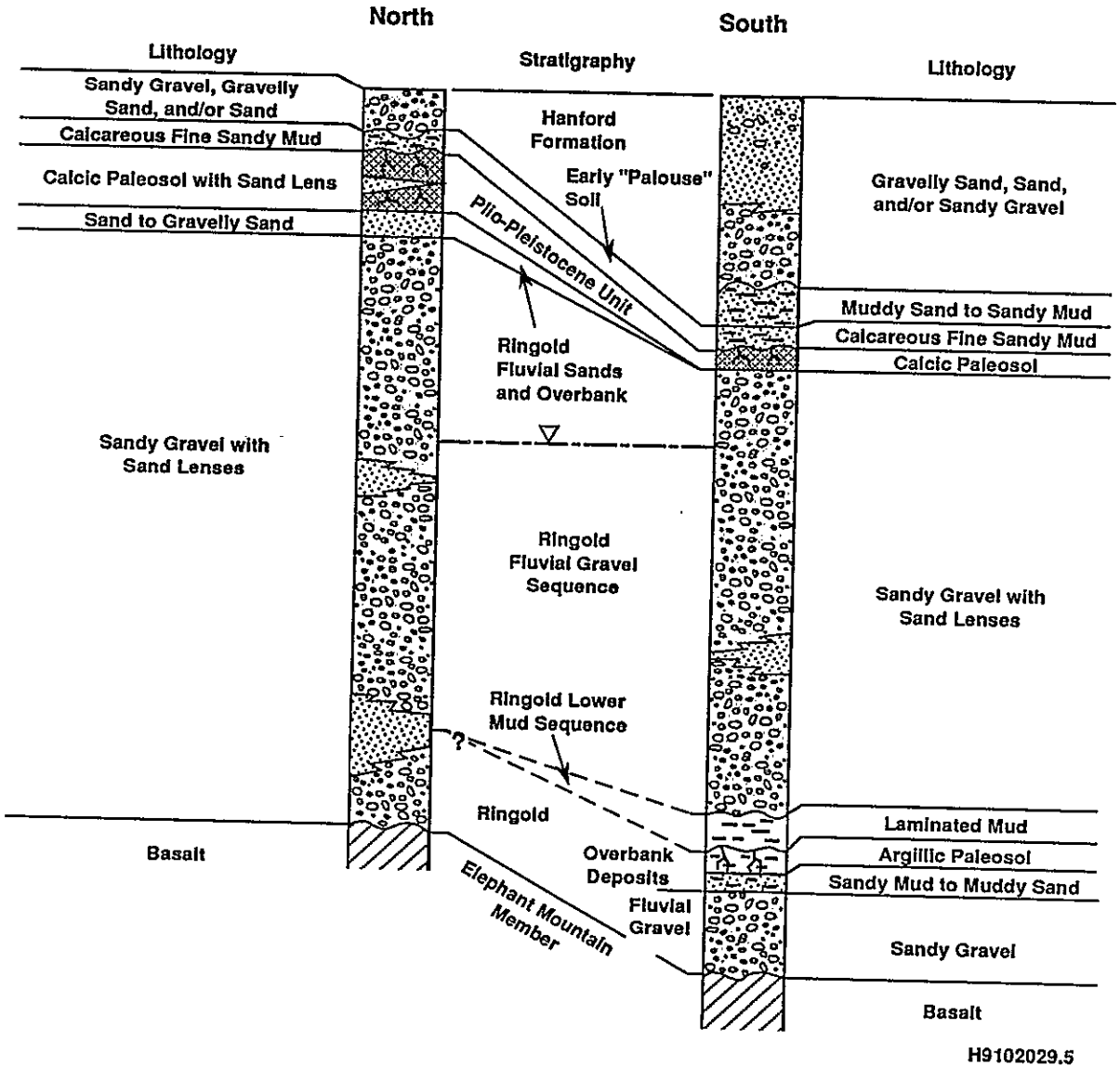


Figure 3-39. Conceptual Geologic and Hydrogeological Column for the 200 West Area. (Last et al. 1989).

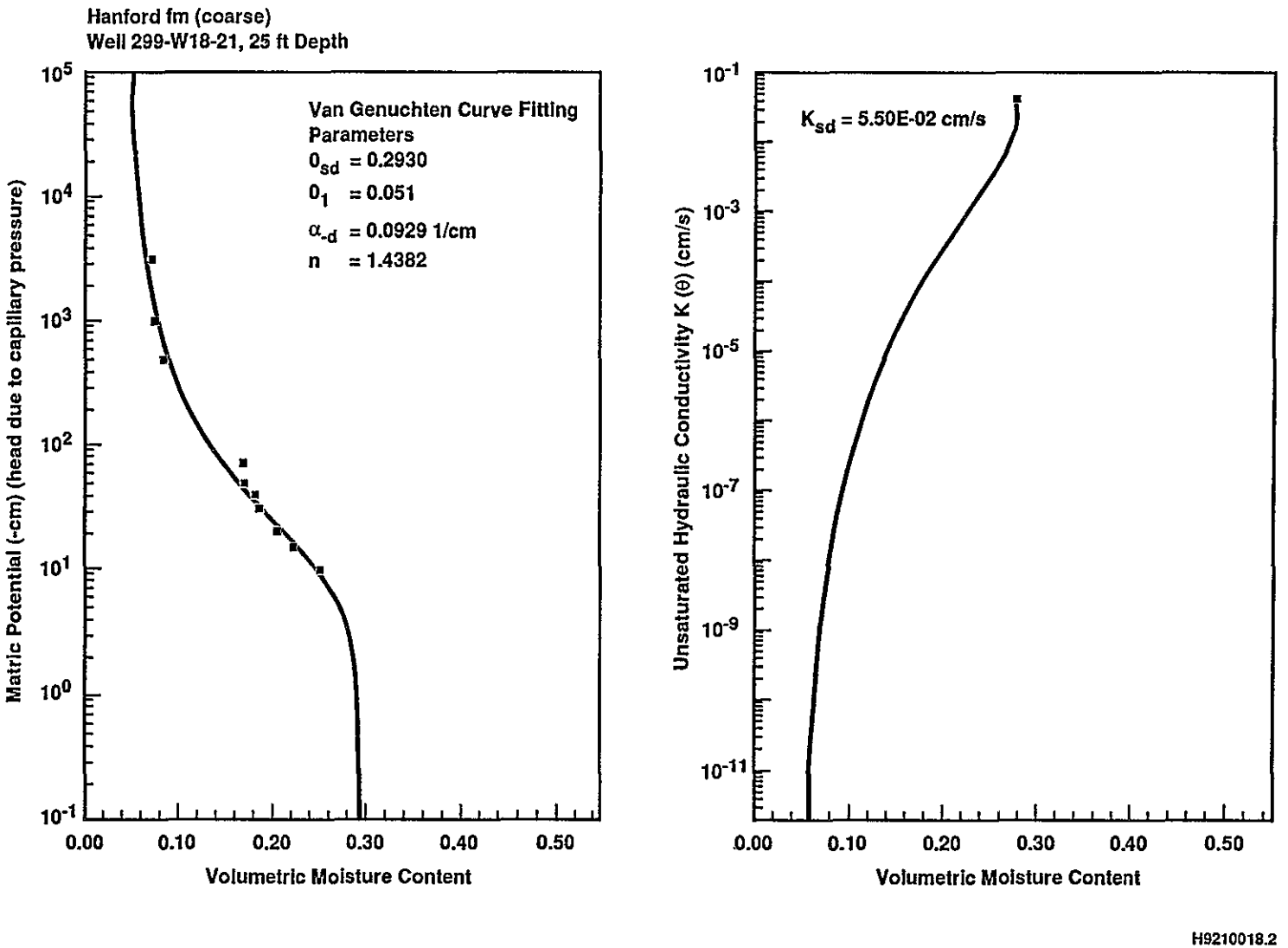
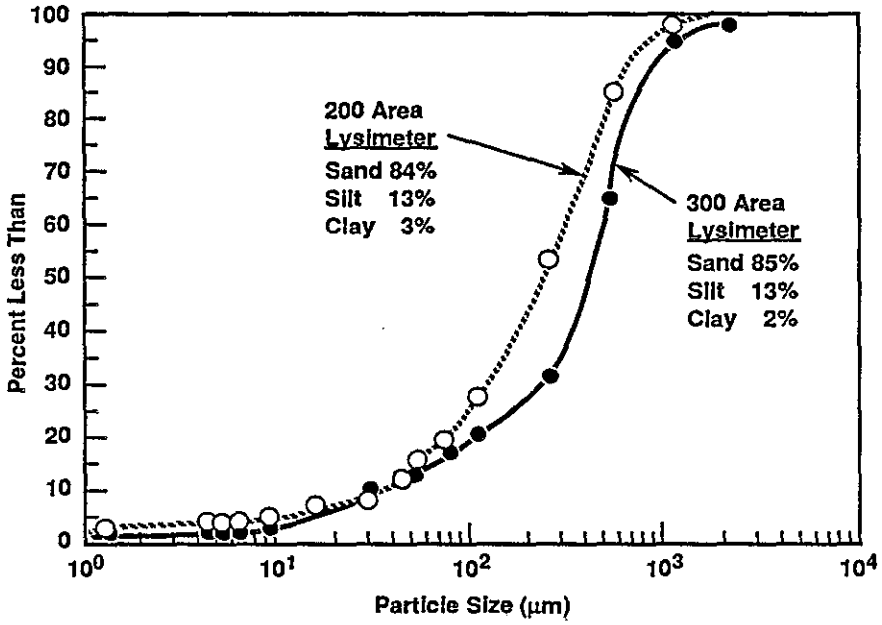
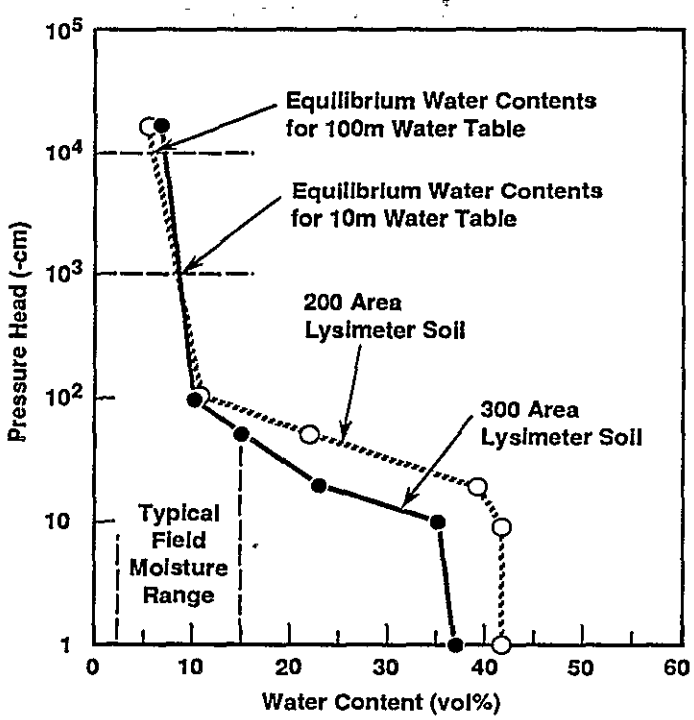


Figure 3-40. Wetting and Drying Curves for Well 299-W18-21



a. Particle Size Distribution



b. Water Retention Characteristics

H9210018.3

Figure 3-41. Particle Size Distribution and Water Retention Characteristics of Soils From Hanford Site Lysimeters. (Gee and Heller 1985)

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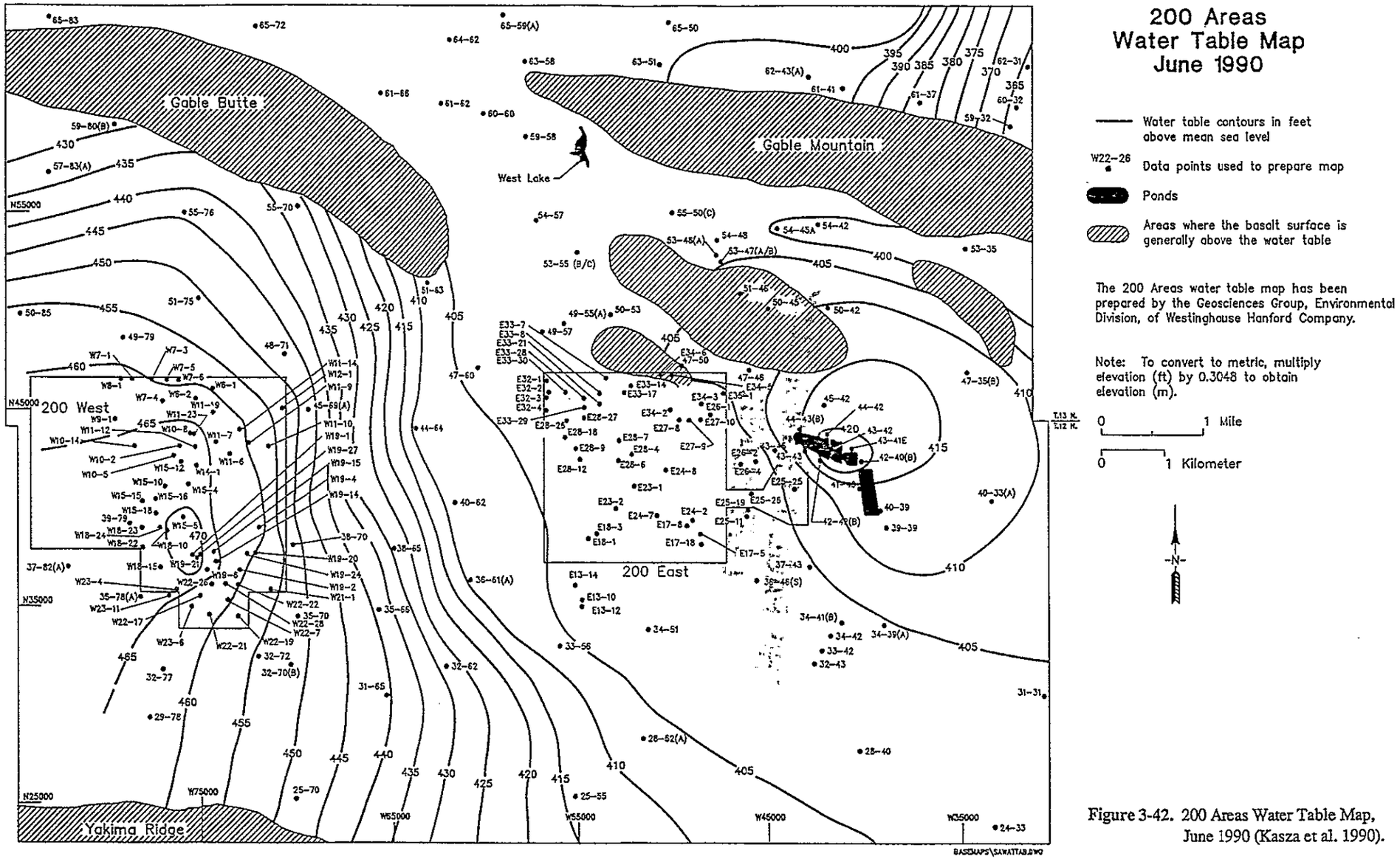

Figure 3-42. 200 Areas Water Table Map, June 1990 (Kasza et al. 1990).

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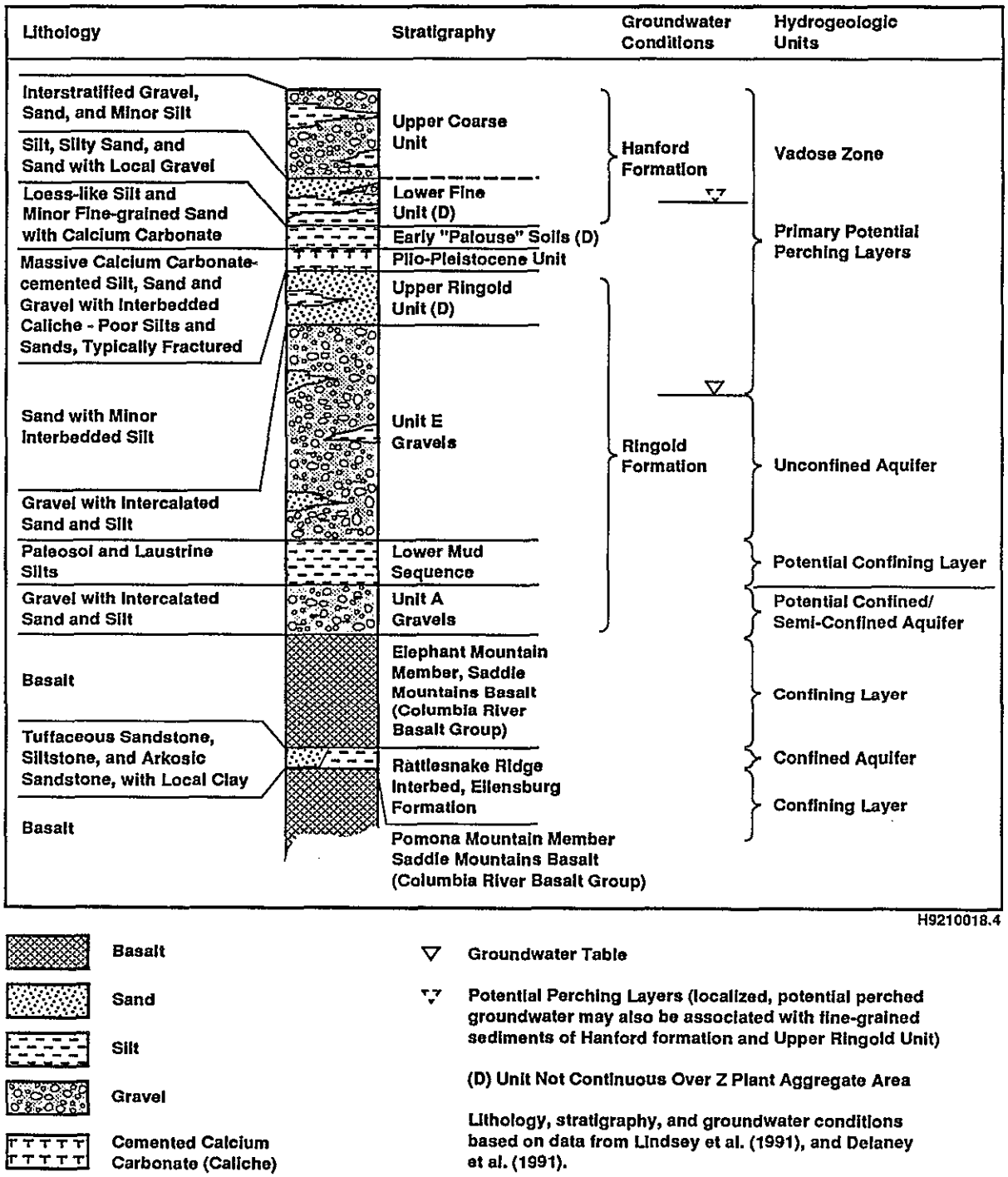


Figure 3-43. Conceptual Hydrogeologic Column for the Z Plant Aggregate Area.

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

Location	Interval tested	Hydraulic conductivity (m/d)
Pasco Basin	Hanford formation	150 - 6,200
	Ringold Formation Unit E	6 - 180
	Ringold Formation Unit A	0.03 - 3
100 Area	Ringold Formation Unit E	9 - 395
200 Areas	Hanford formation	610 - 3,050
	Ringold Formation Unit E	2.7 - 70
	Ringold Formation Unit A	0.3 - 3.6
200 West Area	Ringold Formation Unit E	0.02 - 61
	Ringold Formation Unit A	0.5 - 1.2
	Lower Ringold laboratory	9×10^{-6} - 2.4×10^{-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 Units C/B	0.09 - 1.5
1100 Area	Ringold Formation	2.4×10^{-4}
	Overbank Deposits	0.03

Table 3-2. Summary of Reported Hydraulic Conductivity Values for Hanford Site Vadose Zone Sediments. (Sheet 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
6.7×10^{-7}	10	Sand	200 Area	Lysimeter Soil Experiments
1.7×10^{-8}	7			
1.7×10^{-9}	5.5			
1.7×10^{-10}	5			
1.3×10^{-11}	4.3			
2.6×10^{-3}	31	Sandy soil reported as "typical or many surface materials at the Hanford Site."		Unsaturated column studies.
5.7×10^{-4} (sat)	56			
6.3×10^{-11}	2.9	Near-surface soils	2-km south of 200 East Area	K estimates using water retention curve data.
2.2×10^{-11}	2.8			
5.40×10^{-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.
9.78×10^{-3} (sat)	42.2			
8.4×10^{-3} (sat, arithmetic mean of four measurements)	na			
8×10^{-8}	11	na	BWTF: Southeast Caisson, and North Caisson	Unsteady drainage-flux field measurements.
4×10^{-3} (Southeast Caisson	26	na		
1×10^{-8}	10	na		
1×10^{-2} (North Caisson)	29	na		
4.5×10^{-3} (arithmetic mean of 15 measurements)	Field Saturation	na	BWTF North Caisson and area north of caisson	Guelph permeameter field measurements
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		

Table 3-2. Summary of Reported Hydraulic Conductivity Values for Hanford Site Vadose Zone Sediments. (Sheet 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
8×10^{-7} 9×10^{-4}	16 40	Loam to sandy loam	McGee Ranch:NW of 200 West Area on State Rt. 240	Unsteady drainage-flux field measurements.
9×10^{-4} (arithmetic mean of 9 measurements	Field Saturation	na		Guelph permeameter field measurements.
5×10^{-3} (sat) 1×10^{-3} (sat) 5×10^{-4} (sat) 1×10^{-4} (sat) 5×10^{-5} (sat)	50 50 40 40 40	Sand, Gravel Coarse Sand Fine Sand Sand, Silt Caliche	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.
1.2×10^{-5} (sat) 6.7×10^{-6} to 2.8×10^{-1} (sat) 1.10×10^{-3} (sat) 1.80×10^{-4} to 3.00×10^{-4} (sat)	19.6 to 18.9 37.6 to 41.4 18.3 to 21 24 to 25	Hanford formation Early "Palouse" Soils Upper Ringold Middle Ringold	Well 299-W7-9, 218-W-5 Burial Ground	van Genuchten equation fitted to moisture characteristic curves for Well 299-W7-9 soil samples

Notes:

na - Not identified in source.
sat - Value for saturated soil.
field saturation - Equilibrium water content after several days of gravity drainage.

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

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

Name	Status Federal	State
Peregrine Falcon *(Falco peregrinus)*	FE	SE
Sandhill Crane *(Grus canadensis)*	--	SE
Bald Eagle *(Haliaeetus leucocephalus)*	FT	ST
Ferruginous Hawk *(Buteo regalis)*	FC2	ST
Swainson's Hawk *(Buteo swainsoni)*	FC2	SC
Golden Eagle *(Aquila chrysaetos)*	--	SC
Burrowing Owl *(Athene cuniculuria)*	--	SC
Loggerhead Shrike *(Lanius ludovicianus)*	--	SC
Sage Sparrow *(Amphispiza belli)*	--	SC
Great Blue Heron *(Casmerodius albus)*	--	SM
Merlin *(Falco columbarius)*	--	SM
Prairie Falcon *(Falco mexicanus)*	--	SM
Long-billed Curlew *(Numenius americanus)*	--	SM
Striped Whipsnake *(Masticophis taeniatus)*	--	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 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 potentially applicable or relevant and appropriate requirements (ARARs) (Section 6.0). Contaminant information is assessed in Section 7.0 to provide a basis for selecting remediation technologies which can be implemented at the sites.

Contaminants released into the environment at a waste management unit or unplanned release may migrate from the point of release into other types of media. The potentially affected media in the Z Plant Aggregate Area include surface soil, surface water, vadose zone soil and perched groundwater, air, and biota. The media affected at a specific waste management unit will depend upon the quantities, chemical and physical properties of the material released, and the subsequent history of the waste management unit. 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 radiological and chemical data for the Z 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, many of these studies were limited in scope and did not provide a comprehensive analysis of the character and distribution of the contamination at the waste management unit locations. The types of unit-specific data that are available for some units, include inventory information, surface radiological surveys, external radiation dose rate monitoring, soil and sediment sampling, groundwater sampling, biota sampling, and borehole geophysics.

Table 4-3 summarizes the types of unit-specific data available for each of the waste management units. 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.

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 unit-specific data, there are area-wide data that may not be directly applicable to specific waste management units within the Z Plant Aggregate Area. The primary sources of this general environmental information are the Environmental Surveillance Annual Monitoring Reports for the 200/600 Areas by Rockwell Hanford Operations (RHO) (Elder et al. 1986 and 1987), and Westinghouse Hanford (Elder et al. 1988 and 1989, Schmidt et al. 1990 and 1992). The annual reports describe several different sampling and survey programs including surface soil sampling, external radiation measurements, biota sampling, air sampling, surface water sampling, and radiological surveys. The annual monitoring is generally directed toward assessing the effect of Hanford Site-wide operations (including the 200 Areas production and processing facilities) on the local environment. Until 1990, few of the sample locations were directly associated with specific waste management units identified for the Z Plant Aggregate Area, except for the 200 West Burial Grounds. Much of this information is therefore useful only in characterizing area-wide trends. Beginning in 1990, however, several new sampling locations (shown on Plate 2) were established near specific areas of suspected surface contamination, such as near the main PFP building complex.

An additional source of Hanford site-wide environmental data are Hanford Site Environmental Reports by PNL (e.g., Jaquish and Bryce 1989). As part of the Hanford Site-wide monitoring program, the PNL environmental reports establish regional background concentration data for many radionuclide and chemical parameters. These background data were in turn used as comparative values, or used to derive comparative background values in the RHO Westinghouse Hanford annual monitoring reports.

Area-wide geophysical data also exist, and include gravity, magnetic, magnetotelluric, seismic refraction, and seismic reflection surveys (DOE 1988b). These studies are not useful however, for characterizing the extent of chemical and radionuclide contamination. These data are therefore not presented in Section 4.0 of the this report, but a general discussion of this information is provided in Section 8.0.

The types of data listed on Table 4-3 were reviewed to evaluate whether air, surface soil, vadose zone soil, or groundwater was potentially impacted by waste handling activities at Z Plant Aggregate Area waste management units. The applicability of the information to specific Z Plant Aggregate Area waste management units was qualitatively reviewed, along with the age and nature of the data. As a result of the this evaluation, potentially affected media (air, surface soil, surface water, vadose zone soil, and biota are listed on Table 4-2 for radionuclide contaminants and on Table 4-3 for organic/inorganic chemical contaminants.

Additionally, little or no environmental monitoring data were found in the documents reviewed for some engineered facilities where liquid or solid wastes were transferred, treated, stored, or disposed. Although not listed as actual known or suspected locations of contamination in Tables 4-1 and 4-2, some degree of contamination (as yet undefined) is possibly associated with these facilities. This category includes the tanks that received PFP

process waste (e.g., the 216-Z-8 Settling Tank, the 241-Z-361 Settling Tank, and 241-Z Diversion Boxes No. 1 and No. 2) and many of the burial grounds. These types of facilities are the subject of discussion for "data gaps" addressed in Section 8.0 of this report.

The following subsections of Section 4.1 present results of the evaluation of known and suspected contamination for the Z Plant Aggregate Area. Section 4.1.1 describes analysis results on a media-specific basis. Section 4.1.1.1 presents 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 in Section 4.1.1.4. Vadose Zone sampling data are discussed in Section 4.1.1.5. Although groundwater issues are considered beyond the scope of this study, Section 4.1.1.5 also discusses evidence for contamination migration within the vadose zone to the unconfined aquifer underlying the Z Plant Aggregate Area. Additional assessment of the nature and extent of groundwater contamination is presented in the 200 West Groundwater AAMS report. Evaluation of known and suspected contaminants for each of the Z Plant Aggregate Area waste management units is discussed in Section 4.1.2.

To supplement available radiological and chemical analytical data, historical waste inventory information for the Z 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 (WHC 1991a) and the Hanford Inactive Site Survey (HISS) Database (DOE 1986).

4.1.1 Affected Media

4.1.1.1 Air. This section discusses results of ambient air monitoring applicable to the Z Plant Aggregate Area as reported in RHO/Westinghouse Hanford annual environmental surveillance monitoring reports (Elder et al. 1986 through 1989, Schmidt et al. 1990 and 1992). Ambient air monitoring stations located within the Z Plant Aggregate Area or near its boundary include sites N165, N962, N964, and N994 (Plate 2). As discussed in each of the RHO/Westinghouse Hanford annual environmental monitoring reports for 1985 through 1990, the sampling locations are part of a larger network within the 200 Areas to assess the effect of operations on the local environment, and to assess 200 Areas facilities performance. According to the annual reports, sample station locations throughout the 200 Areas were sited based on prevailing wind directions and potential sources of airborne contaminants. Within the Z Plant Aggregate Area, sample stations N962 and N964 are located near the 218-W-4B Burial Ground to the west (general up-wind direction) of the main PFP building complex (Plate 2). Station N165 is east-southeast of the building complex (general down-wind direction), and station N994 is a fenceline point along the north boundary of the PFP.

The air samplers at each of the monitoring stations contain filters which collect particles entrained in the air. The air samples are collected by drawing samples through a 47-mm (1.8 inch), open-face filter at about 1 m (3 ft) above the ground (0.2 m^3 [2 ft^3]/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.

Air monitoring results from the 1985 through 1989 annual environmental surveillance reports are presented in Table 4-4. Entries in the table are average results over this period for cesium-137, strontium-90, plutonium-239, and total uranium. The complete data set from the annual monitoring reports since 1985 is provided in Table A-3 of Appendix A.

Positive detections for each radionuclide analyzed are common from 1985 to 1989 (Elder et al. 1986, Schmidt et al. 1990). Each of the RHO/Westinghouse Hanford annual monitoring reports conclude that the activities in the 200 Areas contributed to average air radionuclide concentrations that were "slightly above" background. As discussed in the annual reports, the background concentrations were derived from three background monitoring stations located outside the 200 Areas (Yakima and Wye Barricades, and former Hanford Townsite). The Schmidt et al. (1990) conclude that radionuclide concentration trends in air since 1979 have been "generally downward" for the 200 West Area because of overall improvement in operational environmental controls and curtailed operations.

One of the Z Plant Aggregate Area, N962 (southeast corner of 218-W-4B Burial Ground), has shown the highest annual average strontium-90 concentrations of the 200 Areas samples for several years—most recently 1989 (Schmidt et al. 1990). Strontium-90 concentrations up to 58 times greater than background for the Hanford Site have been reported for N962 (1987 annual report, Elder et al. 1988). Annual average concentrations of strontium-90 for the sample location have decreased since 1987. In addition, location N165 near the head of the 216-Z-19 Ditch southeast of the Z Plant building complex had the highest plutonium-239 concentration reported for the 200 Areas air samples in 1986, 1987, and 1988. Plutonium-239 concentrations in sample N165 were up to 100 times greater than background levels for the 200 Areas sites (Elder et al. 1986). The elevated plutonium concentrations are likely attributable to airborne particulate matter from historical plutonium finishing/recovery operations at the Z Plant building complex to the west-northwest, in the general up-wind direction from N165. The 1985 through 1988 annual reports (Elder et al. 1986 through 1989) indicate that the only other gamma-emitting radionuclides found at levels "significantly greater than background" were detected in samples from the 200 East Area. A similar conclusion for these other radionuclides is not included in the 1988 and 1989 annual reports (Elder et al. 1989, Schmidt et al. 1990).

Residue from particulate air contaminants derived from 200 Areas production processing facilities, and possibly Unplanned Release locations and wind-eroded burial ground soils would be expected in Z Plant surface soils due to wind-borne dispersion. As discussed in Section 4.1.1.2, radiological soil contamination has been documented at surface soil grid point sampling locations across the Z Plant Aggregate Area. Results of radiation

surveys also indicate the presence of surface contamination at many locations. Surface soil contamination is also commonly associated with localized areas within the burial grounds and at unplanned release locations. Wind-borne radionuclides likely contributed to the surface contamination detected at these locations.

4.1.1.2 Surface Soil. Several types of data exist for characterizing surface soil contamination or assessing areas of possible contamination. These data include results of aerial and ground radiological surveys, external radiation measurements, and surface soil sampling. These data are presented in the following subsections for the Z Plant Aggregate Area as a whole. In addition, waste management unit-specific radiological and soil sampling are presented in Section 4.1.2.

4.1.1.2.1 Aerial Radiological Surveys. An aerial radiological survey was performed over the 200 West Area in July and August 1988 (Reimann and Dahlstrom 1988). The aerial survey identified general areas gross gamma radiation related to surface and relatively shallow buried radiation sources. 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 (3.28 ft) above the ground surface. Figure 4-1 presents gross gamma radiation data (counts per second [ct/sec]) from the aerial survey on an isoradiation contour map. 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 survey utilized portable radiological counting equipment that detects the presence of any gamma radiation above a threshold energy level. This method of detection is intended to measure the total combined radiation from all radionuclide gamma sources present. Several of the Z Plant Aggregate Area Burial Grounds and the 2702-W RMW Storage Facility have radiation levels exceeding 2,000 ct/sec (Figure 4-1 - Sites 9 through 12).

Results of the aerial survey are useful for providing an overall indication of areas with elevated radiation, and can help to focus more-detailed ground surveys in these areas. Conversion of aerial gross gamma data to accurate surface radiation dose measurements however, is generally not possible 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. A photopeak is a specific energy or wavelength that can be associated with the emissions from a specific radionuclide. 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).

4.1.1.2.2 Surface Radiological Survey Data. Radiological surveys documenting radiation levels dose rates are completed on a regular basis for specific waste management unit areas within the Z Plant Aggregate Area using portable instrumentation. The surveys are performed as part of the Radiation Area Remedial Action program.

The surveillance of ground surface sites for the Radiation Area Remedial Action program is performed in accordance with surveillance frequencies established in Winship and Hughes (1991) to identify those waste management units that require decontamination and/or stabilization: surveillance is also conducted to verify that radioactive contamination is not migrating beyond the posted control boundaries for those sites ranked under Winship and Hughes (1991). This assessment determines if any changes in the radiological status, resulting from an inadequacy of containment of radioactive materials, has occurred in each area. Each radiological survey is intended to determine whether the contamination is essentially confined to the soil surface or if the contaminant source is present at depth. Further, the surveys provide data for confirming that radioactive-contaminated ground sites are posted in accordance with the requirements in WHC (1988c). General areas of known or suspected surface and subsurface radiation in the Z Plant Aggregate Area Burial Grounds were identified by Huckfeldt (1991b), and are shown on Figure 4-2.

Survey results were compiled from the Westinghouse Hanford (WHC 1991a) and from a compilation of Z Plant radiological survey data. Results of the radiological surveys are presented in Table 4-5, and are broken down by contamination levels and dose rate measurements. Survey results for specific waste management units are discussed in Section 4.1.2.

The radiological surveys are either performed by walking the site or utilizing vehicles equipped with β-gamma detectors (scintillation-N_aI (sodium iodide) detectors). Surveys performed on foot report maximum general area dose rates (P-11 Probe with Geiger-Mueller detector or equivalent) and "direct frisk" readings within several cm of the soil surface. Few "smears" are taken in environmental sampling. Vehicle surveys 4.5 m/s (< 10 mph) use detectors positioned approximately 0.5 m (1.6 ft) above the ground. The presence of alpha contamination, when measured, is detected with a portable alpha meter. Depending upon the instrumentation and survey techniques used, results are reported in ct/min, dis/min, or mrem/hr. Typical natural background levels for these measurements are approximately: 50 ct/min, 2,000 dis/min (for an NaI detector), 0.05 mrem/hr and 90 mrem/yr. Beta-gamma contamination is measured in ct/min and converted to dis/min (10 percent counting efficiency). High levels of β contamination are sometimes associated with a dose reading (mrad/hr). Alpha contamination is reported as dis/min (7 to 8 percent counting efficiency). In general, additional conversions of one type of radiation reading to another is not possible because of the detection equipment used, and lack of data regarding the quantities of specific radionuclides contributing to the reading.

4.1.1.2.3 External Radiation Dose Rate Measurements. External (ambient) radiation monitoring via thermoluminescence dosimetry (TLD) are conducted during the RHO/ Westinghouse Hanford annual surveillance monitoring (Elder et al. 1986 through 1989, Schmidt et al. 1990 and 1992). The TLD surveys are completed quarterly at soil grid sampling locations (see Section 4.1.1.2.4 for description of grid locations) to measure dose rates from penetrating radiation. The TLDs measure exposure rates resulting from all types of external radiation, including cosmic radiation, naturally occurring radioactivity in soil and air, fallout from nuclear weapons testing, and contributions from Hanford Site activities. Within the 200 Areas, the TLDs are intended to monitor potential exposure rates near

possible radiation sources near active and inactive waste management units, and along fenceline boundaries. The TLD survey data is used to determine baseline exposure potential for the 200 Areas, and measure dose-equivalent rates reported in millirems per year (mrem/yr). The response of the TLD chips is calibrated in the PNL Radiation Laboratory.

TLD results from the RHO/Westinghouse Hanford annual monitoring reports for five soil grid points within the Z Plant Aggregate Area are presented in Table 4-6 of this report. Results are also reported for sample locations 218-W-2A (immediately east of 218-W-2A Burial Ground), and 216-Z-20 [location identified at 216-Z-18 Crib in 1990 annual report (Schmidt et al. 1992) (Plate 2)]. Where listed in the RHO/Westinghouse Hanford reports, Table 4-6 includes quarterly minimum and maximum values, and the normalized annual equivalent total for each sample location. The table results are reported in terms of an air dose.

For each TLD grid sample locations (except sample 2W2), average annual results ranged from 78 to 85 mrem/yr for each of the years 1985 through 1989 (Elder et al. 1986 through 1989, Schmidt et al. 1990). Each of the annual monitoring reports compared these results against regional background levels obtained annually by PNL during Hanford Site-wide monitoring. The background levels are derived by PNL from TLD survey results obtained at sample locations distant from the Hanford Site (Walla Walla, McNary, Sunnyside, Moses Lake, Washtucna, and Yakima). Annual regional background levels ranged between 52 to 93 mrem/yr between 1985 and 1989. For each of these years the RHO/WHC annual monitoring reports concluded that the 200 Areas TLD results (including Z Plant Aggregate Area locations listed) were "within or slightly above" the PNL background values. Grid sample 2W2 had an averaged annual value of 132 mrem/yr, between 1985 and 1988 (analysis not completed in 1989 and 1990) above the background levels cited. The elevated TLD results from these sites could be indicative of sources of radiological contamination in surface soil or shallow-subsurface materials near these locations. The presence of other external radiation sources in the vicinity, such as waste burial containers could also potentially contribute to the elevated TLD reading for grid sample 2W2. In 1990 TLD sample analysis results were reported for location in the 218-W-2A burial ground and near the head of the 216-Z-20 Crib (Schmidt et al. 1992). Annual totals of 108 and 102 mrem/yr were detected at these locations, respectively. These values were below the maximum readings detected at PNL McNary site (108 mrem/yr) and at the Hanford Site Yakima barricade (112 mrem/yr) in 1989.

4.1.1.2.4 Surface Soil Sampling. Radionuclide data from surface soil samples were reviewed from the RHO/Westinghouse Hanford annual environmental surveillance monitoring reports for 1985 through 1989 (Elder et al. 1986 through 1989, Schmidt et al. 1990). During the annual monitoring, surface soil samples are collected from points on a rectangular grid in the 200 Areas. The grid points are generally located close to the intersection of Hanford Site coordinate lines, with four of the grid points (2W2, 2W3, 2W7, 2W17) located within the Z Plant Aggregate Area (Plate 2). Grid sample locations 2W2 and 2W3 are located in the 218-W-3AE and 218-W-6 Burial Grounds, respectively, in the northern part of the Z Plant Aggregate Area. Sample 2W7 is located along the eastern boundary of the 218-W-2A Burial Ground. Grid points 2W17 and 2W22 are located in the 218-W-4C Burial

Ground in the southwest part of the site. A fenceline soil sample (2WN) was been established along the northern fenceline of the 218-W-3AE Burial Ground.

Sample 2W7 and fenceline sample location 2WN have analytical results for each of the years 1985 through 1989. Other Z Plant Aggregate Area samples were not analyzed for some of the years within this period. Discussion of rationale for which sample sites are selected for analysis each year, and which radiological parameters are analyzed is not provided in the annual reports. Each grid point sampling site is 10 by 10 m (33 by 33 ft) in area, and each fence line sampling point is 1 m by 5 m (3.2 by 16 ft). Soil samples from each sampling site represent soil composited from five individual plugs 2.5 cm (1 inch) in depth by 10 cm (4 inch) in diameter collected over the sampling site. No additional information regarding sampling equipment or methodologies was provided in the annual reports.

The annual reports indicate that the soil sampling grid was established to evaluate general, long-term accumulation trends for a variety of radionuclides in site soils. Fenceline sample points are intended to monitor areas upwind and downwind of specific sources of potential contamination, however the 2WN fenceline location is relatively distant from production and processing facilities. Soil (and biota) grid point and fenceline sampling was discontinued in 1990, and sampling now focuses on buildings and facilities other than waste management units. In 1990, soil samples were collected around the main Z Plant Aggregate Area building complex.

Soil monitoring results from the 1985 through 1989 annual environmental surveillance reports are presented in Table 4-7. Entries in the table are average results over this period for radionuclides analyzed. The complete data set from the annual monitoring reports since 1985 is provided in Table A-4 of Appendix A. Results for six of the radionuclides in Table A-4 show positive detections greater than the counting error for the Z Plant soil samples in Table A-4. These radionuclides include cesium-137, lead-214, plutonium-238, plutonium-239, strontium-90, and uranium. In general, the highest average Z Plant radionuclide concentrations for cesium-137, plutonium-238, plutonium-239, and strontium-90 in soil were detected at the 2W2 sample location in the 218-W-3AE Burial Ground. Average lead-214 and uranium concentrations were highest at sample locations 2W22 (218-W-4C Burial Ground) and 2W3 (218-W-6 Burial Ground). The presence of these radionuclides in soil likely resulted from dispersion of airborne radionuclides from 200 Areas production and processing facilities. Airborne radionuclides transported from unplanned release locations and wind-eroded burial ground areas may also contribute to the elevated radionuclide levels in the surface soil samples.

In the 1989 environmental surveillance report, Schmidt et al. (1990) reported that trend analysis of radionuclide concentrations revealed no overall increase since 1978 for the 200 Areas grid point soil samples. Each of the annual reports also concluded that concentrations of radionuclides other than cesium-137, strontium-90, and plutonium-239 in the grid point samples were determined to be "insignificant compared with background or with the latter radionuclides." Background concentrations cited in the annual reports were

derived by RHO/Westinghouse Hanford from off-site soil monitoring data obtained annually by PNL (Jaquish and Bryce 1989) as part of Hanford Site-wide environmental monitoring activities.

Some degree of surface soil contamination is suspected in several areas around the periphery of the Z Plant building complex, as indicated by elevated plutonium concentrations in soil samples collected in 1990 (see Section 4.1.2.1.2 for discussion).

4.1.1.3 Surface Water. No natural surface water bodies exist within the Z Plant Aggregate Area. During the 1988, 1989, and 1990 annual monitoring, however, water quality data were collected for the 216-Z-21 Seepage Basin. No detectable concentrations of radionuclides, nitrates, and other constituents were identified (Elder et al., 1989, Schmidt et al. 1990 and 1992). However, several radionuclides were detected in vegetation and sediment samples collected in the seepage basin which are discussed in Section 4.1.2.8.2.

4.1.1.4 Biota. Radionuclide analyses were completed for vegetation samples collected from grid points in the 200 West Area during annual monitoring for 1985 through 1989. Average concentrations of radionuclides over this period are presented in Table 4-8. Analytical data from the annual reports for each of these years is provided in Table A-5 of Appendix A. The rationale for selection of sample sites and radiological parameters analyzed each year is not provided in the annual reports.

Since 1985, each of the Z Plant Aggregate Area grid sites sampled had cesium-137 concentrations exceeding background levels as reported in the annual monitoring reports. As reported in the 1989 environmental surveillance report (Schmidt et al. 1990) however, there were no statistically significant differences for cesium-137 concentrations in vegetation sampled from the 200 Areas from 1979 to 1989. Also a sample collected at location 2W17 contained plutonium-238 concentrations above the reported background level in 1985 (Elder et al. 1986), and a sample collected at location 2W22 had strontium-90 concentrations above the background level in 1988 (Elder et al. 1989). Elevated cesium-137 concentrations detected during 1986 were attributed to the affect of the Chernobyl nuclear accident (Jaquish and Bryce 1989). Background concentrations cited in the annual monitoring reports were derived from off-site regional background data in annual PNL Hanford Site monitoring surveys. Other radionuclides were detected at concentrations above the counting error for several of the samples (notably at 2W7 and 2W17 in 1989, Schmidt et al. 1990), but background comparative data were not available from the annual reports. Concentrations of these radionuclides (plutonium-238, and strontium-90) in grid point vegetation samples may be attributable to several sources. Although radionuclides in site soils may be derived from windborne dispersion of material released to air from site production/processing facilities, radioactive fallout from nuclear weapons testing and the Chernobyl accident is also expected to contribute.

An aquatic vegetation sample collected from the 216-Z-21 Seepage Basin contained plutonium-239 concentrations (Table 4-9) above background levels reported for 1989 (Schmidt et al. 1990).

A 1990 surface sample from the 216-Z-9 Trench vegetation contained detectable total uranium (Table 4-9). Comparative background concentrations for total uranium in vegetation were not reported for 1990.

Additional biotic samples within the Z Plant Aggregate Area have been collected for radiological evaluation during annual surveillance monitoring for some years. Samples have included rabbit feces at soil grid point 2W22 in the 218-W-4C Burial Ground (Elder et al. 1986), rabbit feces at the 231-Z fenceline (Elder et al. 1988), and mouse feces west of Z Plant (Schmidt et al. 1992), with radiologic biotic contamination reported in each instance. Radionuclide contaminants include cesium-137, europium-152, strontium-90, and plutonium.

The source of the contaminated material identified in the rabbit feces at 2W22 is indeterminent, because of the mobility of the animal. The contaminated rabbit and mouse feces may be associated with sources within or near the main PFP complex, but are not specifically identified in the annual environmental reports.

4.1.1.5 Vadose Zone Contamination. This section presents sampling and analytical data applicable to vadose zone soils across the Z Plant Aggregate Area as a whole. Information specifically related to individual waste management units, or which applies to a group of units is subsequently discussed under the appropriate subheadings in the Site-Specific Data (Section 4.1.2). The Vadose Zone Contamination section includes three subsections that describe sampling and analysis results from the Expedited Response Action (ERA) Proposal for the 200 West Area Carbon Tetrachloride Plume (DOE-RL 1991b). The report describes the extent and concentrations of carbon tetrachloride in vadose zone soils resulting from disposal of an estimated 363,000 to 580,000 L (96,000 to 153,000 gal) of organic and aqueous waste processing liquids from PFP facilities between 1955 and 1973.

The discussion in Subsection 4.1.1.5.1 summarizes information from ERA Proposal as it pertains to the "far field" distribution of carbon tetrachloride across the Z Plant Aggregate Area. Subsection 4.1.1.5.2 summarizes the approach for screening and interpreting geophysical gamma-ray logs used to evaluate subsurface radionuclide contamination. The results of the log interpretations are in turn discussed in Section 4.1.2 for individual waste management units. Subsection 4.1.1.5.3 presents chemical analysis results from soil samples obtained from Z Plant Aggregate Area monitoring wells. Subsection 4.1.1.5.4 describes the potential for historical migration of wastewater from waste disposal sites to the unconfined aquifer.

4.1.1.5.1 Carbon Tetrachloride Distribution. The Carbon Tetrachloride ERA Proposal (DOE-RL 1991b) presents information regarding carbon tetrachloride and other organic and inorganic chemicals, and radionuclides discharged to PFP cribs. Carbon tetrachloride waste liquids were discharged primarily to the 216-Z-1A Tile Field, 216-Z-9 Trench, and 216-Z-18 Crib. The data from the ERA Proposal include results of soil and soil vapor analyses from samples collected as part of the carbon tetrachloride evaluation.

As part of the ERA Proposal, a discussion is provided for "far field" soil vapor detections of carbon tetrachloride and other volatile organic compounds in boreholes more

distant from the 216-Z-1A Tile Field, 216-Z-9 Trench, and 216-Z-18 Crib areas (Figure 4-3). The compounds were detected using field screening instruments in wells throughout the Z Plant Aggregate Area and 200 West Area drilled since 1987. Field screening was completed via use of photoionization detectors for wells 299-W7-7, 299-W7-8, 299-W7-9, 299-W7-10, 299-W15-19, 299-W15-20, 299-W15-21, 299-W15-23, 299-W15-24, and 299-W15-26 located in the Z Plant Aggregate Area northern and southeastern burial ground areas, as seen on geologist's borehole logs in Goodwin and Bjornstad (1990). Follow-up verification of the presence of carbon tetrachloride or other organic compounds in the vapor samples may not have been completed since results are not reported in the sources cited. The wells are differentiated on Figure 4-3 with respect to whether the organic compounds were detected above or below the Plio-Pleistocene calcic paleosol layer. The Plio-Pleistocene layer is described in Section 3.1.2. Most of the reported field screening detections were below the calcic paleosol layer, although wells west of the 216-Z-18 Crib had detections both above and below the calcic paleosol layer.

The Carbon Tetrachloride ERA Proposal concludes that the vapors below the caliche layer are generally found in an area roughly coincident with the area underlain by carbon tetrachloride-affected groundwater, suggesting that these vapors may have volatilized from the groundwater plume. The affected groundwater extends over much of the Z Plant Aggregate Area. No reports of liquid phase carbon tetrachloride encountered in the subsurface are known. The ERA Proposal states that the carbon tetrachloride groundwater data are consistent with a "point source" from the 216-Z-9 Trench. The report concludes that this source is possibly the result of relatively large volumes of liquid discharged to the crib, or liquid phase carbon tetrachloride moving downward along preferential pathways (e.g., older well casings with no annular seal).

4.1.1.5.2 Geophysical Logging. The extent of radionuclide contamination in vadose zone soils in the Z Plant Aggregate Area has been evaluated using borehole geophysical techniques. Geophysical well logging has been conducted in the Z Plant Aggregate Area since the late 1950s. 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. As part of the current report gamma logs were reviewed from Fecht et al. (1977) and Chamness et al. (1991).

Table 4-10 summarizes results of the gross gamma logging by waste management unit. Interpretation of the logs 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 with other historical logs from the same bore holes. Interpretations are complicated by the fact that logging equipment and procedures evolved with time. Attempts made to normalize data collected at different times have met with limited success (e.g., Fecht et al. 1977), and quantitative interpretations were not possible. For purposes of this report, zones of elevated gamma-ray counts were identified by visual comparison to baseline values on the same gross gamma log. The gross gamma logs were also compared to geologic logs or cross sections for this location to identify the location of the early "Palouse" soil and Plio-Pleistocene unit which are generally naturally higher in gross gamma counts. A standardized, comparative baseline value for

comparing gamma log results is not available because of the evolution of logging equipment and methodology over time. The log interpretations are discussed in detail in Appendix A.1, and results of log interpretations for individual waste management units are also summarized in Section 4.1.2.

4.1.1.5.3 Monitoring Well Soil Sampling Results. Soil samples were collected during installation of nine monitoring wells in the Z Plant Aggregate Area Solid Waste Burial Grounds between 1987 and 1991 (Goodwin and Bjornstad 1990; and Barton et al. 1990). The soil samples were analyzed for one or more of the following parameters:

- Organic compounds
- Inorganic anions
- Gross alpha and beta
- Total organic carbon (TOC).

Soil samples were collected from four well locations near the northern boundary of the Z Plant Aggregate Area (Figure 4-3):

- 218-W-3AE Burial Ground wells 299-W7-7, 299-W7-8, and 299-W7-10
- 218-W-5 Burial Ground well 299-W7-9.

Soil samples were also collected from five well locations on the southwestern boundary of the Aggregate Area:

- 299-W-4B Burial Ground wells 299-W15-19, 299-W15-20, and 299-W15-23
- 218-W-4C Burial Ground wells 299-W15-21 and 299-W18-26.

Soil samples from the wells were collected at depths ranging from 1.5 m (5 ft) to 73 m (240 ft) below ground surface. The results of these analyses are presented in Tables A-7 and A-8 in Appendix A. Only chemicals detected in one or more samples are included in these tables. The following discussion summarizes the general distribution of detected chemicals in the burial ground areas.

4.1.1.5.3.1 Organic and Inorganic Parameters. Levels of most inorganic anions were low or nondetectable in the eight samples in which they were measured. Concentrations of nitrate and sulfate ranged from below detection to 38.5 and 130 mg/kg, respectively. Concentrations of nitrate and sulfate did not show an obvious distribution pattern with depth and did not appear to be greatly elevated in any particular well.

Organic chemicals were analyzed for in selected samples from each well. Many of the samples were analyzed only for chloroform, carbon tetrachloride, methylene chloride,

trichloroethylene, tetrachloroethylene, 1,1,1-trichloroethane, benzene, toluene, and xylenes. One sample (the 38 m [125 ft] sample from well 299-W-15-21) was analyzed for an extensive list of volatile organics; however, most of these were not detected and therefore have not been listed in Table A-8.

Concentrations of volatile organics in samples from the northern Z Plant Aggregate Area burial grounds were generally less than 10 μg/kg or below detection limits. The highest levels of these compounds were observed in the 68 m (220 ft) sample of Well 299-W7-9 and in the 64 m (210 ft) sample of Well 299-W7-8, which were taken approximately at the water table. Concentrations in shallower samples from these wells were below detection limits; thus, these results appear to indicate interception of a plume related to the underlying groundwater rather than a vadose zone source in the burial ground areas.

Halogenated organics were detected in many of the samples obtained from wells in the western Z Plant Aggregate Area burial grounds. Concentrations were generally much higher than in the wells north of the site, with several compounds exceeding 100 μg/kg. The highest concentrations of chemicals detected included methylene chloride, chloroform, benzene, 1,1-dichloroethylene, and trans-1,2-dichloroethylene in wells 299-W15-23 and 299-W18-26. Carbon tetrachloride was also detected in eight of the burial ground wells (Table 4-12), at concentrations up to 12 μg/kg (well 299-W7-9). Chemicals were detected from 6.1 m (20 ft) below the surface to 93 m (240 ft), the greatest depth sampled. This range of depths corresponds to detections both above and below the Plio-Pleistocene calcic paleosol layer. The depth zone of greatest contamination ranged from 55 to 73 m (180 to 240 ft) below ground surface. Concentrations were generally highest at 55 m (180 ft) and decreased with depth; however, this pattern did not hold for individual chemicals in some wells. Due to the low concentrations of these organics in soils above 55 m (180 ft), it appears that these detections do not indicate a source in the immediate area of the well, but rather may indicate interception of an underlying plume of contamination or migration of vapor along the caliche layer.

4.1.1.5.3.2 Radionuclide Parameters. Results of radiological analyses of beta and alpha activity are presented in Tables A-7 and A-8 in Appendix A. Results were reported for all soil samples submitted from each well (Goodwin and Bjornstad 1990 and Barton et al. 1990).

Each sample result is reported in pCi/g. The standard deviation (σ) associated with each count is also included. Beta radiation ranged from 12.2 pCi/g (well 299-W7-7) to 29.1 pCi/g (well 299-W7-8), and generally showed little variation with sample depth or well location. Soil samples from two wells, 299-W7-7 and 299-W7-8, had alpha results of 0.171 and -1.52 pCi/g, respectively; otherwise alpha radiation in the burial ground well soil samples ranged from 1.18 pCi/g (well 299-W15-23) to 15.4 pCi/g (well 299-W15-20). In general, obvious localized sources of radiation are not indicated from the analysis results of the burial ground well soil samples.

4.1.1.5.4 Potential for Migration to the Unconfined Aquifer. As discussed in Subsection 4.1.1.5.1, the Carbon Tetrachloride ERA Proposal (DOE-RL 1991b) concluded

that liquid disposal volumes discharged to the 216-Z-9 Trench were probably sufficient to have migrated to the water table. The ERA Proposal also concluded that it is uncertain whether liquids containing carbon tetrachloride reached the water table at the 216-Z-1A Tile Field or 216-Z-18 Crib. These conclusions are based on a comparison of the waste volumes discharged at each crib, with the specific retention volumes of the cribs, and with the estimated pore volume in the vadose zone soil column below the crib.

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 in Table 4-11. 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 or precipitation; and (3) the average porosity of the soil column is between 0.10 and 0.30 (the upper and lower porosity estimates shown in Table 4-11). If the amount of waste received was greater than the most conservative porosity (0.1) then the waste management unit was considered to have the potential to migrate to the groundwater. According to these calculations, eleven 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.

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 in the U Plant Aggregate Area (Baker et al. 1988).

4.1.2 Site-Specific Data

This section presents site-specific sampling and analysis data, and waste inventory information regarding possible releases for individual Z Plant Aggregate Area waste management units. The information presented was obtained from reference documents reviewed for the current report. For many of the waste management units the information is limited, and the lack of more comprehensive information may constitute significant "data gaps." Issues related to data gaps are discussed in more detail in Section 8.0 of this report.

The waste management units discussed in this section are presented in the same general groupings as described in Section 2.0. These groupings are useful because structurally similar units tend to have similar types of available data. Locations of the waste

management units and unplanned releases are identified on Figures 2-2 through 2-4 and 2-7 through 2-13 in Section 2.0.

4.1.2.1 Plants, Buildings, and Storage Areas. Plant, building, and storage area waste management units at the Z Plant Aggregate Area include the 232-Z Incinerator. Also, the main PFP building complex (consisting of the 234-5Z, 236-Z, 242-Z, 291-Z, 2736-Z, and 2736-ZB Buildings) is included because of several unplanned releases in the vicinity, and 1990 soil sampling data from this area.

4.1.2.1.1 232-Z Incinerator. The 232-Z Incinerator was used to incinerate plutonium-contaminated wastes, and fallout from stack releases may have contributed to elevated plutonium concentrations in Z Plant Aggregate Area surficial soils. Low levels of alpha radiation have been reported in surface radiological surveys, but the area is listed as stabilized.

4.1.2.1.2 Main Z Plant Building Complex. Several unplanned releases (UN-200-W-23, UN-200-W-89, UN-200-W-90, UN-200-W-91, and UN-200-W-103; Table 2-5) are associated with the Main Z Plant Building Complex. In 1990, 22 soil samples were collected at locations adjacent to the main Z Plant building complex for cesium-137 and plutonium analysis (Plate 2). The soil samples were collected as part of annual monitoring activities at the Hanford Site (Schmidt et al. 1992). Detectable cesium-137 concentrations were noted in 10 of the samples along the building complex perimeter fence and adjacent to the plant buildings (Table A-6). Plutonium was detected in 15 of the samples, primarily at locations north of the 234-5Z Building. Additional information regarding soil sampling rationale, methods, and comparisons to regional background levels was not provided in the 1990 Westinghouse Hanford monitoring report (Schmidt et al. 1992).

4.1.2.2 Tanks and Vaults. Z Plant Aggregate Area tanks include the 216-Z-8 Settling Tank, the 241-Z-361 Settling Tank, and the 241-Z-Treatment Tank. No vault structures were identified in the Z Plant Aggregate Area. No specific sampling and analysis information regarding soil and other potentially affected media associated with the 216-Z-8 Settling Tank, the 241-Z-361 Settling Tank, and the 241-Z Treatment Tank were found in the documents reviewed.

4.1.2.2.1 216-Z-8 and 241-Z-361 Settling Tanks. The 216-Z-8 Settling Tank received liquid waste from the RECUPLEX facility from 1955 to 1962. The process waste stream overflowed from the 216-Z-8 Settling Tank into the 216-Z-8 French Drain, where the waste was disposed of to the soil column. The 241-Z-361 Settling Tank received plutonium and other wastes routed to crib disposal sites and the 216-Z-1A Tile Field. No documented releases from either tank were identified in the references reviewed. No monitoring wells were identified near the tanks. Therefore, no geophysical logging data were located for these facilities.

4.1.2.2.2 241-Z Treatment Tank. The 241-Z Treatment Tank is a RCRA TSD facility located inside the 241-Z Building. Three unplanned releases, UN-200-W-74, UN-200-W-75, and UN-200-W-79 (described in Table 2-6) are associated with this area.

These unplanned releases are known to have released radionuclides to the environment. However, no specific sampling data were identified.

4.1.2.3 Cribs and Drains. Z Plant Aggregate Area waste management units in this category include the 216-Z-1, 216-Z-2, 216-Z-3, 216-Z-5, 216-Z-6, 216-Z-7, 216-Z-12, 216-Z-16, and 216-Z-18 Cribs; the 216-Z-8, 216-Z-13, 216-Z-14, and 216-Z-15 French Drains; and the 216-Z-1A Tile Field.

Information available for Z Plant Aggregate Area Cribs, the 216-Z-8 French Drain, and the 216-Z-1A Tile Field includes radionuclide sampling and analyses for waste materials contained in the crib structures and subsurface soils, soil and soil vapor analyses for vadose zone soils, and surface radiological surveys. Due to their historical use for disposal of carbon tetrachloride, the potential for emission of volatile organic compounds to air exists for some of the waste management units, notably the 216-Z-1A Tile Field and the 216-Z-18 Crib. Waste inventory information also indicates the presence of known or suspected vadose zone contamination at virtually all of the crib and tile field locations. The potential for migration of waste liquids from the crib structures to the underlying unconfined aquifer is discussed in Section 4.1.1.5.3.

4.1.2.3.1 216-Z-1, 216-Z-2, and 216-Z-3 Cribs. The 216-Z-1, 216-Z-2, and 216-Z-3 Cribs are located within the overall structure of the 216-Z-1A Tile Field, near its north end. Several monitoring wells are located around the 216-Z-1 and 216-Z-2 Cribs. A review of available gamma scintillation logs revealed elevated gamma response, potentially indicating the presence of radionuclides, between depths of 7 and 21 m (23 to 69 ft) beneath the cribs (Table 4-10). Two monitoring wells (299-W18-67 and 299-W18-68) located inside the 216-Z-3 Crib have not been logged using gamma scintillation equipment. Only natural gamma response has been observed in monitoring well 299-W18-88 which is located southeast of the 216-Z-3 Crib (Table 4-10).

Elevated alpha radiation (15,000 dis/min) and smearable alpha radiation (1,500 dis/min) were detected in a 1989 surface radiation survey at the 216-Z-1 and 216-Z-2 Cribs.

Based on this information, near-surface and deeper vadose zone soil radionuclide contamination is suspected for the 216-Z-1, 216-Z-2, and 216-Z-3 Cribs.

4.1.2.3.2 216-Z-5, 216-Z-6, and 216-Z-7 Cribs. The 216-Z-5, 216-Z-6, and 216-Z-7 Cribs received radionuclide and chemical wastes (mainly inorganic) received from the 231-Z Building. A high cave-in potential was reported for the 216-Z-5, 216-Z-6, and 216-Z-7 Cribs (WHC 1990a). No specific chemical sampling data was identified for these cribs. A review of available gamma scintillation logs (summarized in Table 4-10) revealed elevated gamma response, possibly indicative of radionuclide contamination, between depths of 30 and 40 m (98 to 131 ft) below ground surface (above the water table), and from 50 to 63 m (164 to 207 ft) (below the water table) in well 299-W15-1 which is located on the east side of the 216-Z-5 Crib. Elevated gamma response was also observed between depths of 8 and 23 m (26 and 75 ft) in well 299-W15-212 which is located approximately 100 m (328 ft) north of the 216-Z-5 Crib. The source of this gamma activity is unknown.

Elevated gamma response was also observed in several wells completed in and around the 216-Z-7 Crib between depths of 7 and 46 m (23 to 151 ft) and below the water table (between depths of 45 and 100 m [148 and 328 ft]). No wells monitor conditions in the 216-Z-6 Crib. Based on this information, near-surface and deeper vadose zone soil contamination is suspected for the 216-Z-5 and 216-Z-7 Cribs.

No detectable surface radiation was measured at these cribs during 1991 radiological surveys.

4.1.2.3.3 216-Z-12 Crib. The 216-Z-12 Crib received PFP liquid process waste and analytical development laboratory waste from the 234-5Z Building (via the 241-Z-361 Settling Tank and the 241-Z Diversion Box No. 2). Crib wastes included high-salt liquids containing plutonium which were adjusted to a pH of 8 to 10 prior to disposal. No specific chemical sampling data was identified for this crib. A review of available gamma scintillation logs (summarized in Table 4-10) revealed elevated gamma response, possibly indicative of radionuclide contamination, between depths of 5 and 10 m (16 and 33 ft) below ground surface in several wells inside the crib. Radionuclide and inorganics contamination in near-surface and possibly deeper vadose zone soils from these materials is therefore suspected.

No detectable surface radiation was measured at the 216-Z-12 Crib during a 1991 radiological survey.

4.1.2.3.4 216-Z-16 Crib. The 216-Z-16 Crib received neutral/basic wastes containing plutonium from the 231-Z Building laboratory. Gamma scintillation logging indicated only natural gamma response (Table 4-10) in two monitoring wells located on the south and north margins of the crib (wells 299-W15-10 and 299-W15-11, respectively). While vadose zone contamination is suspected at the crib due to historic liquid waste disposal practices, the areal extent of contamination appears to be limited to the crib boundaries.

No detectable surface radiation was measured at the 216-Z-16 Crib during a 1991 radiological survey.

4.1.2.3.5 216-Z-18 Crib. Along with the 216-Z-9 Trench and the 216-Z-1A Tile Field, the 216-Z-18 Crib received quantities of carbon tetrachloride and other organic radioactive wastes from plutonium processing activities. As discussed in Subsection 4.1.1.5.1, the distribution of carbon tetrachloride in vadose zone soils (and groundwater) in the vicinity of these disposal units, and area-wide ("far field") extent was the subject of the ERA Proposal for the 200 West Area Carbon Tetrachloride Plume (DOE-RL 1991b).

With specific reference to the 216-Z-18 Crib, the ERA Proposal reported carbon tetrachloride detections in down-hole soil vapor samples from vadose zone boreholes and groundwater monitoring wells within and adjacent to the crib structure. The locations of these borehole/well explorations, and similar explorations for monitoring carbon tetrachloride vapor concentrations near the 216-Z-1A Tile Field and 216-Z-9 Trench are shown on

Figure 4-4. The figure refers generically to all the explorations as "wells." The maximum carbon tetrachloride concentrations in the down-hole vapor samples from the 216-Z-18 Crib wells was 140 parts per million volume (ppmv). The ERA Proposal concluded that carbon tetrachloride is present in the vicinity of these structures at depths ranging from 24 to 63 m (79 to 207 ft) below ground surface.

A review of available gamma scintillation logs (summarized in Table 4-10) revealed elevated gamma response, possibly indicative of radionuclide contamination, between depths of 6 and 18 m (20 and 59 ft) below ground surface in several wells inside and up to 10 m (33 ft) south of the crib. Radionuclide and inorganics contamination in near-surface and possibly deeper vadose zone soils from waste materials disposed to this unit is therefore suspected.

No detectable surface radiation was measured at the 216-Z-18 Crib during a 1991 radiological survey.

4.1.2.3.6 216-Z-8 French Drain. Contamination from radionuclides and organic compounds is suspected in vadose zone soils at the 216-Z-8 French Drain, due to overflow of liquid wastes from the 216-Z-8 Settling Tank. A characterization study was previously conducted to evaluate the distribution of radionuclides in soil beneath the 216-Z-8 French Drain and to investigate a suspected leak in the 216-Z-8 Settling Tank. One well was drilled 1m (3 ft) south of the drain, and radiological and geological analyses were performed. The highest plutonium-239 concentration observed in soil samples collected from the well was 4.62 nCi/g and occurred at a depth of 7.6 m (25 ft). The study estimated that approximately 4 to 5 m^3 (180 ft^3) of sediments with radionuclide concentrations greater than 10 mCi/g lay beneath the 216-Z-8 French Drain. Four monitoring wells (299-W15-202, 299-W15-213, 299-W15-214, and 299-W15-215) were identified around the perimeter of the french drain but have not been logged using gamma scintillation equipment. This may be because the grout seals installed in these (relatively new) wells inhibits gamma scintillation counting.

No detectable radiation was measured at the 216-Z-8 French Drain during a 1991 surface radiological survey.

4.1.2.3.7 216-Z-13, 216-Z-14, and 216-Z-15 French Drains. The 216-Z-13, 216-Z-14, and 216-Z-15 French Drains are active non-contact wastewater management units next to the 291-Z Building. Although no releases were reported for these units in the documents reviewed, trace beta activity has been reported for the 216-Z-14 French Drain. Also, previous reports indicate that low level contamination can be assumed due to accidents or unusual events in the process areas. The contamination would be expected to affect vadose zone soils. No gamma scintillation logging wells were identified near these facilities (Table 4-10).

No detectable surface radiation was measured near the French Drains during a 1991 radiological survey.

4.1.2.3.8 216-Z-1A Tile Field. Like the 216-Z-18 Crib (Section 4.1.2.3.5), the 216-Z-1A Tile Field received quantities of carbon tetrachloride and other liquid wastes. The tile field was a key waste management unit considered in the Carbon Tetrachloride ERA Proposal (DOE-RL 1991b) as discussed in Sections 4.1.1.5.2. and 4.1.2.3.5. During downhole vapor sampling conducted at the tile field for the ERA Proposal, the maximum carbon tetrachloride concentration detected was 16.2 ppmv. As part of the ERA Proposal work, the tile field was also the subject of a soil vapor extraction system characterization test. Downhole soil samples were collected during the test, and indicated that carbon tetrachloride at concentrations of up to 89 ppm has migrated to depths of at least 40 m (131 ft) beneath the 216-Z-1A Tile Field. During the test, chloroform was also detected in vapor samples, but at concentrations below the 5 to 10 ppm range of analytical quantitation limits cited in the ERA Proposal. According to the ERA Proposal, analyses also indicated the presence of 2-butanone at concentrations up to 148 ppm, but may be attributable to alcohol used in the analytical method, since 2-butanone was found in the analysis blank sample. Vapor samples from wells near the 216-Z-18 Crib and the 216-Z-9 Trench were not analyzed for volatile compounds other than carbon tetrachloride. Interpretation of the data from the ERA Proposal, and discussion of the extent of carbon tetrachloride in Z Plant Aggregate Area soils is provided in the Vadose Zone Contamination section (4.1.1.5), and in the 216-Z-8 Crib section (4.1.2.3.5).

Price et al. (1979) investigated the distribution of plutonium and americium in soil in the vicinity of the 216-Z-1A Tile Field. During the investigation, 16 wells or vadose zone soil borings were installed to evaluate the lateral and vertical extent of contamination (Figure 4-5). The authors drew the following conclusions:

- The distribution of plutonium and americium beneath the tile field are similar. The highest measured concentration of plutonium (about 4×10^4 nCi/g) and americium (about 2.5×10^3 nCi/g) occurs in sediments located immediately beneath the central distributor pipe.

- The concentration of plutonium and americium in sediments generally decreases with depth below the bottom of the tile field. An increase in concentration with depth was generally associated with an increase in the silt content of the sediments or with contacts between sedimentary units.

- The bulk of the actinide contamination appears to be contained within the first 15 m (48 ft) of sediments beneath the bottom of the 216-Z-1A Tile Field. The maximum vertical penetration of the plutonium and americium contamination (defined by the 10^{-2} nCi/g isopleth) is approximately 30 m (98 ft) below the bottom of the facility, or about 30 m (98 ft) above the water table.

- The distribution of activity in vadose zone wells around the perimeter of the 216-Z-1A Tile Field is discontinuous with depth. The waste appears to have been released to the ground within a few meters of the central distributor pipe and then spread laterally along contacts between dissimilar soil horizons. The

lateral spread was limited to within a 10 m (30 ft) wide zone around the perimeter of the tile field.

A review of available gamma scintillation logs revealed elevated gamma response, possibly indicative of radionuclide contamination, from near ground surface to a maximum depth of 30 m (98 ft) below ground surface in several wells inside the crib (Table 4-10). However, elevated gamma scintillation readings were not observed outside the tile field. In conclusion, radionuclide and inorganics contamination in near-surface and deeper vadose zone soils due to historic waste disposal practices is known to have occurred at this site.

In a 1989 radiological surface survey, detectable radiation (10,000 dis/min), and smearable alpha radiation (500 dis/min) were detected near the tile field.

4.1.2.4 Reverse Wells. Reverse wells at the Z Plant Aggregate Area include only the 216-Z-10 Reverse Well, an inactive underground injection well for waste liquids. The well was completed to a depth of 46 m (150 ft), providing a deeper migration conduit for both chemical and radiological contaminants into the vadose zone. At this location the groundwater table is present at about 63 m (205 ft) below ground surface. As discussed in Subsection 4.1.1.5.3 migration of these waste liquids (and possibly entrained contaminants) is likely at this location due to the volume of liquid injected.

No specific chemical sampling data was identified for the 216-Z-10 Reverse Well. Several monitoring wells are located near the reverse well but have not been logged using gamma scintillation equipment (Table 4-10).

4.1.2.5 Ponds, Ditches, and Trenches. This category of waste management units includes the 216-Z-4 Trench, the 216-Z-9 Trench, and the 216-Z-17 Trench at the Z Plant Aggregate Area. There are no ponds located within the Z Plant Aggregate Area.

4.1.2.5.1 216-Z-4 Trench. The 216-Z-4 Trench received liquid laboratory waste from the 231-Z Building during one month in 1945. The wastes were neutral/basic and contained plutonium. No specific chemical sampling data was identified for the 216-Z-4 Trench. No monitoring wells were identified near the 216-Z-4 Trench. Due to information found regarding historic waste disposal practices, radionuclide and chemical contamination is suspected in vadose zone soils at this location.

4.1.2.5.2 216-Z-9 Trench. The 216-Z-9 Trench received liquid waste containing carbon tetrachloride and TRU wastes from the RECUPLEX facility in the 234-5Z Building. As for the 216-Z-18 Crib and the 216-Z-1A Tile Field, carbon tetrachloride was reportedly detected in down-hole soil vapor samples collected from wells within and adjacent to the 216-Z-9 Trench (DOE-RL 1991b). The maximum carbon tetrachloride concentration detected during the field program was 106 ppmv. Interpretation of the data from the ERA Proposal, and discussion of the extent of carbon tetrachloride in Z Plant Aggregate Area soils are provided in the Vadose Zone Contamination section (4.1.1.5), and in the 216-Z-18 Crib section (4.1.2.3.5).

Within the 216-Z-9 Trench, soil samples were collected in 1959, 1961, and 1963, to evaluate concentrations and distribution of plutonium within the waste unit so that the service life of the trench could be safely extended. Plutonium concentrations of up to 34.5 grams plutonium per liter (gPu/L) of soil were measured in the 1963 samples from the upper 0 to 0.15 m (0 to 0.5 ft) of soil beneath the trench floor. Additional samples collected in 1973 (Smith 1973) confirmed the presence of elevated concentrations of plutonium in the trench. Samples collected in 1973 from a depth of 2.4 m (7.9 ft) contained plutonium concentrations of 0.30 gPu/L of soil, and americium concentrations of 200 to 500 pCi/L of soil. The trench bottom soil was subsequently sprayed with a cadmium nitrate solution to reduce the potential for a criticality event. The upper 30 cm (12 inch) of soil were then excavated in 1978 to reduce the risk of environmental contamination (Ludowise 1978) and the soil was placed in drum containers for disposal.

A number of monitoring wells have been completed near the 216-Z-9 Trench. A review of available gamma scintillation logs indicated elevated gamma response, potentially indicative of radionuclide contamination at several locations 10 to 20 m (33 to 66 ft) from the trench, but generally natural gamma response in wells near the trench (Table 4-10). For example, elevated gamma response has been observed in well 299-W15-6, 20 m (66 ft) northeast of the trench, between depths of 1 and 9 m (49 and 125 ft). Elevated gamma response has also been observed between depths of 15 and 38 m in wells 299-W15-8 and 299-W15-86 which are located approximately 10 m south and southwest of the trench, respectively.

No detectable radiation was measured at the 216-Z-9 Trench during a 1991 surface radiological survey.

4.1.2.5.3 216-Z-17 Trench. The 216-Z-17 Trench received laboratory wastes from the 231-Z Building during 1967 and 1968. Like the 216-Z-4 Trench, waste liquids disposed of in the 216-Z-17 Trench were neutral/basic and contained plutonium. A field radiation survey in the 216-Z-17 Trench before backfilling in 1975 indicated 2,000 dis/min of alpha radioactivity. No specific chemical sampling data was identified for the 216-Z-17 Trench. One monitoring well, 299-W15-204, was identified on the west side of the trench. However, the well has not been logged using gamma scintillation equipment (Table 4-10).

Due to available information regarding historic waste disposal practices, radionuclide and chemical contamination is suspected in vadose zone soils at this location.

A surface radiological survey completed in 1991 did not measure detectable radiation.

4.1.2.6 Septic Tanks and Associated Drain Fields. This category of waste management units includes the 2607-Z, 2607-Z-1, 2607-WA, 2607-WB, and 2607-W-8 Septic Tank and Drain Fields. No specific chemical sampling data was identified for the septic tanks. These units are reported as having received sanitary wastes only. Radiological and chemical contaminants from Z Plant processing facilities are therefore not suspected at these locations.

4.1.2.7 Transfer Facilities, Diversion Boxes, and Pipelines. As shown on Figure 2-10, a number of pipelines and three transfer facilities were identified in the Z Plant Aggregate Area:

- 241-Z Diversion Box No. 1
- 241-Z Diversion Box No. 2
- 231-Z-151 Sump.

4.1.2.7.1 241-Z Diversion Boxes No. 1 and No. 2. Diversion Box No. 1 controlled the flow of liquid wastes at the piping junction to the 216-Z-1A Tile Field, 216-Z-1 Crib, 216-Z-2 Crib, 216-Z-3 Crib, and the 216-Z-12 Crib. Similarly, Diversion Box No. 2 was located north of the 216-Z-12 Crib and controlled flow of wastes to that crib. No specific chemical sampling data was identified for the diversion boxes. One monitoring well, 299-W18-156 is located near Diversion Box No. 2, but has not been logged using gamma scintillation detection equipment. No releases were reported at the locations of these structures in the documents reviewed.

Available information regarding historic use of these facilities suggests that radionuclide and chemical contamination are possible in vadose zone soils at this location.

4.1.2.7.2 231-Z-151 Sump. The 231-Z-151 Sump controlled flow of waste liquids from the 231-Z Building to the 216-Z-5 Crib, 216-Z-6 Crib, 216-Z-7 Crib, 216-Z-16 Crib, 216-Z-16 Crib, 216-Z-10 Reverse Well, and 216-Z-4 Trench, and 216-Z-17 Trench. Unplanned Release UN-200-W-130 was identified near the diversion box and involved a leaking waste line from the 231-Z Building.

No specific chemical sampling data were identified for the 231-Z-151 Sump. No monitoring wells were identified near the sump.

Based on available information regarding historic use of this facility and the information regarding a nearby unplanned release, radionuclide and chemical contamination is suspected in vadose zone soils at this location.

4.1.2.8 Basins. Two basins, the 207-Z Retention Basin and the 216-Z-21 Seepage Basin, are located in the Z Plant Aggregate Area.

4.1.2.8.1 207-Z Retention Basin. The 207-Z Retention Basin is a concrete structure which received potentially contaminated liquid waste from the 234-5Z Building prior to discharge to the 216-Z-1(D)/Z-11 Ditch system. No releases were reported at this locations in the documents reviewed.

No specific chemical sampling data were identified for the 207-Z Retention Basin. No monitoring wells were identified near the basin.

4.1.2.8.2 216-Z-21 Seepage Basin. The 216-Z-21 Seepage Basin currently receives non-contact discharge water from the 234-5Z HVAC system and storm water runoff. As

discussed in Section 4.1.1.4, aquatic vegetation and sediment samples collected from the seepage basin as part of annual Hanford Site environmental surveillance monitoring contained elevated concentrations of plutonium-239 and other radionuclides (Table 4-9) (Schmidt et al. 1990 and 1992). Also beta radioactivity (5,000 ct/min) was detected in a tumbleweed during a 1989 surface radiological survey. Tumbleweeds blow into the seepage basin from outside sources and are periodically removed for disposal. No radionuclides, nitrates, or other constituents were detected in water samples collected from the seepage basin during annual monitoring for 1988, 1989, and 1990. Sediment from the seepage basin was also found to contain elevated concentrations of several radionuclides (Schmidt et al. 1990 and 1992) during the 1989 and 1990 annual monitoring programs (Table 4-9).

One monitoring well, 299-W15-208, has been completed inside the 216-Z-21 Seepage Basin. However, the well has not been logged using gamma scintillation equipment, possibly due to expected attenuation in the grout seal in this well.

4.1.2.9 Burial Sites. Solid Waste Burial Grounds 218-W-1, 218-W-1A, 218-W-2, 218-W-2A, 218-W-3, 218-W-3A, 218-W-3AE, 218-W-4A, 218-W-4B, 218-W-4C, 218-W-5, 218-W-6, 218-W-11, and the Z Plant Burn Pit are located in the Z Plant Aggregate Area. Section 2.9 presents information identified regarding waste materials disposed to the burial sites. Figure 2-12 shows the locations of the burial sites. Soil chemical testing data were collected during the LLWMA groundwater monitoring well installation programs between 1987 and 1990 (Goodwin and Bjornstad 1990; and Barton et al. 1990). Additional data is presented in the Z Plant Geologic and Geophysics Data Package for the 200 Aggregate Area Management Study (Chamness et al. 1991).

Additional analytical data from the Z Plant Aggregate Area burial grounds include results of air, TLD, surface soil, and vegetation sampling during annual environmental monitoring. These data are presented in Section 4.1.1. As discussed in that section, the information is in general, more indicative of area-wide trends in contamination from ongoing production and process operations in the 200 Areas, than it is indicative of localized releases from burial site sources. Results of airborne radiological surveys, and generalized areas of surface/subsurface radiological contamination and posting for the burial grounds were also discussed in Section 4.1.1.

The solid waste burial grounds are the locations of many of the unplanned releases of radioactive materials described in Section 2.3.10. Residual surface contamination may be present at locations of unplanned releases, particularly where remedial efforts involved flushing affected areas with water. Potential for deeper vadose zone or groundwater contamination is low, and is dependent upon a consistent driving force such as natural groundwater recharge via precipitation to promote migration. Issues associated with natural recharge are discussed in Section 3.5.

4.1.2.9.1 218-W-1 Burial Ground. The 218-W-1 Burial Ground is an inactive solid waste disposal facility which received transuranic/mixed solid waste from 1944 to 1953. Three unplanned releases, UN-200-W-11, UPR-200-W-84, and UPR-200-W-134, are associated with the 218-W-1 Burial Ground. A fire in the burial ground in 1952 released

plutonium and likely resulted in surface soil contamination at the burial ground and adjacent areas via wind dispersion. No monitoring wells are associated with the burial ground.

During a 1991 surface radiological survey, 15,000 dis/min of beta radiation was measured at a "small topsoil hot spot" in the 218-W-1 burial ground (Table 4-5).

4.1.2.9.2 218-W-1A Burial Ground. The 218-W-1A Burial Ground is an inactive solid waste disposal facility which received miscellaneous industrial dry waste from 1944 to 1955. Unplanned Release UPR-200-W-158 occurred in the 218-W-1A Burial Ground.

No detectable surface radiation was reported in the 218-W-1A Burial Ground during a 1991 radiological survey.

4.1.2.9.3 218-W-2 Burial Ground. The 218-W-2 Burial Ground is an inactive solid waste disposal facility which received miscellaneous unsegregated dry waste from 1953 to 1956. No unplanned releases are associated with the 218-W-2 Burial Ground. No monitoring wells are associated with the burial ground.

During a 1991 surface radiological survey, 15,000 dis/min of beta radiation was measured at a "small hot spot" in the 218-W-2 burial ground (Table 4-5).

4.1.2.9.4 218-W-2A Burial Ground. The 218-W-2A Burial Ground is an inactive solid waste disposal facility which received low level and mixed solid waste from 1954 to 1985. One unplanned release, UPR-200-W-45, is associated with the 218-W-2A Burial Ground. The collapse of a burial box in 1957 dispersed TRU radionuclides over 730 hectares (1,800 acres) near the burial ground. No monitoring wells are associated with the burial ground.

During a 1991 surface radiological survey, 10,000 dis/min of beta radiation was measured at the 218-W-2A burial ground (Table 4-5).

4.1.2.9.5 218-W-3 Burial Ground. The 218-W-3 Burial Ground is an inactive solid waste disposal facility which received TRU/mixed solid waste from 1957 to 1960 or 1961. No unplanned releases are associated with this unit. No monitoring wells were associated with this waste management unit.

No detectable surface radiation was reported in the 218-W-3 Burial Ground during a 1991 radiological survey.

4.1.2.9.6 218-W-3A Burial Ground. The 218-W-3A Burial Ground is an active solid waste disposal facility which began receiving TRU/mixed solid waste in 1971. Three wells potentially monitor conditions in this waste management unit. Gamma scintillation logging performed in 1987 indicated only natural gamma response. Unplanned Release UPR-200-W-158, which occurred in the 218-W-1A Burial Ground, resulted in some surface contamination in the 218-W-3A Burial Ground.

During a 1991 surface radiological survey, 40,000 dis/min of beta radiation was measured over a 1 by 1 m (3 by 3 ft) area in the 218-W-3A Burial Ground (Table 4-5).

4.1.2.9.7 218-W-3AE Burial Ground. The 218-W-3AE Burial Ground is an active solid waste disposal facility which began receiving mixed solid waste in 1982. No unplanned releases are associated with this unit. Seven wells potentially monitor conditions in this waste management unit. Gamma scintillation logging performed in different monitoring wells in 1987, 1989, and 1990 indicated only natural gamma response.

4.1.2.9.8 218-W-4A Burial Ground. The 218-W-4A Burial Ground is an inactive solid waste disposal facility which received transuranic/mixed waste from 1958 to 1968. Four unplanned releases, UPR-200-W-16, UPR-200-W-26, UPR-200-W-53, and UPR-200-W-72, are associated with the 218-W-4A Burial Ground. As described in Table 2-6, the unplanned releases resulted in plutonium and ruthenium contamination of surface soils within and outside the burial ground. The 218-W-4A Burial Ground contains two steel-drum caissons which might be a source of radionuclides (Section 2.3.9.8). No monitoring wells were identified within the 218-W-4A Burial Ground.

During a 1991 surface radiological survey, 10,000 dis/min of beta radiation was measured over a 7 by 1 m (23 by 3 ft) hot spot in the burial ground (Table 4-5).

Due to the unplanned releases and the presence of caissons, vadose zone soil contamination is suspected at this unit.

4.1.2.9.9 218-W-4B Burial Ground. The 218-W-4B Burial Ground is an active unit which began receiving transuranic and mixed solid waste in 1967. No unplanned releases are associated with the 218-W-4B Burial Ground. Elevated surface radiation monitoring readings have been reported at the unit.

Three monitoring wells located around the perimeter of the 218-W-4B Burial Ground were logged using gamma scintillation equipment in 1989 and 1990. The gamma scintillation logs indicated only natural gamma response (Table 4-10).

4.1.2.9.10 218-W-4C Burial Ground. The 218-W-4C Burial Ground is an active facility which began receiving transuranic and mixed solid waste in 1974. An unplanned release associated with the 241-UR Diversion Box (a U Plant Aggregate Area transfer facility), UN-200-W-132, contaminated two areas in the eastern part of the burial ground of approximately 11.2 and 41.9 m^2 (121 and 451 ft^2) in 1956 (Table 2-6). A total of eleven monitoring wells were identified in the 218-W-4C Burial Ground; all but one have been logged using gamma scintillation detection equipment (Table 4-10). Gamma scintillation logging performed in July 1987 indicated possibly elevated gamma response in one well, 299-W15-18, located 30 m (98 ft) west of the northern portion of the burial ground. The elevated gamma response was observed between depths of 55 and 58 m (180 and 190 ft) below ground surface.

Due to the unplanned release and elevated gamma response in one monitoring well, vadose zone soil contamination is suspected in the eastern parts of the 218-W-4C Burial Ground.

4.1.2.9.11 218-W-5 Burial Ground. The 218-W-5 Burial Ground is an active waste management unit which receives low-level/mixed solid waste. No unplanned releases are associated with the 218-W-5 Burial Ground. Wells 299-W7-1, 299-W7-9, 299-W8-1, 299-W9-1, 299-W10-13, and 299-W10-14 potentially monitor site conditions.

No releases are associated with the unit. Consequently, no contamination is suspected at the 218-W-5 Burial Ground.

4.1.2.9.12 218-W-6 Burial Ground. The 218-W-6 Burial Ground is a proposed facility located in the northeast corner of the Z Plant Aggregate Area. No releases of hazardous materials are indicated at this unit. However, unplanned release UN-200-W-158 may have caused some surface contamination in the proposed burial ground. One monitoring well, 299-W6-1, was identified near the center of the 218-W-6 Burial Ground. Gamma scintillation logging performed in April 1963 indicated only natural gamma response.

4.1.2.9.13 218-W-11 Burial Ground. The 218-W-11 Burial Ground is an inactive facility that received low-level and mixed waste during 1960. No unplanned releases are associated with this burial ground. One monitoring well, 299-W15-2, is associated with the 218-W-11 Burial Ground. Gamma scintillation logging performed in November 1976 indicated only natural gamma response.

Only minor vadose zone soil contamination is suspected at the 218-W-11 Burial Ground.

No surface radiation was detected during a 1991 radiological survey of the 218-W-11 Burial Ground area.

4.1.2.9.14 Z Plant Burn Pit. Releases may be associated with the estimated 1,000 m^3 (35,000 ft^3) of chemical waste disposed at the Z Plant Burn Pit, but were not reported in the documents reviewed. The Z Plant Burn Pit is east of the main Z Plant building complex. No specific chemical sampling data were identified for the burn pit. Also, no monitoring wells were identified near the Z Plant Burn Pit.

Non-hazardous chemical contaminants are suspected in vadose zone soils at this location.

4.1.2.10 Unplanned Releases. No specific chemical sampling data were identified for the unplanned releases. Also, no monitoring wells were identified near unplanned releases. Historical information discussed in Section 2.3.10 and Table 2-6 indicates that radionuclide contamination is suspected at most of the unplanned releases but insufficient information was identified to characterize the nature and extent of contamination. Tables 4-2 and 4-3 summarize available information regarding media potentially affected by unplanned releases.

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 Z Plant Aggregate Area. The assessment includes a discussion of 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 Z Plant Aggregate Area waste management unit contaminants. Such risk assessments cannot be performed until additional waste management unit characterization data are acquired. Risk assessments will be performed in accordance with the *Hanford Site Baseline Risk Assessment Methodology* document (DOE-RL 1992b) being prepared in response to the 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 1991c).

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 Z Plant Aggregate Area. The extent of Z 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 Z 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

Z 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 bare soil. For these types of waste management units, if discharges to the unit contained chemicals 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, caissons, vaults, tanks, retention basins, 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. 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 was 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-12 Crib) were ineffective in preventing releases to the subsurface.

The efficacy and integrity of concrete liners (207-Z Retention Basin), concrete and steel pads (high-level TRU caissons and vaults), and concrete plugs in corrugated piping (low-level radioactive waste caissons) have not been determined. For those waste management 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 waste management 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 Z Plant Aggregate Area have experienced cave-ins in recent years due to decomposition of the wooden framework of the cribs. Such collapse can lead to high levels of direct radiation at the surface and the potential for spread of contaminated

materials by wind erosion. The Westinghouse Hanford RARA Program is responsible for detecting and remediating cave-ins by covering the cribs with additional soil. Thus, any exposures from these incidents are generally short-term. Waste management units that were remediated due to cave-ins during 1991 were the 216-Z-5 and 216-Z-7 Cribs.

4.2.2 Transport Pathways

Transport pathways expected within the Z 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 or 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 Z 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 a perched zone or the unconfined aquifer, which lies at a depth of approximately 60 m (200 ft) below ground surface. These factors are discussed in the following subsections.

4.2.2.1.1 Depth of Release. As a general rule, for a given volume, waste management units which 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-Z-10 Reverse Well is the primary example of a deep release at the Z Plant Aggregate Area. This unit discharged wastes to the vadose zone approximately 45 m (150 ft) below the surface, or approximately 15 m (50 ft) above the water table in the unconfined aquifer.

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 Z Plant Aggregate Area, the primary sources of moisture for mobilizing contaminants are waste management units which discharge liquid waste to the soil column and precipitation recharge. As discussed in Section 3.5.2, a number of studies have been estimated of natural precipitation recharge range from 0 to 10 cm/yr (0 to 4 inch/yr), primarily depending on surface soil type, vegetation, and topography. The upper end of the range is based on a prediction from a numerical model; the true recharge rate is likely to be lower. Gravelly surface soils with no or minor shallow-rooted vegetation appear to facilitate precipitation recharge. One modeling 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 inch/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 which are capped with fine-grained soils or impermeable covers.

With respect to artificial recharge, as discussed in Section 4.1.8, several waste management units (e.g., the 216-Z-12 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 period of use of these facilities. Because vadose zone hydraulic conductivities are maximized at water contents near saturation, the volume of liquid waste water historically discharged to the waste management units identified in Table 4-11 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 waste management 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 U Plant 216-U-16 Crib where lateral migration of acidic waste above a caliche layer mobilized radionuclides in the 216-U-1 and 216-U-2 Cribs (Baker et al. 1988). No examples of interactions between waste management units are known to have occurred within the Z Plant Aggregate Area.

4.2.2.1.3 Soil Moisture Transport Properties. As discussed in Section 3.5.2, 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 (Freeze and Cherry, 1979). Due to the stratified nature of Hanford Site vadose zone soils and the moisture content dependence of unsaturated hydraulic conductivity, vertical anisotrophy is expected, i.e., vadose zone soils are likely more permeable in the horizontal direction than in the vertical. This vertical anisotrophy 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. A general discussion and literature review of factors affecting mobility of chemicals in soil is provided by Dragun (1988). 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 by Serne and Wood (1990). Some of the processes that have been shown to control the rate of transport are:

- **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 Site 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 was suggested as a mechanism for concentration of plutonium in certain sedimentary layers at the 216-Z-1A Tile Field. This finding suggests that migration of suspended particulates may be an important mechanism of transport for poorly soluble chemicals.

- **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. Leachant having high ionic strength (high salt content) can bias the sorption equilibrium toward desorption,

leading to higher concentrations of the chemical in the soil pore water. Wastes within the Z Plant Aggregate Area that can be considered high ionic strength include the PFP process wastes and the RECUPLEX and PRF aqueous wastes.

- **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. Percent $CaCO_3$ measurements on soil samples from three monitoring wells from the Z Plant Aggregate Area are shown in Table A-2 of Appendix A. The soils in the Hanford formation beneath the Z Plant Aggregate Area generally have carbonate contents in the range of 0.1 to 5 percent. Higher carbonate contents (20 to 30 percent) are observed within the Plio-Pleistocene caliche layer.

  Once the leaching solution has been neutralized the dissolved constituents may reprecipitate or become readsorbed to the soil. Observations of pH impacts on waste transport at the Hanford Site include:

  - Mobilization of plutonium and americium isotopes beneath the 216-Z-1A Tile Field by acid liquid waste depends on a combination of pH effects and complexation by organic components of the waste. These processes were implicated in migration of the radionuclides to a depth of 30 m (98 ft) below the bottom of the crib

  - Leaching of americium from 216-Z-9 Trench sediments was found to be solubility controlled and correlated to solution pH (Rai et al. 1981).

4.2.2.1.5 Complexation by Organics. Certain organic materials disposed of at Z Plant Aggregate Area are known to form complexes with inorganic ions, which can enhance their solubility and mobility. Tributylphosphate is the primary organic complexing agent disposed of at the Z Plant Aggregate Area. Nonionic organic solvents such as carbon tetrachloride are not expected to be strong complexants for inorganic ions. However, if these solvents are present as a separate phase in the subsurface, they could affect the mobility of inorganic ions by other mechanisms. Carbon tetrachloride has been observed to alter the structure of clays, leading to shrinkage and possible formation of cracks (Green et al. 1983). In addition, passage of a carbon tetrachloride phase through the soil may change the extent of sorption of inorganic ions to soil organic matter.

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 of radionuclides decays over time, which generally decreases the quantities and impacts from radioactive isotopes. However, for some radioactive decay chains, ingrowth of daughter products can lead to a net increase in radioactive emissions over time.

- **Biotransformation.** Microorganisms in the soil may degrade organic chemicals such as acetone 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 thereby 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 chloroform, 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 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, $^{14}CO_2$, ^{129}I, or ^{3}H) 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 general, the earthen covers on cribs and trenches are not designed to retard volatile emissions. However, waste management units where high-level radioactive mixed wastes were disposed of, such as the burial caissons, generally have air filtration devices on outlet vents, designed to prevent release of contaminants to the atmosphere while the units were being filled. The effectiveness of these devices for preventing ongoing volatile releases is not known.

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 Z Plant Aggregate Areas to overall fugitive dust emissions at the Hanford Site boundary is expected to be relatively minor, based on results of air monitoring downwind of Z Plant Aggregate Area waste management units (Schmidt et al. 1992).

4.2.2.3 Transport from Soils to Surface Water. There are no natural surface water bodies within the Z Plant Aggregate Area. The 216-Z-21 Seepage Basin is occasionally flooded with water from the Plutonium Recovery Facility storm drains and cooling water. Although the water entering the seepage basin is non-contact wastewater and thus should not contain contaminants, accidental releases to the Plutonium Recovery facility drains could lead to contaminants entering this unit.

Transport of contaminants to surface water bodies outside of the Z 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 the Z 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 Z 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 program (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 assure 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 transported to the surface by burrowing animals, thus exposing contaminants for release to the air. Additionally, animals that become contaminated by contact with subsurface waste can spread contamination in their feces on the surface and outside of the waste management unit. Rabbits were noted as causing the greatest spread of contamination in the 200 Areas in 1985 (Elder et al. 1986).

4.2.3 Conceptual Model

Figure 4-6 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 Z Plant Aggregate Area on humans and biota (conceptual model).

The sources of potentially hazardous chemicals and radionuclides identified at the Z Plant Aggregate Area include process wastes, cooling water, stack releases, sewage, settling tank solids, laboratory wastes, and process feed materials. Also radioactive mixed wastes from nuclear production facilities on and off the Hanford Site were disposed of in the 200 West Burial Grounds. The sources displayed in this figure were identified from historical and current process information and from waste management unit inventories, as described in Section 2. In addition to the known or suspected releases to waste management units, Unplanned Releases due to spills, leaks in piping, and other accidental sources have led to release of radionuclides and other chemicals to the environment. Some of the unplanned releases are associated with the specific waste sites, and are shown on Figure 4-6 as dashed lines with "U" designations.

The column in the Conceptual Model titled "Treatment or Disposal" is used to indicate waste streams that were routed to waste management units outside of the aggregate area, and waste streams that were routed through treatment tanks or settling tanks before being released to units within the aggregate area. The units are grouped in the model by type, as was done in Section 2.0.

Contaminants from the sources noted on Figure 4-6 have been disposed of into the waste management units under investigation. Waste site groups include retention basins, seepage basins, settling tanks, trenches, cribs, french drains, reverse wells, tile fields, septic tanks and drain fields, and burial grounds. The vaults and caissons which comprise part of the 200 West Burial Grounds were assigned to a different waste site group than the burial trenches, since release mechanisms applicable to these concrete-lined containment structures would be expected to be different than for the earth-lined burial trenches. Each of the waste site groups represents a collection of units with similar construction, waste type (i.e., solid vs. liquid) and potential release mechanisms.

From the Z Plant Aggregate Area waste management units, various release mechanisms may have transported chemicals to the potentially affected media. Waste management units where liquid wastes were disposed of (cribs, trenches, drain fields, retention basins) impacted the vadose zone and may have impacted groundwater by infiltration of liquids through the soil. Reverse wells and french drains released wastes directly to the vadose zone by injection of liquids.

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 off-site disposal.

Stack releases may have led to deposition of contaminants on surface soils and vegetation within and outside of the aggregate area. Ambient air quality data for the Z Plant Aggregate Area is presented in Section 4.1. Due to resuspension of dust from soils within and outside of the aggregate area, it is not possible to use these data to distinguish stack releases from other sources of airborne contaminants.

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 4-7 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 unplanned releases which involved surface spills. Small-scale contaminant releases are much less likely to impact the lower vadose zone or groundwater than large-scale releases. Table 4-11 identifies liquid waste management units that had liquid discharges large enough to reach the unconfined aquifer.

This conceptual model for liquid waste management units is most applicable to radionuclide and non-volatile chemical contaminants. With regard to carbon tetrachloride, a

volatile organic compound disposed of at several Z Plant Aggregate Area waste management units (e.g., the 216-Z-1A Tile Field and the 216-Z-9 Trench), two conceptual models have been identified (DOE-RL 1991b). One conceptual model is that vaporization of residual carbon tetrachloride in the unsaturated zone moves downward and laterally away from the primary disposal sites to provide an ongoing source of contamination to groundwater (see Figure 4-8).

An alternative model is that carbon tetrachloride discharged as a phase-separated liquid has also reached the unconfined aquifer in a liquid phase. There the carbon tetrachloride remains in a separate phase and slowly dissolves, providing a continuous source of contamination to groundwater (Figure 4-9).

Contaminant distributions near the low-level burial grounds in the Z Plant Aggregate Area are likely significantly different from those associated with the liquid waste management units. Because the burial grounds received only dry waste and the disposed waste was generally secured in burial containers and/or engineered structures designed to minimize contaminant migration, the burial grounds are unlikely to release contaminants to the vadose zone. As a result, only surface contaminant releases have been identified at the burial grounds. In this case, wind and near-surface biological activity are the dominant processes for transporting and redistributing contaminants.

The conditions depicted on Figures 4-7 through 4-9 are based upon the stratigraphy underlying the Z Plant Aggregate Area, the chemical characteristics of the primary suspected contaminants in the area, and on 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 216-Z-18 Crib, the 216-Z-8 French Drain, the 200-BP-1 Operable Unit Cribs (the BY Cribs) (Buckmaster and Kaczor 1992), the 216-U-10 Pond (Last and Duncan 1980), the 216-Z-19 Ditch (Last and Duncan 1980), and the 218-W-2, 218-W-3AE, 218-W-4B, 218-W-4C, and 218-W-5 Burial Grounds. 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 Z Plant Aggregate Area.

Some of the general conclusions that may be drawn from these previous studies include the following:

- 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.

- Radionuclide contamination is not expected to spread laterally more than 50 to 100 m (164 to 328 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.

- 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 (60 ft) depth.

- The maximum lateral radionuclide contaminant movement tends to occur along relatively impermeable horizons.

- 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.

- Perched water zones are most likely to occur immediately above the caliche layer. With rapid loading, perched 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.

- The caliche layer is an important physical and chemical barrier to vertical contaminant migration.

- 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 (off site and on site) 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

- Direct radiation from waste materials, surface soils, building surfaces, or fugitive dusts.

4.2.4 Characteristics of Contaminants

Table 4-13 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 Z Plant Aggregate Area. In addition, Table 4-13 includes chemicals that have not been detected or reported in PFP wastes or environmental samples but are expected to be present (e.g., decay products of radionuclide contaminants). Table 4-14 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 pose the greatest risk to human health or the environment.

The EPA Region 10 guidance on risk-based contaminant screening (EPA 1991c), as summarized in the *Hanford Baseline Risk Assessment Methodology* (DOE-RL 1992b), was consulted to establish the Z 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 Z 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 Z 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 4-15 lists the contaminants of concern for the Z Plant Aggregate Area. This list was developed from Table 4-13 and includes only those contaminants which meet the following criteria:

- Radionuclides that have a half-life 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 building up of the short-lived radionuclide activity to a level of 1 percent 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 EPA non-carcinogenic 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 tributylphosphate.

- Contaminants which are mobile in the environment via one of the transport pathways identified in the conceptual model.

In practice, the last criterion was not used to eliminate contaminants from the list, since contaminants that are not of concern for groundwater migration (high K_d) may be of concern for airborne transport.

It should be noted that the majority of the listed chemicals and radionuclides were reported disposed of in the 200 West Burial Grounds. The potential for these materials to enter the environment will depend on the extent to which free liquids were co-disposed in the burial areas, and the extent to which container leakage and infiltration has occurred, or may occur in the future, and the potential for disruption of the soil cover.

The following characteristics will be discussed for the contaminants listed in Table 4-13:

- Detection of contaminants in environmental media
- Historical association with plant activities
- Mobility
- Persistence
- Toxicity
- Bioaccumulation.

4.2.4.1 Detection of Contaminants in Environmental Media. The nature and extent of surface and subsurface soils, surface water, and biota contamination have not yet been adequately characterized for the Z Plant Aggregate Area. All recent environmental monitoring data that could be obtained for this study were reviewed and summarized for each media in Section 4.1.

The most extensive monitoring data available are for groundwater. Because groundwater will be evaluated in the 200 West Groundwater AAMSR, it will not be discussed further here. Surface soil and vegetation 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 Z Plant Aggregate Area as a whole. Air and external radiation samples have been collected at several locations within or adjacent to the Z Plant Aggregate Area. These sampling locations 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. In addition, limited

soil sampling was performed in 1979 at the 216-Z-1A Crib, in 1981 at the 216-Z-9 Trench (Rai et al. 1981), and in 1983 at the 216-Z-8 French Drain during special studies of radionuclide migration, and at the 200 West Burial Grounds during studies of carbon tetrachloride distribution (DOE-RL 1991b). The former samples were analyzed only for plutonium and americium, and the latter only for volatile organic compounds. In addition, soil samples from the 200 West Burial Grounds taken in 1990 were analyzed for organic and inorganic constituents (Goodwin and Bjornstad 1990).

4.2.4.2 Historical Association with Z Plant Aggregate Area Activities. Radionuclides that are known components of Z Plant Aggregate Area waste streams are listed in Table 2-10. This list includes chemicals known to occur in the process wastes as well as chemicals that were detected at elevated levels in PFP 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.

Radionuclides that are known to have been disposed of to Z Plant Aggregate Area waste management units in the greatest quantities, based on the data and records of the 200 West Burial Grounds (WHC 1991a), are as follows:

- ^{239}Pu
- ^{240}Pu
- ^{137}Cs
- ^{90}Sr
- ^{3}H
- ^{60}Co
- ^{106}Ru

Note that a complete radionuclide analysis of the PFP waste streams is not available, and no information was located on the composition of wastes from the 231-Z Building. Thus, it is possible that additional radionuclides were disposed of to Z Plant Aggregate Area waste management units that are not reported in the waste inventories.

Nonradioactive chemicals reportedly released into Z Plant Aggregate Area waste management units in large quantities include nitric acid, nitrates, sodium, phosphate, sodium hydroxide, fluorides, tributylphosphate, carbon tetrachloride, dibutyl phosphate, calcium, magnesium, and iron.

4.2.4.3 Mobility. Since most wastes at the Z 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 chemicals listed in Table 4-13 varies widely and depends on site-specific factors as well as the intrinsic properties of the contaminant. The 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 the RI/FS process.

However, it is possible to make general statements about the relative mobility of the candidate chemicals 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 4-16 presents a summary of soil-water distribution coefficients that have been developed for many of the candidate inorganic chemicals of concern at the Z 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 (Am, Cs, Co, Cu, I, Pu, Ru, Sr, 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 value of <1 is recommended for Am, Cs, Pu, and Sr under acidic conditions.

Strenge 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 4-17 are for conditions of neutral waste pH and less than 10 percent 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 conservative default values otherwise: highly mobile ($K_d<5$), moderately mobile ($5<K_d<100$), and low

mobility ($K_d > 100$). Assignment of an element to a mobility class is not exact. The actual mobility of a chemical in Hanford soils is influenced by a range of environmental factors, including the nature of the soil pore water (pH, ionin strength, and presence of liquids), the valence state of the element (which depends on the pH and redox potential of the soil), and the makeup of the soil matrix. Site-specific mobilities will be determined in future investigations. Table 4-18 lists the mobility classes for each of the inorganic contaminants of concern.

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 disposed of or detected at Z Plant Aggregate Area waste management units are listed in Table 4-17. 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, certain 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, ^{3}H, 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 candidate organic chemicals of concern are presented in Table 4-17. Compounds with a K_h greater than about 10^{-3} will be lost rapidly to the atmosphere from surface water and shallow soils. Organic compounds that fall into this class include:

Benzene	Hexane
Carbon tetrachloride	Methylene chloride
Chlorobenzene	Tetrachloroethylene
Chloroform	Toluene
Cyclohexane	Tributylphosphate
1,2-Dichloroethane	1,1,1-Trichloroethane
1,2-Dichloroethylene	Trichloroethylene
Ethylbenzene	Vinyl chloride
Freon II	Xylenes

4.2.4.4 Persistence. Once released to environmental media, the concentration of a chemical 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 Z Plant Aggregate Area contaminants are discussed below.

The persistence of radionuclides depends primarily on their half-lives. A comparison of the half-lives and specific activities for all radionuclides detected or disposed of at the Z Plant Aggregate Area is presented in Table 4-19. This table also includes daughters of long-lived parent radionuclides, whether or not the daughter species have been detected or reported. 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 4-19 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 often themselves radioactive.

Decay will occur during transport (e.g., through the vadose zone to the aquifer and 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 and sulfate undergo chemical and biological transformations that may lead to their loss to the atmosphere (as N_2 and H_2S) 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 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. Tetrachloroethylene and trichloroethylene may be converted to the more toxic compound vinyl chloride under some redox conditions. Volatile aromatics such as toluene are generally intermediate in their biodegradability between these two example groups.

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 in 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 1989a).

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 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 radionuclides by inhaling air, drinking water, ingesting soil, and by external irradiation are shown in Table 4-20. 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/m^3 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 1991a). 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 1991c).

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 Region 10 risk assessment staff or 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 1991c).

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 4-20, the highest risk for exposure to 1 pCi/m^3 in air is from plutonium, americium and uranium isotopes, which are alpha emitters. Among the radionuclides detected in environmental samples at the Z Plant Aggregate Area, the highest risks from ingestion of soil at 1 pCi/g are for ^{227}Ac, ^{241}Am, ^{243}Am, ^{238}Pu, ^{244}Cm, and

^{243}Cm. The primary gamma-emitters are ^{214}Bi, ^{60}Co, ^{134}Cs, ^{137}Cs (because of its metastable decay product, ^{137m}Ba), ^{152}Eu, and ^{154}Eu.

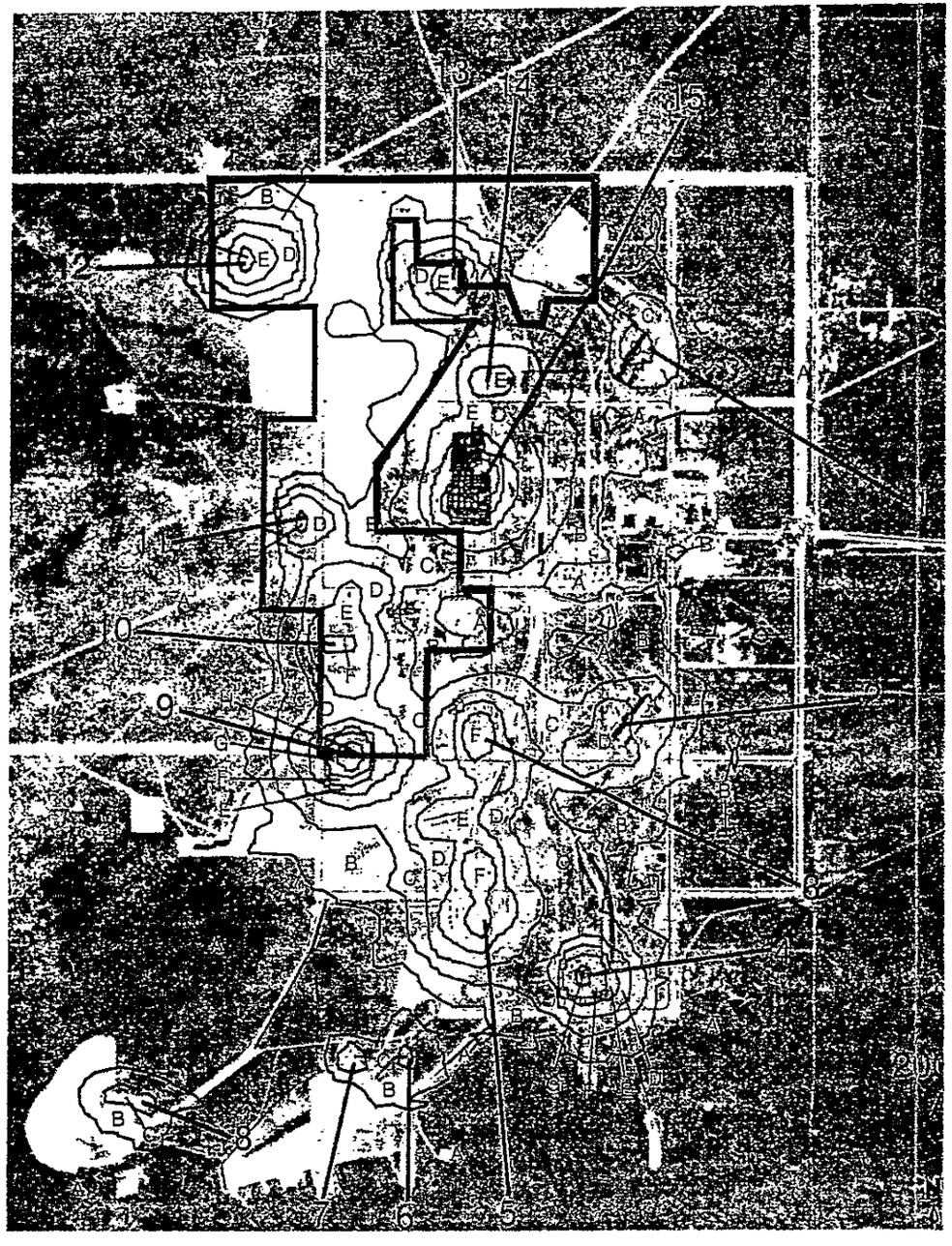
The standard EPA risk assessment methodology assumes that the probability of a carcinogenic effect increases linearly with dose at low dose levels, i.e., there is no threshold for carcinogenic response. The EPA methodology also assumes that the combined effect of exposure to multiple carcinogens is additive without regard to target organ or cancer mechanism. However, the additive risk from chemical carcinogens and radionuclides should be computed separately (EPA 1989a).

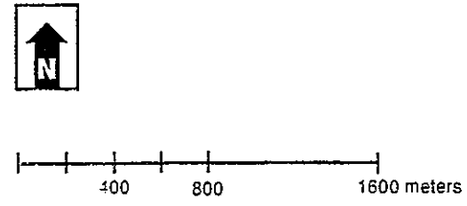
4.2.4.5.2 Hazardous Chemicals. Carcinogenic and non-carcinogenic health effects associated with chemicals known or suspected to occur within the Z Plant Aggregate Area are summarized in Table 4-21. The basis for these potential health effects are described in the respective reference documents and may 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: Integrated Risk Information System (IRIS) (EPA 1991b), Health Effects Assessment Summary Tables (HEAST) (EPA 1991a), 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 chronic toxicity for which toxicity factors are presently not available include:

creosote
ethanol
Freon II (trichlorofluoromethane)
isopropanol
lead
methanol
kerosene
naphthylamine (untritiated)
tributylphosphate.

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 tissue (e.g., concentration of organic chemicals in fatty tissues).





Zone A = <700 ct/s
Zone B = 700 to 2,200 ct/s
Zone C = 2,200 to 7,000 ct/s
Zone D = 7,000 to 22,000 ct/s
Zone E = 22,000 to 70,000 ct/s
Zone F = 70,000 to 220,000 ct/s
Zone G = 220,000 to 700,000 ct/s
Zone H = 700,000 to 2,200,000 ct/s
9 = 218-W-4C Burial Ground
10 = Plutonium Finishing Plant
11 = 2702-W RMW Storage Complex
12 = 218-W-5 Burial Ground
Other numbers refer to sites outside the Z Plant Aggregate Area.
Z Plant Aggregate Area is outlined in red.
The results are displayed as relative levels of man-made radionuclide activity.

Figure 4-1. Gamma Isoradiation Contour Map of the 200 West Area. (Reiman and Dahlstrom 1988)

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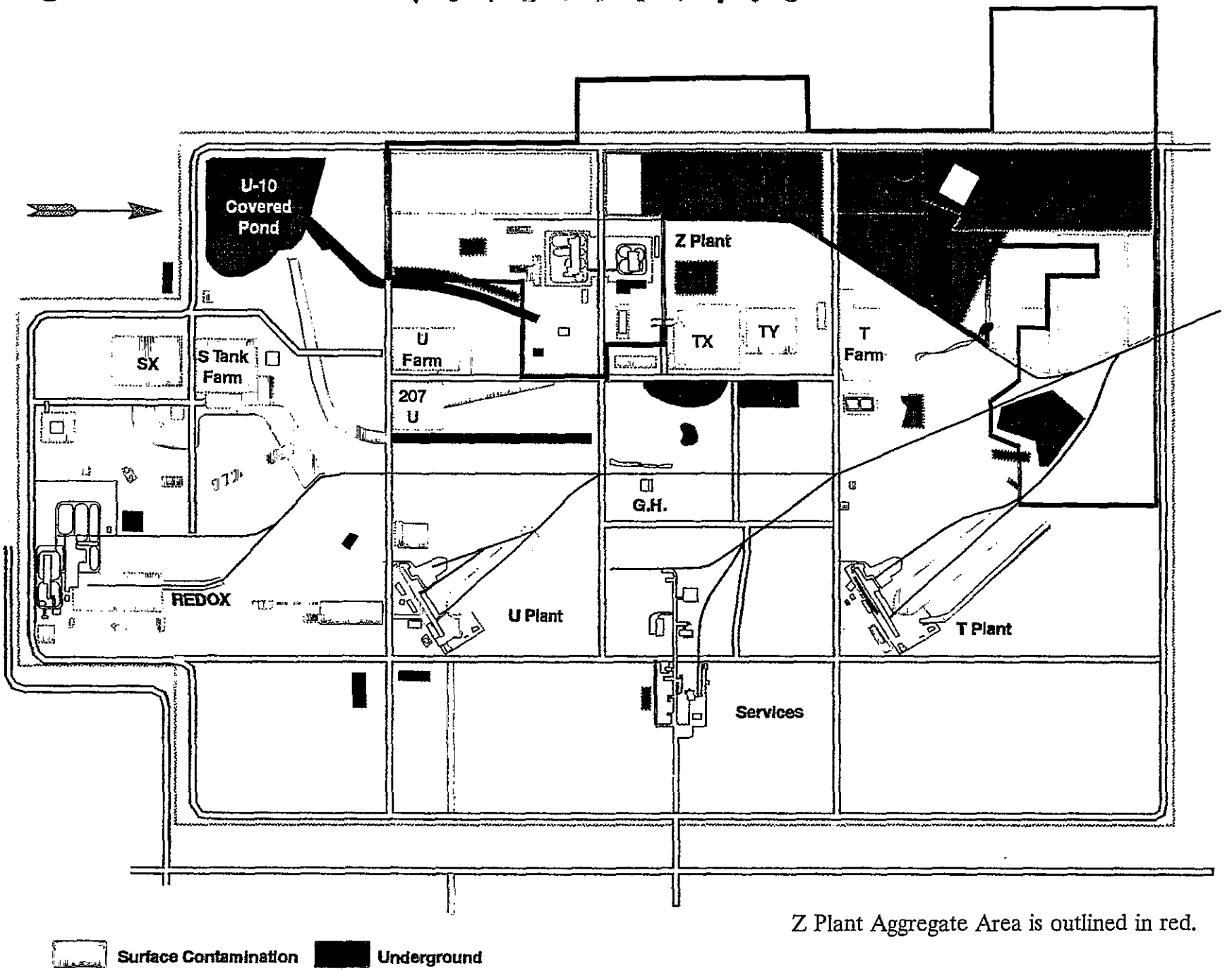


Figure 4-2. Surface, Underground and Migrating Contamination Map of the 200 West Area (Huckfeldt 1991b).

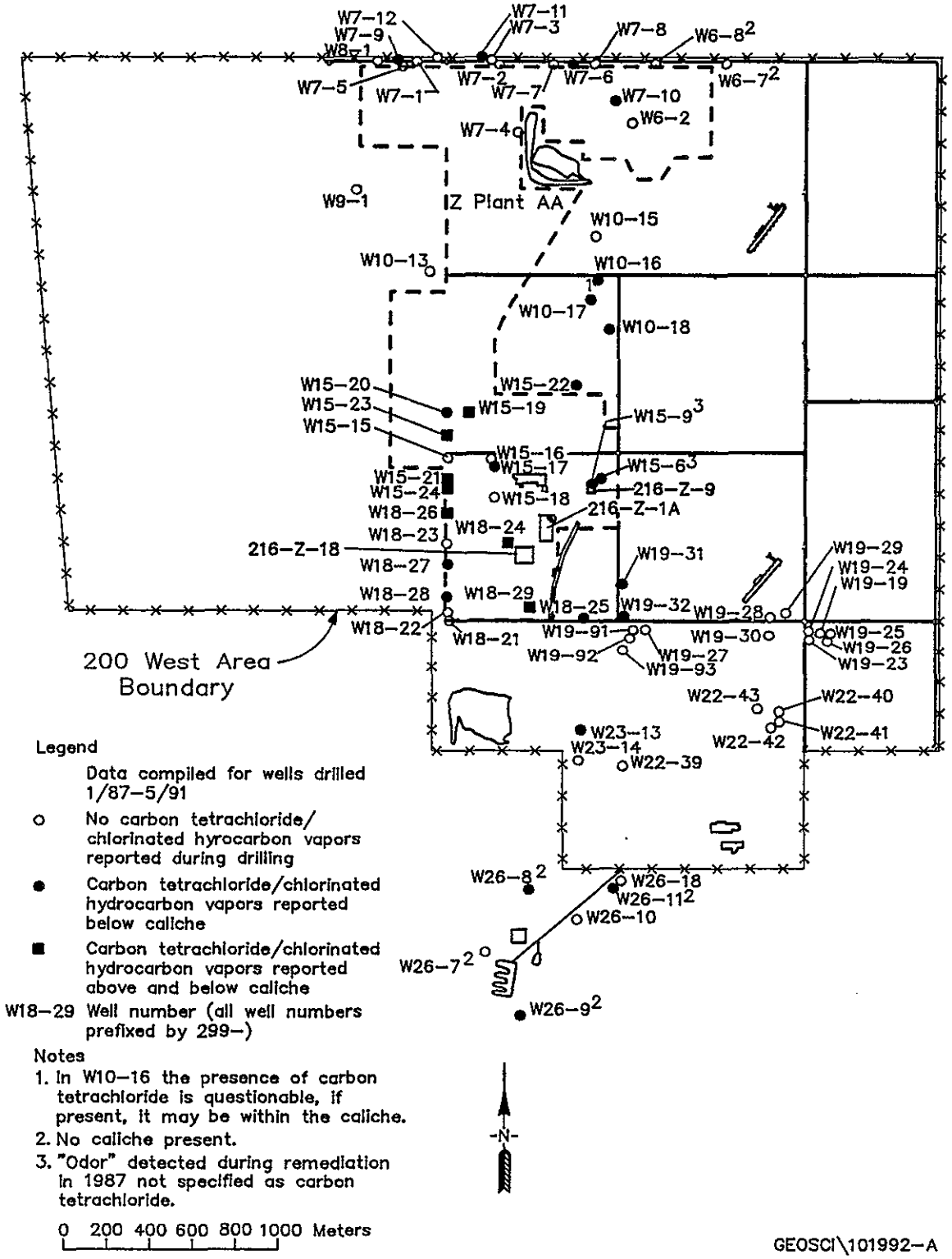


Figure 4-3. Wells in Which Carbon Tetrachloride/Chlorinated Hydrocarbon Vapor was Detected during Drilling in the 200 West Area, 1987-1991. (DOE/RL 1991b)

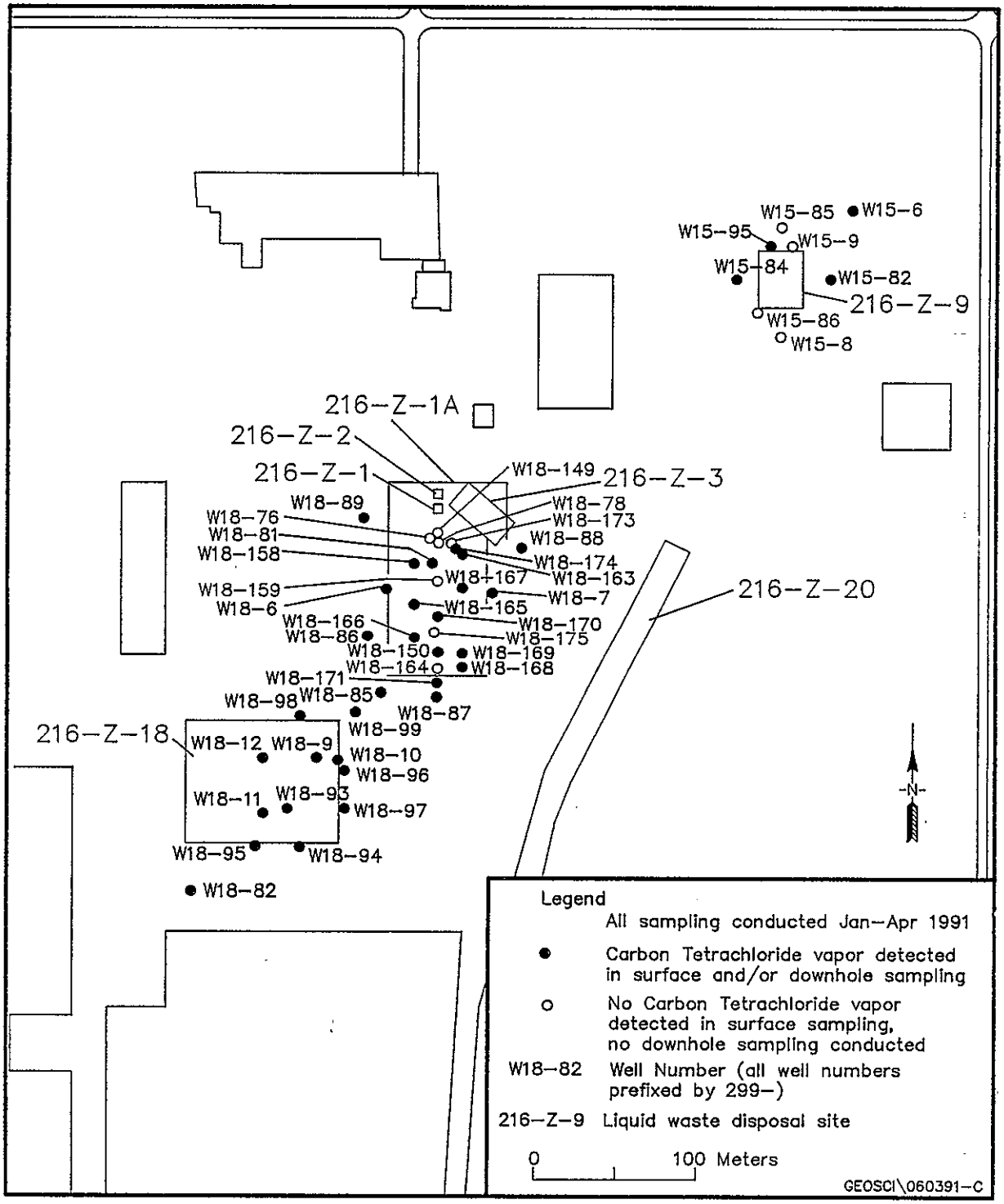


Figure 4-4. Wells in Which Carbon Tetrachloride Vapor was Detected in the Z Plant Aggregate Area, 1991. (DOE/RL 1991b).

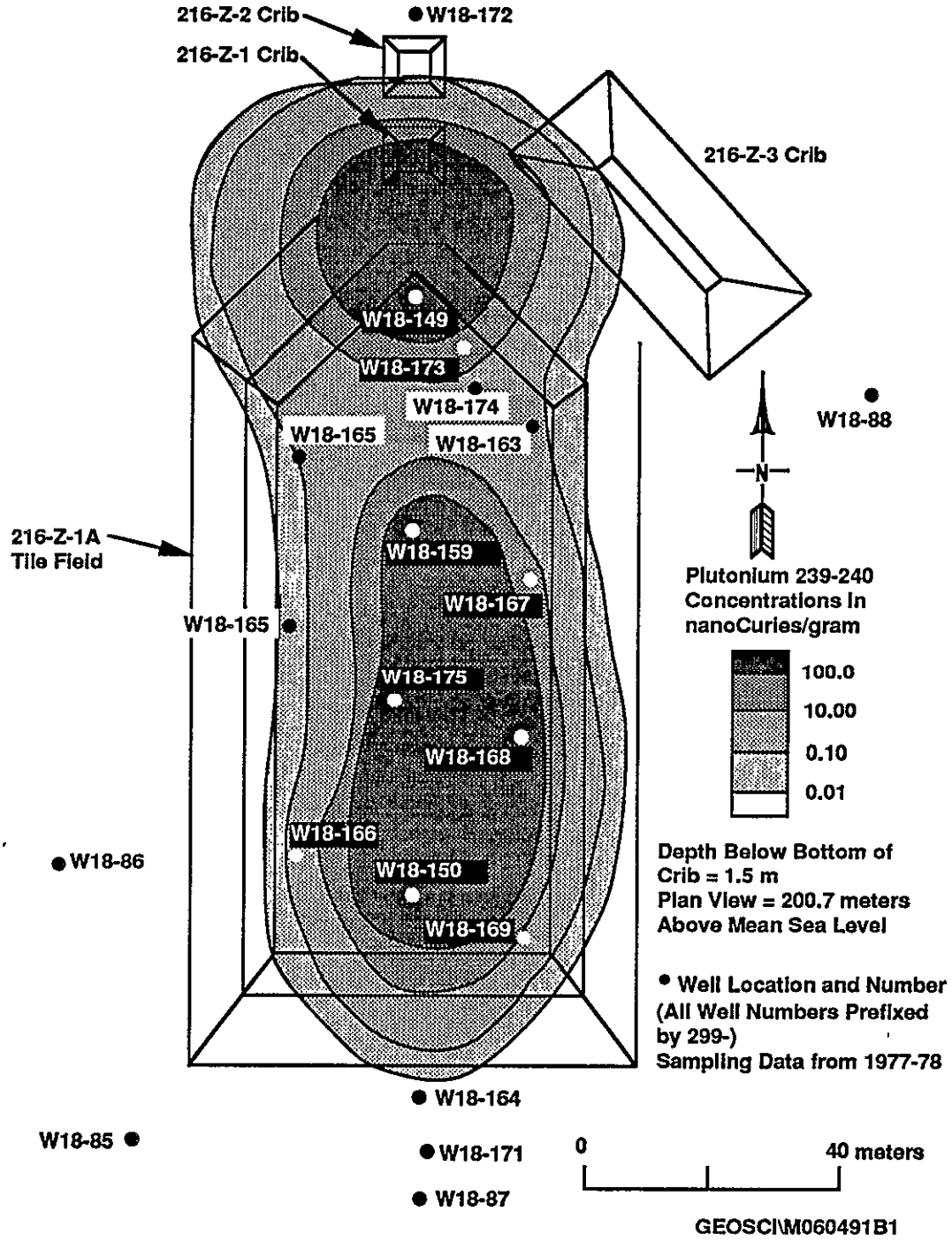


Figure 4-5. Map of 1977 Plutonium Concentrations in Unsaturated Zone 1.5 m below Bottom of the 216-Z-1A Tile Field.

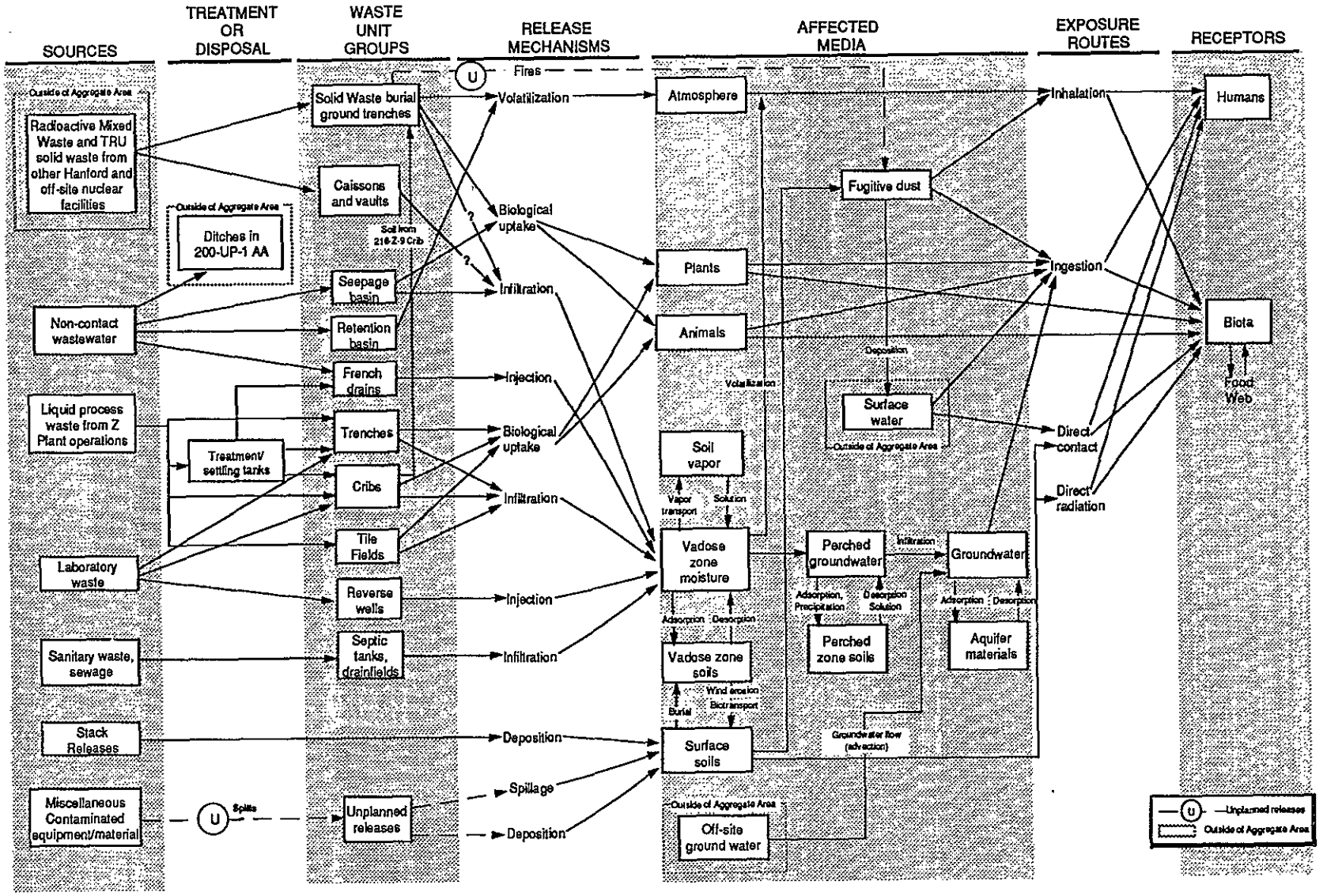
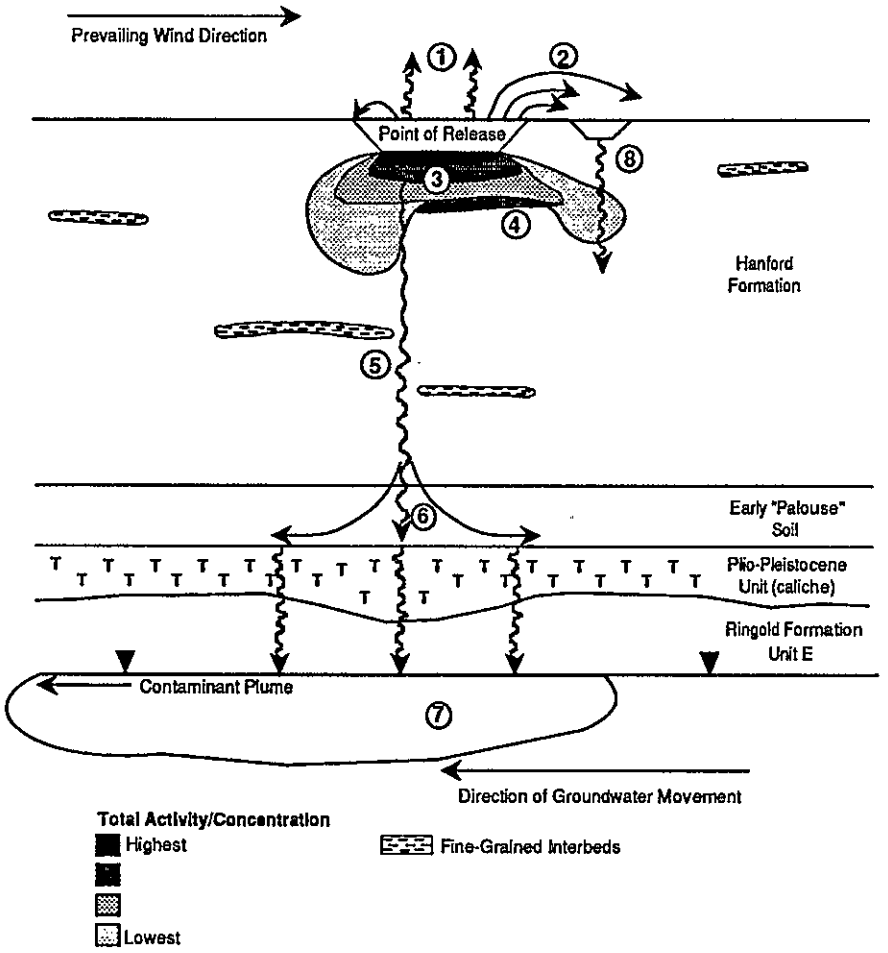


Figure 4-6. Conceptual Model.



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 4-7. Physical Conceptual Model of Contaminant Distribution for Liquid Disposal Sites.

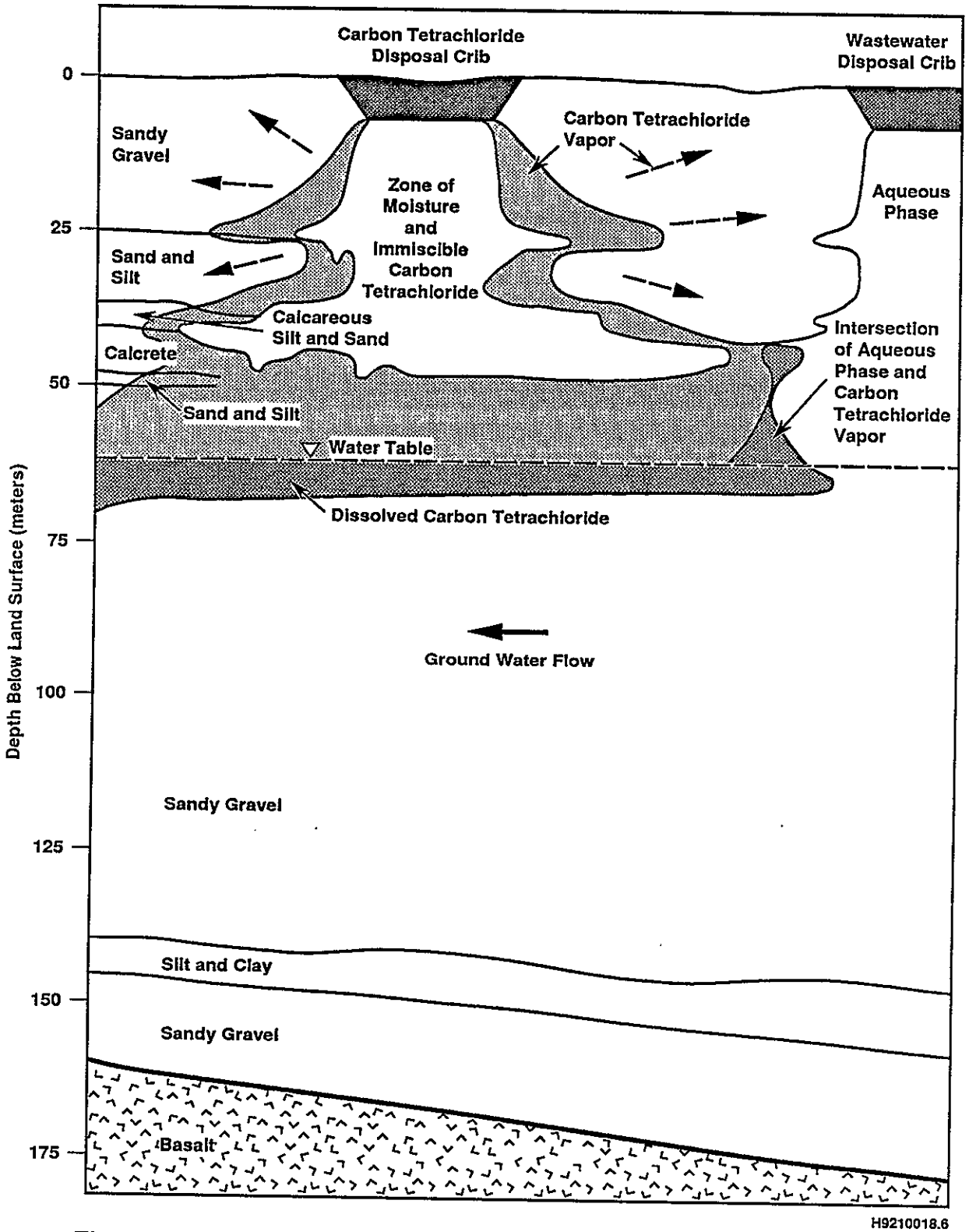


Figure 4-8. Conceptual Model of Migration Paths and Distribution of Carbon Tetrachloride that Remains Primarily in the Unsaturated Zone (DOE/RL 1991b).

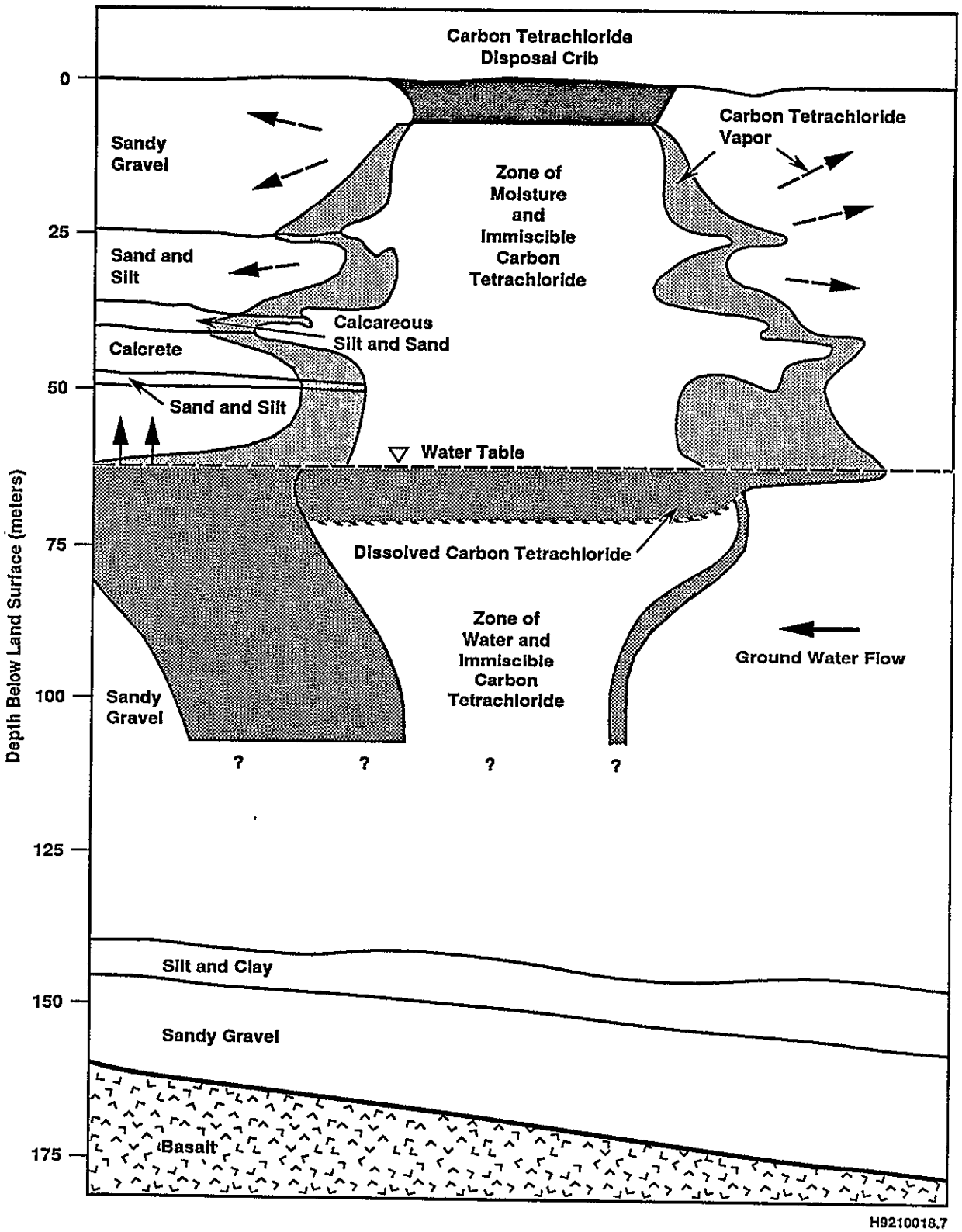


Figure 4-9. Conceptual Model of Migration Paths and Distribution of Carbon Tetrachloride that has Reached the Groundwater as an Immiscible Phase (DOE/RL 1991b).

Table 4-1. Summary of Radionuclide Contamination in Various Affected Media for the Z Plant Aggregate Area. (Sheet 1 of 5)

Waste Management Unit	Air	Surface Soil (0 to 1 m)	Surface Water	Biota	Vadose Zone	Remarks
Plants, Buildings, and Storage Areas						
232-Z Incinerator	—	s	—	—	—	Slightly elevated external radiation.
Tanks and Vaults						
216-Z-8 Settling Tank	—	—	—	—	s	Single wall steel tank containing 1.6 kg Pu (1974).
241-Z-361 Settling Tank	—	—	—	—	—	
241-Z Treatment Tank	—	k, r	—	—	s	See UPR-200-W-79.
Cribs and Drains						
216-Z-1 & 216-Z-2 Cribs	—	s	—	—	s	Elevated external radiation.
216-Z-3 Crib	—	—	—	—	s	
216-Z-5 Crib	—	k	—	—	s	High cave-in potential reported.
216-Z-6 Crib	—	—	—	—	s	High cave-in potential reported.
216-Z-7 Crib	—	k	—	—	s	Elevated gamma to groundwater.
216-Z-12 Crib	—	—	—	—	s	Elevated gamma to 8 m.
216-Z-16 Crib	—	—	—	—	s	
216-Z-18 Crib	—	—	—	—	s	Elevated gamma to 9 m.
216-Z-8 French Drain	—	—	—	—	k	^{239}Pu to 7.6 m.
216-Z-13 French Drain	—	—	—	—	s	Floor drainage from 291-Z Building.
216-Z-14 French Drain	—	—	—	—	s	Trace beta activity reported.
216-Z-15 French Drain	—	—	—	—	s	Received Evaporative cooler water.

Table 4-1. Summary of Radionuclide Contamination in Various Affected Media for the Z Plant Aggregate Area. (Sheet 2 of 5)

Waste Management Unit	Air	Surface Soil (0 to 1 m)	Surface Water	Biota	Vadose Zone	Remarks
216-Z-1A Tile Field	—	s	—	—	k	Pu and Am to 30 m.
Reverse Well						
216-Z-10 Reverse Well	—	—	—	—	s	
Ponds, Ditches and Trenches						
216-Z-4 Trench	—	—	—	—	s	Only used one month.
216-Z-9 Trench	—	k	—	k	k	Elevated gamma to more than 30 m.
216-Z-17 Trench	—	—	—	—	s	Received laboratory waste.
Septic Tanks and Associated Drain Fields						
2607-Z Septic Tank and Drain Field	—	—	—	—	—	Sanitary wastes only.
2607-Z-1 Septic Tank and Drain Field	—	—	—	—	—	Sanitary wastes only.
2607-WA Septic Tank and Drain Field	—	—	—	—	—	Sanitary wastes only.
2607-WB Septic Tank and Drain Field	—	—	—	—	—	Sanitary wastes only.
2607-W-8 Septic Tank and Drain Field	—	—	—	—	—	Sanitary wastes only.

Table 4-1. Summary of Radionuclide Contamination in Various Affected Media for the Z Plant Aggregate Area. (Sheet 3 of 5)

Waste Management Unit	Air	Surface Soil (0 to 1 m)	Surface Water	Biota	Vadose Zone	Remarks
Transfer Facilities, Diversion Boxes, and Pipelines						
241-Z-Diversion Box No. 1	—	—	—	—	s	
241-Z-Diversion Box No. 2	—	—	—	—	s	
231-Z-151 Sump	—	—	—	—	s	See UN-200-W-130
Basins						
207-Z Retention Basin	—	—	—	—	—	
241-Z-21 Seepage Basin	—	k	nc	k	—	Contaminated aquatic vegetation and sediment.
Burial Sites						
218-W-1 Burial Ground	—	k, r?	—	—	—	Elevated external radiation. See UPR-200-45, UPR-200-W-84, UPR-200-W-134.
218-W-1A Burial Ground	—	—	—	—	—	
218-W-2 Burial Ground	—	s	—	—	—	Elevated external radiation.
218-W-2A Burial Ground	—	s	—	k	—	Elevated external radiation. Contaminated vegetation.
218-W-3 Burial Ground	—	—	—	—	—	
218-W-3A Burial Ground	—	s	—	—	—	Elevated external radiation.
218-W-3AE Burial Ground	—	—	—	—	—	
218-W-4A Burial Ground	k	k, r?	—	—	s	See UPR-200-W-16, UPR-200-W-26, UPR-200-W-53, and UPR-200-W-72. Elevated external radiation.
218-W-4B Burial Ground	—	k	—	—	—	Small area of contaminated mulch.
218-W-4C Burial Ground	—	s	—	k	—	Contaminated vegetation.
218-W-5 Burial Ground	—	—	—	—	—	

Table 4-1. Summary of Radionuclide Contamination in Various Affected Media for the Z Plant Aggregate Area. (Sheet 4 of 5)

Waste Management Unit	Air	Surface Soil (0 to 1 m)	Surface Water	Biota	Vadose Zone	Remarks
218-W-6 Burial Ground	—	—	—	k	—	Proposed site. Contaminated vegetation.
218-W-11 Burial Ground	—	k	—	k	—	Small area of contaminated mulch
Z Plant Burn Pit	—	—	—	—	—	
Unplanned Releases						
UN-200-W-11	—	s	—	—	—	
UPR-200-W-16	s	r?	—	—	—	Elevated external radiation (historical).
UN-200-W-23	—	s	—	—	—	
UPR-200-W-26	s	r?	—	—	—	Elevated external radiation (historical).
UN-200-W-44	s	s	—	—	—	Elevated external radiation (historical).
UPR-200-W-45	k	r?	—	—	—	Elevated external radiation (historical). Ruthenium spill affected 1,800 acres. .
UPR-200-W-53	k	r?	—	—	—	Elevated external radiation (historical). Ruthenium spill affected 250 acres.
UPR-200-W-72	s	r?	—	—	—	Elevated external radiation (historical).
UN-200-W-74	—	r	—	—	—	Elevated external radiation (historical). 241-Z Treatment Tank Area.
UN-200-W-75	—	r	—	—	—	Elevated external radiation (historical). 241-Z Treatment Tank Area.
UN-200-W-79	—	r	—	—	—	241-Z Treatment Tank Area. Elevated external radiation (historical).
UPR-200-W-84	s	r?	—	—	—	Elevated external radiation (historical).
UN-200-W-89	s	r	—	—	—	Elevated external radiation (1985).

Table 4-1. Summary of Radionuclide Contamination in Various Affected Media for the Z Plant Aggregate Area. (Sheet 5 of 5)

Waste Management Unit	Air	Surface Soil (0 to 1 m)	Surface Water	Biota	Vadose Zone	Remarks
UN-200-W-90	s	r	—	—	—	Elevated external radiation (1985).
UN-200-W-91	s	r?	—	—	—	Elevated external radiation (1985).
UN-200-W-103	—	r?	—	—	s	Elevated external radiation. 216-Z-18 Crib line
UN-200-W-130	—	r?	—	—	s	Elevated external radiation (historical).
UN-200-W-132	—	s	—	—	s	
UPR-200-W-134	nc	nc	—	—	—	
UPR-200-W-158	—	s	—	—	—	Elevated external radiation (historical).
UN-200-W-159	—	—	—	—	—	

Notes:

s Suspected contamination, based on WHC (1991a), other waste inventory data, and available sampling and analysis information.
k Known contamination based on WHC (1991a), or other source.
r Complete remediation reported.
r? Remediation attempted, effectiveness not documented.
nc No contamination indicated by the available data.
Blank entires indicate no applicable data found during document review.

Table 4-2. Summary of Chemical Contamination for Various Affected Media for the Z Plant Aggregate Area. (Sheet 1 of 5)

Waste Management Unit	Air	Surface Soil (0 to 1 m)	Surface Water	Biota	Vadose Zone Soil	Remarks
Plants, Buildings, and Storage Areas						
232-Z Incinerator	—	—	—	—	—	
Tanks and Vaults						
216-Z-8 Settling Tank	—	—	—	—	—	Single wall steel tank.
241-Z-361 Settling Tank	—	—	—	—	—	
241-Z Treatment Tank	—	k, r	—	—	—	See UPR-200-W-79.
Cribs and Drains						
216-Z-1 & 216-Z-2 Cribs	s	—	—	—	k	Carbon tetrachloride disposal area.
216-Z-3 Crib	—	—	—	—	s	Mainly inorganics.
216-Z-5 Crib	—	—	—	—	s	Mainly inorganics.
216-Z-6 Crib	—	—	—	—	s	Mainly inorganics.
216-Z-7 Crib	—	—	—	—	s	Mainly inorganics.
216-Z-12 Crib	—	—	—	—	s	Received laboratory waste.
216-Z-16 Crib	—	—	—	—	s	
216-Z-18 Crib	s	—	—	—	k	Carbon tetrachloride disposal area.
216-Z-8 French Drain	—	—	—	—	s	
216-Z-13 French Drain	—	—	—	—	nc	Floor drainage from 291-Z Building.
216-Z-14 French Drain	—	—	—	—	nc	
216-Z-15 French Drain	—	—	—	—	nc	Received Evaporative cooler water.
216-Z-1A Tile Field	s	—	—	—	k	Carbon tetrachloride disposal area.

Table 4-2. Summary of Chemical Contamination for Various Affected Media for the Z Plant Aggregate Area. (Sheet 2 of 5)

Waste Management Unit	Air	Surface Soil (0 to 1 m)	Surface Water	Biota	Vadose Zone Soil	Remarks
Reverse Well						
216-Z-10 Reverse Well	—	—	—	—	s	
Ponds, Ditches, and Trenches						
216-Z-4 Trench	—	—	—	—	s	Only used one month. Received laboratory waste.
216-Z-9 Trench	s	—	—	—	k	Carbon tetrachloride disposal area.
216-Z-17 Trench	—	—	—	—	s	Received laboratory waste.
Septic Tanks and Associated Drain Fields						
2607-Z Septic Tank and Drain Field	—	—	—	—	nc	Sanitary wastes only.
2607-Z-1 Septic Tank and Drain Field	—	—	—	—	nc	Sanitary wastes only.
2607-WA Septic Tank and Drain Field	—	—	—	—	nc	Sanitary wastes only.
2607-WB Septic Tank and Drain Field	—	—	—	—	nc	Sanitary wastes only.
2607-W-8 Septic Tank and Drain Field	—	—	—	—	nc	Sanitary wastes only.
Transfer Facilities, Diversion Boxes, and Pipelines						
241-Z-Diversion Box No. 1	—	—	—	—	—	
241-Z-Diversion Box No. 2	—	—	—	—	—	
231-Z-151 Sump	—	—	—	—	—	
Basins						

Table 4-2. Summary of Chemical Contamination for Various Affected Media for the Z Plant Aggregate Area. (Sheet 3 of 5)

Waste Management Unit	Air	Surface Soil (0 to 1 m)	Surface Water	Biota	Vadose Zone Soil	Remarks
207-Z Retention Basin	—	—	—	—	—	
216-Z-21 Seepage Basin	—	—	nc	—	—	
Burial Sites						
218-W-1 Burial Ground	—	—	—	—	—	See UPR-200-45, UPR-200-W-84, UPR-200-W-134.
218-W-1A Burial Ground	—	—	—	—	—	
218-W-2 Burial Ground	—	—	—	—	—	
218-W-2A Burial Ground	—	—	—	—	—	
218-W-3 Burial Ground	—	—	—	—	—	
218-W-3A Burial Ground	—	—	—	—	—	
218-W-3AE Burial Ground	—	—	—	—	—	Doesn't receive radioactive waste.
218-W-4A Burial Ground	—	—	—	—	—	See UPR-200-W-16, UPR-200-W-26, UPR-200-W-53, and UPR-200-W-72.
218-W-4B Burial Ground	—	—	—	—	—	Small area of contaminated mulch.
218-W-4C Burial Ground	—	—	—	—	—	
218-W-5 Burial Ground	—	—	—	—	—	
218-W-6 Burial Ground	—	—	—	—	—	Proposed site.
218-W-11 Burial Ground	—	—	—	—	—	Small area of contaminated mulch.
Z Plant Burn Pit	—	—	—	—	—	
Unplanned Releases						
UN-200-W-11	—	—	—	—	—	
UPR-200-W-16	—	—	—	—	—	

Table 4-2. Summary of Chemical Contamination for Various Affected Media for the Z Plant Aggregate Area. (Sheet 4 of 5)

Waste Management Unit	Air	Surface Soil (0 to 1 m)	Surface Water	Biota	Vadose Zone Soil	Remarks
UN-200-W-23	—	—	—	—	—	
UPR-200-W-26	—	—	—	—	—	
UN-200-W-44	—	—	—	—	—	
UPR-200-W-45	—	—	—	—	—	
UPR-200-W-53	—	—	—	—	—	
UPR-200-W-72	—	—	—	—	—	
UN-200-W-74	—	—	—	—	—	241-Z Treatment Tank Area.
UN-200-W-75	—	—	—	—	—	241-Z Treatment Tank Area.
UN-200-W-79	—	—	—	—	—	241-Z Treatment Tank Area.
UPR-200-W-84	—	—	—	—	—	
UN-200-W-89	—	—	—	—	—	
UN-200-W-90	—	—	—	—	—	
UN-200-W-91	—	—	—	—	—	
UN-200-W-103	—	—	—	—	—	216-Z-18 Crib line.
UN-200-W-130	—	—	—	—	—	
UN-200-W-132	—	—	—	—	—	
UPR-200-W-134	—	—	—	—	—	
UPR-200-W-158	—	—	—	—	—	
UN-200-W-159	—	—	—	—	—	

Notes:

Table 4-2. Summary of Chemical Contamination for Various Affected Media for the Z Plant Aggregate Area. (Sheet 5 of 5)

s Suspected contamination, primarily based on WHC (1991a), and other waste inventory data.
k Known contamination based on chemical analysis data, WHC (1991a), or other source.
r Complete remediation reported.
r? Remediation attempted, effectiveness not documented.
nc No contamination indicated by the available data.
— indicates no applicable data found during document review.

Table 4-3. Types of Data for the Z Plant Aggregate Area Waste Management Units. (Sheet 1 of 5)

Waste Management Unit	Waste Inventory Database (WIDS)	Surface Soil/Sediment Data	External Radiation Monitoring Data	Biota Sampling Data	Subsurface Vapor/Soil Sampling Data	Borehole Geophysics Data
Plants, Buildings, and Storage Areas						
232-Z Incinerator	—	—	R	—	—	—
Tanks and Vaults						
216-Z-8 Settling Tank	C, R	—	—	—	—	—
241-Z-361 Settling Tank	C, R	—	—	—	—	—
241-Z Treatment Tank	C, R	—	—	—	—	—
Cribs and Drains						
216-Z-1 & 216-Z-2 Cribs	C, R	—	R	—	—	R
216-Z-3 Crib	C, R	—	R	—	—	R
216-Z-5 Crib	C, R	—	R	—	—	R
216-Z-6 Crib	C, R	—	R	—	—	—
216-Z-7 Crib	C, R	—	R	—	—	R
216-Z-12 Crib	C, R	—	R	—	—	R
216-Z-16 Crib	R	—	R	—	—	R
216-Z-18 Crib	C, R	—	R	—	C	R
216-Z-8 French Drain	R	—	R	—	R	—
216-Z-13 French Drain	R	—	R	—	—	—
216-Z-14 French Drain	R	—	R	—	—	—
216-Z-15 French Drain	R	—	R	—	—	—

Table 4-3. Types of Data for the Z Plant Aggregate Area Waste Management Units. (Sheet 2 of 5)

Waste Management Unit	Waste Inventory Database (WIDS)	Surface Soil/Sediment Data	External Radiation Monitoring Data	Biota Sampling Data	Subsurface Vapor/Soil Sampling Data	Borehole Geophysics Data
216-Z-1A Tile Field	C, R	—	R	—	C, R	R
Reverse Well						
216-Z-10 Reverse Well	C, R	—	R	—	—	—
Ponds, Ditches, and Trenches						
216-Z-4 Trench	R	—	R	—	—	—
216-Z-9 Trench	C, R	—	R	R	C, R	R
216-Z-17 Trench	R	—	R	—	—	—
Septic Tanks and Associated Drain Fields						
2607-Z Septic Tank and Drain Field	—	—	—	—	—	—
2607-Z-1 Septic Tank and Drain Field	—	—	—	—	—	—
2607-WA Septic Tank and Drain Field	—	—	—	—	—	—
2607-WB Septic Tank and Drain Field	—	—	—	—	—	—
2607-W-8 Septic Tank and Drain Field	—	—	—	—	—	—

Table 4-3. Types of Data for the Z Plant Aggregate Area Waste Management Units. (Sheet 3 of 5)

Waste Management Unit	Waste Inventory Database (WIDS)	Surface Soil/Sediment Data	External Radiation Monitoring Data	Biota Sampling Data	Subsurface Vapor/Soil Sampling Data	Borehole Geophysics Data
Transfer Facilities, Diversion Boxes, and Pipelines						
241-Z-Diversion Box No. 1	—	—	—	—	—	—
241-Z-Diversion Box No. 2	—	—	—	—	—	—
231-Z-151 Sump	—	—	—	—	—	—
Basins						
207-Z Retention Basin	—	—	—	—	—	—
216-Z-21 Seepage Basin	—	R	R	R	—	—
Burial Sites						
218-W-1 Burial Ground	R	—	R	—	—	—
218-W-1A Burial Ground	R	—	R	—	—	—
218-W-2 Burial Ground	R	—	R	—	C	—
218-W-2A Burial Ground	R	—	R	R	—	—
218-W-3 Burial Ground	R	—	R	—	—	—
218-W-3A Burial Ground	R	—	R	—	—	R
218-W-3AE Burial Ground	R	—	—	R	C, R	R
218-W-4A Burial Ground	R	—	R	—	—	—
218-W-4B Burial Ground	R	—	R	—	C, R	R
218-W-4C Burial Ground	R	—	—	R	C, R	R
218-W-5 Burial Ground	R	—	—	—	C, R	R

Table 4-3. Types of Data for the Z Plant Aggregate Area Waste Management Units. (Sheet 4 of 5)

Waste Management Unit	Waste Inventory Database (WIDS)	Surface Soil/Sediment Data	External Radiation Monitoring Data	Biota Sampling Data	Subsurface Vapor/Soil Sampling Data	Borehole Geophysics Data
218-W-6 Burial Ground	—	—	—	—	—	R
218-W-11 Burial Ground	R	—	R	—	—	R
Z Plant Burn Pit	—	—	—	—	—	—
Unplanned Releases						
UN-200-W-11	—	—	—	—	—	—
UPR-200-W-16	—	—	R	—	—	—
UN-200-W-23	—	—	R	—	—	—
UPR-200-W-26	—	—	R	—	—	—
UN-200-W-44	R	—	R	—	—	—
UPR-200-W-45	R	—	R	—	—	—
UPR-200-W-53	R	—	R	—	—	—
UPR-200-W-72	R	—	R	—	—	—
UN-200-W-74	R	—	R	—	—	—
UN-200-W-75	R	—	R	—	—	—
UN-200-W-79	R	—	R	—	—	—
UPR-200-W-84	R	—	R	—	—	—
UN-200-W-89	R	—	R	—	—	—
UN-200-W-90	R	—	R	—	—	—
UN-200-W-91	R	—	R	—	—	—

Table 4-3. Types of Data for the Z Plant Aggregate Area Waste Management Units. (Sheet 5 of 5)

Waste Management Unit	Waste Inventory Database (WIDS)	Surface Soil/Sediment Data	External Radiation Monitoring Data	Biota Sampling Data	Subsurface Vapor/Soil Sampling Data	Borehole Geophysics Data
UN-200-W-103	R	—	R	—	—	—
UN-200-W-130	R	—	R	—	—	—
UN-200-W-132	—	—	—	—	—	—
UPR-200-W-134	—	—	—	—	—	—
UPR-200-W-158	R	—	R	—	—	—
UN-200-W-159	C	—		—	—	—

Notes:

C Nonradioactive organic or inorganic constituents
R Radiological constituents
— indicates no applicable data found during document review.

Table 4-4. Summary of Air Sampling Results (1985 through 1989).

Radionuclide in pCi/m³	Sites			
	N165	N962	N964	N994
Strontium -90	6.55E-04	2.25E-03	7.45E-04	6.26E-05
Cesium -137	1.37E-04	5.95E-04	7.80E-05	1.70E-04
Plutonium - 239	2.37E-04	3.28E-05	2.04E-05	2.10E-06
Uranium (Total)	5.43E-05	4.73E-05	3.66E-05	2.31E-05

Notes:
Table values are averages for radionuclide concentrations in air from 1985 through 1989 in pCi/m³.
See Table A-3 for complete data set.
See Plate 2 for sampling locations.

Table 4-5. Radiation and Dose Rate Surveys at the Z Plant Aggregate Area Waste Management Units. (Sheet 1 of 6)

			Radiation Survey				
Waste Management Unit	Ref.	Inspection Date	ct/min	dis/min	mrem/hr	Smearable Alpha in dis/min	Radiation Type, Notes
Plants, Buildings, and Storage Areas							
232-Z Incinerator	2	—	—	—	—	—	Low levels of α, stabilized
Tanks and Vaults							
216-Z-8 Settling Tank	—	—	—	—	—	—	—
241-Z-361 Settling Tank	—	—	—	—	—	—	—
241-Z Treatment Tank	—	—	—	—	—	—	—
Cribs and Drains							
216-Z-1 & 216-Z-2 Cribs	1	Jan. 4, 1989	ND	15,000	ND	1,500	α
216-Z-3 Crib	2	March, 1986	NA	NA	ND	ND	—
216-Z-5 Crib	1	Sept. 5, 1991	NA	ND	NA	NA	Stabilized (backfilled) 9/5/91
216-Z-6 Crib	1	Aug. 13, 1991	NA	ND	NA	ND	—
216-Z-7 Crib	1	Sept. 9, 1991	NA	ND	NA	ND	Stabilized (backfilled) 9/11/91
216-Z-12 Crib	1	July 18, 1991	NA	ND	ND	ND	—
216-Z-16 Crib	1	Feb. 28, 1991	NA	ND	ND	NA	—
216-Z-18 Crib	1	July 9, 1991	ND	ND	ND	NA	—
216-Z-8 French Drain	1	July 2, 1991	NA	ND	ND	ND	—
216-Z-13 French Drain	1	Feb. 28, 1991	ND	ND	ND	NA	—
216-Z-14 French Drain	1	Feb. 28, 1991	NA	ND	ND	NA	—

Table 4-5. Radiation and Dose Rate Surveys at the Z Plant Aggregate Area Waste Management Units. (Sheet 2 of 6)

			Radiation Survey				
Waste Management Unit	Ref.	Inspection Date	ct/min	dis/min	mrem/hr	Smearable Alpha in dis/min	Radiation Type, Notes
216-Z-15 French Drain	1	Feb. 28, 1991	NA	ND	ND	NA	–
216-Z-1A Tile Field	1	Jan. 3, 1989	NA	10,000	ND	500	–
Reverse Well							
216-Z-10 Reverse Well	1	Aug. 13, 1991	–	–	ND	NA	–
Ponds, Ditches, and Trenches							
216-Z-4 Trench	1	Aug. 13, 1991	NA	ND	NA	ND	–
216-Z-9 Trench	1	July 10, 1991	NA	ND	ND	ND	–
216-Z-17 Trench	1	Aug. 13, 1991	NA	ND	ND	ND	–
Septic Tanks and Associated Drain Fields							
2607-Z Septic Tank and Drain Field	–	–	–	–	–	–	–
2607-Z-1 Septic Tank and Drain Field	–	–	–	–	–	–	–

Table 4-5. Radiation and Dose Rate Surveys at the Z Plant Aggregate Area Waste Management Units. (Sheet 3 of 6)

			Radiation Survey				
Waste Management Unit	Ref.	Inspection Date	ct/min	dis/min	mrem/hr	Smearable Alpha in dis/min	Radiation Type, Notes
2607-WA Septic Tank and Drain Field	—	—	—	—	—	—	—
2607-WB Septic Tank and Drain Field	—	—	—	—	—	—	—
2607-W-8 Septic Tank and Drain Field	—	—	—	—	—	—	—
Transfer Facilities, Diversion Boxes, and Pipelines							
241-Z-Diversion Box No. 1	—	—	—	—	—	—	—
241-Z-Diversion Box No. 2	—	—	—	—	—	—	—
231-Z-151 Sump	—	—	—	—	—	—	—
Basins							
207-Z Retention Basin	—	—	—	—	—	—	—
216-Z-21 Seepage Basin	1	Jan. 25, 1989	NA	5,000	ND	NA	β, Contaminated tumbleweed
Burial Sites							
218-W-1 Burial Ground	1	Aug. 8, 1991	NA	15,000	NA	NA	β, Small hot spot - topsoil
218-W-1A Burial Ground	1	June 19, 1991	ND	ND	NA	NA	—

Table 4-5. Radiation and Dose Rate Surveys at the Z Plant Aggregate Area Waste Management Units. (Sheet 4 of 6)

			Radiation Survey				
Waste Management Unit	Ref.	Inspection Date	ct/min	dis/min	mrem/hr	Smearable Alpha in dis/min	Radiation Type, Notes
218-W-2 Burial Ground	1	Aug. 8, 1991	NA	15,000	NA	NA	β, Small hot spot - topsoil
218-W-2A Burial Ground	1	June 6, 1991	NA	10,000	ND	NA	β
218-W-3 Burial Ground	1	June 6, 1991	ND	ND	ND	ND	—
218-W-3A Burial Ground	1	Mar. 15, 1991	4,000	40,000	18	NA	β, Hot spot 1 x 1 m (3 x 3 ft)
218-W-3AE Burial Ground	—	—	—	—	—	—	—
218-W-4A Burial Ground	1	Aug. 8, 1991	NA	10,000	NA	NA	β, Hot spot 7 x 1 m (20 x 3 ft)
218-W-4B Burial Ground	1	Aug. 8, 1991	NA	ND	ND	NA	—
218-W-4C Burial Ground	—	—	—	—	—	—	—
218-W-5 Burial Ground	—	—	—	—	—	—	—
218-W-6 Burial Ground	—	—	—	—	—	—	—
218-W-11 Burial Ground	1	Aug. 8, 1991	NA	ND	NA	NA	—
Z Plant Burn Pit	—	—	—	—	—	—	—
Unplanned Releases							
UN-200-W-11	2	1952	—	—	—	—	Plutonium - levels unknown
UPR-200-W-16	2	1952	—	200,000	—	—	Unknown, disposed of into 218-W-4A
UN-200-W-23	2	1953	—	10,000	—	—	Paved, posted
UPR-200-W-26	2	1953	—	—	2,000	—	Spotty contamination with ^{106}Ru
UN-200-W-44	2	1957	—	—	2,000	—	Unknown

Table 4-5. Radiation and Dose Rate Surveys at the Z Plant Aggregate Area Waste Management Units. (Sheet 5 of 6)

			Radiation Survey				
Waste Management Unit	Ref.	Inspection Date	ct/min	dis/min	mrem/hr	Smearable Alpha in dis/min	Radiation Type, Notes
UPR-200-W-45	2	1957	—	—	1,100	—	Unknown, occurred within 218-W-1
UPR-200-W-53	2	1959	—	—	50	—	Unknown, 250 acres, ^{106}Ru
UPR-200-W-72	2	1975	100,000	70,000	—	—	α, β, γ, waste removed, covered with clean soil
UN-200-W-74	2	1976	—	8,000	—	—	α, remediated soil
UN-200-W-75	2	1975	—	40,000	—	—	Unknown, remediated
UN-200-W-79	2	1978	—	2,000	—	—	α
UPR-200-W-84	2	1980	—	—	2,000	—	Unknown, placed in 218-W-1
UN-200-W-89	2	Dec. 1985	—	50,000	—	—	α, remediated to background
UN-200-W-90	2	May, 1985	—	10,000	—	—	α, remediated to background
UN-200-W-91	2	Dec., 1985	—	20,000	—	—	α, remediated to background
UN-200-W-103	2	1971	—	—	—	76,000,000	α, soil excavated, covered with 2 m (6 ft) of clean soil
UN-200-W-130	2	1967	—	40,000	100 β 500 γ	—	β, γ
UN-200-W-132	2	1956	—	—	—	—	Level not reported, remediated
UPR-200-W-134	2	1975	—	—	—	—	Improper drum disposal - no release
UPR-200-W-158	2	1960	1,000	—	60	—	Unknown
UN-200-W-159	2	1959	—	—	—	—	Non-radioactive spill

Table 4-5. Radiation and Dose Rate Surveys at the Z Plant Aggregate Area Waste Management Units. (Sheet 6 of 6)

Notes:
Refs: 1. WHC (1991a); 2. Z Plant Aggregate Area Radiological Surveys - Compilation
ND Measured but not detected
NA Parameter was not available (not measured) in most recent survey
ct/min Counts per minute
dis/min Disintegrations per minute
mrem/hr Millirem per hour
— indicates no applicable data found during document review

Table 4-6. Results of External Radiation Monitoring: TLD Readings

Location		Readings in mrem/yr						
		1985	1986	1987	1988	1989	1990	Annual Average
218-W-2A								
	max	—	—	—	—	—	124	
	min	—	—	—	—	—	100	
	total	—	—	—	—	—	108	108
216-Z-20								
	max	—	—	—	—	—	116	
	min	—	—	—	—	—	88	
	total	—	—	—	—	—	102	102
2W2								
	max	160	178	131	156	—	—	
	min	96	134	106	123	—	—	
	total	126	152	118	133	—	—	132
2W3								
	max	80	93	105	118	—	—	
	min	64	65	79	90	—	—	
	total	74	76	89	101	—	—	85
2W7								
	max	98	118	115	136	120	—	
	min	69	74	91	94	60	—	
	total	85	93	102	110	99	—	78
2W17								
	max	78	96	117	117	—	—	
	min	68	68	79	95	—	—	
	total	73	76	95	106	—	—	88
2W22								
	max	82	96	110	124	—	—	
	min	66	62	68	93	—	—	
	total	73	75	83	105	—	—	84

Notes:
— indicates results not reported.
Monthly/quarterly dose rates normalized to annual dose rate equivalent.
max - maximum quarterly value reported.
min - minimum quarterly value reported.
total - Annual average value reported.
Data Sources: Elder et al. 1986 through 1989, Schmidt et al. 1990 and 1992.
See Plate 2 for sample locations.

Table 4-7. Summary of Soil Sampling Results (1985 through 1989).

Radionuclide in pCi/g	Sites					
	2W2	2W3	2W7	2W17	2W22	2WN
Cerium - 141	—	—	-5.64E-02	9.60E-03	—	3.63E-03
Cerium - 144	—	—	-2.48E-02	3.00E-02	—	-3.37E-02
Cobalt - 58	—	1.30E-01	-6.82E-03	-6.65E-03	—	-1.03E-02
Cobalt - 60	-4.60E-03	-1.50E-03	7.59E-03	-8.33E-03	9.50E-03	-3.55E-03
Cesium - 134	—	5.00E-02	4.98E-02	3.53E-02	3.00E-02	1.13E-03
Cesium - 137	6.40E+00	1.74E+00	4.51E+00	5.40E-01	1.90E+00	1.44E-01
Europium - 152	5.90E-02	9.80E-02	7.55E-02	9.44E-02	1.42E-01	6.21E-02
Europium - 154	-2.30E-02	1.80E-02	-2.90E-02	6.57E-03	1.80E-02	4.87E-03
Europium - 155	5.50E-02	2.60E-02	3.31E-02	8.80E-02	4.50E-02	3.45E-02
Iodine - 129	—	—	-1.58E-02	1.96E+01	—	—
Potassium - 40	—	—	1.59E+01	1.36E+01	—	1.44E+01
Manganese - 54	1.30E-02	1.70E-02	2.07E-02	-2.69E-03	-2.40E-03	1.62E-02
Niobium - 95	3.20E-02	3.90E-03	-4.88E-02	-5.95E-02	-1.70E-02	-7.52E-02
Lead - 212	—	—	7.10E-01	8.09E-01	—	7.99E-01
Lead - 214	600E-01	6.20E-01	5.36E-01	5.70E-01	6.50E-01	5.92E-01
Plutonium - 238	1.70E-03	1.07E-03	3.41E-03	4.50E-03	2.60E-03	6.40E-05
Plutonium - 239	7.90E-01	1.80E-01	5.63E-02	1.15E-01	5.73E-02	4.60E-03
Ruthenium - 106	6.10E-02	3.30E-01	1.44E-01	6.47E-02	2.29E-01	-8.83E-02
Strontium - 90	9.10E-01	6.50E-01	4.39E-01	2.09E-01	6.33E-01	6.90E-02
Technetium - 99	—	—	1.27E-01	-7.71E-02	—	—
Uranium	3.00E-01	3.50E-01	3.17E-01	3.27E-01	3.50E-01	3.82E-01
Zinc - 65	—	4.40E-01	-1.04E-01	-1.79E-03	—	-3.62E-02
Zirconium - 95	3.70E-03	2.00E-02	-1.67E-03	1.17E-02	3.40E-02	-7.67E-03

Notes:
Table values are averages for radionuclide concentrations in soil from 1985 through 1989 in pCi/g.
— indicate radionuclide not analyzed or results not reported.
See Table A-4 for complete data set.
See Plate 2 for sample locations.

Table 4-8. Summary of Vegetation Sampling Results (1985 through 1989).

Radionuclides in pCi/g	Sites				
	2W2	2W3	2W7	2W17	2W22
Beryllium - 7			1.19E+00	2.13E+00	
Cerium - 141			-1.56E-02	-6.42E-03	
Cobalt - 58					
Cobalt - 60	-5.20E-03	5.30E-03	8.02E-03	5.52E-02	6.40E-03
Cesium - 134		9.60E-02	1.12E-01		1.77E-01
Cesium - 137	1.40E-01	1.84E-01	3.85E-01	9.88E-02	1.84E-01
Europium - 152	1.60E-02	2.30E-02	2.72E-02	6.24E-02	-2.70E-02
Europium - 154	3.50E-02	1.20E-01	2.10E-02	-1.04E-02	7.10E-03
Europium - 155	1.90E-02	4.70E-04	1.04E-02	1.47E-02	3.70E-02
Iodine - 129			-1.84E-02	6.07E-02	
Niobium - 95	-5.40E-02	-3.60E-02	1.56E+00	1.30E+01	5.50E-02
Plutonium - 238			-4.90E-03	1.07E-02	
Plutonium - 239			4.10E-01	5.94E-02	
Ruthenium - 103		1.19E-01	3.23E-01	7.17E-02	
Ruthenium - 106			1.04E-03	8.07E-04	1.69E-01
Strontium - 90			4.68E-03	2.39E-02	
Technetium - 99			1.70E-01	8.30E-02	1.90E-01
Zinc - 65			2.88E-01		
Zirconium - 95			1.91E-01	1.66E-01	

Notes:
Table values are averages for radionuclide concentrations in vegetation from 1985 through 1989 in pCi/g.
Blank entries indicate radionuclide not analyzed or results not reported.
See Table A-5 for complete data set.
See Plate 2 for sample location.

Table 4-9. Radionuclide Concentrations in Vegetation and Sediment: 216-Z-21 Seepage Basin (Sample RM30) and 216-Z-9 Trench.

216-Z-21 Seepage Basin (Sample RM30)				216-Z-9 Trench
	1989		1990	1990
Radionuclide	Aquatic Vegetation	Sediment	Sediment	Vegetation
Concentration in pCi/g				
Bismuth-214	—	—	—	—
Cerium-144	—	—	—	—
Cobalt-60	—	—	—	—
Cesium-144	—	—	—	—
Cesium-137	0.3	0.1	1.2	<0.3
Lead-212	—	—	—	—
Lead-214	—	—	—	—
Plutonium-239	0.3	0.4	1.7	<0.3
Ruthenium-106	—	—	—	—
Tin-125	—	—	—	—
Strontium-90	0.4	0.5	0.87	—
Thallium-208	—	—	—	—
Uranium-total in g/g	7.18E-08	3.88E-07	1.40E-06	5.10E-08

— indicates sample not analyzed, or analysis result not reported.
(1) Data for 1989 and 1990 only.
Source: Schmidt et al. 1990 and 1992.
(2) Data Available for 1990 only.
Source: Schmidt et al. 1992.

Table 4-10. Summary of Gamma-Radiation Logs Reviewed. (Sheet 1 of 6)

Waste Management Unit	Well Number	Number of Times Logged	Inclusive Dates
	Cribs and Drains		
216-Z-1 Crib	299-W18-64	3	8/63 to 9/67
	299-W18-65	1	7/86
216-Z-2 Crib	299-W18-60	1	7/86
	299-W18-61	1	7/86
	299-W18-62	1	7/86
	299-W18-63	1	7/86
	299-W18-172	1	7/86
216-Z-3 Crib	299-W18-67	0	Not logged.
	299-W18-68	0	Not logged.
	299-W18-88	3	04/73 to 09/86
216-Z-5 Crib	299-W15-1	2	12/59 to 5/63
	299-W15-52	0	Not Logged
	299-W15-53	0	Not Logged
	299-W15-54	0	Not Logged
	299-W15-55	0	Not Logged
	299-W15-56	0	Not Logged
	299-W15-57	0	Not Logged
	299-W15-58	0	Not Logged
	299-W15-212	2	3/84 to 6/86
216-Z-7 Crib	299-W15-7	4	4/66 to 5/76
	299-W15-62	3	05/76 to 07/86
	299-W15-63	2	05/76 to 07/86
	299-W15-64	3	05/76 to 07/86
	299-W15-76	2	05/76 to 07/86
	299-W15-77	2	05/76 to 07/86
	299-W15-78	3	05/76 to 07/86

Table 4-10. Summary of Gamma-Radiation Logs Reviewed. (Sheet 2 of 6)

Waste Management Unit	Well Number	Number of Times Logged	Inclusive Dates
216-Z-12 Crib	299-W18-2	6	7/59 to 7/87
	299-W18-4	4	7/59 to 7/87
	299-W18-5	7	7/59 to 5/73
	299-W18-8	4	2/67 to 5/76
	299-W18-8	4	2/67 to 5/76
	299-W18-13	0	Not logged.
	299-W18-14	0	Not logged.
	299-W18-24	1	7/87
	299-W18-69	2	2/67 to 2/68
	299-W18-70	0	Not Logged
	299-W18-71	3	2/70 to 08/87
	299-W18-72	2	5/73 to 8/87
	299-W18-73	2	5/73 to 8/87
	299-W18-74	2	5/73 to 8/87
	299-W18-75	1	7/86
	299-W18-151	1	7/86
	299-W18-152	1	7/86
	299-W18-153	1	7/86
	299-W18-154	1	7/86
	299-W18-155	1	7/86
	299-W18-156	0	Not Logged
	299-W18-157	1	7/86
	299-W18-162	0	Not logged.
	299-W18-179	0	Not logged.
	299-W18-180	0	Not logged.
	299-W18-181	0	Not logged.
	299-W18-182	0	Not logged.
	299-W18-183	0	Not logged.
	299-W18-184	0	Not logged.

Table 4-10. Summary of Gamma-Radiation Logs Reviewed. (Sheet 3 of 6)

Waste Management Unit	Well Number	Number of Times Logged	Inclusive Dates
	299-W18-185	0	Not logged.
	299-W18-242	0	Not logged.
	299-W18-243	0	Not logged.
	299-W18-244	0	Not logged.
	299-W18-245	0	Not logged.
216-Z-16 Crib	299-W15-10	3	2/68 to 5/76
	299-W15-11	3	3/68 to 5/76
216-Z-18 Crib	299-W18-9	6	12/68 to 07/87
	299-W18-10	4	12/68 to 5/76
	299-W18-11	5	03/70 to 07/87
	299-W18-12	3	3/70 to 5/76
	299-W18-82	4	2/70 to 7/87
	299-W18-83	3	1/70 to 7/87
	299-W18-93	3	5/76 to 7/87
	299-W18-94	4	5/73 to 7/87
	299-W18-95	4	5/73 to 7/87
	299-W18-96	4	4/73 to 7/87
	299-W18-97	4	5/73 to 7/87
	299-W18-98	4	5/73 to 7/87
	299-W18-99	3	5/73 to 7/87
216-Z-1A Tile Field	299-W18-6[1/]	3	02/70 to 02/87
	299-W18-7[1/]	9	03/64 to 07/87
	299-W18-56	3	8/63 to 5/73
	299-W18-57	4	8/63 to 1/66
	299-W18-58	4	8/63 to 9/67
	299-W18-59	4	8/63 to 5/73
	299-W18-66	1	7/86
	299-W18-76	1	5/73
	299-W18-77	0	Not logged.

Table 4-10. Summary of Gamma-Radiation Logs Reviewed. (Sheet 4 of 6)

Waste Management Unit	Well Number	Number of Times Logged	Inclusive Dates
	299-W18-78	1	5/73
	299-W18-79	0	Not Logged
	299-W18-80	0	Not Logged
	299-W18-81	1	5/73
	299-W18-85	4	2/70 to 7/87
	299-W18-86	4	2/70 to 7/87
	299-W18-87[1/]	4	2/70 to 07/87
	299-W18-89	4	2/70 to 7/87
	299-W18-149	0	Not Logged
	299-W18-150	1	7/86
	299-W18-158	1	7/86
	299-W18-159	1	7/86
	299-W18-163	1	7/86
	299-W18-164	1	7/86
	299-W18-165	1	7/86
	299-W18-166	1	7/86
	299-W18-167	1	7/86
	299-W18-168	1	7/86
	299-W18-169	1	7/86
	299-W18-170	1	7/86
	299-W18-171	2	7/86 to 7/87
	299-W18-173	1	7/86
	299-W18-174	1	7/86
	299-W18-175	1	7/86
	Reverse Wells		
216-Z-10 Reverse Well	299-W15-51	0	Not logged.
	299-W15-59	0	Not logged.
	299-W15-60	0	Not logged.
	299-W15-61	0	Not logged.

Table 4-10. Summary of Gamma-Radiation Logs Reviewed. (Sheet 5 of 6)

Waste Management Unit	Well Number	Number of Times Logged	Inclusive Dates
	Ponds, Ditches, and Trenches		
216-Z-9 Trench	299-W15-6	6	07/59 to 03/87
	299-W15-8	6	10/68 to 03/87
	299-W15-9	7	02/67 to 03/87
	299-W15-82	3	05/63 to 03/87
	299-W15-84	4	05/63 to 03/87
	299-W15-85	4	5/63 to 2/87
	299-W15-86	4	05/63 to 03/87
	299-W15-94	1	5/63
	299-W15-95	6	05/63 to 03/87
	299-W15-101	2	2/67 to 4/73
216-Z-17 Trench	299-W15-204	0	Not logged.
	Transfer Facilities, Diversion Boxes, and Pipelines		
241-Z Diversion Box No. 2	299-W15-156	0	Not logged.
	Basins		
216-Z-21 Seepage Basin	299-W15-208	0	Not logged.
	Burial Sites		
218-W-3A Burial Ground	299-W7-2	1	9/87
	299-W7-3	1	10/87
	299-W10-179	0	Not logged.
218-W-3AE Burial Ground	299-W6-2	1	10/87
	299-W7-4	1	11/87
	299-W7-5	1	11/87
	299-W7-6	1	10/87
	299-W7-7	1	11/89
	299-W7-8	1	11/89
	299-W7-10	2	1/90

Table 4-10. Summary of Gamma-Radiation Logs Reviewed. (Sheet 6 of 6)

Waste Management Unit	Well Number	Number of Times Logged	Inclusive Dates
218-W-4B Burial Ground	299-W15-19	2	8/89 to 9/89
	299-W15-20	1	10/89
	299-W15-23	1	01/90
218-W-4C Burial Ground	299-W15-14	0	Not logged.
	299-W15-15	1	8/87
	299-W15-16	1	8/87
	299-W15-17	1	9/87
	299-W15-18	1	07/87
	299-W15-21	1	9/89
	299-W15-24	1	12/89
	299-W18-3	3	7/59 to 4/73
	299-W18-21	1	7/87
	299-W18-22	1	08/87
	299-W18-23	1	06/87
	299-W18-26	1	9/89
	299-W18-84	2	2/70 to 5/73
218-W-5 Burial Ground	299-W7-1	1	7/87
	299-W7-9	2	11/89 to 01/90
	299-W8-1	1	7/87
	299-W9-1	1	10/87
	299-W10-13	1	9/87
	299-W10-14	1	10/87
218-W-6 Burial Ground	299-W6-1	3	4/58 to 4/63
218-W-11 Burial Ground	299-W15-2	4	04/58 to 11/76
	299-W15-5	3	04/58 to 05/63

1/ Also logged by WHC Tank Surveillance Group.

Table 4-11. Potential for Past Migration of Liquid Discharges to the Unconfined Aquifer.

Liquid Discharge Source	Range of Soil Column Pore Volumes in m^3(3)	Liquid Effluent Volume Received in m^3	Past Migration to Unconfined Aquifer
Cribs and Drains			
216-Z-1 and 216-Z-2 Cribs	220 to 660	33,700	Yes
216-Z-3 Crib	145 to 435	178,000	Yes
216-Z-5 Crib	160 to 480	31,000	Yes
216-Z-6 Crib	180 to 540	98	No
216-Z-7 Crib	10,270 to 30,800	79,000	Yes
216-Z-12 Crib	500 to 1,500	281,000	Yes
216-Z-16 Crib	750 to 2,250	100,000	Yes
216-Z-18 Crib	3,700 to 11,340	3,860	Yes(1)
216-Z-1A Tile Field	14,700 to 44,100	5,310	No(2)
216-Z-8 French Drain	4 to 11	10	Yes(1)
Ponds, Ditches, and Trenches			
216-Z-4 Trench	55 to 165	11	No
216-Z-9 Trench	835 to 2,505	4,090	Yes(1)
216-Z-17 Trench	1,110 to 3,330	37,000	Yes
Reverse Well			
216-Z-10 Reverse Well	<1	1,000	Yes

Assumptions:
- Area for infiltration equal to the dimension of the base of crib/trench/tile field
- No evapotranspiration
- No lateral flow assumed

(1) The pore volume of the soil column is roughly the same order of magnitude as the total known volume of the waste received. Given the high permeability of the soil column, it is likely that the discharge waste volume reached the groundwater.

(2) The liquid waste discharged to the 216-Z-1A Tile Field is 12 percent of the pore volume available underlying the base of the tile field. However, this calculation assumes that the liquid waste was discharged over the entire base of the tile field which may not be accurate given that the waste was distributed through an array of perforated pipes.

(3) Pore volume calculation: (waste unit section area) x (nominal depth to groundwater) x (porosity). Pore volume based on nominal depth to groundwater of 50 m (164 ft) for all waste unit structures, except 216-Z-10 Reverse Well (15 m used for depth to groundwater from bottom of reverse well) and the 216-Z-8 French Drain (54 m used). Lower pore volume value reflects 0.10 porosity, higher pore volume reflects 0.30 porosity. Pore volume calculation does not account for the ability of the soil to retain the liquid discharged.

(4) Liquid Effluent volumes for 216-Z-13, 216-Z-14, and 216-Z-15 French Drains not found in documents reviewed.

Table 4-12. Carbon Tetrachloride Concentrations in Z Plant Aggregate Area Well Soil Samples. (Sheet 1 of 2)

	Depth in Meters (Feet)	Concentration in nanograms/gram
Well 299-W7-7	7.6 (5)	6.5
	30.5 (100)	<0.01
	36.6 (120)	<0.02
	48.8 (160)	0.53
	54.9 (180)	<0.13
	67.1 (220)	0.75
Well 299-W7-8	6.3 (20.5)	<0.05
	9.3 (30.5)	<0.08
	12.5 (41)	<0.05
	14.6 (48)	<0.07
	15.3 (50)	0.09
	16.8 (55)	0.09
	18.9 (62)	0.07
	23.8 (78)	<0.07
	27.5 (90)	<0.06
	33.6 (110)	<0.06
	39.7 (130)	<0.06
	45.8 (150)	<0.05
	51.9 (170)	<0.07
	58.0 (190)	<0.11
	64.1 (210)	0.30
	70.2 (230)	0.36
Well 299-W7-9	12.2 (40)	<0.2
	31.1 (102)	<0.2
	56.1 (184)	0.2
	67.1 (220)	12
	73.2 (240)	<0.08
Well 299-W7-10	24.4 (80)	<0.1
	48.8 (160)	<0.2
	61.0 (200)	<0.3
	67.1 (220)	<0.3
	73.2 (240)	<0.3
Well 299-W15-19	12.2 (40)	0.55
	24.4 (80)	1.4
	36.6 (120)	0.56
	67.1 (220)	5.8
	73.2 (240)	8.1
Well 299-W15-20	6.1 (20)	<0.4
	24.4 (80)	3.2
	54.9 (180)	9.5
	67.1 (220)	0.3
	73.2 (240)	<0.5

Table 4-12. Carbon Tetrachloride Concentrations in Z Plant Aggregate Area Well Soil Samples. (Sheet 2 of 2)

	Depth in Meters (Feet)	Concentration in nanograms/gram
Well 299-W15-21	36.6 (120)	0.31
	38.4 (126)	0.14
	42.7 (140)	0.12
	48.5 (159)	2.8
	67.1 (220)	6.2
	70.2 (230)	<0.1
Well 299-W15-23	18.3 (60)	0.2
	47.3 (155)	0.5
	61.0 (200)	<0.1
	67.1 (220)	3.8
	73.2 (240)	<0.1
Well 299-W18-26	39.7 (130)	0.12
	54.9 (180)	2.3
	67.1 (220)	2.6
	73.2 (240)	4.3

Sources: Wells 299-W7-7, 299-W7-8, 299-W15-19, 299-W15-20, 299-W15-21, and 299-W18-26 from Goodwin and Bjornstad (1990).

Well locations shown on Figure 4-3.

Note: Nanograms/gram equivalent to parts per billion.

Table 4-13. Candidate Contaminants of Potential Concern for the Z Plant Aggregate Area[a]. (Sheet 1 of 2)

TRANSURANICS	Cobalt-60	Tellurium-127*
	Europium-152	Tellurium-129m*
Americium-241	Europium-154	Thallium-204
Americium-242*	Europium-155	Thorium-227
Americium-242m	Gadolinium-153*	Thorium-229
Americium-243	Germanium-68*	Thorium-230
Curium-242*	Gold-195*	Thorium-231
Curium-243	Iodine-123*	Thorium-232
Curium-244	Iodine-125*	Thorium-234
Curium-245	Iodine-129	Thulium-170*
Einsteinium-254*	Iodine-131*	Tin-113*
Neptunium-237	Iron-55	Tin-123m*
Neptunium-239	Iron-59*	Tritium
Plutonium-238	Krypton-85	Vanadium-49*
Plutonium-239	Lead-209	Yttrium-88*
Plutonium-240	Lead-210	Yttrium-90
Plutonium-241	Lead-211	Zinc-65*
	Lead-212*	Zirconium-95*
URANIUM	Lead-214	
	Manganese-54*	METALS
Uranium-233	Molybdenum-93	
Uranium-234	Nickel-59	Aluminum
Uranium-235	Nickel-63	Barium
Uranium-236	Niobium-91	Beryllium
Uranium-238	Niobium-93m	Cadmium
	Niobium-94	Chromium
FISSION PRODUCTS	Niobium-95*	Copper
	Phosphorus-32*	Iron
Actinium-225	Polonium-210	Lead
Actinium-227	Polonium-214	Magnesium
Aluminum-28*	Polonium-215*	Mercury
Antimony-122*	Polonium-218	Nickel
Antimony-124*	Potassium-40	Silver
Antimony-125	Promethium-147	Zinc
Antimony-126*	Protactinium-231	
Barium-133	Radium-225	
Barium-137m	Radium-226	OTHER
Beryllium-7*	Radium-228	INORGANICS
Beryllium-10	Rhenium-187	
Bismuth-210	Ruthenium-106	Ammonia
Bismuth-211	Samarium-151	Asbestos
Bismuth-213	Scandium-46*	Boron
Bismuth-214	Selenium-75*	Calcium
Cadmium-109	Selenium-79	Chloride
Carbon-14	Silver-108*	Cyanide
Cerium-141*	Silver-110m*	Fluoride
Cerium-144*	Sodium-22	Nitrate/Nitrite
Cesium-134	Strontium-85*	Phosphate
Cesium-137	Strontium-90	Potassium
Chlorine-36	Sulfur-35*	Silica
Chromium-51*	Tantalum-182*	Sodium
Cobalt-57*	Technetium-99	Sulfate
Cobalt-58*	Tellurium-125m	

Table 4-13. Candidate Contaminants of Potential Concern for the Z Plant Aggregate Area[a]. (Sheet 2 of 2)

VOLATILE ORGANICS	SEMIVOLATILE ORGANICS
Benzene	Acetone
Butyl Acetate	Acetonitrile
Carbon tetrachloride	Coal Tars
Chlorobenzene	Creosote
Chloroform	Cyclohexanone
Cyclohexane	Decane
1,2-Dichloroethane	Dibutyl phosphate
cis/trans-1,2-Dichloroethene	Dibutyl butyl phosphonate
Ethylbenzene	Ethanol
Fluoromethane	Ethanolamine
Freon II	Ethylene glycol
Hexane	Hexanol
Methylene chloride	Isopropanol
Methyl isobutyl ketone (MIBK)	Kerosene
Tetrachloroethene	Methanol
Tetrahydrofuran	Naphthylamine tritium
Toluene	Naphthylamine
Tributyl phosphate	Normal paraffins
1,1,1-Trichloroethane	Polychlorinated biphenyls
Trichloroethene	Polyurethane
Vinyl Chloride	Pseudocumene (1,2,5-trimethylbenzene)
Xylenes	Trioctyl phosphine

[a] Candidate chemicals of concern are those that were reported in waste management unit inventories, detected at elevated levels in environmental media within the aggregate area, or are expected to occur based on historical association with waste processes.

[b] 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.

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Table 4-14. Summary of Known and Suspected Contamination in Each Waste Management Unit and Unplanned Release at Z Plant Aggregate Area. (Sheet 1 of 4)

Waste Management Unit or Unplanned Release	TRU	Fission Products	Uranium	Metals	Other Inorganics	Volatiles	Semi-volatiles
Plants, Buildings, and Storage Areas							
232-Z Incinerator	K	S	—	—	—	—	—
Tanks and Vaults							
216-Z-8 Settling Tank	K	S	—	S	S	S	S
241-Z-361 Settling Tank	K	S	—	S	S	S	S
241-Z Treatment Tank	S	S	—	S	—	—	—
Cribs and Drains							
216-Z-1 & 216-Z-2 Cribs	K	K	K	S	K	K	S
216-Z-3 Crib	K	K	K	S	K	—	—
216-Z-5 Crib	K	K	K	—	K	—	—
216-Z-6 Crib	K	K	K	—	K	—	—
216-Z-7 Crib	K	K	K	—	K	—	—
216-Z-12 Crib	K	K	K	S	K	—	—
216-Z-16 Crib	K	S	—	—	S	—	—
216-Z-18 Crib	K	S	—	S	K	K	K
216-Z-8 French Drain	K	S	—	S	S	S	S
216-Z-13 French Drain	S	S	—	—	S	—	—
216-Z-14 French Drain	S	S	—	—	S	—	—
216-Z-15 French Drain	S	S	—	—	S	—	—
216-Z-1A Tile Field	K	K	—	S	K	K	K
Reverse Well							
216-Z-10 Reverse Well	K	S	—	S	K	—	—
Ponds, Ditches, and Trenches							

Table 4-14. Summary of Known and Suspected Contamination in Each Waste Management Unit and Unplanned Release at Z Plant Aggregate Area. (Sheet 2 of 4)

Waste Management Unit or Unplanned Release	TRU	Fission Products	Uranium	Metals	Other Inorganics	Volatiles	Semi-volatiles
216-Z-4 Trench	K	K	K	—	S	—	—
216-Z-9 Trench	K	K	K	S	K	K	K
216-Z-17 Trench	K	S	K	—	S	—	—
Septic Tanks and Associated Drain Fields							
2607-Z Septic Tank and Drain Field	—	—	—	—	—	—	—
2607-Z-1 Septic Tank and Drain Field	—	—	—	—	—	—	—
2607-WA Septic Tank and Drain Field	—	—	—	—	—	—	—
2607-WB Septic Tank and Drain Field	—	—	—	—	—	—	—
2607-W-8 Septic Tank and Drain Field	—	—	—	—	—	—	—
Transfer Facilities, Diversion Boxes, and Pipelines							
241-Z-Diversion Box No. 1	K	K	K	S	K	K	S
241-Z-Diversion Box No. 2	K	K	K	S	K	—	—
231-Z-151 Sump	K	K	K	S	S	—	—
Basins							
207-Z Retention Basin	S	S	—	—	S	—	—
216-Z-21 Seepage Basin	S	S	S	S	S	S	S

Table 4-14. Summary of Known and Suspected Contamination in Each Waste Management Unit and Unplanned Release at Z Plant Aggregate Area. (Sheet 3 of 4)

Waste Management Unit or Unplanned Release	TRU	Fission Products	Uranium	Metals	Other Inorganics	Volatiles	Semi-volatiles
Burial Sites							
218-W-1 Burial Ground	K	K	K	S	S	S	S
218-W-1A Burial Ground	K	K	K	S	S	S	S
218-W-2 Burial Ground	K	K	K	S	S	S	S
218-W-2A Burial Ground	S	K	—	S	S	S	S
218-W-3 Burial Ground	K	K	K	S	S	S	S
218-W-3A Burial Ground	K	K	—	S	S	S	S
218-W-3AE Burial Ground	K	K	—	S	S	S	S
218-W-4A Burial Ground	K	K	—	S	S	S	S
218-W-4B Burial Ground	K	K	—	K	S	S	S
218-W-4C Burial Ground	K	K	—	S	S	S	S
218-W-5 Burial Ground	K	K	—	K	S	S	S
218-W-6 Burial Ground	—	—	—	—	—	—	—
218-W-11 Burial Ground	S	K	K	S	S	S	S
Z Plant Burn Pit	—	—	—	—	S	—	—
Unplanned Releases							
UN-200-W-11	S	S	—	—	—	—	—
UPR-200-W-16	S	S	—	—	—	—	—
UN-200-W-23	S	S	—	—	—	—	—
UPR-200-W-26	S	S	—	—	—	—	—
UN-200-W-44	—	S	—	—	—	—	—
UPR-200-W-45	—	S	—	—	—	—	—
UPR-200-W-53	—	S	—	—	—	—	—

Table 4-14. Summary of Known and Suspected Contamination in Each Waste Management Unit and Unplanned Release at Z Plant Aggregate Area. (Sheet 4 of 4)

Waste Management Unit or Unplanned Release	TRU	Fission Products	Uranium	Metals	Other Inorganics	Volatiles	Semi-volatiles
UPR-200-W-72	—	S	—	—	—	—	—
UN-200-W-74	S	S	—	—	—	—	—
UN-200-W-75	S	S	—	—	—	—	—
UN-200-W-79	S	S	—	—	—	—	—
UPR-200-W-84	S	S	—	—	—	—	—
UN-200-W-89	S	S	—	—	—	—	—
UN-200-W-90	S	S	—	—	—	—	—
UN-200-W-91	S	S	—	—	—	—	—
UN-200-W-103	S	S	—	—	—	—	—
UN-200-W-130	S	S	—	—	—	—	—
UN-200-W-132	—	—	S	—	—	—	—
UPR-200-W-134	S	—	—	—	—	—	—
UPR-200-W-158	S	S	—	—	—	—	—
UN-200-W-159	—	—	—	—	K	—	—

Notes:

K Contamination of environmental media is known to have occurred based on waste inventory or sampling data and knowledge of waste release mechanism.

S Contamination of environmental media is suspected to have occurred based on historical process information or indications from nonspecific sampling data (e.g., gamma logs).

— indicates no data found in documents reviewed.

Table 4-15. Contaminants of Potential Concern for the Z Plant Aggregate Area.

TRANSURANICS	Niobium-94	1,2-Dichloroethane
	Polonium-210	cis/trans-1,2-Dichloroethene
Americium-241	Polonium-214	Ethylbenzene
Americium-242m	Polonium-218	Freon II
Americium-243	Potassium-40	Hexane
Curium-243	Promethium-147	Methylene chloride
Curium-244	Protactinium-231	Methyl isobutyl ketone (MIBK)
Curium-245	Radium-225	Tetrachloroethene
Neptunium-237	Radium-226	Toluene
Neptunium-239	Radium-228	Tributyl phosphate
Plutonium-238	Rhenium-187	1,1,1-Trichloroethane
Plutonium-239	Ruthenium-106	Trichloroethene
Plutonium-240	Samarium-151	Vinyl Chloride
Plutonium-241	Selenium-79	Xylenes
	Sodium-22	
URANIUM	Strontium-90	
	Technetium-99	SEMIVOLATILE ORGANICS
Uranium-233	Tellurium-125m	
Uranium-234	Thallium-204	Acetone
Uranium-235	Thorium-227	Acetonitrile
Uranium-236	Thorium-229	Creosote
Uranium-238	Thorium-230	Cyclohexanone
	Thorium-231	Dibutyl phosphate
FISSION PRODUCTS	Thorium-232	Ethanol
	Thorium-234	Isopropanol
Actinium-225	Tritium	Kerosene
Actinium-227	Yttrium-90	Methanol
Antimony-125		Naphthylamine
Barium-133	METALS	Polychlorinated biphenyls
Barium-137m		
Beryllium-10	Barium	
Bismuth-210	Beryllium	
Bismuth-211	Cadmium	
Bismuth-213	Chromium	
Bismuth-214	Copper	
Cadmium-109	Lead	
Carbon-14	Mercury	
Cesium-134	Nickel	
Cesium-137	Silver	
Chlorine-36	Zinc	
Cobalt-60		
Europium-152	OTHER	
Europium-154	INORGANICS	
Europium-155		
Iodine-129	Asbestos	
Iron-55	Boron	
Krypton-85	Cyanide	
Lead-209	Fluoride	
Lead-210	Nitrate/Nitrite	
Lead-211		
Lead-214	VOLATILE ORGANICS	
Molybdenum-93		
Nickel-59	Benzene	
Nickel-63	Carbon tetrachloride	
Niobium-91	Chlorobenzene	
Niobium-93m	Chloroform	

Table 4-16. Soil-Water Distribution Coefficients (K_d) for Candidate Radionuclides[a] and Inorganics of Potential Concern at Z Plant Waste Management Units. (Sheet 1 of 3)

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] (Strenge and Peterson 1989) in ml/g	Mobility Class
Actinium	—	—	228	Low
Aluminum	—	—	35,300	Low
Americium	100 - 1,000 (<1 at pH 1-3)	100	82	Low
Antimony	—	—	2	High
Asbestos	—	—	100,000	Low
Barium	—	50	530	Moderate
Beryllium	—	—	70	Moderate
Bismuth	—	20	—	Moderate
Boron	—	—	0.19	High
Cadmium	—	15	14.9	Moderate
Calcium	—	10	70	Moderate
Carbon (^{14}C)	—	—	0	High
Cesium	200 - 1,000 1 - 200 (acidic waste)	50	51	Low
Chloride	<1	0	—	High
Chromium (VI)	—	0	16.8	Moderate-High
Cobalt	500 - 2,000	10	1.9	Low
Copper	—	15	41.9	Moderate
Cyanide	—	—	—	Moderate-High[d]
Curium	100 - >2,000	100	82	Low
Europium	—	50	228	Low
Fluoride	—	—	0	High
Iodine	<1	0	0	High
Iron	—	20	15	Moderate

Table 4-16. Soil-Water Distribution Coefficients (K_d) for Candidate Radionuclides[a] and Inorganics of Potential Concern at Z Plant Waste Management Units. (Sheet 2 of 3)

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] (Strenge and Peterson 1989) in ml/g	Mobility Class
Krypton	—	—	0	High
Lead	—	30	234	Moderate
Magnesium	—	—	70	Moderate
Manganese	—	20	16.5	Moderate
Mercury	—	—	322	Low
Molybdenum	—	0	40	High
Neptunium	<1 to 5	3	3	High
Nickel	—	15	12.2	Moderate
Niobium	—	—	50	Moderate
Nitrate/nitric acid	—	—	0	High
Phosphate	—	—	50	Moderate
Plutonium	100 - 1,000 < 1 at pH 1 - 3	100	10	Low
Polonium	—	—	5.9	Moderate
Potassium	—	—	0	High
Promethium	—	—	—	Unknown
Protactinium	—	—	0	High
Radium	—	20	24.3	Moderate
Rhenium	—	—	—	Unknown
Ruthenium	20 - 700 (<2 at >1 M nitrate)	—	274	Low-Moderate
Samarium	—	—	228	Low
Selenium	—	0	5.91	High
Silica	—	—	5.0	High
Silver	—	20	0.4	Moderate
Sodium	—	3	0	High

Table 4-16. Soil-Water Distribution Coefficients (K_d) for Candidate Radionuclides[a] and Inorganics of Potential Concern at Z Plant Waste Management Units. (Sheet 3 of 3)

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] (Strenge and Peterson 1989) in ml/g	Mobility Class
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
Tritium	0	0	0	High
Uranium	—	0	0	High
Vanadium	—	—	50	Moderate
Yttrium	—	—	278	Low
Zinc	—	15	12.7	Moderate

[a] Radionuclides with half-lives of greater than one year or short-lived products of long-lived precursors.
[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% (Strenge and Peterson 1989).
[d] Cyanide mobility is highly dependent on identity of complexing agent. Simple cyanides (e.g., NaCN) are more mobile than complex cyanides.
— Value was not provided for this element in above references.

Table 4-17. Physical/Chemical Properties of Candidate Organic Compounds of Potential Concern at Z Plant Waste Management Units. (Sheet 1 of 3)

Compound	Molecular Weight in g/mole	Water Solubility in mg/liter	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	2.1×10^{-5}	2.2
Acetonitrile	41.0	miscible	7.4	4.0×10^{-6}	2.2
Benzene	78	1,800	95	5.6×10^{-3}	83
Butyl acetate[a]	116.16	14,000	15	3.2×10^{-4}	233
Caffeine[a]	194.19	"slightly soluble"	na	na	na
Carbon tetrachloride	154.0	758	90	2.4×10^{-2}	110
Chlorobenzene	112.56	470	12	3.7×10^{-3}	330
Chloroform (trichloromethane)	119	8,200	150	2.9×10^{-3}	31
Coal tars[b]	276	5.3×10^{-4}	1×10^{-10}	7×10^{-8}	1,600,000
Creosote	130.0	5000	3.2×10^{-3}	1.1×10^{-7}	40
Cyclohexane	84.18	49	100	2.5×10^{-1}	1,700
Cyclohexanone	98.16	50,000	4.5	1.3×10^{-5}	4
Decane[a]	142.28	0.052	1.43	na	22,200
Dibutyl butyl phosphonate[a]	250.36	"insoluble"	na	na	na
Dibutyl phosphate[a]	210.21	"v. low"	1	na	na
1,2-dichloroethane	98.96	8,500	64	9.8×10^{-4}	14
1,2-dichloroethene (cis/trans)	96.94	6,300	320	6.6×10^{-3}	59
Ethanol	46.1	miscible	59	1.2×10^{-5}	0.3
Ethanolamine[a]	61.08	miscible	0.4	4×10^{-8}	5
Ethylbenzene	106.17	150	7	6.4×10^{-3}	1,100

Table 4-17. Physical/Chemical Properties of Candidate Organic Compounds of Potential Concern at Z Plant Waste Management Units. (Sheet 2 of 3)

Compound	Molecular Weight in g/mole	Water Solubility in mg/liter	Vapor Pressure in mm Hg	Henry's Law Constant in atm-m^3/mo	Soil/Organic Matter Partition Coef. K_{oc} in ml/g
Ethylene glycol	62.1	miscible	0.065	1×10^{-8}	0.027
Fluoromethane	na	na	na	na	na
Freon II (trichlorofluoromethane)	137.4	1,100	670	1.1×10^{-1}	160
Hexane	86.2	19	180	1.6	4,600
Hexanol[a]	102.17	na	1	na	na
Isopropanol	60.1	miscible	48	3.8×10^{-5}	0.69
Kerosene[f]	142.2	32	0.045	2.9×10^{-4}	4,500
Methanol	32.0	miscible	130	2.8×10^{-5}	0.1
Methylene chloride	84.9	20,000	360	2×10^{-3}	8.8
Methyl isobutyl ketone (MIBK)	100.16	19,000	6	4.2×10^{-5}	19
1-Naphthylamine	143.2	2,400	6.5×10^{-5}	5.2×10^{-9}	61
2-Naphthylamine	143.2	590	2.6×10^{-4}	8.2×10^{-8}	130
Normal paraffins[e]	na	"insoluble"	na	na	na
Oil	na	na	na	na	na
PCBs (average)[c]	328.0	0.031	7.7×10^{-5}	1.1×10^{-3}	53,000
Polyurethane	na	na	na	na	na
Pseudocumene (1,2,5-trimethylbenzene)	120.2	64	1.4	na	1,600
Tetrachloroethene	165.9	150	18	2.6×10^{-2}	360
Tetrahydrofuran	72.1	69,000	370	5.1×10^{-4}	1.8
Toluene	92.2	1,550[d]	28.4	6.4×10^{-3}	300

Table 4-17. Physical/Chemical Properties of Candidate Organic Compounds of Potential Concern at Z Plant Waste Management Units. (Sheet 3 of 3)

Compound	Molecular Weight in g/mole	Water Solubility in mg/liter	Vapor Pressure in mm Hg	Henry's Law Constant in atm-m^3/mo	Soil/Organic Matter Partition Coef. K_{oc} in ml/g
Tributyl phosphate	266.3	280	15	1.9×10^{-2}	6,000
1,1,1-Trichloroethane	133.41	1,500	120	1.4×10^{-2}	150
Trichloroethene	131.3	1,100	58	9.1×10^{-3}	130
Trioctyl phosphine	na	na	na	na	na
Vinyl Chloride	62.5	2,700	2,700	6.9×10^{-1}[e]	8.2[e]
Xylenes (total)	106.2	200	10	7.0×10^{-3}	240

Sources: Strenge and Peterson 1989, except as noted in footnotes below.

[a] Values listed in Hazardous Substance Data Base (HSDB), National Library of Medicine database (HSDB 1991).
[b] Properties of coal tar are represented by data for indeno(1,2,3-c,d)pyrene.
[c] Average value for all aroclor mixtures.
[d] Value from Banerjee et al. 1980.
[e] Value from MacKay and Shiu 1981.
[f] Kerosene properties are represented by 2-methyl naphthalene.

na Value not available from above sources.

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Table 4-18. Mobility of Inorganic Species in Soil.

Highly mobile ($K_d < 5$)	
Antimony	Neptunium
Boron	Nitrate, nitrite
Carbon (as $^{14}CO_2$)	Potassium
Chloride	Protactinium
Chromium (VI)	Selenium
Cyanide	Sodium
Fluoride	Technetium
Iodine	Thallium
Krypton	Tritium
Molybdenum	Uranium
Moderately mobile ($5 < K_d < 100$)	
Barium	Niobium
Beryllium	Phosphate
Bismuth	Potassium
Cadmium	Radium
Calcium	Ruthenium
Copper	Silver
Iron	Strontium
Lead	Thorium
Nickel	Vanadium
	Zinc
Low mobility ($K_d > 100$)	
Actinium	Europium
Asbestos	Mercury
Americium	Plutonium
Cesium	Samarium
Cobalt	Yttrium
Curium	

Table 4-19. Radiological Properties of Candidate Radionuclides of Potential Concern for Z Plant Waste Management Units. (Sheet 1 of 4)

Radionuclide	Half-Life	Specific Activity[a] in Ci/g	Radiation of Concern[b]
^{225}Ac	10 d	5.8×10^{4}	α
^{227}Ac	21.8 yr	7.2×10^{1}	β, α
^{108}Ag	2.4 min	2.7×10^{13}	β
^{110}Ag	24.6 sec	4.2×10^{9}	β
^{28}Al	2.24 min	3.0×10^{9}	β, γ
^{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
^{195}Au	30.5 sec	1.9×10^{9}	γ [c]
^{133}Ba	10.5 yr	2.5×10^{2}	γ [c]
^{137m}Ba	2.6 min	5.3×10^{8}	γ
^{7}Be	53.4 d	3.5×10^{-5}	γ
^{10}Be	1.6×10^{6} yr	2.2×10^{-2}	β
^{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
^{45}Ca	163.8 d	1.8×10^{4}	β
^{109}Cd	453 d	2.6×10^{3}	γ [c]
^{141}Ce	32.5 d	2.8×10^{4}	β, γ [c]
^{144}Ce	284.9 d.	3.2×10^{3}	β, γ [c]
^{36}Cl	3.0×10^{5} yr	3.3×10^{-2}	β
^{242}Cm	163.2 d	3.3×10^{3}	α
^{243}Cm	28.5 yr	5.2×10^{1}	α
^{244}Cm	18.1 yr	8.1×10^{1}	α
^{245}Cm	8,500 yr	1.7×10^{-1}	α, γ
^{57}Co	271.8 d	8.5×10^{3}	γ [c]
^{58}Co	70.92 d	3.2×10^{4}	γ [c]
^{60}Co	5.3 yr	1.1×10^{3}	γ
^{51}Cr	27.7 d	9.2×10^{4}	γ [c]
^{134}Cs	2.06 yr	1.3×10^{5}	γ
^{137}Cs	30 yr	8.7×10^{1}	γ [c]

Table 4-19. Radiological Properties of Candidate Radionuclides of Potential Concern for Z Plant Waste Management Units. (Sheet 2 of 4)

Radionuclide	Half-Life	Specific Activity[a] in Ci/g	Radiation of Concern[b]
^{254}Es	275 d	1.9×10^{3}	α, γ
^{152}Eu	13.3 yr	7.7×10^{2}	β, γ [c]
^{154}Eu	8.8 yr	2.7×10^{2}	β, γ [c]
^{155}Eu	4.96 yr	4.6×10^{2}	β
^{55}Fe	2.73 yr	2.5×10^{3}	γ [c]
^{59}Fe	44.5 d	4.9×10^{4}	β
^{153}Gd	241.6 d	3.5×10^{3}	γ [c]
^{68}Ge	287 d	6.7×10^{3}	γ [c]
^{3}H	12.3 yr	9.7×10^{3}	β
^{123}I	13.2 hr	1.9×10^{6}	γ [c]
^{125}I	60.14 d	1.7×10^{4}	γ [c]
^{129}I	1.6×10^{7} yr	1.7×10^{-4}	β
^{131}I	8.0 d	1.2×10^{5}	β, γ [c]
^{40}K	1.3×10^{9} yr	6.7×10^{-6}	β, γ [c]
^{85}Kr	10.7 yr	3.9×10^{2}	β
^{54}Mn	312.2 d	7.7×10^{3}	γ [c], e^-
^{93}Mo	5,300 yr	1.1×10^{9}	γ [c]
^{22}Na	2.6 yr	6.3×10^{3}	β, γ [c]
^{91}Nb	10,000 yr	3.9×10^{-1}	γ [c]
^{93m}Nb	14.6 yr	2.8×10^{2}	γ [c]
^{94}Nb	20,300 yr	1.87×10^{-1}	β, γ [c]
^{95}Nb	34.97 d	3.9×10^{4}	β, γ
^{59}Ni	75,000 yr	7.6×10^{4}	γ [c]
^{63}Ni	100.1 yr	6.2×10^{1}	β
^{237}Np	2.14×10^{6} yr	7.0×10^{-4}	α, γ
^{239}Np	2.35 d	2.3×10^{5}	β
^{32}P	14.3 d	2.9×10^{5}	β
^{231}Pa	32,800 yr	4.7×10^{-2}	α
^{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}	β, γ [c]

Table 4-19. Radiological Properties of Candidate Radionuclides of Potential Concern for Z Plant Waste Management Units. (Sheet 3 of 4)

Radionuclide	Half-Life	Specific Activity[a] in Ci/g	Radiation of Concern[b]
^{214}Pb	26.8 min	3.3×10^{7}	β, γ [c]
^{147}Pm	2.62 yr	9.3×10^{2}	β
^{210}Po	128 d	4.9×10^{3}	α
^{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
^{228}Ra	5.75 yr	2.3×10^{2}	β
^{86}Rb	18.7 d	8.1×10^{4}	β
^{187}Re	5×10^{10} yr	3.8×10^{8}	β
^{103}Ru	39.2 d	3.2×10^{4}	β, γ [c]
^{106}Ru	1.0 yr	3.4×10^{3}	β, γ [c]
^{35}S	87.5 d	4.3×10^{4}	β
^{122}Sb	2.7 d	4.0×10^{5}	β, γ [c]
^{124}Sb	60.2 d	1.8×10^{4}	β, γ [c]
^{125}Sb	2.73 yr	1.0×10^{3}	β, γ [c]
^{126}Sb	12.4 d	8.4×10^{4}	β, γ [c]
^{46}Sc	83.8 d	3.4×10^{4}	β, γ [c]
^{75}Se	119.8 d	1.5×10^{4}	γ [c]
^{79}Se	<65,000 yr	7.0×10^{-2}	β
^{151}Sm	90 yr	2.6×10^{1}	β
^{113}Sn	115.1 d	1.0×10^{4}	γ [c]
^{123m}Sn	129 d	8.2×10^{3}	β, γ [c]
^{82}Sr	25 d	6.4×10^{4}	γ [c]
^{90}Sr	28.5 yr	1.4×10^{2}	β
^{182}Ta	115 d	6.3×10^{3}	β, γ [c]
^{99}Tc	213,000 yr	1.7×10^{-2}	β
^{121}Te	16.8 d	6.4×10^{4}	γ [c]
^{125m}Te	58 d	1.8×10^{4}	e^{-}, γ [c]

Table 4-19. Radiological Properties of Candidate Radionuclides of Potential Concern for Z Plant Waste Management Units. (Sheet 4 of 4)

Radionuclide	Half-Life	Specific Activity[a] in Ci/g	Radiation of Concern[b]
^{127}Te	9.35 hr	2.6×10^{6}	β
^{129m}Te	33.6 d	3.0×10^{4}	β, γ [c]
^{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
^{232}Th	1.4×10^{10} yr	1.1×10^{-7}	α
^{234}Th	24.1 d	2.3×10^{-4}	β
^{204}Tl	3.78 yr	4.6×10^{4}	β
^{170}Tm	128.6 d	4.3×10^{3}	β
^{233}U	159,000 yr	9.7×10^{-3}	α
^{234}U	244,500 yr	6.2×10^{-3}	α
^{235}U	7.0×10^{8} yr	2.2×10^{-6}	α, γ
^{236}U	2.3×10^{7} yr	6.5×10^{-5}	α
^{238}U	4.5×10^{9} yr	3.4×10^{-7}	α
^{49}V	330 d	8.1×10^{3}	γ [c]
^{87}Y	80.3 hr	4.5×10^{5}	γ [c]
^{88}Y	106.6 d	5.6×10^{5}	γ [c]
^{90}Y	6.41 hr	5.4×10^{5}	β
^{65}Zn	244 d	8.2×10^{3}	γ [c]
^{95}Zr	64 d	2.1×10^{4}	β

[a] Calculated from half-life and atomic weight.
[b] α - alpha decay; β - negative beta decay; γ - release of gamma rays.
[c] Gamma radiation due to daughter product.

Table 4-20. Comparison of Radionuclide Relative Risks for Radionuclides of Potential Concern at the Z Plant Aggregate Area. (Sheet 1 of 3)

Radionuclide	Half-Life	Air Unit Risk[a] in $(pCi/m^3)^{-1}$	Drinking Water Unit Risk[b] in $(pCi/L)^{-1}$	Soil Ingestion Unit Risk[c] in $(pCi/g)^{-1}$	External Exposure Unit Risk[d] in $(pCi/g)^{-1}$
^{225}Ac	10 d	1.2×10^{-3}	8.7×10^{-7}	4.6×10^{-8}	9.4×10^{-6}
^{227}Ac	21.8 yr	4.2×10^{-2}	1.8×10^{-5}	9.5×10^{-7}	1.3×10^{-7}
^{241}Am	433 yr	2.1×10^{-2}	1.6×10^{-5}	8.4×10^{-7}	1.6×10^{-5}
^{242m}Am	152 yr	na	na	na	na
^{243}Am	7,380 yr	2.1×10^{-2}	1.5×10^{-5}	8.1×10^{-7}	3.6×10^{-5}
^{133}Ba	10.5 yr	na	na	na	na
^{137m}Ba	2.6 min	3×10^{-10}	1.2×10^{-10}	6.5×10^{-12}	3.4×10^{-4}
^{10}Be	1.6×10^{6} yr	na	na	na	na
^{210}Bi	5.01 d	4.1×10^{-5}	9.7×10^{-8}	5.1×10^{-9}	0
^{211}Bi	2.13 min	9.7×10^{-8}	6.1×10^{-10}	3.2×10^{-11}	2.8×10^{-5}
^{213}Bi	45.6 min	1.6×10^{-7}	1.2×10^{-8}	6.2×10^{-10}	8.1×10^{-5}
^{214}Bi	19.9 min	1.1×10^{-6}	7.2×10^{-9}	3.8×10^{-10}	8.0×10^{-4}
^{14}C	5,730 yr	3.2×10^{-9}	4.7×10^{-8}	2.5×10^{-9}	0
^{109}Cd	453 d	na	na	na	na
^{36}Cl	3.0×10^{5} yr	na	na	na	na
^{243}Cm	28.5 yr	1.6×10^{-2}	1.2×10^{-5}	6.2×10^{-7}	8.2×10^{-5}
^{244}Cm	18.1 yr	1.4×10^{-2}	1.0×10^{-5}	5.4×10^{-7}	5.9×10^{-7}
^{245}Cm	8,500 yr	na	na	na	na
^{60}Co	5.3 yr	8.1×10^{-5}	7.8×10^{-7}	4.1×10^{-8}	1.3×10^{-3}
^{134}Cs	2.06 yr	1.4×10^{-5}	2.1×10^{-6}	1.1×10^{-7}	8.9×10^{-4}
^{137}Cs	30 yr	9.6×10^{-6}	1.4×10^{-6}	7.6×10^{-8}	0
^{152}Eu	13.3 yr	6.1×10^{-3}	1.1×10^{-7}	5.7×10^{-9}	6.3×10^{-4}
^{154}Eu	8.8 yr	7.2×10^{-5}	1.5×10^{-7}	8.1×10^{-9}	6.8×10^{-4}
^{155}Eu	4.96 yr	na	na	na	
^{55}Fe	2.73 yr	na	na	na	na
^{3}H	12.3 yr	4.0×10^{-8}	2.8×10^{-9}	1.5×10^{-10}	0

Table 4-20. Comparison of Radionuclide Relative Risks for Radionuclides of Potential Concern at the Z Plant Aggregate Area. (Sheet 2 of 3)

Radionuclide	Half-Life	Air Unit Risk[a] in $(pCi/m^3)^{-1}$	Drinking Water Unit Risk[b] in $(pCi/L)^{-1}$	Soil Ingestion Unit Risk[c] in $(pCi/g)^{-1}$	External Exposure Unit Risk[d] in $(pCi/g)^{-1}$
^{129}I	1.6×10^7 yr	6.1×10^{-5}	9.6×10^{-6}	5.1×10^{-7}	1.5×10^{-5}
^{40}K	1.3×10^9 yr	4.0×10^{-6}	5.7×10^{-7}	3.0×10^{-8}	7.8×10^{-5}
^{85}Kr	10.7 yr	na	na	na	na
^{93}Mo	5,300 yr	na	na	na	na
^{22}Na	2.6 yr	na	na	na	na
^{91}Nb	10,000 yr	na	na	na	na
^{93m}Nb	14.6 yr	na	na	na	na
^{94}Nb	20,300 yr	1.1×10^{-4}	1.1×10^{-7}	5.7×10^{-9}	8.9×10^{-4}
^{59}Ni	75,000 yr	3.5×10^{-7}	4.4×10^{-9}	2.3×10^{-10}	3.4×10^{-7}
^{63}Ni	100.1 yr	8.7×10^{-7}	1.2×10^{-8}	6.2×10^{-10}	0
^{237}Np	2.14×10^6 yr	1.8×10^{-2}	1.4×10^{-5}	7.3×10^{-7}	1.8×10^{-5}
^{239}Np	2.35 d	7.7×10^{-7}	4.8×10^{-8}	2.5×10^{-9}	1.1×10^{-4}
^{231}Pa	32,800 yr	2.0×10^{-2}	9.7×10^{-6}	5.1×10^{-7}	2.0×10^{-5}
^{209}Pb	3.25 hr	3.6×10^{-8}	4.3×10^{-9}	2.3×10^{-10}	0
^{210}Pb	22.3 yr	8.7×10^{-4}	3.4×10^{-5}	1.8×10^{-6}	1.8×10^{-6}
^{211}Pb	36.1 min	1.5×10^{-6}	9.2×10^{-9}	4.9×10^{-10}	2.9×10^{-5}
^{214}Pb	26.8 min	1.5×10^{-6}	9.2×10^{-9}	4.9×10^{-10}	1.5×10^{-4}
^{147}Pm	2.62 yr	na	na	na	na
^{210}Po	128 d	8.7×10^{-4}	3.4×10^{-5}	1.8×10^{-6}	1.8×10^{-6}
^{214}Po	6×10^{-5} sec	1.4×10^{-13}	5.1×10^{-16}	2.7×10^{-17}	4.7×10^{-8}
^{215}Po	7.8×10^{-4} sec	2.9×10^{-12}	1.4×10^{-14}	7.6×10^{-16}	8.7×10^{-8}
^{218}Po	3.05 min	3.0×10^{-7}	1.4×10^{-9}	7.6×10^{-11}	0
^{238}Pu	87.7 yr	2.1×10^{-2}	1.4×10^{-5}	7.6×10^{-7}	5.9×10^{-7}
^{239}Pu	24,400 yr	2.6×10^{-2}	1.6×10^{-5}	8.4×10^{-8}	2.6×10^{-7}
^{239}Pu oxide	24,400 yr	2.6×10^{-2}	1.6×10^{-6}	8.4×10^{-8}	2.6×10^{-7}
^{240}Pu	6,560 yr	2.1×10^{-2}	1.6×10^{-5}	8.4×10^{-8}	5.9×10^{-7}
^{240}Pu oxide	6,560 yr	2.1×10^{-2}	1.6×10^{-6}	8.4×10^{-8}	5.9×10^{-7}
^{241}Pu	14.4 yr	1.5×10^{-4}	2.5×10^{-7}	1.3×10^{-8}	0

Table 4-20. Comparison of Radionuclide Relative Risks for Radionuclides of Potential Concern at the Z Plant Aggregate Area. (Sheet 3 of 3)

Radionuclide	Half-Life	Air Unit Risk[a] in $(pCi/m^3)^{-1}$	Drinking Water Unit Risk[b] in $(pCi/L)^{-1}$	Soil Ingestion Unit Risk[c] in $(pCi/g)^{-1}$	External Exposure Unit Risk[d] in $(pCi/g)^{-1}$
^{225}Ra	14.8 d	8.2×10^{-4}	3.4×10^{-6}	1.8×10^{-7}	8.0×10^{-6}
^{226}Ra	1,600 yr	1.5×10^{-3}	6.1×10^{-6}	3.2×10^{-7}	4.1×10^{-6}
^{228}Ra	5.75 yr	3.4×10^{-4}	5.1×10^{-6}	2.7×10^{-7}	5.6×10^{-13}
^{187}Re	5×10^{10} yr	na	na	na	na
^{106}Ru	1.0 yr	2.3×10^{-4}	4.9×10^{-7}	2.6×10^{-8}	0
^{125}Sb	2.73 yr	na	na	na	na
^{79}Se	<65,000 yr	na	na	na	na
^{151}Sm	90 yr	na	na	na	na
^{90}Sr	28.5 yr	2.8×10^{-5}	1.7×10^{-6}	8.9×10^{-8}	0
^{99}Tc	213,000 yr	4.2×10^{-6}	6.6×10^{-8}	3.5×10^{-9}	0
^{125m}Te	58 d	na	na	na	na
^{227}Th	18.72 d	2.5×10^{-3}	2.5×10^{-7}	1.3×10^{-8}	6.6×10^{-6}
^{229}Th	7,340 yr	3.9×10^{-2}	2.0×10^{-6}	1.1×10^{-7}	5.8×10^{-5}
^{230}Th	77,000 yr	1.6×10^{-2}	1.2×10^{-6}	6.5×10^{-8}	5.9×10^{-7}
^{231}Th	25.5 hr	2.5×10^{-7}	2.0×10^{-8}	1.1×10^{-9}	1.1×10^{-5}
^{204}Tl	3.78 yr	na	na	na	na
^{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}
^{236}U	2.3×10^{7} yr	na	na	na	na
^{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 hr	2.8×10^{-6}	1.6×10^{-7}	8.6×10^{-9}	0

a Excess cancer risk associated with lifetime exposure to 1 pCi/m^3 (10^{-12} curies) per day in air (EPA 1991a).
b Excess cancer risk associated with lifetime exposure to 1 pCi (10^{-12} curies) per day in drinking water (EPA 1991a).
c Excess cancer risk associated with lifetime exposure to 1 pCi/g (10^{-12} curies/g) per day in soil (EPA 1991a).
d Excess cancer risk associated with lifetime exposure to surface soils containing 1 pCi/g of gamma-emitting radionuclides (EPA 1991a).

na No information available.

Table 4-21. Potential Chronic Human Health Effects of Candidate Chemicals of Potential Concern at the Z Plant Aggregate Area. (Sheet 1 of 3)

Chemical	Tumor Site Inhalation Route; Oral Route [Weight of Evidence Group[a]]	Ref.	Non-carcinogenic Chronic Health Effects Inhalation Route; Oral Route	Ref.
INORGANIC CHEMICALS				
Aluminum				
Ammonium ion			decreased pulmonary function; degrades odor, taste of water	1;2
Asbestos	lung and mesothelioma [A]; large intestine [A]	1;2		
Barium			fetotoxicity; increased blood pressure	2;1
Beryllium	lung [B2]; total tumors [B2]	1;1	NA; none observed	1;1
Boron			NA; testicular atrophy	1;1
Cadmium	respiratory tract [B1]; NA	1;1	cancer; proteinuria	2;1
Calcium				
Chloride				
Chromium	lung [A] - Cr(VI) only; NA	1;1	nasal mucosa atrophy; hepatotoxicity	2;2
Copper			NA; gastrointestinal irritation	1;2
Fluoride			NA; dental fluorosis	1;1
Iron				
Lead	[B2][b]; [B2]	1;1	central nervous system (CNS) effects[b]; CNS effects	2;2
Magnesium				
Mercury			neurotoxicity; kidney effects	2;2
Nickel	respiratory tract [A]; NA	2;2	cancer; reduced weight gain	2;1
Nitrate/Nitrite			NA; methemoglobinemia in infants[c]	1;1
Phosphate				
Potassium				
Silica				
Silver				
Sodium				
Sulfate				
Uranium (soluble salts)			NA; body weight loss, nephrotoxicity	1;1
Zinc			NA; anemia	2;2

Table 4-21. Potential Chronic Human Health Effects of Candidate Chemicals of Potential Concern at the Z Plant Aggregate Area. (Sheet 2 of 3)

Chemical	Tumor Site Inhalation Route; Oral Route [Weight of Evidence Group[a]]	Ref.	Non-carcinogenic Chronic Health Effects Inhalation Route; Oral Route	Ref.
ORGANIC CHEMICALS				
Acetone			NA; kidney and liver effects	1;1
Acetonitrile			blood effects, hepatotoxicity; blood effects, hepatotoxicity	2;1
Benzene	blood (leukemia, [A]; blood [A]	1;1		
Butyl Acetate				
Caffeine				
Carbon tetrachloride	liver [B2]; liver [B2]	1;1	NA; liver lesions	1;1
Chlorobenzene			liver, kidney effects; liver, kidney	2;1
Chloroform	liver; kidney [B2]	1;1	NA; liver lesions	1;1
Coal tars	lung [NA]; NA	2;2		
Creosote	NA [B1][a]; NA [B1][a]	1;1		
Cyclohexane				
Cyclohexanone			NA; body weight loss	1;1
Decane				
Dibutyl butyl phosphonate				
Dibutyl phosphate			NA; respiratory irritation	;3
1,2-Dichloroethane	circulatory system [B2]; circulatory system [B2]	1;1		
cis-1,2-Dichloroethene			NA; blood chemistry effects	1;2
trans-1,2-Dichloroethene			NA; increased serum phosphatase	1;1
Ethanol			NA; CNS, reproductive effects	;3
Ethanolamine				
Ethylbenzene			developmental toxicity; liver and kidney	1;1
Ethylene glycol			NA; mortality,liver and kidney	1;2
Fluoromethane				
Freon II (trichlorofluoromethane)			Elevated BON, lung lesions; survival, histopathology	2;1
Hexane			neurotoxicity; neuropathy or testicular atrophy	1;2
Hexanol				

Table 4-21. Potential Chronic Human Health Effects of Candidate Chemicals of Potential Concern at the Z Plant Aggregate Area. (Sheet 3 of 3)

Chemical	Tumor Site Inhalation Route; Oral Route [Weight of Evidence Group[a]]	Ref.	Non-carcinogenic Chronic Health Effects Inhalation Route; Oral Route	Ref.
Isopropanol			NA; liver, kidney damage	;3
Methanol			NA; blood system effects, decreased brain weight	1;1
Methylene chloride	lung, liver [B2]; liver [B2]	1;1	NA; liver toxicity	1;1
Methyl isobutyl ketone			liver and kidney effects; liver and kidney effects	2;2
Naphthylamine tritium[d]	NA; multiple sites	;3		
Normal paraffins				
Polychlorinated biphenyls	NA [B2]; liver [B2]	1;1		
Polyurethane				
Pseudocumene (1,2,5-trimethyl-benzene)				
Tetrachloroethene	leukemia, liver [B2]; liver [B2]	2;2	NA; hepatotoxicity; weight gain	1;1
Tetrahydrofuran				
Toluene			CNS effects, eye irritation; change in liver and kidney weights	2;1
Tributyl phosphate			respiratory irritant; kidney damage	3;3
1,1,1-Trichloroethane			liver toxicity; liver toxicity	2;2
Trichloroethene	lung [B2]; liver [B2]	2;2		
Trioctyl phosphine				
Vinyl chloride	liver [A]; lung [A]	2;2		
Xylenes			CNS effects, nose and throat irritation; hyperactivity, decreased body weight	2;1

[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.
[d] Toxic effect of untritiated naphthylamine.
[e] Dermally acting carcinogen.
NA Information not available.

Sources:
1. EPA, 1991a
2. EPA, 1991b
3. NIOSH, 1987

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5.0 HEALTH AND ENVIRONMENTAL CONCERNS

This preliminary qualitative evaluation of potential human health and environmental concerns is intended to provide input to the Z 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 Z 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 Z 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 4-13. 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 Z 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 Z 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).

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5.1 CONCEPTUAL FRAMEWORK FOR RISK-BASED SCREENING

The range of potential human health and environmental exposure pathways at the Z 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 Z Plant Aggregate Area contaminants is currently constrained by the lack of data. This gap in the Z 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 1989a) 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 Z 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 Z 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 Z 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 Z 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 radiation doses from direct external exposure are presented in Table 5-1 from the available survey data. Radiation survey data were available for only 36 of the 53 Z Plant Aggregate Area waste management units and unplanned release sites. Eighteen units that have radiation survey data were reported as having radiation detected. However, twelve of those positive detections are for unplanned release sites that were monitored only at the time of the release. Radiation surveys were not available for one settling tank, the septic tanks and drain fields, the transfer facilities, and the seepage basins.

Westinghouse Hanford manual WHC-CM-4-10, Section 7 (WHC 1988c) was used as the basis for setting one of the criteria that are used to identify waste management units that can be considered a high priority for remediation. The manual indicates that posting ("Radiation Area") and access controls are to be implemented at a level of 2 mrem/hr for the purpose of personnel protection. With the same objective in mind, the level of 2 mrem/hr is recommended as one of the criteria for distinguishing high priority from lower priority waste management units. None of the regularly surveyed units listed in Table 5-1 exceeds this criterion.

High levels of radiation (up to 2,000 mrem/hr) 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 recent survey data were not located. 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 were not located. Thus, with the exception of those unplanned releases located within engineered waste units, which are routinely surveyed, information on the current radiological status of these remediated unplanned releases is lacking and is identified as a data gap in Section 8.

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 affects 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 Z Plant Aggregate Area waste management units are provided in Table 5-1.

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 1988c) 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%.

The following waste management units exceed the criterion based on recent radiation survey results:

- 216-Z-1 and 216-Z-2 Cribs
- 216-Z-1A Tile Field
- 218-W-1 Burial Ground
- 218-W-2 Burial Ground
- 218-W-4A Burial Ground
- 216-Z-21 Seepage Basin
- UPR-200-W-16
- UN-200-W-23
- UPR-200-W-26
- UN-200-W-44
- UPR-200-W-53
- UPR-200-W-72
- UPR-200-W-84
- UN-200-W-91
- UN-200-W-130
- UPR-200-W-158.

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 RARA program.

The Westinghouse 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 1991a). Measurements of

smearable alpha were made at 10 of the 36 waste management units surveyed, and smearable alpha was not detected at 8 of the 10 units. Waste management units where smearable alpha was detected are:

- 216-Z-1A Tile Field at 500 dis/min
- 216-Z-2 Crib at 1,500 dis/min.

Sampling data for contaminants in surface soils were not located for the Z Plant Aggregate Area waste management units. Therefore, the potential for workers to be exposed to nonradioactive chemicals via direct contact or inhalation or airborne particulates cannot be evaluated with certainty at this time.

Units subject to collapse of containment structures pose a potential threat of exposure by release of chemicals to surface soils. Cribs that were constructed with wood are likely to suffer structural failure, and should be considered to pose a risk of releases to surface soil, include the following:

- 216-Z-1 and 216-Z-2
- 216-Z-5 Crib
- 216-Z-6 Crib
- 216-Z-7.

Units subject to wind erosion because of insufficient soil cover or erodible cover materials pose a potential threat of exposure via surface soil. Wind erosion has been noted as a problem in the 200 West Burial Grounds, particularly at the 218-W-3 and 218-W-4A Burial Grounds. These units contain radionuclides that would pose a potential health risk if released to the surface.

Animal burrows have been noted in a number of units, including the 216-Z-1, 216-Z-2, and 216-Z-3 Cribs. Burrows and rabbit and mouse feces were also noted around the perimeter of the 200 West Burial Grounds. To date, no contamination associated with these burrows has been detected; however, disturbance of cover materials by animals could be a source of exposure in the future.

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 Z Plant Aggregate Area. Limited sampling of soils and soil gas was performed at the periphery of the 200 West Burial Grounds (see Tables A-7 and A-8). A number of volatile organics were detected in these samples, including carbon tetrachloride and methylene chloride. These data do not indicate an overlying source of these chemicals in the immediate vicinity of the soil borings. It appears from the observed distribution of

volatile organics, that the detections are due to the presence of a plume of contaminated groundwater beneath the site. Lateral migration of chemical vapors along the caliche layer may also have contributed to the detected concentrations. Waste inventories of hazardous chemicals disposed of to the 200 West Burial Ground indicate that numerous volatile organics were disposed of in these waste management units, including freons, trichloroethane, vinyl chloride, and xylenes (Last et al. 1989). If these compounds are available for volatilization from shallow buried wastes, or are contained in vapors emitted from vent pipes, they would pose a potential risk of exposure to workers at the Hanford Site.

Based on available knowledge about the disposal of carbon tetrachloride in Z Plant Aggregate Area waste management units, it is likely that airborne emissions of this chemical have occurred in the past.

The primary volatile radionuclide of concern disposed of in the 200 West Burial Grounds was tritium. Approximately 280,000 curies of tritium (decayed through 1990) were disposed of in these units, with the majority going to the 218-W-3A Burial Ground (Anderson et al. 1991). The mode of disposal of this material could not be determined from available information. Exposure to tritium (as tritiated water vapor) is of concern as is the potential for tritium release via radiolytic production of hydrogen from aqueous radioactive wastes.

Due to the uncertainty as to whether a driving force exists for release of volatiles to the atmosphere, none of the Z Plant Aggregate Area waste management units will be classified as high priority based on this exposure pathway.

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 Z Plant AAMS. However, the potential for individual units to impact groundwater has been discussed in Section 4.1.

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 1991a).

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 Z 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. 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, 24 of the 53 Z Plant Aggregate Area waste management units were assigned rankings. Of the units scored, four were given a score of 28.5 or greater. All other units were assigned rankings less than 2.0. The high-ranking units, and their scores, are as follows:

- 216-Z-1 & 216-Z-2 Cribs 52.85
- 216-Z-7 Crib 50.33
- 216-Z-10 Reverse Well 47.81
- 216-Z-17 Trench 45.30

For the mHRS ranking, 20 waste management units were ranked and 3 were given a score of 28.5 or greater. Scores from the mHRS were similar to the HRS scores for all waste management units except the 216-Z-17 Trench, which received a mHRS score of 1.18. The difference between the rankings assigned by the two systems is probably due to the fact that HRS does not consider concentrations or radionuclide decay.

Of the waste management units that were not assigned HRS or mHRS scores in the PA/SI, five (burial grounds) were assigned scores based on similarity to scored units. Twenty units were assigned a qualitative "low" score. Eight units 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 the PA/SI.

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 Z Plant Aggregate Area waste management units that exceeded one or more of the screening criteria identified in the preceding sections. In total, 19 waste management units were identified as high priority.

Radiation survey results (dose rate and/or contamination) were available for 36 of the 53 waste management units and unplanned releases. Eighteen were reported as having no detectable results. Of the remaining 18 units, all eighteen had survey results that exceeded one or more of the criteria (2 mrem/hr, 100 ct/min beta/gamma, or 20 dis/min alpha). Of these, however, ten unplanned releases had historical surveys indicating radiation levels exceeding one or more of the criteria with no information to indicate remediation had been accomplished. Current radiation levels at these unplanned release sites are unknown.

For the HRS scores, 4 waste management units were given scores of 28.5 or greater. For the mHRS, 3 units received a score of 28.5 or greater. Two waste management units received a Westinghouse Environmental Protection Group score of 7 or greater. Some of the sites were designated as high priority for more than one of the criteria, hence only a total of nineteen waste management sites are designated high priority.

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Table 5-1. Identification of High Priority Waste Management Units for the Z Plant Aggregate Area. (Sheet 1 of 4)

Waste Management Unit or Unplanned Release	HRS Rating	mHRS Rating	Radiation Surveys			Westinghouse Environmental Protection Group Score	High Priority
			ct/min	dis/min	mrem/hr		
Tanks and Vaults							
216-Z-8 Settling Tank	Low	Low	—	—	—	—	No
241-Z-361 Settling Tank	Low	Low	—	—	—	—	No
Cribs and Drains							
216-Z-1 & 216-Z-2 Cribs	52.85	57.73	ND	15,000	ND	—	Yes
216-Z-3 Crib	1.31	1.31	NA	NA	ND	—	No
216-Z-5 Crib	2.00	1.91	NA	ND	NA	7	No[b]
216-Z-6 Crib	1.03	0.71	NA	ND	NA	—	No
216-Z-7 Crib	50.33	43.70	NA	ND	NA	10	Yes
216-Z-12 Crib	1.36	1.36	NA	ND	ND	—	No
216-Z-16 Crib	0.98	0.16	NA	ND	ND	—	No
216-Z-18 Crib	1.36	1.36	ND	ND	ND	—	No
216-Z-8 French Drain	1.03	0.71	NA	ND	ND	—	No
216-Z-13 French Drain	Low	Low	ND	ND	ND	—	No
216-Z-14 French Drain	Low	Low	NA	ND	ND	—	No
216-Z-15 French Drain	Low	Low	NA	ND	ND	—	No
216-Z-1A Tile Field	1.09	1.09	NA	10,000	ND	—	Yes

Table 5-1. Identification of High Priority Waste Management Units for the Z Plant Aggregate Area. (Sheet 2 of 4)

Waste Management Unit or Unplanned Release	HRS Rating	mHRS Rating	Radiation Surveys			Westinghouse Environmental Protection Group Score	High Priority
			ct/min	dis/min	mrem/hr		
Reverse Well							
216-Z-10 Reverse Well	47.81	32.72	NA	NA	ND	—	Yes
Ponds, Ditches, and Trenches							
216-Z-4 Trench	1.03	0.82	NA	ND	NA	—	No
216-Z-9 Trench	2.27	2.27	NA	ND	ND	—	No
216-Z-17 Trench	45.30	1.18	NA	ND	ND	—	Yes
Septic Tanks and Associated Drain Fields							
2607-Z Septic Tank and Drain Field	Low	Low	—	—	—	—	No
2607-Z-1 Septic Tank and Drain Field	Low	Low	—	—	—	—	No
2607-WA Septic Tank and Drain Field	Low	Low	—	—	—	—	No
2607-WB Septic Tank and Drain Field	Low	Low	—	—	—	—	No
2607-W-8 Septic Tank and Drain Field	Low	Low	—	—	—	—	No
Transfer Facilities, Diversion Boxes, and Pipelines							
241-Z Diversion Box No. 1	Low	Low	—	—	—	—	No
241-Z Diversion Box No. 2	Low	Low	—	—	—	—	No
231-Z-151 Sump	Low	Low	—	—	—	—	No

Table 5-1. Identification of High Priority Waste Management Units for the Z Plant Aggregate Area. (Sheet 3 of 4)

Waste Management Unit or Unplanned Release	HRS Rating	mHRS Rating	Radiation Surveys			Westinghouse Environmental Protection Group Score	High Priority
			ct/min	dis/min	mrem/hr		
Basins							
241-Z Retention Basin	1.03	—	—	—	—	—	No
216-Z-21 Seepage Basin	Low	Low	NA	5,000	NA	—	Yes
Burial Sites							
218-W-1	0.70	0.50	NA	15,000	NA	—	Yes
218-W-1A	0.70	0.90	ND	ND	NA	—	No
218-W-2	0.70	0.80	NA	15,000	NA	—	Yes
218-W-3	0.70	0.50	ND	ND	ND	—	No
218-W-3AE	0.90[e]	0.90[e]	—	—	—	—	No
218-W-4A	0.70	0.90	NA	10,000	NA	—	Yes
218-W-11	ENS	—	NA	ND	NA	—	No
Burn Pit	0.00	0.00	—	—	—	—	No
Unplanned Releases							
UN-200-W-11	ENS	—	—	—	—	—	No
UPR-200-W-16	ENS	—	—	200,000	—	—	Yes
UN-200-W-23	0.90	—	—	10,000	—	—	Yes
UPR-200-W-26	Low	—	—	—	2,000	—	Yes
UN-200-W-44	0.90	—	—	—	2,000	—	Yes
UPR-200-W-53	Low	—	—	—	50	—	Yes
UPR-200-W-72	ENS	—	100,000	70,000	—	—	Yes
UPR-200-W-84	ENS	—	—	—	2,000	—	Yes

Table 5-1. Identification of High Priority Waste Management Units for the Z Plant Aggregate Area. (Sheet 4 of 4)

Waste Management Unit or Unplanned Release	HRS Rating	mHRS Rating	Radiation Surveys			Westinghouse Environmental Protection Group Score	High Priority
			ct/min	dis/min	mrem/hr		
UN-200-W-89	Low	—	—	50,000	—	—	No[d]
UN-200-W-90	Low	—	—	10,000	—	—	No[d]
UN-200-W-91	ENS	—	—	20,000	—	—	Yes
UN-200-W-103	1.04	—	—	—	—	—	No
UN-200-W-130	ENS	—	—	40,000	600	—	Yes
UPR-200-W-134	ENS	—	—	—	—	—	No
UPR-200-W-158	0.82	—	1,000	—	60	—	Yes
UN-200-W-159	Low	—	—	—	—	—	No

Notes:
ENS - Waste management unit was not scored in the PA/SI because insufficient information on the release was available.
— - Waste management unit was not assigned an mHRS score or no radiation survey was performed.
NA - Radiation was monitored at this waste management unit but survey data was not located for this type of radiation.
ND - Radiation was monitored but not detected at this waste management unit.
ct/min - counts per minute.
dis/min - disintegrations per minute.
mrem/hr - millirem per hour.

[a] If no mHRS or HRS score was available and waste management unit could not be scored based on similarity to other units, a qualitative ranking was developed for this report. An assigned score of "high" is equivalent to ≥28.5, "low" is <28.5.
[b] Unit was stabilized in September 1991 by RARA Program.
[c] Waste management unit was assigned a score based on similarity to other units.
[d] Historical information indicates that the release was remediated to background (Table 2-6).

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 Z 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 Z Plant Aggregate Area, potential contaminant-specific ARARs address chemical constituents and/or radionuclides. The potential contaminant-specific ARARs that were evaluated for the Z 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 Z 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 Z 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 Z 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 Z Plant Aggregate Area are outlined in Table 4-15. 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 Z Plant Aggregate Area, as no natural surface water bodies exist. The only existing manmade surface water bodies at Z 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 Z 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 redisposed 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 Z 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 Z 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 Z 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 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 Z 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 Z 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 Z 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 Z 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 Z 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 Z Plant Aggregate Area. However, Wild and Scenic Rivers Act requirements may be potential ARARs for actions taken as a result of Z 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)

- 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 Z 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.

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 m^3 (1,000 ft^3) 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 Z 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 Z 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 Z 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 Z 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 Z 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 Z 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 Z 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

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 Z 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 Z 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 Z 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 Z 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 Z 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 Z 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 Z 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. (Sheet 1 of 2)

	RCRA TCLP Designation Limits in mg/L	RCRA Land Ban Limits Non-wastewater		MTCA Method A Cleanup Levels Industrial Soil mg/kg	WCAA Toxic Air Pollutants ASIL in ug/m³	RCRA Corrective Action Levels (1) –(Proposed)–	
		CCWE in mg/L	CCW in mg/kg			Air in ug/m³	Soil in mg/kg
INORGANICS							
Asbestos	—	—	—	—	4.2 (2)	—	—
Barium	100.0	100.0	—	—	1.7	0.4	4000.0
Beryllium	—	—	—	—	0.00042	0.0004	0.2
Boron	—	—	—	—	—	—	—
Cadmium	1.0	1.0	—	10.0	0.00056	0.0006	40.0
Chromium (VI)	5.0	5.0	—	500.0	0.000083	0.00009	40.0
Chromium (III)	5.0	—	—	500.0	1.7	—	—
Chromium (total)	5.0	—	—	500.0	—	—	—
Copper	—	—	—	—	3.3	—	—
Lead	5.0	5.0	—	1000.0	—	—	—
Mercury	0.2	0.2	—	1.0	—	—	20.0
Nickel	—	—	—	—	—	—	2000.0
Silver	5.0	5.0	—	—	0.3	—	—
Zinc	—	—	—	—	—	—	—
Cyanide	—	—	590 (3)	—	16.7	—	2000.0
Fluoride	—	—	—	—	8.3	—	—
Nitrate (as Nitrogen)	—	—	—	—	—	—	—
Nitrite (as Nitrogen)	—	—	—	—	—	—	—
ORGANICS							
Acetone	—	0.59	160.0	—	5927.4	—	8000.0
Acetonitrile	—	—	—	—	233.1	—	500.0
Benzene	0.5	—	3.7	0.5	0.12	—	—
Carbon tetrachloride	0.5	0.96	5.6	—	0.067	0.03	5.0
Chlorobenzene	100	0.05	5.7	—	1165.5	20.0	2000.0
Chloroform	6.0	—	5.6	—	0.043	0.04	100.0

Table 6-1. Potential Contaminant-Specific ARARs and TBCs for Preliminary Inorganic and Organic Contaminants of Concern. (Sheet 2 of 2)

	RCRA TCLP Designation Limits in mg/L	RCRA Land Ban Limits Non-wastewater		MTCA Method A Cleanup Levels Industrial Soil mg/kg	WCAA Toxic Air Pollutants ASIL in ug/m³	RCRA Corrective Action Levels (1) –(Proposed)–	
		CCWE in mg/L	CCW in mg/kg			Air in ug/m³	Soil in mg/kg
ORGANICS (Continued)							
Creosote	—	—	—	—	—	—	—
Cyclohexanone	—	0.75	—	—	333.0	—	—
Dibutyl phosphate	—	—	—	—	16.7	—	—
1,2-Dichloroethane	0.5	—	7.2	—	0.04	0.04	8.0
cis-1,2-Dichloroethylene	—	—	—	—	2630.7	—	—
trans-1,2-Dichloroethylene	—	—	33.0	—	2630.7	—	—
Ethanol	—	—	—	—	6327	—	—
Ethylbenzene	—	0.053	6.0	20.0	1448.6	—	8000.0
Freon II (trichlorofluoromethane)	—	0.96	33.0	—	18648.0	—	—
Isopropanol	—	—	—	—	3263.4	—	—
Kerosene	—	—	—	200 (TPH)	—	—	—
Methanol	—	0.75	—	—	865.8	—	—
Methylene chloride	—	0.96	33.0	0.5	2.0	0.3	90.0
Methyl isobutyl ketone	—	0.33	33.0	—	682.7	70.0	4000.0
Polychlorinated biphenyls	—	—	—	10.0	—	—	0.09
Tetrachloroethylene	0.7	0.05	5.6	0.5	1.1	1.0	10.0
Toluene	—	0.33	28.0	40.0	1248.8	7000.0	20,000.0
Tributyl phosphate	—	—	—	—	8.3	—	—
1,1,1-Trichloroethane	—	0.41	5.6	20.0	6327.0	1000.0	7000.0
Trichloroethylene	0.5	0.091	5.6	0.5	0.8	—	60.0
Vinyl chloride	0.2	—	33.0	—	0.023	—	—
Xylenes (Total)	—	0.15	28.0	20.0	1448.6	1000.0	200,000.0

FOOTNOTES

ASIL = Acceptable Source Impact Level RCRA = Federal Resource Conservation and Recovery Act (1) RCRA Corrective Action Levels are only proposed
CCWE = Constituent Concentration in Waste Extract TCLP = Toxicity Characteristic Leaching Procedure at this time (40 CFR Part 264 Subpart S), so are
CCW = Constituent Concentration in Waste WCAA = Washington State Clean Air Act not ARARs yet; they are "To Be Considered."
MTCA = Washington State Model Toxics Control Act mg/L = milligrams per liter (2)
Measured as fibers per cubic meter.
mg/kg = milligrams per kilogram (3) Total cyanide. 30 mg/kg for amenable cyanide.
ug/m³ = micrograms per cubic meter

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 et seq; 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
	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

Table 6-2. Potential Location-Specific ARARs.

Location	Requirement	Prerequisite	Citation
	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
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

Table 6-2. Potential Location-Specific ARARs.

Location	Requirement	Prerequisite	Citation
Uppermost aquifer.	Bottom of lowest liner of new solid waste disposal facility must be at least 3 m (10 ft) above seasonal high water in uppermost aquifer (1.5 m [5 ft] if hydraulic gradient controls installed).	New solid waste disposal.	WAS 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 Groundwater Management Areas.	Activities within a Groundwater Management Area.	Chapter 90.44 RCW; Chapter 173-100 WAC
DRINKING WATER SUPPLY:			
Drinking water supply well.	New solid waste disposal areas prohibited within 305 m (1,000 ft) upgradient, or 90 days travel time of drinking water supply well.	New solid waste disposal within 305 m (1,000 ft) 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

Table 6-2. Potential Location-Specific ARARs.

Location	Requirement	Prerequisite	Citation
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 CFR 17
	Actions within critical habitats must conserve endangered/threatened species.	Activities where endangered or threatened species exist.	50 CFR Parts 200 and 402
Parks.	No new solid waste disposal areas within 305 m (1,000 ft) 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 et seq; 50 CFR 35.1 et seq
Wildlife refuge.	Restrictions on actions in areas that are part of the National Wildlife Refuge System.	Activities within designated wildlife refuges.	16 USC 668dd et seq; 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

Table 6-2. Potential Location-Specific ARARs.

Location	Requirement	Prerequisite	Citation
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 et seq; 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
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 archaeologic properties and resources, and minimize harm to national landmarks.	Activities that could affect historic or archaeologic sites or artifacts.	16 UST 469, 470 et seq; 36 CFR Parts 65 and 800; Chapters 27.34, 27.53, and 27.58 RCW

Table 6-2. Potential Location-Specific ARARs.

Location	Requirement	Prerequisite	Citation
LAND USE:			
Neighboring properties.	No new solid waste disposal areas within 30.5 m (100 ft) of the facility's property line.	New solid waste disposal within 30.5 m (100 ft) of facility property line.	WAC 173-304-130
	No new solid waste disposal areas within 76 m (250 ft) of property line of residential zone properties.	New solid waste disposal within 76 m (250 ft) 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 ft) (turbojet aircraft)/(1,524 m) (5,000 ft) (piston-type aircraft) of airport runways.	Garbage disposal near airports.	WAC 173-304-130

7.0 PRELIMINARY REMEDIAL ACTION TECHNOLOGIES

Previous sections identified contaminants of concern at the Z 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 Z 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 Z 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 Z 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 Z 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 Z 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.

To focus remedial actions with a bias for action through implementing IRMs, preliminary RAOs are identified for the 200 Areas and Z 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 Z Plant Aggregate Area. The media of concern for the Z 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.

9 3 1 2 3 0 7 3 9 4

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 Z Plant Aggregate Area, and are presented in Table 7-2. The following are the general response actions followed by a brief description for the Z 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)(l)(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

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 may 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 criteron 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 Z 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 Z 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.

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 Z 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

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 Z 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

discharged to the disposal sites with VOCs (e.g., carbon tetrachloride). 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.

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 Z 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.

9 3 1 2 5 7 0 9 1 0 6

- In situ soil vapor extraction (Alternative 6) could be used on any waste management unit or unplanned release sites that contains volatile organic compounds.

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.

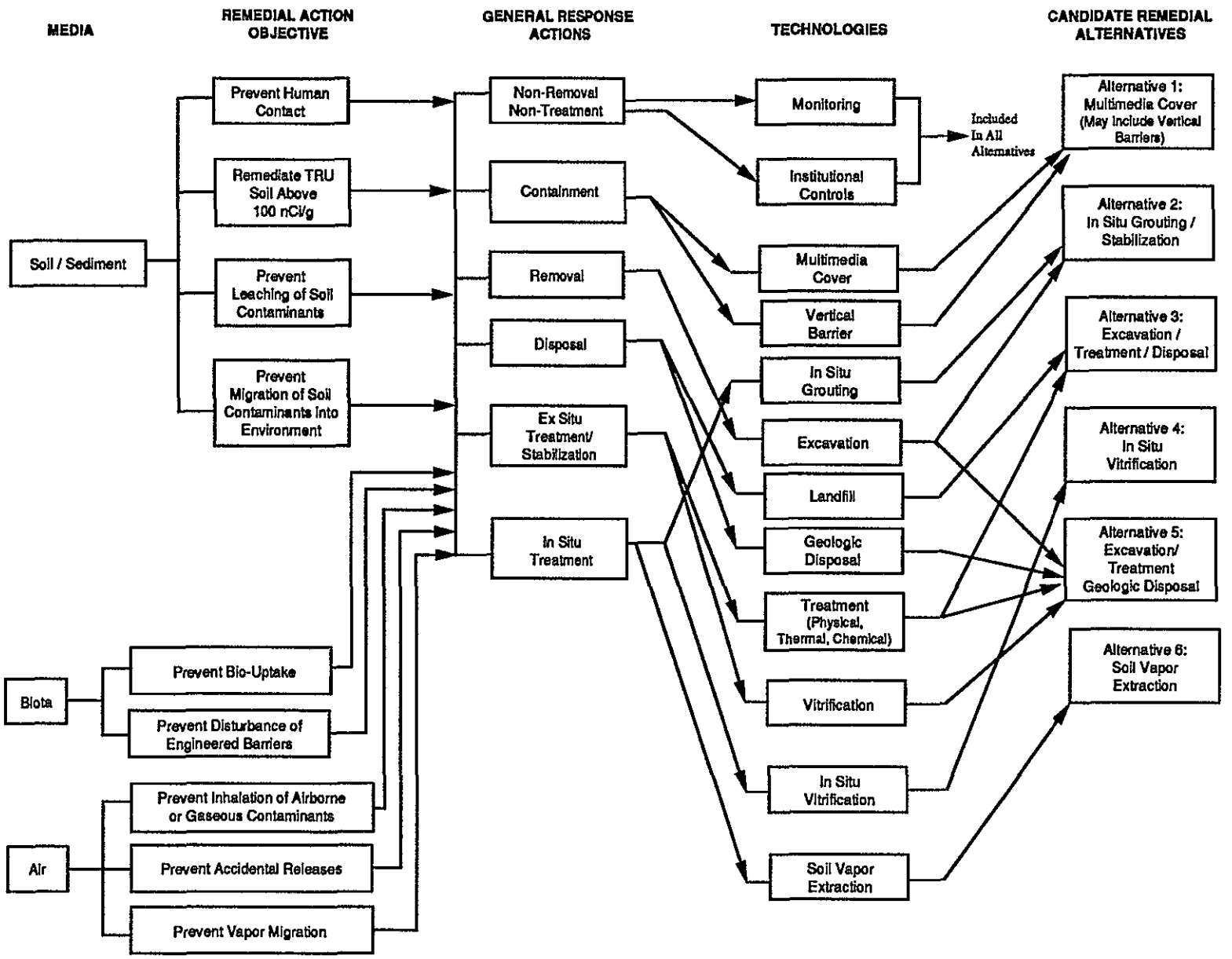

Figure 7-1. Development of Candidate Remedial Alternatives for Z Plant Aggregate Area.

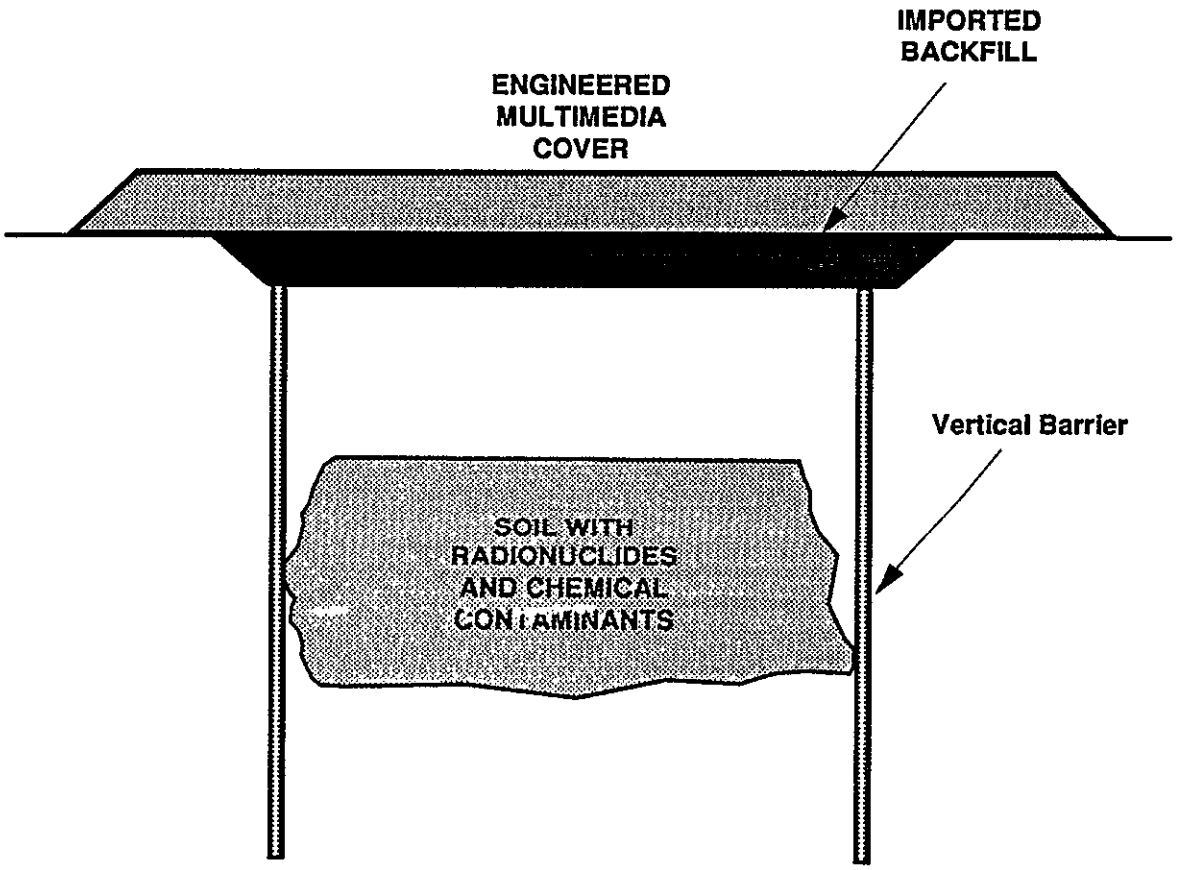

Figure 7-2. Alternative 1: Multimedia Cover with Vertical Barriers.

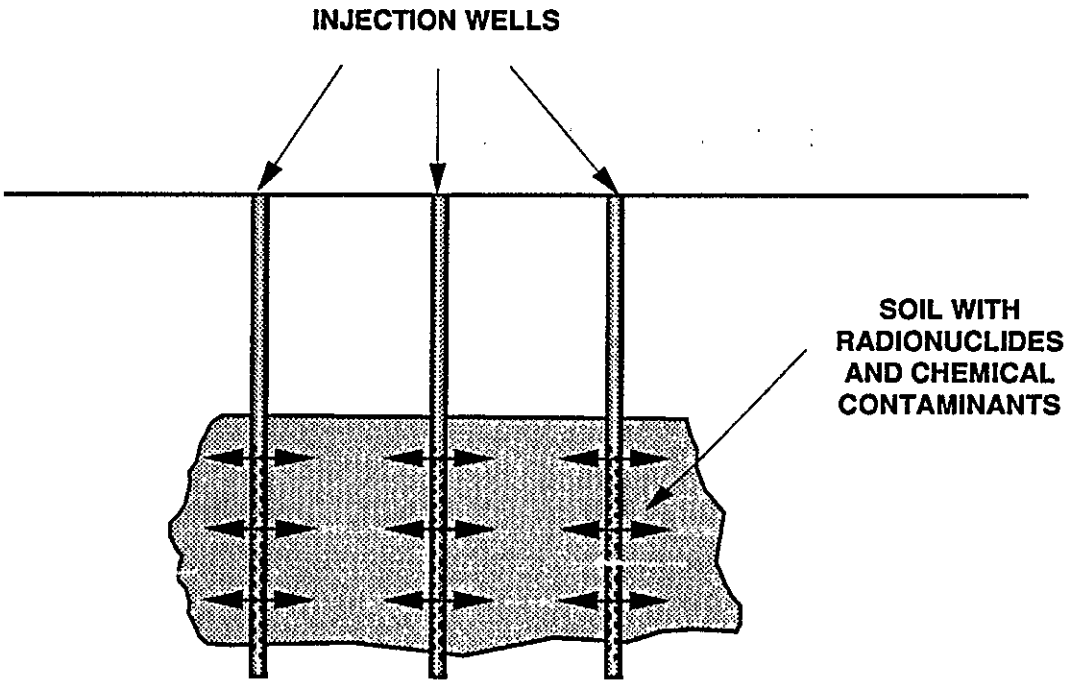

Figure 7-3. Alternative 2: In Situ Grouting of Soil.

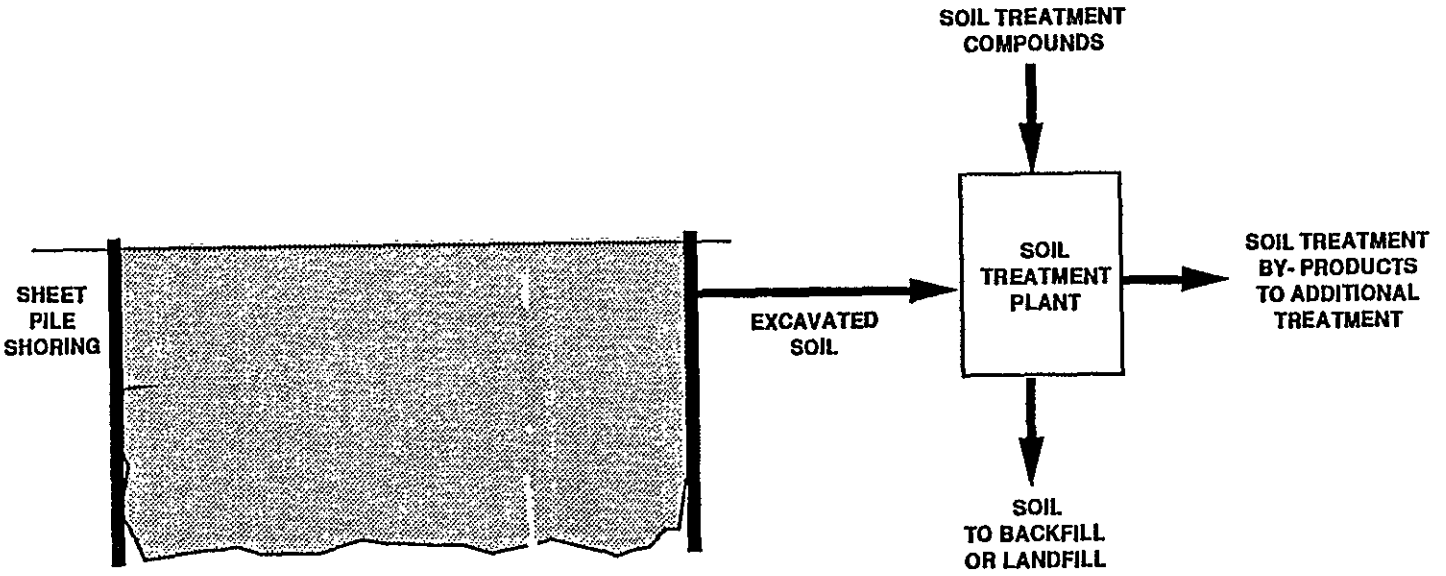

Figure 7-4. Alternative 3: Excavation, Treatment, and Disposal.

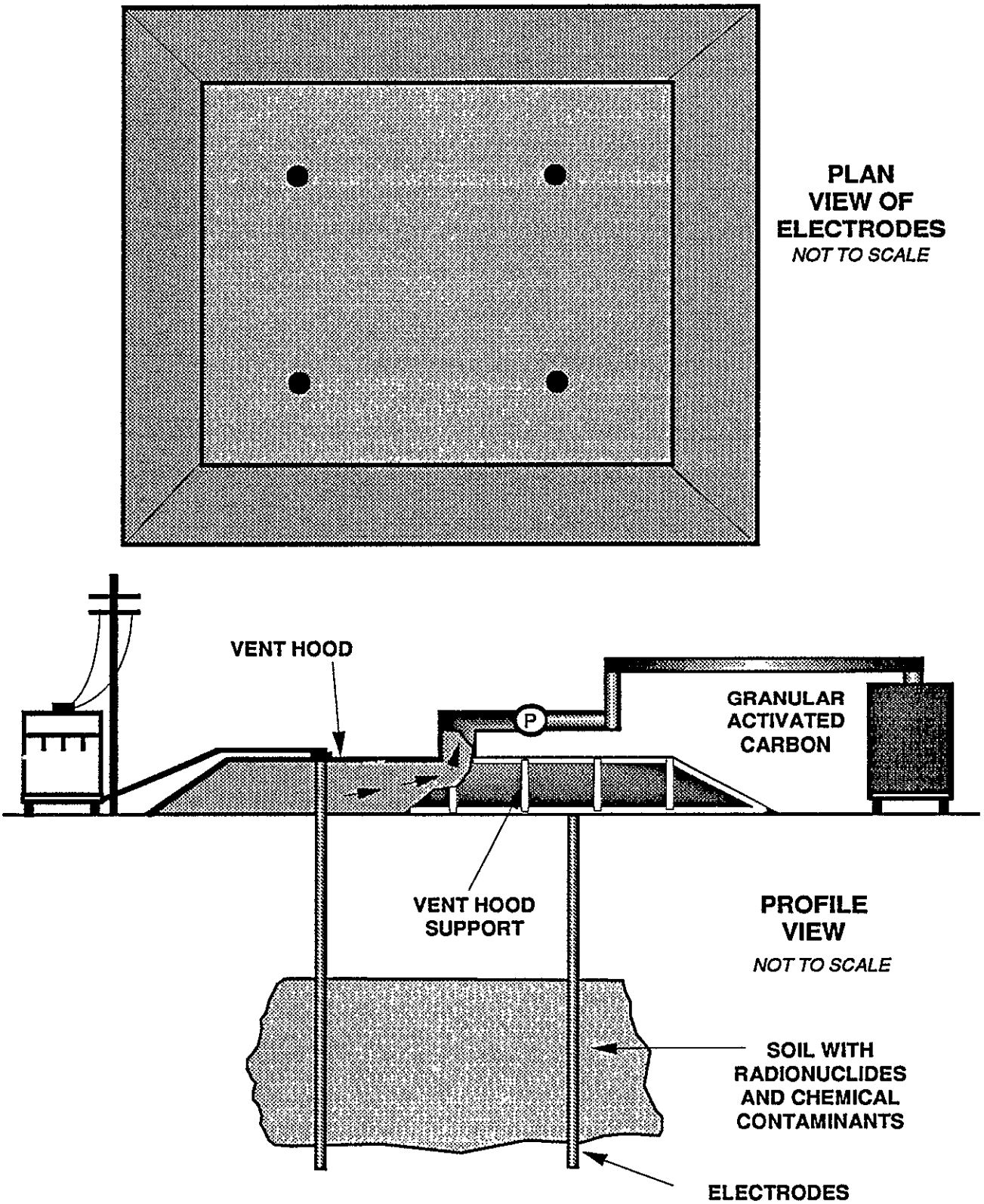

Figure 7-5. Alternative 4: In Situ Vitrification of Soil.

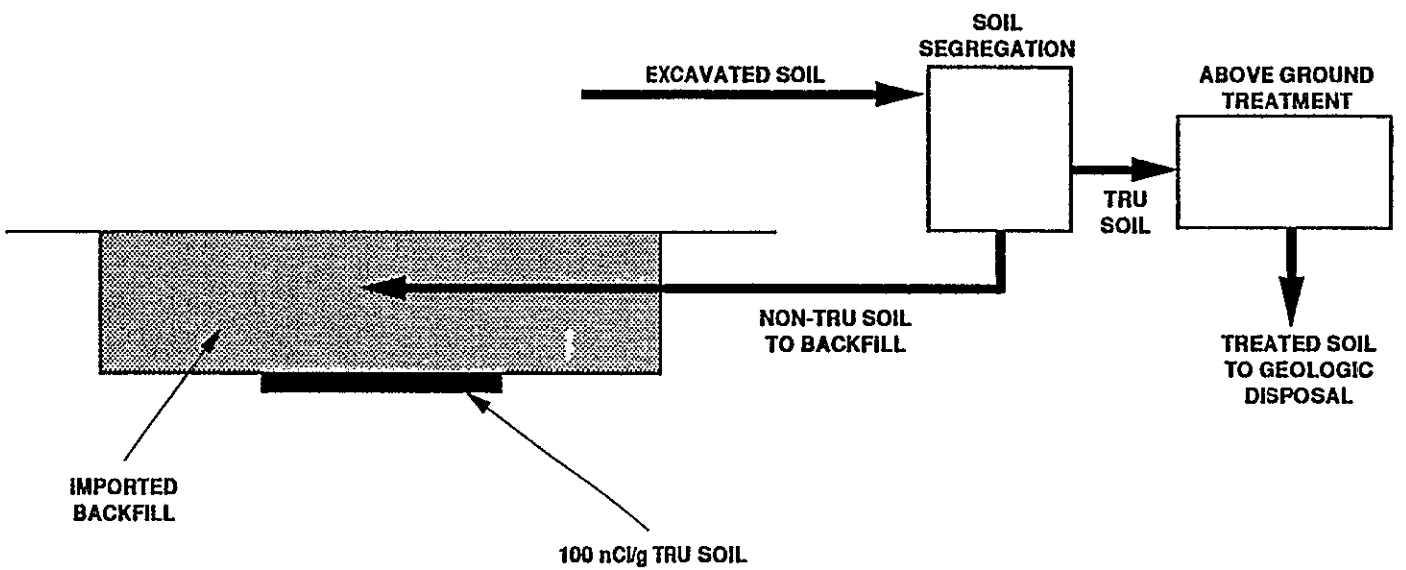

Figure 7-6. Alternative 5: Excavation, Vitrification, and Geologic Disposal of Soil with TRU Radionuclides.

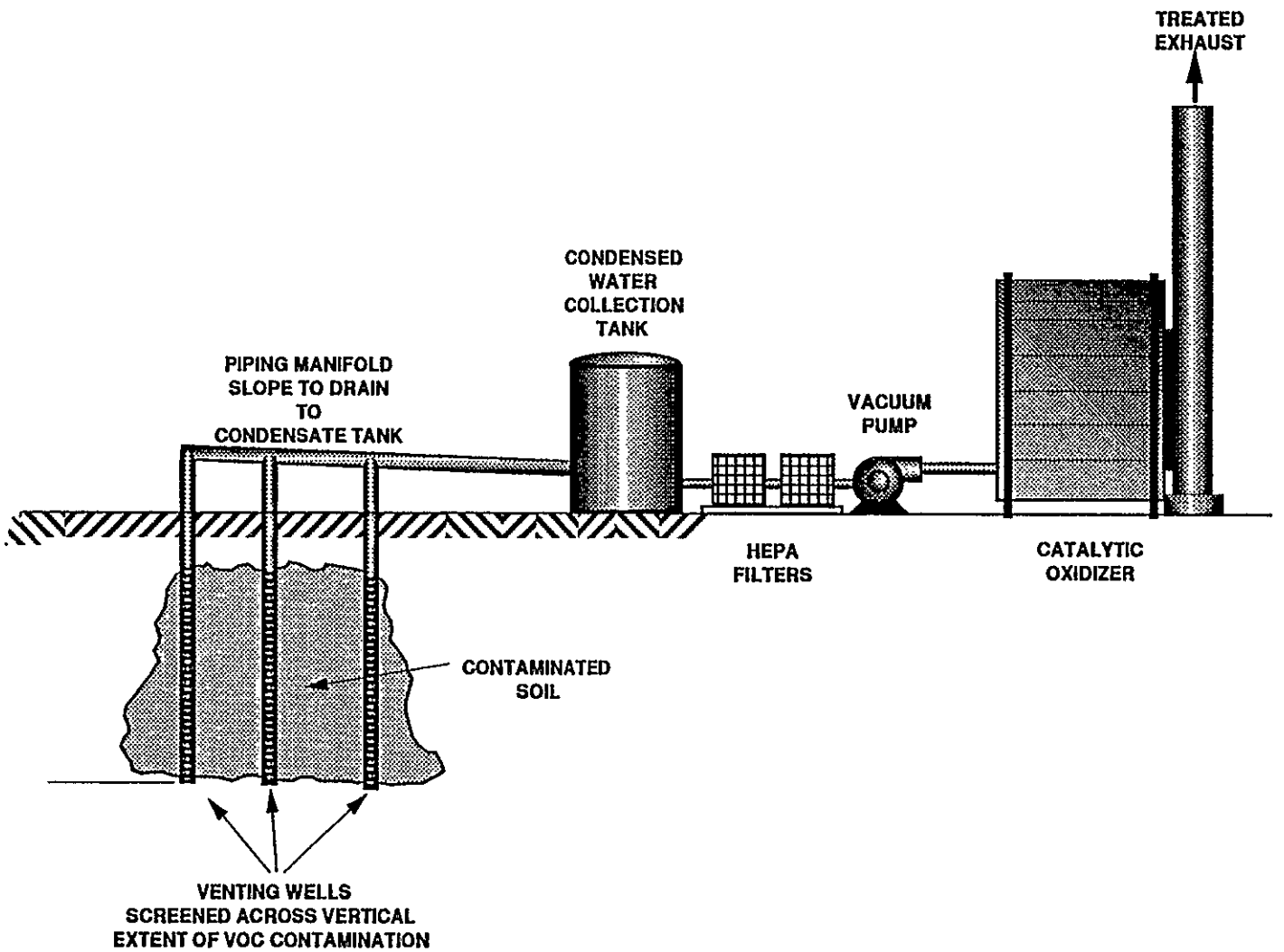

Figure 7-7. Alternative 6: Soil Vapor Extraction for VOCs.

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	• 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).	• 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.	• No Action • Institutional Controls/Monitoring • Waste Removal, Treatment, and Disposal • Waste Containment • In Situ Treatment
Biota	• Prevent bio-uptake by plants. • Prevent disturbance of engineered barriers by biota.	• Prevent bio-uptake of radioactive contaminants.	• No Action • Institutional Controls/Monitoring • Waste Removal, Treatment, and Disposal • Waste Containment • In Situ Treatment
Air (1)	• Prevent inhalation of contaminated airborne particulates and/or volatile emissions exceeding MTCA and DOE limits from soils/sediments.	• Prevent adverse environmental impacts on local biota. • Prevent accidental release from collapse of containment structures.	
Settling Tank Waste		• Interim stabilization of tanks and ancillary piping and transfer facilities to prevent release to the environment (remediation will be remanded to RCRA).	• Removal of Drainable Liquid/Isolation of Source Materials for Environment • Interim stabilization of tanks, ancillary piping, and transfer facilities
Buried Containers	• Prevent leakage of liquids from buried containers that would cause groundwater concentrations to exceed MTCA standards at the compliance point location, or which could result in volatilization emissions of leaking chemicals to the atmosphere.	• Prevent wind erosion of soil cover material that would expose buried wastes. • Prevent wind erosion of contaminated soil that would lead to exposure exceeding MTCA or DCGs.	• No Action/Institutional Controls/ Monitoring • Wind Barriers Installed • Capping • Drum Removal • Subsurface Barriers

Note: (1) No General Response Actions are required for the air because soil remediation will eliminate the air contamination source.

Table 7-2. Preliminary Remedial Action Technologies. (Sheet 1 of 3)

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	Signs/Fences	NA
			Entry Control	NA
		Monitoring	Monitoring	NA
	Containment	Capping	Multi-Media	I,M,R,O
		Vertical Barriers	Slurry Walls	I,M,R,O
			Grout Curtains	I,M,R,O
			Cryogenic Walls	I,M,R,O
		Dust & Vapor Suppression	Membranes/Sealants/ Wind Breaks/Wetting Agents	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
			Hydrolysis	I,O
			Chemical Dechlorination	O

Table 7-2. Preliminary Remedial Action Technologies. (Sheet 2 of 3)

Media	General Response Action	Technology Type	Process Option	Contaminants Treated
		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 (Landfarming)	O
			Anaerobic	O
	Disposal	Landfill Disposal	On-site Landfill	I,M,R,O
			Off-site Landfill	I,M,O
		Geologic Repository	Geologic Repository	T (I,M,O, non-transuranic radionuclides 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
			Grouting	I,M,R
			Fixation/Solidification/ Stabilization	I,M,R,O
		Biological Treatment	Aerobic	O
			Anaerobic	O

Table 7-2. Preliminary Remedial Action Technologies. (Sheet 3 of 3)

Media	General Response Action	Technology Type	Process Option	Contaminants Treated
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	Multi-Media	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 = Transuranic Radionuclides applicability

Table 7-3. Screening of Process Options. (Sheet 1 of 10)

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	Multi-Media	Fine soil 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.

Table 7-3. Screening of Process Options. (Sheet 2 of 10)

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 pond 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	Rejected because of limited duration of integrity and protection.
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. (Sheet 3 of 10)

Technology Type	Process Option	Description	Effectiveness	Implementability	Relative Cost	Conclusions
Thermal Treatment	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.	Implementable. 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.	Implementable. Technology is well developed. Mobile units are 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 and wastewater generation and low organic content of soils.
	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.	Potentially implementable. 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. (Sheet 4 of 10)

Technology Type	Process Option	Description	Effectiveness	Implementability	Relative Cost	Conclusions
	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 Treatment	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.	Difficult to implement. 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.	Difficult to implement. Common industrial process. Use for treatment of soils not well demonstrated.	Medium	Rejected because of limited effectiveness and unproven for 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.

Table 7-3. Screening of Process Options. (Sheet 5 of 10)

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 soils. May work with only low level radiologically contaminated soil. May not work with humus soil. Generally more effective on contaminants than partition to the fine soil fraction. Radioactivity will not be reduced.	Implementable. Treatability tests are necessary. Well developed technology and commercially available. Requires treatment of the rejected 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.	Implementable. Laboratory testing necessary to determine appropriate solvent and operating conditions.	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.	Implementable. 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. (Sheet 6 of 10)

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 mobility. Effectiveness for organic stabilization is highly dependent on the binding agent.	Implementable. 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 implementable for low concentration waste. Disposal or safe storage of containers required. Regulatory constraints may prevent disposal of containers with certain waste types.	Low	Retained because of potential effectiveness and implementability.
Biological Treatment	Aerobic (Landfarming)	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.	Potentially implementable. 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.
	Anaerobic	Microbial degradation in an oxygen deficient environment.	Effectiveness is contaminant- and concentration-specific. Treatment has been demonstrated on a variety of organic compounds. Not effective on inorganics or radionuclides.	Potentially implementable. 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. (Sheet 7 of 10)

Technology Type	Process Option	Description	Effectiveness	Implementability	Relative Cost	Conclusions
Disposal	Landfill Disposal	Place contaminated soil in an existing on-site landfill or off-site RCRA landfill.	Does not reduce the soil contamination but moves all forms of contamination to a more secure place.	Easily implemented if sufficient storage is available in an approved landfill area.	Medium	Retained because of potential effectiveness and implementability.
	Geologic Repository	Put the contaminated or pretreated soil in a safe geologic repository.	Does not reduce the soil contamination, but is a very effective long-term method of storing radionuclides. Probably unnecessary for nonradioactive waste.	Difficult to implement because of limited site availability, and permits for transporting radioactive wastes are hard to get. Requires pretreatment of contaminated soil.	High	Retained because of effectiveness on transuranic wastes.
In Situ Thermal Treatment	Vitrification	Electrodes are inserted into the soil and a carbon/glass frit is placed between the electrodes to act as a starter path for initial melt to take place.	Effective in immobilizing radionuclides and most inorganics. Effectively destroys some organics through pyrolysis. Some volatilization of organics and inorganics may occur.	Potentially implementable. Implementability depends on site configuration, e.g., lateral and vertical extent of contamination. Treatability studies required.	High	Retained because of potential ability to immobilize radionuclides and destroy organics.
	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.

Table 7-3. Screening of Process Options. (Sheet 8 of 10)

Technology Type	Process Option	Description	Effectiveness	Implementability	Relative Cost	Conclusions
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 hydrogeology. Flushing solutions posing environmental threat likely to be needed. Difficult recovery of flushing solution.	Difficult to implement. Not implementable for complex mixtures of contaminants. Flushing solution difficult to recover. Chemical additives likely to pose environmental threat.	Medium	Rejected because of implementation problems.
	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 semivolatile organics, inorganics, 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.
	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.

Table 7-3. Screening of Process Options. (Sheet 9 of 10)

Technology Type	Process Option	Description	Effectiveness	Implementability	Relative Cost	Conclusions
	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.
In Situ Biological Treatment	Aerobic	Microbial growth utilizing organic contaminants as substrate is enhanced by injection of or spraying with oxygen source and nutrients.	Effective for most organics under 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 some 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.
BIOTA 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 agriculture.	Ineffective if entered. Does not reduce contamination.	Administrative decision is easily implemented.	Low	Retained to be used in conjunction with other process options.

Table 7-3. Screening of Process Options. (Sheet 10 of 10)

Technology Type	Process Option	Description	Effectiveness	Implementability	Relative Cost	Conclusions
Access Controls	Signs/Fences	Install a fence and signs around areas of contamination to keep people out and the biota in.	Effective in limiting access 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.	Easily implemented equipment and personnel and readily available.	Low	Retained to be used in conjunction with other process options.
Monitoring	Monitoring	Biota sampling and testing 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	Multi-Media	Fine soil 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.
Excavation	Standard Excavating Equipment	Remove affected biota and load it onto process system equipment.	Effective in moving and transporting biota.	Easily implemented. 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 landfill.	Medium	Retained because of potential effectiveness and implementability.

Table 7-4. Preliminary Remedial Action Alternatives Applicable to Waste Management Units and Unplanned Release Sites. (Sheet 1 of 4)

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 Disposal of Transuranic Soil	Alt 6. In Situ Soil Vapor Extraction for Volatile Organic Compounds
Tanks and Vaults						
216-Z-8 Settling Tank	•	•	•	•	•	
241-Z-361 Settling Tank	•	•	•	•	•	
Cribs and Drains						
216-Z-1 & 216-Z-2 Cribs	•	•	•	•	•	•
216-Z-3 Crib	•	•	•	•	•	
216-Z-5 Crib	•	•	•	•	•	
216-Z-6 Crib	•	•	•	•	•	
216-Z-7 Crib	•	•	•	•	•	
216-Z-12 Crib	•	•	•	•	•	
216-Z-16 Crib	•	•	•	•	•	
216-Z-18 Crib	•	•	•	•	•	•
216-Z-8 French Drain	•	•	•	•	•	
216-Z-13 French Drain (1)	•	•	•	•		
216-Z-14 French Drain (1)	•	•	•	•		
216-Z-15 French Drain (1)	•	•	•	•		
216-Z-1A Tile Field	•	•	•	•	•	•

Table 7-4. Preliminary Remedial Action Alternatives Applicable to Waste Management Units and Unplanned Release Sites. (Sheet 2 of 4)

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 Disposal of Transuranic Soil	Alt 6. In Situ Soil Vapor Extraction for Volatile Organic Compounds
Reverse Wells						
216-Z-10 Reverse Well	•	•			•	
Ponds, Ditches, and Trenches						
216-Z-4 Trench	•	•	•	•	•	
216-Z-9 Trench	•	•	•	•	•	•
216-Z-17 Trench	•	•	•	•	•	
Septic Tanks and Associated Drain Fields						
2607-Z Septic Tank and Drain Field (1)	•	•	•	•		
2607-Z-1 Septic Tank and Drain Field (1)	•	•	•	•		
2607-WA Septic Tank and Drain Field (1)	•	•	•	•		
2607-WB Septic Tank and Drain Field (1)	•	•	•	•		
2607-W-8 Septic Tank and Drain Field (1)	•	•	•	•		
Transfer Facilities, Diversion Boxes and Pipelines						
241-Z Diversion Box No. 1	•	•	•	•	•	
241-Z Diversion Box No. 2	•	•	•	•	•	
231-Z-151 Sump	•	•	•	•	•	
Basins						
241-Z Retention Basin	•		•			
216-Z-21 Seepage Basin (1)	•	•	•	•		

Table 7-4. Preliminary Remedial Action Alternatives Applicable to Waste Management Units and Unplanned Release Sites. (Sheet 3 of 4)

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 Disposal of Transuranic Soil	Alt 6. In Situ Soil Vapor Extraction for Volatile Organic Compounds
Burial Sites						
218-W-1 Burial Ground	•	•	•	•	•	•
218-W-1A Burial Ground	•	•	•	•	•	•
218-W-2 Burial Ground	•	•	•	•	•	•
218-W-3 Burial Ground	•	•	•	•	•	•
218-W-4A Burial Ground	•	•	•	•	•	•
218-W-11 Burial Ground	•	•	•	•	•	•
Z Plant Burn Pit	•	•	•	•		
Unplanned Releases						
UN-200-W-11	•	•	•	•	•	
UPR-200-W-16	•	•	•	•	•	
UN-200-W-23	•	•	•	•	•	
UPR-200-W-26	•	•	•	•		
UN-200-W-44	•	•	•	•		
UPR-200-W-53	•	•	•	•		
UPR-200-W-72	•	•	•	•		
UPR-200-W-84	•	•	•	•		
UN-200-W-89 (2)						
UN-200-W-90 (2)						
UN-200-W-91	•	•	•	•	•	

Table 7-4. Preliminary Remedial Action Alternatives Applicable to Waste Management Units and Unplanned Release Sites. (Sheet 4 of 4)

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 Disposal of Transuranic Soil	Alt 6. In Situ Soil Vapor Extraction for Volatile Organic Compounds
UN-200-W-103	•	•	•	•	•	
UN-200-W-130	•	•	•	•		
UPR-200-W-134	•	•	•	•	•	
UPR-200-W-158	•	•	•	•		
UN-200-W-159 (2)						

Notes: (1) This is an active unit.
(2) Records indicate that all environmental contamination resulting from this unplanned release was removed and disposed. Therefore no applicable alternative(s) was identified.

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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 Z 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)

- 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 Z Plant AAMS.

8.1.1 Data Users

The data users for the Z 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 Z 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

- 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 Z 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 2.3 and 2.4)

- Issue 3: Sampling events of waste effluents and affected media (Section 2.3 and 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).

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 Z 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 Z 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. Generally, no inventory data were identified for unplanned releases.

- 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 sediment sampling in basins, ponds, cribs, and ditches. 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 216-Z-18 Crib, the 216-Z-8 French Drain, and the 218-W-2, 218-W-3AE, 218-W-4B, 218-W-4C, and 218-W-5 Burial Grounds. However, laboratory analyses have generally been performed for a limited number of constituents, e.g., americium and plutonium, or carbon tetrachloride, and a limited number of samples. No laboratory testing certificates and laboratory quality assurance documentation were identified to enable validation of these data. (Issue 5)

- Grid Sampling--There is also a set of soil sampling and analysis data which was conducted for several years on a grid pattern that extends across all three operable units in the Z Plant Aggregate Area. These data indicate impacts from historical operations at the Hanford Site in the vicinity of the grid points.

However, the impacts cannot be ascribed to particular units and do not contribute to the decision-making process on a unit-by-unit basis but may be used to estimate background contamination levels.

- Biota Sampling--These data could assist assessment of radiological contamination through bio-uptake and -transfer. The sampling points include: soil grid point 2W22 (rabbit feces), 231-Z fenceline (rabbit feces), a site west of Z Plant (mouse feces), 216-Z-21 Seepage Basin (aquatic vegetation), and the 216-Z-10 Crib (rabbit feces). (Issue 5)

- Borehole Geophysics--These data, for a number of waste management units which discharged to the soil column (selected cribs and french drains) 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. A list of these surveys that have been conducted in the Z Plant Aggregate Area is included in the Data Package Topical Report prepared for this study (Chamness et al. 1991). These 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 historical 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 Z 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 should also (like gross gamma logging) be able to assess the vertical extent of the presence of the radionuclides. It will be conducted in about ten wells located in the Z Plant Aggregate Area and will be available with completion of the AAMS process. (Issue 5)

- Soil Physical and Chemical Properties--Moisture contents, particle size distributions, and calcium carbonate contents have been measured in soil samples from monitoring wells (primarily near the low-level burial grounds) in the Z Plant Aggregate Area. These parameters can be used to estimate transport of contaminants in the subsurface. (Issue 6)

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 Z 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:

- *Z 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 Z 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 Z 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 Z 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 Z 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 Z 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 Z 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 Z 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 Z 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 Z 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 Z 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 Z 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.

8.1.4 Conceptual Models

The initial conceptual model of the waste management units and unplanned releases in the Z Plant Aggregate Area is presented and described in Section 4.2. The model is based on best estimates of where contaminants were discharged and the potential for migration of contaminants from the point-of-release to the current location. The conceptual model is designed to be conservative and assumes insufficient data for delineation of the full extent of chemical and radiological contamination. This means that a migration pathway was included in the model if there was any possibility of contamination travelling through it, historically or presently. In most cases there may not be a significant flux of such contaminant migration for many of the pathways shown on the figure. Significant refers to a quantity causing an unacceptable risk for the receptors of the pathway.

There are many significant uncertainties regarding the contaminant levels in the migration pathways shown on the conceptual model. Yet, almost none of these pathways have been sampled to determine whether any contamination still exists in any of the locations specified in the conceptual model. Likewise for those locations that have been sampled, there is little data regarding which constituents are present, to what extent they are present, and what the contaminant levels are in the various media. Until these data are available, the various pathways cannot be prioritized. This affects the ability of DOE and Westinghouse Hanford to specify appropriate remedial response actions and to specify the risk assessment objectives.

8.1.5 Aggregate Area Management Study Objectives and Decisions

The specific objectives of the Z 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 4.0)
- 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).

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 Z 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 Z 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 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 Z 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 Z 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.
- 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 subsurface soil sampling which has been done at several of the waste management units, e.g., the 216-Z-1A Tile Field, 216-Z-9 Trench, and 216-Z-12 Crib and on the periphery of the low-level Burial Grounds.
- The likely depth of contaminants--this information is mainly obtained from the gross gamma borehole logging for many of the sites, but soil sampling information is available for the three units noted above.

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.

- 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 for the plutonium and americium beneath the 216-Z-1A Tile Field.

Table 8-1 also presents a first expression of the data needs for the individual waste management units in the Z Plant Aggregate Area, which must be addressed for remediation approaches to be developed.

8.2.2 Data Needs

The data needs for the Z 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 Z 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 Z 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 7.0 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 Z 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 Z 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 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 Z 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 μg/kg in soils, while the Model Toxics Control Act (MTCA) Method C Industrial soils cleanup level is 50 μg/kg (Ecology 1991). 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.

Comparability will be met through the use of Westinghouse Hanford standard procedures generally incorporated into the *Environmental Investigation and Site Characterization Manual* (WHC 1988b).

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 Z 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 Z 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 1988b).

8.3.2 General Strategy

The overall objective of any field investigation (LFI, IRM, or RI) of the sites in the Z 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 1988b). 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 Z 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.

- Conduct nonintrusive surface geophysical surveys at specific waste management units (e.g., the 2607-Z-1 Septic Tank and Drain Field) 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 μR 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 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 4-11) 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 207-Z Retention Basin and the 216-Z-21 Seepage 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 UO_3 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.

- 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 Z Plant AAMS are met
- To confirm that data are representative of the media sampled and that QA/QC criteria have been met.

Table 8-1. Uses of Existing Data for Z Plant Aggregate Area Waste Management Units. (Sheet 1 of 4)

Waste Management Unit	Development of Sampling Plans			Health and Safety	
	Location	Possible Contamination	Depth of Contamination	Surface Radiation	Expected Max. Level
Tanks and Sanitary Vaults					
216-Z-8 Settling Tank	X	X			
241-Z-361 Settling Tank	X				
Cribs, Trenches, and Tile Fields					
216-Z-1 and 216-Z-2 Cribs	X	X	X	X	
216-Z-3 Crib	X	X	X	X	
216-Z-5 Crib	X	X	X	X	
216-Z-6 Crib	X	X	X	X	
216-Z-7 Crib	X	X	X	X	
216-Z-12 Crib	X	X	X	X	
216-Z-16 Crib	X	X	X	X	
216-Z-18 Crib	X	X	X	X	
216-Z-8 French Drain	X	X	X	X	X
216-Z-13 French Drain	X	X		X	
216-Z-14 French Drain	X	X		X	
216-Z-15 French Drain	X	X		X	
216-Z-1A Tile Field	X	X	X	X	X

Table 8-1. Uses of Existing Data for Z Plant Aggregate Area Waste Management Units. (Sheet 2 of 4)

Waste Management Unit	Development of Sampling Plans			Health and Safety	
	Location	Possible Contamination	Depth of Contamination	Surface Radiation	Expected Max. Level
Reverse Well					
216-Z-10 Reverse Well	X	X	X	X	
Ponds, Ditches, and Trenches					
216-Z-4 Trench	X	X		X	
216-Z-9 Trench	X	X	X	X	X
216-Z-17 Trench	X	X	X	X	
Septic Tanks					
2607-Z Septic Tank and Drain Field	X				
2607-Z-1 Septic Tank and Drain Field	X				
2607-WA Septic Tank and Drain Field	X				
2607-WB Septic Tank and Drain Field	X				
2607-W-8 Septic Tank and Drain Field	X				
Transfer Facilites, Diversion Boxes, and Pipelines					
241-Z Diversion Box No.1	X	X			
241-Z Diversion Box No. 2	X	X			
231-Z-151 Sump	X	X			

Table 8-1. Uses of Existing Data for Z Plant Aggregate Area Waste Management Units. (Sheet 3 of 4)

Waste Management Unit	Development of Sampling Plans			Health and Safety	
	Location	Possible Contamination	Depth of Contamination	Surface Radiation	Expected Max. Level
Basins					
207-Z Retention Basin	X	X			
216-Z-21 Seepage Basin	X	X			
Solid Waste Burial Sites					
218-W-1 Burial Ground	X	X		X	
218-W-1A Burial Ground	X	X		X	
218-W-2 Burial Ground	X	X		X	
218-W-3 Burial Ground	X	X		X	
218-W-4A Burial Ground	X	X		X	
218-W-11 Burial Ground	X	X		X	
Z-Plant Burn Pit	X				
Unplanned Releases					
UN-200-W-11	X	X			
UPR-200-W-16	X	X			
UN-200-W-23	X	X			
UPR-200-W-26	X	X			
UN-200-W-44		X			
UPR-200-W-53	X	X			
UPR-200-W-72	X	X			

Table 8-1. Uses of Existing Data for Z Plant Aggregate Area Waste Management Units. (Sheet 4 of 4)

Waste Management Unit	Development of Sampling Plans			Health and Safety	
	Location	Possible Contamination	Depth of Contamination	Surface Radiation	Expected Max. Level
UPR-200-W-84	X	X			
UN-200-W-89	X	X			
UN-200-W-90	X	X			
UN-200-W-91	X	X			
UN-200-W-103	X	X		X	
UN-200-W-130	X	X			
UPR-200-W-134	X				
UPR-200-W-158	X	X			
UN-200-W-159		X			

Table 8-2. Data Needs for Preliminary Remedial Action Alternatives for the Z Plant Aggregate Area.

Alternative	Physical Attribute	Chemical/Radiochemical Attribute
1. Multimedia Cover (plus possible vertical barriers)	• areal extent • depth of contamination • structural integrity (collapse potential) • run-off/run-on potential • cover properties (permeability)	• surface radiation • biologic transport potential
2. In Situ Grouting/ Stabilization	• areal extent • depth • particle size • hydraulic properties (permeability/porosity) • stratigraphy • borehole spacing • grout/additive mix parameters	• solubility • reactivity • leachability from grout medium
3. Excavation, Soil Treatment, and Disposal	• areal extent[a/] • depth[a/] • particle size • silt-size (dust) content • excavation stability	• 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	• areal extent • depth • soil/waste conductivity • thermal properties • moisture content • voids • air permeability	• volatility • reactivity • leachability/integrity • off-gas treatment waste disposal options
5. Excavation, Above Ground Treatment,and Geologic Disposal	• areal extent[a/] • depth[a/] • mineralogy of soil/waste • particle size • silt-size (dust) content • excavation stability • treatment parameters	• 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	• areal extent • depth • locations/depth of highest concentrations (vapors, adsorbed) • stratigraphy • soil permeability/porosity • voids	• 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 Z Plant Aggregate Area.

Level	Description
LEVEL I	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.
LEVEL II	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.
LEVEL III	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.
LEVEL IV	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.
LEVEL V	Nonstandard methods. Analyses which may require method modification and/or development are considered Level V by CLP Special Analytical Services (SAS).

Table 8-4. Comprehensive List of Analytes and Parameters for the Z Plant Aggregate Area. (Sheet 1 of 5)

Radionuclides	Soil/Sediment				Water			
	Analysis[1/]	PQL[1/] in pCi/g	Precision[2/] in RPD	Accuracy[2/] in %	Analysis[1/]	PQL[1/] in pCi/L	Precision[2/] in RPD	Accuracy[2/] in %
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
Gross Gamma	TBD	TBD	±30	±25	TBD	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	±20
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
Barium-133	TBD	TBD	±30	±25	TBD	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-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

Table 8-4. Comprehensive List of Analytes and Parameters for the Z Plant Aggregate Area. (Sheet 2 of 5)

Radionuclides	Soil/Sediment				Water			
	Analysis[1/]	PQL[1/] in pCi/g	Precision[2/] in RPD	Accuracy[2/] in %	Analysis[1/]	PQL[1/] in pCi/L	Precision[2/] in RPD	Accuracy[2/] in %
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	D3649 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
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

Table 8-4. Comprehensive List of Analytes and Parameters for the Z Plant Aggregate Area. (Sheet 3 of 5)

Radionuclides	Soil/Sediment				Water			
	Analysis[1/]	PQL[1/] in pCi/g	Precision[2/] in RPD	Accuracy[2/] in %	Analysis[1/]	PQL[1/] in pCi/L	Precision[2/] in RPD	Accuracy[2/] in %
Selenium-79	TBD	TBD	±30	±25	TBD	2.5	±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
Technetium-99	Tc-01 M	TBD	±30	±25	Tc-01	TBD	±25	±25
Thallium-204	TBD	TBD	±30	±25	TBD	300	±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-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-236	U	TBD	±30	±25	908.0	TBD	±25	±25
Uranium-238	U	TBD	±30	±25	908.0	TBD	±25	±25
Yittrium-90	Sr-02	TBD	±30	±25	Sr-02	TBD	±25	±25

Table 8-4. Comprehensive List of Analytes and Parameters for the Z Plant Aggregate Area. (Sheet 4 of 5)

Inorganics	Soil/Sediment				Water			
	Analysis[1/]	PQL[1/] in mg/kg	Precision[2/] (RPD)	Accuracy[2/] (%)	Analysis[1/]	PQL[1/] in μg/L	Precision[2/] (RPD)	Accuracy[2/] (%)
Aluminum	6010	0.45	±25	±30	6010	450	±20	±25
Ammonia	350.2 M	500	±25	±30	350.2	500	±20	±25
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
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	340 M	TBD	±25	±30	340	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	0.002	±25	±30	245.2	2	±20	±25
Nickel	6010	1.5	±25	±30	6010	50	±20	±25
Nitrate	353 M	TBD	±25	±30	353	130	±20	±25
Nitrite	353 M	TBD	±25	±30	353	40	±20	±25
Selenium	6010	0.75	±25	±30	270.2	20	±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

Table 8-4. Comprehensive List of Analytes and Parameters for the Z Plant Aggregate Area. (Sheet 5 of 5)

Organics	Soil/Sediment				Water			
	Analysis[1/]	PQL[1/] in mg/kg	Precision[2/] (RPD)	Accuracy[2/] (%)	Analysis[1/]	PQL[1/] in μg/L	Precision[2/] (RPD)	Accuracy[2/] (%)
Acetone	8240	0.1	±25	±30	8240	100	±20	±25
Carbon tetrachloride	8240	0.005	±25	±30	8240	1	±20	±25
Chloroform	8240	0.005	±25	±30	8240	5	±20	±25
DDT	8080	0.008	±25	±30	8080	0.1	±20	±25
Kerosene	8015 M	20	±35	±30	8015 M	500	±35	±25
Methylene chloride	8240	0.005	±25	±30	8240	5	±20	±25
MIBK	8015	0.5	±25	±30	8015	5	±20	±25
Toluene	8240	0.005	±25	±30	8240	5	±20	±25
Tributyl phosphate	TBD	TBD	±35	±30	TBD	TBD	±30	±25

Notes:

TBD To Be Determined
M EPA method modified to include extraction from the solid medium, extraction method is matrix- and laboratory-specific is therefore TBD.
PQL Practical Quantitation Limits
RPD Relative Percent Difference
mg/kg milligrams per kilogram
μg/L micrograms per liter

1/ *Prescribed Procedures for Measurements of Radioactivity in Drinking Water* (EPA 1980a)
Test Methods for Evaluation of Solid Waste (SW 846) Third Edition (EPA 1986)
Methods for Chemical Analysis of Water and Waste (EPA 1983a)
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)

2/ Precision and accuracy are goals. Since these parameters are highly matrix dependent they could vary greatly from the goals listed.

Table 8-5. Data Gaps by Waste Management Unit Category.

Waste Management Unit Category	Identified Data Gaps
Tanks	• Integrity of tanks and piping • Contaminant concentrations in tank wastes • Volume of tank wastes • Contaminant concentrations and distributions in soils beneath tank
Cribs, Trenches, Tile Fields, Drain Fields	• Surface soil contaminant concentrations • Subsurface soil contaminant concentrations • Soil gas contaminant concentrations • Vertical/lateral extent of contamination • Specific constituents (especially organics and heavy metals)
French Drains, Reverse Wells	• Subsurface soil contaminant concentrations • Vertical/lateral extent of contamination • Specific constituents
Burn Pit	• Specific constituents (organics, heavy metals)
Retention Basin	• Surface radiation readings • Surface sediment contaminant concentrations • Subsurface soil contaminant concentrations • Specific constituents
Seepage Basin	• Surface water concentrations • Sediment concentrations • Vertical/lateral extent of contamination
Burial Grounds	• Surface soil contaminant concentrations • Subsurface soil contaminant concentrations • Vertical/lateral extent of contamination • Specific constituents (organics/heavy metals)
Unplanned Releases	• Constituents and concentrations in subsurface soils. • Distribution/extent of subsurface contamination.

Table 8-6. Applicable Characterization Methods at Z Plant Aggregate Area Waste Management Units. (Sheet 1 of 4)

Waste Management Unit	Surface Radiation Survey	Subsurface Spectral Geophysics	Surface Geophysics	Soil Gas Survey	Surface Soil Sampling	Subsurface Soil Sampling	Perched Zone Monitor-ing Wells	Remarks
Tanks and Vaults								
216-Z-8 Settling Tank	X				X			Analogous Site
241-Z-361 Settling Tank	X				X			Analogous Site
Cribs and Drains								
216-Z-1 & 216-Z-2 Cribs	X	X			X			Analogous Site
216-Z-3 Crib	X	X			X			Analogous Site
216-Z-5 Crib	X	X			X			Analogous Site
216-Z-6 Crib	X	X			X			Analogous Site
216-Z-7 Crib	X	X			X			Analogous Site
216-Z-12 Crib	X	X			X	A	A	Analogous Site
216-Z-16 Crib	X	X			X			Analogous Site
216-Z-18 Crib	X	X			X			Analogous Site
216-Z-8 French Drain	X	X			X	X		
216-Z-13 French Drain	X				X	X		
216-Z-14 French Drain	X				X	X		
216-Z-15 French Drain	X				X	X		
216-Z-1A Tile Field	X	X		A	X	A	A	Analogous Site*
Reverse Well								
216-Z-10 Reverse Well	X	X			X	X	X	

Table 8-6. Applicable Characterization Methods at Z Plant Aggregate Area Waste Management Units. (Sheet 2 of 4)

Waste Management Unit	Surface Radiation Survey	Subsurface Spectral Geophysics	Surface Geophysics	Soil Gas Survey	Surface Soil Sampling	Subsurface Soil Sampling	Perched Zone Monitor-ing Wells	Remarks
Ponds, Ditches, and Trenches								
216-Z-4 Trench	X	X			X			Analogous Site*
216-Z-9 Trench	X	X		X	X			Analogous Site*
216-Z-17 Trench	X	X			X			Analogous Site*
Septic Tanks and Associated Drain Fields								
2607-Z Septic Tank and Drain Field			X			X	X	
2607-Z-1 Septic Tank and Drain Field			X			X		
2607-WA Septic Tank and Drain Field			X			X	X	
2607-WA Septic Tank and Drain Field			X			X		
2607-W-8 Septic Tank and Drain Field			X			X		
Transfer Facilities, Diversion Boxes, and Pipeline								
241-Z Diversion Box No. 1	X				X			Analogous Site*
241-Z Diversion Box No. 2	X				X			Analogous Site*
231-Z-151 Sump	X				X			Analogous Site*
Basins								
241-Z Retention Basin	X				X	X		
216-Z-21 Seepage Basin					X	X	X	

Table 8-6. Applicable Characterization Methods at Z Plant Aggregate Area Waste Management Units. (Sheet 3 of 4)

Waste Management Unit	Surface Radiation Survey	Subsurface Spectral Geophysics	Surface Geophysics	Soil Gas Survey	Surface Soil Sampling	Subsurface Soil Sampling	Perched Zone Monitor-ing Wells	Remarks
Burial Sites								
218-W-1 Burial Ground					X			Analogous Site
218-W-1A Burial Ground					X			Analogous Site
218-W-2 Burial Ground					X			Analogous Site
218-W-3 Burial Ground					X			Analogous Site
218-W-4A Burial Ground					X	A		Analogous Site
218-W-11 Burial Ground	X				X			Analogous Site
Z Plant Burn Pit	X				X	X		
Unplanned Releases								
UN-200-W-11	X				X			218-W-1 Burial Ground
UPR-200-W-16	X				X			218-W-4A Burial Ground
UN-200-W-23	X				X	X		
UPR-200-W-26	X				X			218-W-4A Burial Ground
UN-200-W-44	X				X			
UPR-200-W-53	X				X			218-W-4A Burial Ground
UPR-200-W-72	X				X			218-W-4A Burial Ground
UPR-200-W-84	X				X			218-W-1 Burial Ground
UN-200-W-89	X				X			
UN-200-W-90	X				X			
UN-200-W-91	X				X			
UN-200-W-103	X				X	X		

Table 8-6. Applicable Characterization Methods at Z Plant Aggregate Area Waste Management Units. (Sheet 4 of 4)

Waste Management Unit	Surface Radiation Survey	Subsurface Spectral Geophysics	Surface Geophysics	Soil Gas Survey	Surface Soil Sampling	Subsurface Soil Sampling	Perched Zone Monitor-ing Wells	Remarks
UN-200-W-130	X				X	X		231-Z-151 Sump
UPR-200-W-134	X				X			218-W-1 Burial Ground
UPR-200-W-158	X				X			218-W-1A Burial Ground
UN-200-W-159	X				X			

Notes:
A Representative analogue site for investigation of units in this waste management unit category.
* Analogous to cribs.

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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 Z 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 Z 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.

An ERA for liquid removal from two settling tanks is recommended to minimize potential leakage. Several waste management units assessed within the ERA path were

recommended for actions that fall within the scope of existing operational programs. Wooden cribs with collapse potential and waste management units with elevated levels of surface radionuclide contamination are addressed by the RARA program. Expedited Response Actions are recommended for three sites which may contribute to volatile organic contaminant migration.

A majority of 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. No waste management units or unplanned releases are recommended for IRMs (Section 9.2.2.). LFIs were recommended for all cribs, trenches, a tile field, six solid waste burial grounds (Section 9.2.3) and associated unplanned releases. Inclusion in the aggregate area risk assessment was recommended for one unplanned release for which sufficient information appears to exist to perform the assessment; available information indicates that the risk assessment would likely conclude that no further remediation will be necessary (Section 9.2.4.2). Inclusion in the aggregate area RI is recommended for the remaining liquid waste disposal units and solid waste disposal units, along with their corresponding unplanned releases (Section 9.2.4.1).

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 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. An aggregate area-based field characterization study is recommended to be undertaken to assess volatile gases in the Z Plant Agregate Area (primarily carbon tetrachloride) and associated meteorological affects (see Section 9.6). 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. No new sites were identified in the Z Plant Aggregate Area.

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, the 241-Z Treatment Tank, the 216-Z-13, 216-Z-14, and 216-Z-15 French Drains, five septic tanks and associated drain fields, the 216-Z-21 Seepage Basin, and several solid waste burial grounds. 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 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 Z 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

Twelve waste management units met all the criteria for an ERA prior to determining whether the proposed action was within the scope of an operational program. The twelve ERA candidates are:

- 216-Z-8 Settling Tank
- 216-Z-361 Settling Tank
- 216-Z-18 Crib
- 216-Z-1A Tile Field
- 216-Z-9 Trench
- 216-Z-1 and 216-Z-2 Crib
- 216-Z-5 Crib
- 216-Z-6 Crib
- 216-Z-7 Crib
- 218-W-2 Burial Ground

- 218-W-4A Burial Ground
- 216-Z-21 Seepage Basin.

Two inactive settling tanks 216-Z-8 Settling Tank and 241-Z-361 Settling Tank, were recommended for an ERA. Six ERA candidates, consisting of cribs with collapse potential and surface contamination sites, were recommended for disposition under the RARA program. Three inactive liquid waste management units were recommended for expedited action under the ongoing carbon tetrachloride ERA. A discussion of the recommendations for these waste management units are included in this section. Since the anticipated response actions are not expected to fully remediate the ERA candidates, all of the units will be included for further data evaluation in the assessment paths.

9.2.1.1 Sites Contributing to Volatile Organic Contamination Migration. Three waste management units in the Z Plant Aggregate Area, the 216-Z-18 Crib, the 216-Z-1A Tile Field, and the 216-Z-9 Trench received substantial quantities of carbon tetrachloride during the RECUPLEX and PRF operations. The quantity of carbon tetrachloride, a known carcinogen, disposed of to these three units (approximately 920,000 Kg [2 million lb]) exceeds 100 times the CERCLA reportable quantity (10 Kg [22 lb]). Carbon tetrachloride vapors are known to emanate from Z Plant Aggregate Area soils. Due to the density and volatility of carbon tetrachloride, vapor phase migration is likely. Continued migration of carbon tetrachloride vapors may result in soil and groundwater contamination exceeding 100 times applicable standards. Carbon tetrachloride has been detected in groundwater at concentrations of over 5,000 μg/L near the crib, tile field, and trench, which is more than 1,000 times the Drinking Water MCL of 5 μg/L.

Actions for control of subsurface vapor migration have been implemented at the 216-Z-18 Crib and the 216-Z-1A Tile Field as part of the Carbon Tetrachloride Expedited Response Action Program (DOE/RL 1991b). A soil vapor extraction system coupled with granular activated carbon adsorption units to remove entrained volatile organics is operating at these two units. A similar extraction and treatment system is expected to be brought online at the 216-Z-9 Trench in the Spring 1993.

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 concentration standards. Cribs with potential collapse problems include:

- 216-Z-1 and 216-Z-2
- 216-Z-5

- 216-Z-6
- 216-Z-7.

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 for the 200 Areas 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 Sites with Significant Surface Contamination. There are four waste management units in the Z Plant Aggregate Area evaluated in the AAMS program with levels of surface contamination that are high enough to be of immediate concern. Surface contamination is the most immediately accessible to humans 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 waste management units would be greater than 100 times reportable quantity and concentration standards. The corrective action for waste management units with surface contamination is addressed within the scope of the RARA Program.

As discussed in Section 5.2.2, recent radiation survey results indicate that the following waste management units exceed surface contamination criteria:

- 216-Z-1 and 216-Z-2 Cribs
- 216-Z-1A Tile Field
- 218-W-2 Burial Ground
- 218-W-4A Burial Ground.

Surface contamination control activities at these units are recommended for evaluation and implementation under the RARA program.

9.2.1.4 Tanks with Leak Potential. Two tanks, the 241-Z-361 Settling Tank and the 216-Z-8 Settling Tank, contain drainable liquids. These tanks are estimated to be over 35 years old and have the potential to leak radioactive and hazardous liquid to the soil. The settling tanks are inactive facilities. It is recommended that the liquid stored within the tanks be removed to prevent future leakage.

9.2.1.5 Active Waste Management Units. One active liquid effluent unit operates within the Z Plant Aggregate Area, the 216-Z-21 Seepage Basin. Operation of this unit 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 this unit by June 1995. In the interim, hazardous wastes will not be discharged to this unit. Evaluation and deactivation of this unit 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 unit will be deferred until after deactivation of the unit.

9.2.1.6 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 contaminants. Natural recharge from local precipitation was not considered a significant short-term driving force. Specifics for each waste management unit and unplanned release are provided in Table 9-2.

A majority of the unplanned releases 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

Nineteen of the 53 waste management units addressed in the Z Plant Aggregate Area data evaluation process were identified as high priority sites (refer to Section 5.0) and were assessed as candidates for IRMs. Three of the waste management units designated as high priority sites (216-Z-7 Crib, 216-Z-17 Trench, and the 216-Z-10 Reverse Well) were so designated because of high HRS scores. Five waste management units (216-Z-1A Tile Field, 216-Z-21 Seepage Basin, 218-W-1 Burial Ground, 218-W-2 Burial Ground, and 218-W-4A Burial Ground) were designated as high priority because of surface radiation measurements. Ten unplanned releases (UPR-200-W-16, UN-200-W-23, UPR-200-W-26, UN-200-W-44, UPR-200-W-53, UPR-200-W-72, UPR-200-W-84, UN-200-W-91, UN-200-W-130, and UPR-200-W-158) were designated as high priority due to elevated surface radiation measurements. One waste management unit (216-Z-1 and 216-Z-2 Cribs) was identified as a high priority site due to high HRS scores and elevated surface radiation measurements.

Another eighteen waste management units and unplanned releases (216-Z-3 Crib, 216-Z-5 Crib, 216-Z-6 Crib, 216-Z-12 Crib, 216-Z-16 Crib, 216-Z-18 Crib, 241-Z-361 Settling Tank, 216-Z-8 Settling Tank, 241-Z Diversion Box No. 1, 241-Z Diversion Box No. 2, 231-Z-151 Sump, 216-Z-4 Trench, 216-Z-9 Trench, 218-W-3 Burial Ground, 218-W-1A Burial Ground, 218-W-11 Burial Ground, UN-200-W-11, and UPR-200-W-134) were tentatively identified as having sufficient proximity and/or similarity to the high priority sites to warrant inclusion in the IRM assessment path.

None of the 37 candidate waste management units are recommended for IRMs without first conducting LFIs. The reason for this determination is that there was not adequate data for any of the evaluated units to support performing a qualitative risk assessment and/or select a final remedy. Two waste management units evaluated in the IRM path, the 216-Z-10 Reverse Well, and the 216-Z-21 Seepage Basin, do not remain as IRM candidates because it was determined that LFIs would not result in collecting sufficient data to proceed with consideration as an IRM candidate. The 216-Z-10 Reverse Well and the 216-Z-21 Seepage Basin were carried forward to the final remedy selection path for further evaluation and are discussed in Section 9.2.4. Similarly, three high priority unplanned releases (UN-200-W-23, UN-200-W-44, and UN-200-W-91) are recommended for direct inclusion in the final remedy selection path discussed in Section 9.2.4.1 because it was determined that an LFI would not result in collecting sufficient data to proceed with consideration as an IRM candidate. Thirty-two waste management units remain as IRM candidates but require LFIs to obtain sufficient information to proceed with the IRM evaluation. Discussion of the recommended LFIs is provided in Section 9.2.3.

9.2.3 Proposed Sites for Limited Field Investigation Activities

Thirty-two 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. At least partial inventory information was identified for most of the IRM candidate sites. Limited soil sample chemical and radionuclide testing data were found for the 216-Z-1A Tile Field, the 216-Z-9 Trench, the 216-Z-12 Crib, the 216-Z-18 Crib, and the 218-W-2 Burial Ground. No soil sample chemical or radionuclide testing data were found for the remaining IRM candidate units. Gross gamma logging data were identified for the 216-Z-1 & 216-Z-2 Cribs, the 216-Z-3, 216-Z-5, 216-Z-7, 216-Z-12, 216-Z-16 and 216-Z-18 Cribs, the 216-Z-1A Tile Field, and the 216-Z-9 Trench. Deep vadose zone sampling data were limited, but sufficient information was identified to indicate that maximum concentrations of most constituents exist at or near the surface and decrease with depth. These existing data, together with limited additional investigation of selected representative facilities should be adequate to characterize these sites for risk assessments and IRMs.

The rationale and scope of the LFIs will be defined and implemented via work plans; however, the following addresses possible considerations for 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 units and unplanned releases, and if so, assess the extent
- Assess the nature and extent of contaminant migration from the waste management units and unplanned releases in support of focused feasibility studies.

Each waste management unit that is recommended for an LFI will generally 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 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 were assembled into analogous groups for study. Two primary analogous groups have been identified in the Z Plant Aggregate Area: (1) cribs, trenches, and a tile field; and (2) burial grounds. Specific waste management units and unplanned releases were then identified that were 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 those units or releases that received the most waste and were considered as conservative examples in terms of release mechanisms, media of concern, exposure routes, and receptors.

9.2.3.1 Cribs, Trenches, and 216-Z-1A Tile Field. Twelve waste management units have been assigned to this analogous group due to their similar operational history (operated during PFP plutonium and americium recovery processes), waste stream received (low to high salt, neutral to acidic, low to high organic process waste and laboratory waste), and

location (clustered around the PFP). Five additional waste management units (two settling tanks and three diversion boxes) were assigned to this analogous group because they are part of the transfer system used to route liquid waste to the various cribs and trenches. The settling tanks and diversion boxes should be investigated or remediated concurrently with the piping associated with the cribs and trenches. These units include the following:

- 216-Z-1 and 216-Z-2 Cribs
- 216-Z-3 Crib
- 216-Z-5 Crib
- 216-Z-6 Crib
- 216-Z-7 Crib
- 216-Z-12 Crib
- 216-Z-16 Crib
- 216-Z-18 Crib
- 216-Z-1A Tile Field
- 216-Z-4 Trench
- 216-Z-9 Trench
- 216-Z-17 Trench
- 216-Z-8 Settling Tank
- 241-Z-361 Settling Tank
- 241-Z Diversion Box No. 1
- 241-Z Diversion Box No. 2
- 231-Z-151 Sump and Unplanned Release UN-200-W-130.

The physical and chemical setting for releases from these waste management units is also similar:

- Relatively large-scale liquid releases (11,000 to 281,000,000 L [2,900 to 74,000,000 gal]) occurred at these waste management units likely affecting near-surface and deeper vadose zone soils.

- The waste management units were completed to roughly the same depths and thus are likely completed in the same stratigraphic horizon. Likewise, the depth to groundwater, approximately 50 m (164 ft), is similar for all of these waste management units.

- Generally uniform soil stratigraphy, consisting of relatively permeable sands and gravels of the Hanford formation overlying the relatively impermeable early "Palouse" soil and Plio-Pleistocene unit which in turn overlie the highly permeable gravels of the Ringold Formation is observed near the PFP where the cribs and trenches are located. These soil conditions would tend to favor primarily downward fluid movement with limited lateral spreading in near-surface soils with perching and lateral spreading likely at the contact with the early "Palouse" soil and Plio-Pleistocene unit.

- The waste management units likely received wastewater from the 234-5Z Building, 231-Z Building, and support facilities containing TRUs and various inorganics such as nitrate, nitric acid, sodium, and fluoride.

The 216-Z-12 Crib is proposed as an analogue LFI site for the 216-Z-3 Crib, the 216-Z-5 Crib, the 216-Z-6 Crib, the 216-Z-7 Crib, the 216-Z-16 Crib, the 216-Z-4 Trench, and the 216-Z-17 Trench. The 216-Z-8 Settling Tank, the 241-Z-361 Settling Tank, the 241-Z Diversion Box No. 1, the 241-Z Diversion Box No. 2, and the 231-Z-151 Sump are recommended for inclusion in the crib and trench LFI because they are integral parts of the crib and trench liquid effluent disposal system. The unplanned release (UN-200-W-130) associated with the 231-Z-151 Sump is also recommended for inclusion in the LFI due to its proximity to the sump. The 216-Z-12 Crib received the largest volume of waste in the group (281,000,000 L [74,000,000 gal]) and received a substantial inventory of total plutonium and Uranium (25 Kg [55 lb] and 1.7×10^{-5} Ci, respectively). In addition, the time of use of the 216-Z-12 Crib (1959 to 1973) overlaps the operating periods for the other facilities. Thus, the 216-Z-12 Crib would be a conservative representative, with a common operating history, for the other cribs, trenches, and tile fields in this analogous group.

The 216-Z-12 Crib is also proposed as a partial analogue LFI site for the waste management units that received waste liquids containing carbon tetrachloride (216-Z-1 and 216-Z-2 Cribs, 216-Z-18 Crib, 216-Z-1A Tile Field, and 216-Z-9 Trench). The inventory of waste volumes and radionuclides received by the 216-Z-12 Crib compare to or exceed those

received by these four waste management units. The physical and chemical setting for releases from the 216-Z-1 and 216-Z-2 Cribs, the 216-Z-18 Crib, the 216-Z-1A Tile Field, and the 216-Z-9 Trench should be basically similar to the physical and chemical setting described above for the other cribs and trenches (including the 216-Z-12 Crib). Thus, the 216-Z-12 Crib should be able to serve as an analogue for the 216-Z-1 and 216-Z-2 Cribs, the 216-Z-18 Crib, the 216-Z-1A Tile Field, and the 216-Z-9 Trench in many aspects of contaminant migration, exposure pathways, and impacts on groundwater.

A significant difference, related to the waste streams received, is the carbon tetrachloride content of the waste stream disposed of to the 216-Z-1 and 216-Z-2 Cribs, the 216-Z-18 Crib, the 216-Z-1A Tile Field, and the 216-Z-9 Trench. Because carbon tetrachloride was used to extract plutonium during the PRF and RECUPLEX processes, it has a potential for enhancing the mobility of residual plutonium in waste streams in which it is present. Also, carbon tetrachloride was generally codisposed with acidic (nitric acid) waste. As a result, plutonium and other radionuclides might be expected to have been more mobile in the subsurface at these four locations than at other waste disposal sites which did not receive carbon tetrachloride or acidic waste. Additionally, because carbon tetrachloride is a carcinogen, its presence in waste streams is also a health and environmental concern.

Remediation of the carbon tetrachloride present in soil beneath the 216-Z-18 Crib, the 216-Z-1A Tile Field, and the 216-Z-9 Trench should be addressed by the Carbon Tetrachloride ERA (DOE/RL 1991b). However, additional LFIs are recommended for these units to obtain supplemental data, specific to these cribs, regarding the potential distribution of radionuclides potentially affected by concurrent disposal of carbon tetrachloride and related compounds (e.g., tributylphosphate, DBBP). Because it has a substantial amount of soil sampling data, the 216-Z-1A Tile Field is recommended as the analogue for the carbon tetrachloride disposal units. The LFIs for the two cribs, trench, and tile field should focus on gathering information about the unique contaminants released to the waste management units and their migration in the environment. The data could then be used to augment the information gathered from the 216-Z-12 Crib LFI to determine if opportunities for IRMs exist at all of these facilities.

9.2.3.2 Burial Grounds. The second analogous group consists of solid waste burial grounds and associated unplanned releases. These include:

- 218-W-1 Burial Ground and Unplanned Releases UN-200-W-11, UPR-200-W-84, and UPR-200-W-134
- 218-W-1A Burial Ground and Unplanned Release UPR-200-W-158
- 218-W-2 Burial Ground
- 218-W-3 Burial Ground

- 218-W-4A Burial Ground and unplanned releases UPR-200-W-16, UPR-200-W-26, UPR-200-W-53, and UPR-200-W-72

- 218-W-11 Burial Ground

The six burial grounds listed above are proposed as an analogous group due to their similar operational history, waste material received (TRU mixed solid waste), and location (all near east central portion of Z Plant Aggregate Area).

The physical and chemical setting for releases from the burial grounds is also similar:

- These burial grounds reportedly received dry TRU and mixed solid waste from various Hanford Site operations. All of the facilities have been inactive for at least 20 years.

- The burial ground trenches were completed to roughly the same depths and thus are likely completed in the same stratigraphic horizon. Likewise, the depth to groundwater, approximately 69 m (220 ft), is similar for all of these waste management units.

- Generally uniform soil stratigraphy, consisting of relatively permeable sands and gravels of the Hanford formation overlying the relatively impermeable early "Palouse" soil and Plio-Pleistocene unit which in turn overlie the highly permeable gravels of the Ringold Formation, is observed near the east central part where these burial grounds are located. If fluids had been introduced, these soil conditions would tend to favor primarily downward fluid movement with limited lateral spreading in near-surface soils with perching and lateral spreading likely at the contact with the early "Palouse" soil and Plio-Pleistocene unit.

- No liquid releases are known to have occurred in these waste management units. However, surface releases which consequently involved fugitive dust migration affect nearby surficial soils at several of the burial grounds (218-W-1, 218-W-1A, and 218-W-4A).

The 218-W-4A Burial Ground is proposed as an analogue LFI site for the 218-W-1, 218-W-1A, 218-W-2, 218-W-3, and 218-W-11 Burial Grounds. The 218-W-4A Burial Ground received the largest volume of waste in the group (18,000 m^3 [636,000 ft^3]) and received a substantial inventory of plutonium and cesium-137 (35 Kg [77 lb] and 39.3 Ci, respectively). Four unplanned releases (UPR-200-W-16, UPR-200-W-26, UPR-200-W-53, and UPR-200-W-72) involving surface soil contamination by plutonium and/or ruthenium are

associated with this unit. Thus, the 218-W-4A Burial Ground would be a conservative representative, with a common operating history, for the other burial grounds in this analogous group.

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. It was determined that sufficient information may exist to perform a RA and select a final remedy for one unplanned release; this is discussed in Section 9.2.4.2. 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 is recommended for several groups of waste management units and unplanned releases in the Z Plant Aggregate Area. These groups consist of the following:

- French drains which generally received waste water containing only traces of radionuclides and hazardous chemicals.
- Septic tanks and sanitary drain fields which are not believed to have received radionuclides and hazardous chemicals.
- Basins, one of which is still active, which are low priority sites.
- 216-Z-10 Reverse Well, which, although a high priority unit, is sufficiently unique as to require RI.
- Low priority solid waste burial sites.
- Low priority unplanned releases.

9.2.4.1.1 French Drains. A RI is recommended to include each of the french drains:

- 216-Z-8
- 216-Z-13

- 216-Z-14
- 216-Z-15.

These four waste management units all are low priority and they are not sufficiently similar to high priority units to warrant evaluation under the IRM path, so they could not be recommended for LFIs.

Insufficient data exist at these units to conduct a RA. Inclusion in the aggregate area RI is recommended for each of these units to provide nature and extent of contamination information to perform a RA for final remedy selection.

9.2.4.1.2 Septic Tanks and Drain Fields. A RI is recommended to include each of the septic tanks and drain fields:

- 2607-Z
- 2607-Z-1
- 2607-WA
- 2607-WB
- 2607-W-8.

These five waste management units all have been assigned low HRS scores by comparison with other waste management units and they are not sufficiently similar to high priority units to warrant evaluation under the IRM path, so they could not be recommended for LFIs.

There are no sampling or inventory data for any of these units and so a RA cannot be performed. The purpose of a limited sampling program under an aggregate area RI would be to confirm that no contamination exists in the septic tanks and drain fields. If no contamination is found, then no further action would likely be recommended.

9.2.4.1.3 Basins. A RI is recommended to include the following basins:

- 241-Z Retention Basin
- 216-Z-21 Seepage Basin

The 216-Z-21 Seepage Basin was first assessed in the ERA path, but due to potential adverse consequences associated with halting discharges to the seepage basin, an ERA could

not be recommended. Both basins in this group are low priority units and they are not sufficiently similar to high priority units to warrant evaluation under the IRM path, so they could not be recommended for LFIs.

Insufficient data exist at these units to conduct a RA. Therefore, inclusion in the aggregate area RI is recommended for each of these units to provide nature and extent of contamination information to perform a RA for final remedy selection. Investigation of 216-Z-21 Seepage Basin should begin after wastewater discharges to the unit have been terminated.

9.2.4.1.4 Reverse Well. The 216-Z-10 Reverse Well was initially evaluated along the ERA path, but an ERA could not be recommended because it was determined that appropriate technology for treating and remediating the unit in an expedited manner was not available. The 216-Z-10 Reverse Well was further evaluated in the IRM path, but it was not retained as an IRM candidate because it was determined that an LFI would not result in collecting sufficient data to proceed with consideration as an IRM candidate.

Insufficient data exist at this unit to conduct a RA. Therefore, inclusion in the aggregate area RI is recommended to provide nature and extent of contamination information to perform a RA for final remedy selection.

9.2.4.1.5 Z Plant Burn Pit. A RI is recommended for the Z Plant Burn Pit. This waste management unit has been assigned a low HRS score by comparison with other units and it is not sufficiently similar to another high priority unit to warrant evaluation under the IRM path, so it could not be recommended for LFI. No sampling or inventory data were identified for the area, so a RA cannot be performed. Historical data regarding the Z Plant Burn Pit does not indicate the disposal of any radioactive or hazardous material.

This unit was recommended for inclusion in the aggregate area RI to provide enough data to confirm that contamination is not present. If no contamination is found, then no further action would likely be recommended.

9.2.4.1.6 Unplanned Releases. Six unplanned releases are recommended as candidates for inclusion in an aggregate area or operable unit RI. These unplanned releases are:

- UN-200-W-23
- UN-200-W-44
- UN-200-W-89
- UN-200-W-90

- UN-200-W-91
- UN-200-W-103.

Unplanned Releases UN-200-W-23, UN-200-W-44, UN-200-W-89, UN-200-W-90, and UN-200-W-103 all have HRS scores below 28.5, and do not have sufficient data to conduct a risk assessment. Unplanned Release UN-200-W-91 had insufficient information available for HRS scoring.

A lack of soil sample data and inconsistent survey data prevent RA completion for these six unplanned releases. Inclusion in the aggregate area RI has been recommended to provide enough data to confirm that contamination does not exist. If no contamination is found, no further action would likely be recommended.

9.2.4.2 Proposed Sites for Risk Assessment. One candidate, Unplanned Release UN-200-W-159, was recommended for direct inclusion in the aggregate area RA under the final remedy selection path. Unplanned release UN-200-W-159 was assigned a "low" HRS score (less than 28.5) by comparison to other unplanned releases. The exact location of the unplanned release was not identified. The contaminated area was remediated by excavating affected soil and placing it in a solid waste burial ground trench.

It is recommended that a RA be performed encompassing this unplanned release using available information. If the RA confirms that no contamination warranting remediation remains, it is likely that no further action will be required at this unplanned 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 Sites Deferred to Other Aggregate Areas or Programs

No Z Plant Aggregate Area waste management units and unplanned releases are recommended for consideration under other aggregate areas. 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.

The 232-Z Incinerator Building is scheduled for decontamination and decommissioning in fiscal year 1999 under the Decommissioning and RCRA Closure Program. Because no information was found indicating releases to the soil column below the facility had occurred or might occur in the near future, the 232-Z Incinerator Building should be kept within the scope of the Decommissioning and RCRA Closure Program and no further action would be pursued under the AAMS program.

Remediation of the RCRA TSDs (a treatment tank and seven burial grounds) should be addressed as part of the facility closure and/or final status permitting that will occur under RCRA. The unplanned releases associated with these units would most logically be remediated during the RCRA closure and/or permitting activities.

Deactivation of active liquid effluent units should remain within the existing Waste Management Program. The active facilities include the 216-Z-21 Seepage Basin and the 216-Z-20 Crib (note: the 216-Z-20 Crib is currently a U Plant waste management unit but has been recommended for transfer to the Z Plant Aggregate Area). Investigation of these facilities will be deferred until after deactivation.

9.3.2 Z Plant Operable Unit Redefinition

Redefinition of the 200-ZP-1, 200-ZP-2, and 200-ZP-3 Operable Units is suggested based on the data evaluation in this report. It is recommended that the source components of the 200-ZP-1 and 200-ZP-2 Operable Units be combined. This source operable unit should be designated as 200-ZP-2. A separate groundwater operable unit designated as 200-ZP-1 should be created. The 200-ZP-1 Groundwater Operable Unit should be defined by the hydrologic regime north of the U Pond mound including the groundwater beneath the Z and T Plant Aggregate Areas. This groundwater operable unit should be assigned a high priority consistent with the 200-ZP-2 Source Operable Unit.

The redefined 200-ZP-1 Groundwater Operable Unit should be as follows:

- Investigation of groundwater should be removed from the scope of the originally defined 200-ZP-1 and 200-ZP-2 operable units which are currently designated as combined source and groundwater operable units and included in a 200 West Area Groundwater Operable Unit designated 200-ZP-1. Groundwater beneath the operable unit interacts with all surrounding operable units since it is not confined by geographic boundaries. Groundwater contamination from nearby operable units has migrated beneath the 200-ZP Operable Units. Similarly, groundwater contamination originating within 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. No evidence of lateral contaminant migration in perched water-bearing zones, if present beneath the 200-ZP Operable Units, to or from locations outside the operable units was indicated by the available data. Consequently, perched water should remain within the scope of the source AAMS, since this generally is a localized phenomena within the unsaturated zone attributed to specific waste management units.

The redefined 200-ZP-2 Source Operable Unit should be as follows:

- All liquid waste disposal units (e.g., cribs, trenches, french drains) currently identified with the 200-ZP-1 and 200-ZP-2 Operable Units should be consolidated and the current boundaries reconfigured to only one operable unit (the 200-ZP-2) encompassing all of the liquid waste disposal units. Additionally, all unplanned releases within the reconfigured boundary should be included in the 200-ZP-2 Operable Unit.

- High-level waste transfer facilities and pipelines should remain within the scope of the Waste Management Program and the Decommissioning and RCRA Closure Programs. These facilities are also structures with no associated 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.

- Investigation of the 232-Z Incinerator 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. Remediation of the facility is likely to be only a decontamination and decommissioning action which is best suited for the Decommissioning and RCRA Closure Program.

- Include the 216-Z-20 Crib, an active liquid waste disposal facility currently defined within the scope of the 200-UP-1 Operable Unit, in the proposed 200-ZP-2 Operable Unit. The waste discharges to the 216- Z-20 Crib are from the PFP. 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 Z Plant Burn Pit in the 200-ZP-3 Operable Unit. No evidence of liquid waste disposal to the Z Plant Burn Pit was identified in data found for this unit. Even though the unit lies geographically within the boundaries of the 200-ZP-1 Operable Unit,t he operational history of the Burn Pit more closely parallels that of the Z Plant Aggregate Area solid waste burial grounds than the liquid waste disposal units. The basis of the LFI strategy in the AAMS is to evaluate facilities with similar operational histories as a group. Therefore, the Z Plant Burn Pit should be investigated with the other Z Plant Aggregate Area solid waste burial sites.

The redefined 200-ZP-3 Operable Unit should be as follows:

- High-level waste transfer facilities and pipelines should remain with the Waste Management Program and the Decommissioning and RCRA Closure Programs as discussed above.

- Include the Z Plant Burn Pit in the 200-ZP-3 Operable Unit as discussed above.

9.3.3 Investigation Prioritization

Very little if any data exist to rank the waste management units and unplanned releases within the Z 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 available information about inventories of wastes and contaminants, facility construction, and operational history, it is recommended that investigations be prioritized as follows:

- Facilities which discharged liquid waste containing radionuclides and/or hazardous constituents to the soil column should be evaluated first. First priority within this grouping is recommended for the cribs and associated transfer units, which received the largest quantities of contamination, with secondary priority given to the trenches, the reverse well, the tile field, the french drains, the basins, and the settling tanks.

- The burial grounds pose a potential for wind erosion and subsequent release to air, therefore they should be evaluated second.

- Other facilities which discharged liquid wastes that are not suspected of containing radionuclides and hazardous constituents, such as the septic tanks and associated drain fields, should be evaluated third.

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. Specific priorities for each waste management unit will be developed in subsequent work plans.

9.3.4 Resource Conservation and Recovery Act Facility Interface

As previously discussed in Section 9.3.1, there are a number of RCRA facilities in the Z Plant Aggregate Area. These facilities belong to a separate program with separate Tri-Party Agreement milestones. Some environmental releases at these facilities may have commingled and interacted with other source units at the Z Plant Aggregate Area, depending on the extent of contamination that has occurred. For example, contamination from the 218-W-2A and 218-W-3A Burial Grounds, which are TSD facilities deferred to the RCRA program, may have affected the 218-W-3 Burial Ground, which is covered under this AAMS. Given the number of RCRA facilities in the Z Plant Aggregate Area and their proximity to other units, it is expected that there will be a need for RCRA facility interface for some of the Z Plant waste management units.

The RCRA Part B permit application for the burial grounds proposes that final closure be initiated in about the year 2081, with partial closures of portions of the burial grounds to occur as each portion is filled. A definitive schedule for partial closures has not been established yet. Corrective actions associated with ongoing activities and future closure actions have not been defined in the Part B permit application at this time. A site-wide RCRA permit is currently being negotiated which will eventually finalize Hanford Facility closure schedules and corrective actions. All closure schedules and corrective actions at the burial grounds are still subject to regulatory agency approval until the final RCRA permit is issued.

Investigations have been recommended for several non-RCRA burial ground units under this AAMS. Since partial closures and corrective actions of the RCRA burial grounds have not been established, the recommended investigations may precede or overlap with RCRA activities. It will be necessary to ensure that investigations at non-RCRA units are integrated with schedules and proposed actions for the RCRA burial grounds as they are incorporated into the final status permit.

In addition, there are a number of unplanned releases associated with RCRA TSD facilities within the Z Plant Aggregate Area which are recommended to be addressed during RCRA closure and/or permitting activities. Investigation and remediation of affected soils

associated with these unplanned releases, if any, would result in a need to interface with the planned RCRA facility activities.

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 Z 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 Z 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 the 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 Z 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).

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 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 ^{137}Cs 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.

9.6 PROPOSED AGGREGATE AREA BASED FIELD CHARACTERIZATION STUDY

It has been established that carbon tetrachloride emanates from the Z Plant Aggregate Area soils and wells during certain meteorological conditions. In addition, other volatile gases have caused work shutdowns to protect employees in the area. Presently, little is understood regarding the nature and sources of these volatile gases, yet there remains a strong need to respond to this health and safety issue for worker protection purposes. As a result of this need, an aggregate area-based field characterization program is proposed. This effort will characterize the volatile gases in the Z Plant Aggregate Area (primarily carbon tetrachloride) and associated meteorological effects. Additional consideration should also be given to extending the program to other portions of the 200 West Area where ambient air quality may be a concern.

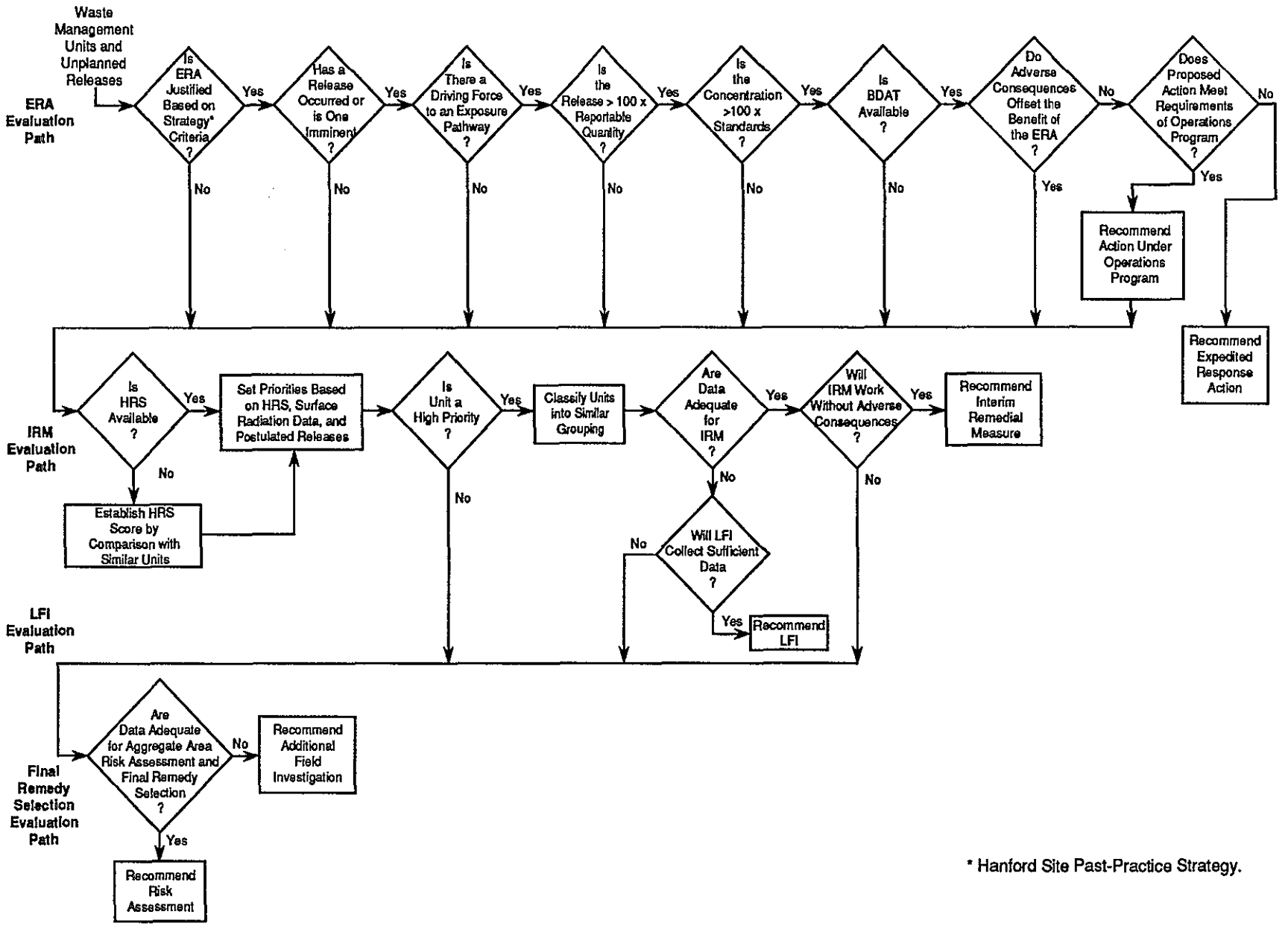

Figure 9-1. 200 Aggregate Area Management Study Data Evaluation Process.

Table 9-1. Summary of Results of Data Evaluation Process Assessment for Z Plant Aggregate Area. (Sheet 1 of 4)

Waste Management Unit or Unplanned Release	Current Operable Unit	ERA	IRM	LFI	RA	RI	OPS	Remarks
Tanks and Vaults								
216-Z-8 Settling Tank	200-ZP-2	X	X	X	-	-	-	Remove drainable liquids
241-Z-361 Settling Tank	200-ZP-1	X	X	X	-	-	-	Remove drainable liquids Redefined to 200-ZP-2 Operable Unit
Cribs and Drains								
216-Z-1 & 216-Z-2 Cribs	200-ZP-1	-	X	X	-	-	X	RARA - Surface Contamination Redefined to 200-ZP-2 Operable Unit
216-Z-3 Crib	200-ZP-1	-	X	X	-	-	-	Redefined to 200-ZP-2 Operable Unit
216-Z-5 Crib	200-ZP-2	-	X	X	-	-	X	RARA - Cave-in Potential
216-Z-6 Crib	200-ZP-2	-	X	X	-	-	X	
216-Z-7 Crib	200-ZP-2	-	X	X	-	-	X	
216-Z-12 Crib	200-ZP-1	-	X	X	-	-	-	Redefined to 200-ZP-2 Operable Unit
216-Z-16 Crib	200-ZP-2	-	X	X	-	-	-	
216-Z-18 Crib	200-ZP-1	X	X	X	-	-	-	Carbon Tetrachloride ERA Proposal Unit Redefined to 200-ZP-2 Operable Unit
216-Z-8 French Drain	200-ZP-2	-	-	-	-	X	-	
216-Z-13 French Drain	200-ZP-1	-	-	-	-	X	-	Redefined to 200-ZP-2 Operable Unit
216-Z-14 French Drain	200-ZP-1	-	-	-	-	X	-	Redefined to 200-ZP-2 Operable Unit
216-Z-15 French Drain	200-ZP-1	-	-	-	-	X	-	Redefined to 200-ZP-2 Operable Unit
216-Z-1A Tile Field	200-ZP-1	X	X	X	-	-	X	RARA - Surface Contamination; Carbon Tetrachloride ERA Proposal Unit Redefined to 200-ZP-2 Operable Unit

Table 9-1. Summary of Results of Data Evaluation Process Assessment for Z Plant Aggregate Area. (Sheet 2 of 4)

Waste Management Unit or Unplanned Release	Current Operable Unit	ERA	IRM	LFI	RA	RI	OPS	Remarks
Reverse Well								
216-Z-10 Reverse Well	200-ZP-2	-	-	-	-	X	-	
Ponds, Ditches, and Trenches								
216-Z-4 Trench	200-ZP-2	-	X	X	-	-	-	
216-Z-9 Trench	200-ZP-2	X	X	X	-	-	-	Carbon Tetrachloride ERA Proposal Unit
216-Z-17 Trench	200-ZP-2	-	X	X	-	-	-	
Septic Tanks and Associated Drain Fields								
2607-Z Septic Tank and Drain Field	200-ZP-2	-	-	-	-	X	-	Active-Waste Management
2607-Z-1 Septic Tank and Drain Field	200-ZP-2	-	-	-	-	X	-	Active-Waste Management
2607-WA Septic Tank and Drain Field	200-ZP-2	-	-	-	-	X	-	Active-Waste Management
2607-WB Septic Tank and Drain Field	200-ZP-2	-	-	-	-	X	-	Active-Waste Management
2607-W-8 Septic Tank and Drain Field	200-ZP-2	-	-	-	-	X	-	Active-Waste Management
Transfer Facilities, Diversion Boxes, and Pipelines								
241-Z Diversion Box No. 1	200-ZP-1	-	X	X	-	-	-	Redefined to 200-ZP-2 Operable Unit
241-Z Diversion Box No. 2	200-ZP-1	-	X	X	-	-	-	Redefined to 200-ZP-2 Operable Unit
231-Z-151 Sump	200-ZP-1	-	X	X	-	-	-	Redefined to 200-ZP-2 Operable Unit
Basins								
241-Z Retention Basin	200-ZP-2	-	-	-	-	X	-	
216-Z-21 Seepage Basin	200-ZP-2	-	-	-	-	X	X	Active-Waste Management Potential for migration of contaminants

Table 9-1. Summary of Results of Data Evaluation Process Assessment for Z Plant Aggregate Area. (Sheet 3 of 4)

Waste Management Unit or Unplanned Release	Current Operable Unit	ERA	IRM	LFI	RA	RI	OPS	Remarks
Burial Sites								
218-W-1	200-ZP-3	-	X	X	-	-	-	
218-W-1A	200-ZP-3	-	X	X	-	-	-	
218-W-2	200-ZP-3	-	X	X	-	-	X	RARA - Surface Contamination
218-W-3	200-ZP-3	-	X	X	-	-	-	
218-W-4A	200-ZP-3	-	X	X	-	-	X	RARA - Surface Contamination
218-W-11	200-ZP-3	-	X	X	-	-	-	
Z Plant Burn Pit	200-ZP-2	-	-	-	-	X	-	Redefined to 200-ZP-3 Operable Unit
Unplanned Releases								
UN-200-W-11	200-ZP-3	-	X	X	-	-	-	
UPR-200-W-16	200-ZP-3	-	X	X	-	-	-	
UN-200-W-23	200-ZP-1	-	-	-	-	X	-	Redefined to 200-ZP-2 Operable Unit
UPR-200-W-26	200-ZP-3	-	X	X	-	-	-	
UN-200-W-44	200-ZP-3	-	-	-	-	X	-	
UPR-200-W-53	200-ZP-3	-	X	X	-	-	-	
UPR-200-W-72	200-ZP-3	-	X	X	-	-	-	
UPR-200-W-84	200-ZP-3	-	X	X	-	-	-	
UN-200-W-89	200-ZP-1	-	-	-	-	X	-	Redefined to 200-ZP-2 Operable Unit
UN-200-W-90	200-ZP-1	-	-	-	-	X	-	Redefined to 200-ZP-2 Operable Unit
UN-200-W-91	200-ZP-1	-	-	-	-	X	-	Redefined to 200-ZP-2 Operable Unit
UN-200-W-103	200-ZP-1	-	-	-	-	X	-	Redefined to 200-ZP-2 Operable Unit
UN-200-W-130	200-ZP-2	-	X	X	-	-	-	
UPR-200-W-134	200-ZP-3	-	X	X	-	-	-	

Table 9-1. Summary of Results of Data Evaluation Process Assessment for Z Plant Aggregate Area. (Sheet 4 of 4)

Waste Management Unit or Unplanned Release	Current Operable Unit	ERA	IRM	LFI	RA	RI	OPS	Remarks
UPR-200-W-158	200-ZP-3	-	X	X	-	-	-	Only the portion of the release associated with 218-W-1A Burial Ground.
UN-200-W-159	200-ZP-1	-	-	-	X	-	-	Redefined to 200-ZP-2 Operable Unit

Notes:

ERA Expedited Response Action
IRM Interim Remedial Measure
LFI Limited Field Investigation
RA Risk Assessment
RI Remedial Investigation; Feasibility study will be conducted if RA indicates remedial action necessary.
OPS Operational Programs

Table 9-2. Z Plant Aggregate Area Data Evaluation Decision Matrix. (Sheet 1 of 4)

	ERA Evaluation Path								IRM Evaluation Path			LFI Path	Final Remedy
Waste Management Unit or Unplanned Release	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													
216-Z-8 Settling Tank	Y	Y	Y	Y	Y	Y	N	N	N	-	-	-	N
241-Z-361 Settling Tank	Y	Y	Y	Y	Y	Y	N	N	N	-	-	-	N
Cribs and Drains													
216-Z-1 & 216-Z-2 Cribs	Y	Y	Y	Y	Y	Y	N	Y	Y	N	-	Y	-
216-Z-3 Crib	Y	Y	N	-	-	-	-	-	N[a]	N	-	Y	-
216-Z-5 Crib	Y	Y	Y	Y	Y	Y	N	Y	Y	N	-	Y	-
216-Z-6 Crib	Y	Y	Y	Y	Y	Y	N	Y	N[a]	N	-	Y	-
216-Z-7 Crib	Y	Y	Y	Y	Y	Y	N	Y	Y	N	-	Y	-
216-Z-12 Crib	Y	Y	N	-	-	-	-	-	N[a]	N	-	Y	-
216-Z-16 Crib	Y	Y	N	-	-	-	-	-	N[a]	N	-	Y	-
216-Z-18 Crib	Y	Y	Y	Y	Y	Y	N	N	N[a]	N	-	Y	-
216-Z-8 French Drain	Y	Y	N	-	-	-	-	-	N	-	-	-	N
216-Z-13 French Drain	Y	N	-	-	-	-	-	-	N	-	-	-	N
216-Z-14 French Drain	Y	N	-	-	-	-	-	-	N	-	-	-	N
216-Z-15 French Drain	Y	N	-	-	-	-	-	-	N	-	-	-	N
216-Z-1A Tile Field	Y	Y	Y	Y	Y	Y	N	N	Y	N	-	Y	-

Table 9-2. Z Plant Aggregate Area Data Evaluation Decision Matrix. (Sheet 2 of 4)

	ERA Evaluation Path								IRM Evaluation Path			LFI Path	Final Remedy
Waste Management Unit or Unplanned Release	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?
Reverse Well													
216-Z-10 Reverse Well	Y	Y	Y	Y	Y	N	-	-	Y	N	-	N	N
Ponds, Ditches, and Trenches													
216-Z-4 Trench	Y	Y	N	-	-	-	-	-	N[v]	N	-	Y	-
216-Z-9 Trench	Y	Y	Y	Y	Y	Y	N	N	N[v]	N	-	Y	-
216-Z-17 Trench	Y	Y	N	-	-	-	-	-	Y	N	-	Y	-
Septic Tanks and Associated Drain Fields													
2607-Z Septic Tank and Drain Field	Y	N	-	-	-	-	-	-	N	-	-	-	N
2607-Z-1 Septic Tank and Drain Field	Y	N	-	-	-	-	-	-	N	-	-	-	N
2607-WA Septic Tank and Drain Field	Y	N	-	-	-	-	-	-	N	-	-	-	N
2607-WB Septic Tank and Drain Field	Y	N	-	-	-	-	-	-	N	-	-	-	N
2607-W-8 Septic Tank and Drain Field	Y	N	-	-	-	-	-	-	N	-	-	-	N
Transfer Facilities, Diversion Boxes, and Pipelines													
241-Z Diversion Box No. 1	Y	N	-	-	-	-	-	-	N[v]	N	-	Y	-

Table 9-2. Z Plant Aggregate Area Data Evaluation Decision Matrix. (Sheet 3 of 4)

	ERA Evaluation Path								IRM Evaluation Path			LFI Path	Final Remedy
Waste Management Unit or Unplanned Release	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?
241-Z Diversion Box No. 2	Y	N	-	-	-	-	-	-	N[a]	N	-	Y	-
231-Z-151 Sump	Y	Y	N	-	-	-	-	-	N[a]	N	-	Y	-
Basins													
241-Z Retention Basin	Y	N	-	-	-	-	-	-	N	-	-	-	N
216-Z-21 Seepage Basin	Y	Y	Y	Y	Y	Y	Y	Y	N	-	-	-	N
Burial Sites													
218-W-1	Y	Y	N	-	-	-	-	-	N[a]	N	-	Y	-
218-W-1A	Y	Y	N	-	-	-	-	-	N	-	-	-	N
218-W-2	Y	Y	Y	Y	Y	Y	N	Y	Y	N	-	Y	-
218-W-3	Y	Y	N	-	-	-	-	-	N[a]	N	-	Y	-
218-W-4A	Y	Y	Y	Y	Y	Y	N	Y	Y	N	-	Y	-
218-W-11	Y	Y	N	-	-	-	-	-	N	-	-	-	N
Burn Pit	Y	Y	N	-	-	-	-	-	N	-	-	-	N
Unplanned Releases													
UN-200-W-11	Y	Y	N	-	-	-	-	-	N	-	-	-	N
UPR-200-W-16	Y	Y	N	-	-	-	-	-	N	-	-	-	N
UN-200-W-23	Y	Y	N	-	-	-	-	-	N	-	-	-	N
UPR-200-W-26	Y	Y	N	-	-	-	-	-	N	-	-	-	N
UN-200-W-44	Y	Y	N	-	-	-	-	-	N	-	-	-	N

Table 9-2. Z Plant Aggregate Area Data Evaluation Decision Matrix. (Sheet 4 of 4)

	ERA Evaluation Path								IRM Evaluation Path			LFI Path	Final Remedy
Waste Management Unit or Unplanned Release	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?
UPR-200-W-53	Y	Y	N	-	-	-	-	-	N	-	-	-	N
UPR-200-W-72	Y	Y	N	-	-	-	-	-	N	-	-	-	Y
UPR-200-W-84	Y	Y	N	-	-	-	-	-	N	-	-	-	Y
UN-200-W-89	Y	Y	N	-	-	-	-	-	N	-	-	-	N
UN-200-W-90	Y	Y	N	-	-	-	-	-	N	-	-	-	N
UN-200-W-91	Y	Y	N	-	-	-	-	-	N	-	-	-	N
UN-200-W-103	Y	Y	N	-	-	-	-	-	N	-	-	-	N
UN-200-W-130	Y	Y	N	-	-	-	-	-	N	-	-	-	N
UPR-200-W-134	Y	Y	N	-	-	-	-	-	N	-	-	-	Y
UPR-200-W-158 (1)	Y	Y	N	-	-	-	-	-	N	-	-	-	N
UN-200-W-159	Y	Y	N	-	-	-	-	-	N	-	-	-	Y

Y Yes
N No
- Indicates decision point not reached.
[a] Evaluated as high priority site because of proximity and/or similarity to other high priority sites.
(1) Only the part of unplanned release UPR-200-W-158 associated with the 218-W-1A Burial Ground.

Table 9-3. Waste Management Units and Unplanned Releases Addressed by Other Programs.

Site Name[a]	Site Type	Program	Active/Inactive	Operable Unit
Plants, Buildings, and Storage Areas				
232-Z	Incinerator	D&RCP	Inactive	200-ZP-1
Tanks and Vaults				
241-Z/UN-200-W-74, UN-200-W-75, UN-200-W-79	Treatment Tank	D&RCP	Active	200-ZP-1
Burial Sites				
218-W-2A/UPR-200-W-45	Burial Ground	D&RCP	Inactive	200-ZP-3
218-W-3A/UN-200-W-158	Burial Ground	D&RCP	Active	200-ZP-3
218-W-3AE	Burial Ground	D&RCP	Active	200-ZP-3
218-W-4B	Burial Ground	D&RCP	Active	200-ZP-3
218-W-4C/UN-200-W132	Burial Ground	D&RCP	Active	200-ZP-3
218-W-5	Burial Ground	D&RCP	Active	200-ZP-3
218-W-6/UN-200-W-158	Burial Ground	D&RCP	Proposed	200-ZP-3

D&RCP - Decommissioning and RCRA Closure Program

[a] Waste management unit and associated unplanned release, if any.

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9 3 1 2 3 0 7 5 1 3

Westinghouse Hanford Company
Aggregate Area Management Studies

Z PLANT AGGREGATE AREA
PLATE 1 - Topography

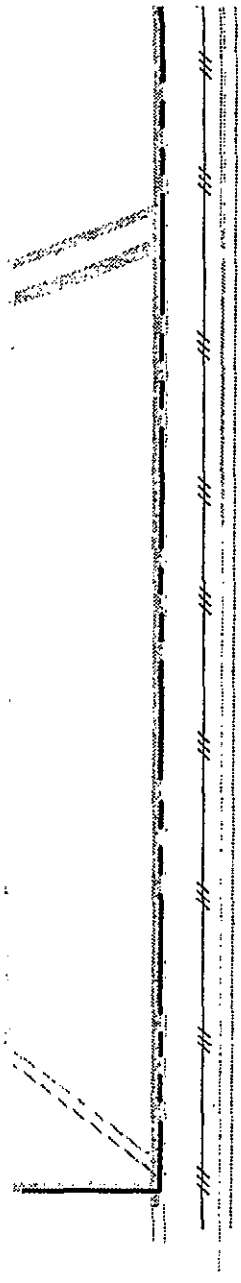
LEGEND

Aggregate Area Boundary

Security Systems/Fences

Perimeter Boundary

Buildings



LEGEND

231–Z — Z–PLANT BUILDING LOCATION AND NUMBER

218–W–3 — SOLID WASTE BURIAL GROUND LOCATION AND NUMBER

2W7 ▲ — ANNUAL SURFACE GRID POINT SAMPLING LOCATION AND NUMBER

N165 ■ — ANNUAL AIR MONITORING STATION LOCATION AND NUMBER

2WN ⊡ — FENCELINE SURFACE SAMPLE LOCATION AND NUMBER

2 ✦ — 1990 Z PLANT SOIL SAMPLE LOCATION AND NUMBER

N

0 100 200

Scale in Meters

Plate 2. Z Plant Aggregate Area Surface Media and Air Sampling Locations.

APPENDIX A

SUPPLEMENTAL DATA

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SUPPLEMENTAL DATA

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A.1.0 SUBSURFACE GEOPHYSICAL LOGS

Geophysical well logging has been conducted at the Z Plant Aggregate Area since at least as early as 1954 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 and groundwater monitoring wells have been constructed at many of the Z Plant Aggregate Area waste management units. Geophysical well logs have been acquired from monitoring wells at the following eighteen waste management units, the remaining waste management units did not have monitoring structures in the immediate vicinity:

- 216-Z-1 Crib
- 216-Z-2 Crib
- 216-Z-3 Crib
- 216-Z-5 Crib
- 216-Z-7 Crib
- 216-Z-12 Crib
- 216-Z-16 Crib
- 216-Z-18 Crib
- 216-Z-1A Tile Field
- 216-Z-9 Trench
- 216-W-3A Burial Ground
- 216-W-3AE Burial Ground
- 216-W-4B Burial Ground
- 216-W-4C Burial Ground
- 216-W-5 Burial Ground
- 216-W-6 Burial Ground
- 216-W-11 Burial Ground.

As part of this Aggregate Area Management Study, select geophysical well logs from these twenty-four 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 three-volume document by Fecht et al. (1977), in which gross gamma-ray logs were reviewed and evaluated for potential contamination. Several additional published and unpublished documents exist such as gross-gamma logs acquired from monitoring inactive cribs and logs acquired as part of the low-level burial ground monitoring well installation program (Chamness et al. 1991). Pertinent results of previously conducted studies or observations are discussed along with results of this study in sections describing individual waste management units.

The following vadose zone fluid migration pathways have been recognized in the 200 West Area: 1) vertical downward migration; 2) lateral migration at the interface of an underlying coarser-grained zone or low permeability zone; 3) a combination of vertical and

lateral migration that may be manifested in adjacent wells as digitate clean and contaminated zones; and 4) vertical downward migration along the well casings in poorly constructed wells. Additional complications in interpreting the migration of contaminants include the natural decay of radionuclides and the different migration rates of various radionuclides.

A.1.1 AVAILABLE GEOPHYSICAL WELL LOGS

The array of geophysical logs acquired from the Z Plant Aggregate Area includes gross gamma-ray logs, gamma-gamma logs, neutron-epithermal-neutron logs, density logs, sonic logs, and temperature logs. Spectral gamma-ray logs have been acquired at two locations within the Z Plant Aggregate Area: within the 216-Z-1A Tile Field and along the 216-Z-20 Ditch. However, because the 216-Z-20 Ditch is a U Plant Aggregate Area waste management unit, it is not discussed in this report. 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 anthropogenic radionuclides in the unsaturated zone. Ancillary logs, such as the neutron and density logs, may also provide useful information. 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.

The available gross gamma-ray logs were acquired from Z Plant Aggregate Area monitoring wells by the Pacific Northwest Laboratory (PNL) under contract by the primary Department of Defense Westinghouse Hanford contractor.

PNL began recording gross gamma-ray logs from Z Plant Aggregate Area monitoring wells in 1958. On the basis of log presentation, three generations of logging equipment have been used in the Z 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 by Fecht et al. (1977), procedural or equipment modifications may even have been made annually. Beginning in 1982, procedures were implemented to improve log quality and consistency (Lewis 1991). 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. Detailed logging procedures are described in WHC (1991).

The gross gamma-ray logs identified for this study are listed in Table A-9. The logs listed in Table A-9 constitute a comprehensive list of all logs acquired in the Z Plant Aggregate Area through 1990. Logs were identified for eight cribs, one tile field, one trench, and eight burial grounds.

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).

The bulk of the gamma logs available for the Z Plant Aggregate Area were collected with scintillation probes by Pacific Northwest Laboratories (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; 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 counts per seconds. If the activity is above that level, the system will become "paralyzed" and read 0 counts per second until it resets itself. The maximum count rate of the TFSA&S system currently in use is about 100,000 counts per second with Probe No. 4. 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 counts per second (Brodeur and Koizumi 1989; Arthur 1990), and that currently in use by TFSA&S with Probe No. 4 becomes saturated around 70,000 counts per second.

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 (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 (low 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 15 feet per minute (0.25 feet per second) 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 5 feet per minute (1 inch per second) and the time constant to 1 second. The expected vertical resolution and "depth lag" of these logs is 2.54 cm (1 inch). 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 Z 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. 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 herein 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 1.5 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) 0.23 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 (0.23 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 ct/sec on the logarithmic scale. The cross sections are scaled horizontally at an exaggerated scale. To obtain a true picture of the sealed 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 were avoided since the data are not suitable to be used in such a quantitative fashion.

A.1.4 EVALUATION OF DATA IDENTIFIED FOR WASTE MANAGEMENT UNITS

Based on availability of both gross gamma and geologic logs for a particular waste management unit and indications of elevated gamma activity, an analysis of the potential nature and extent of radionuclide contamination was performed. Sections A.1.4.1 through A.1.4.5 discuss data identified for the following waste management units:

- The 216-Z-18 Crib
- The 216-Z-9 Trench
- The 216-Z-1A Tile Field, 216-Z-1 and 216-Z-2 Cribs, and 216-Z-3 Crib
- The 216-Z-7 Crib
- The 216-Z-12 Crib.

Cross sections were not prepared for other Z Plant Aggregate Area waste management units because monitoring wells were not identified near these facilities (e.g., the 216-Z-13 French Drain) or available wells have not been logged (most likely due to inappropriate well construction).

A.1.4.1 216-Z-18 Crib

A.1.4.1.1 Waste Description. This section briefly summarizes information presented in Tables 2-1 and 2-2, and Sections 2.3 and 4.1.

Source - High salt, acidic, organic waste from 236-Z Building.

Service Dates - 1969 - 1973.

Fluid Volume Received (Liters) - 3,860,000.

Quantity of Radionuclides Disposed of in Unit (Curies)

Waste Management Unit	Total Pu in gm	^{238}U	^{137}Cs	^{106}Ru	^{90}Sr	^{60}Co	^{239}Pu	^{240}Pu
216-Z-18 Crib	23,000						1,310	353

A.1.4.1.2 Scintillation Probe Profile Evaluation. Cross Sections A-A' and B-B' through the 216-Z-18 Crib are shown on Figures A-2 and A-3. Figure A-1 shows an isopach of elevated gamma responses in the 216-Z-18 Crib. As shown on Figure A-2, elevated gamma response is observed just beneath the base of the northeast corner of the crib in monitoring well 299-W18-9. Additional intervals of elevated gamma response are observed at depths of 10 m (30 ft) below ground surface in monitoring wells 299-W18-94 and 299-W18-93 (Figure A-2). Monitoring well 299-W18-98, approximately 8 m (25 ft) north of the crib, shows only natural gamma response. Monitoring wells 299-W18-9 and 299-W18-10 exhibit intervals of elevated gamma response from the base of the crib to the top of the Early "Palouse" soil horizon. Intervals of elevated gamma response, likely associated with minor fine-grained soil horizons, also are evident in well 299-W18-10 below the base of the Plio-Pleistocene horizon. Monitoring well 299-W18-12, located near the center of the crib exhibits only natural gamma response.

Review of these gamma scintillation logs suggests that radionuclide migration to the top of the Early "Palouse" soil horizon and possibly deeper has occurred in the northeastern portion of the crib.

A.1.4.2 216-Z-9 Trench

A.1.4.2.1 Waste Description. This section briefly summarizes information presented in Tables 2-1 and 2-2, and Sections 2.3 and 4.1.

Source - Radioactive, acidic, organic wastes from RECUPLEX process (234-5Z Building), 242-Z Building inorganic process wastes, and 236-Z Building waste

Service Dates - 1955 - 1962.

Fluid Volume Received (Liters) 4,090,000

Quantity of Radionuclides Disposed of in Unit (Curies)

Waste Management Unit	Total Pu in gm	^{238}U	^{137}Cs	^{106}Ru	^{90}Sr	^{60}Co	^{239}Pu	^{240}Pu
216-Z-9 Trench	48,000	2×10^{-5}	0.052 (0.0556)	1.9×10^{-8}	0.049 (0.0535)	0.00395	2,190	590

A.1.4.2.2 Scintillation Probe Profile Evaluation. Cross Sections C-C' and D-D' through the 216-Z-9 Trench are shown on Figures A-5 and A-6. Figure A-4 shows an isopach map of elevated gamma response in the 216-2-9 Trench. As shown on Figure A-5, elevated gamma response is observed at a depth of approximately 11 m (35 ft) beneath ground surface in well 299-W15-86 which is located approximately 8 m (25 ft) southwest of the trench. Monitoring well 299-W15-101, located on the east side of the trench, exhibits elevated gamma response from ground surface to a depth of 6 m (20 ft). A second interval of elevated gamma response in monitoring 299-W15-86 corresponds with the top of the Early "Palouse" horizon and may be natural.

Radionuclide migration below the Early "Palouse" and Plio-Pleistocene horizons are not evident at the 216-Z-9 Trench.

A.1.4.3 216-Z-1A Tile Field and 216-Z-1 & 216-Z-2 Cribs

A.1.4.3.1 Waste Description. This section briefly summarizes information presented in Tables 2-1 and 2-2, and Sections 2.3 and 4.1.

Source

216-Z-1A Tile Field - Overflow from the 216-Z-1, 216-Z-2, or 216-Z-3 Cribs, PFP process wastes (234-5Z Building), PRF process waste (236-Z Building), and 242-Z process wastes.

216-Z-1 & 216-Z-2 Cribs - PRF (236-Z) and 242-Z process waste, 234-5Z laboratory wastes.

Service Dates

216-Z-1A Tile Field - 1949 to 1959; 1964 to 1969.

216-Z-1 & 216-Z-2 Cribs - 1949 to 1952; 1964 to 1966; 1968 to 1969.

Fluid Volume Received (Liters)

216-Z-1A Tile Field - 5,210,000

216-Z-1 & 216-Z-2 Cribs - 33,700,000

Quantity of Radionuclides Disposed of in Unit (Curies)

Waste Management Unit	Total Pu in gm	^{238}U	^{137}Cs	^{106}Ru	^{90}Sr	^{60}Co	^{239}Pu	^{240}Pu
216-Z-1A Tile Field	57,000		0.16	5.2×10^{-6}	0.15		137	37
216-Z-1 & 216-Z-2 Cribs	7,000	0.027	0.04 (0.165)	1.6×10^{-11}	0.37 (0.0159)	0.017 1	2,680	992

A.1.4.3.2 Scintillation Probe Profile Evaluation. 216-Z-1A Tile Field - Cross Sections E-E' and F-F' through the 216-Z-1A Tile Field are shown on Figures A-8 and A-9. Figure A-7 shows an isopach of elevated gamma response in the 216-Z-1A Tile Field. As shown on Figure A-8, elevated gamma response is observed just beneath the base of the tile field in monitoring wells 299-W18-150, 299-W18-170, and 299-W18-159. Monitoring wells 299-W18-159 and 299-W18-167 exhibit secondary intervals of elevated gamma response immediately above the contact between the upper coarse-grained Pasco gravels member and lower fine-grained silt-dominated sequence of the Hanford formation and near the bottom of the fine-grained unit of the Hanford formation. Only minor gamma response peaks which could be associated with the natural response of thin fine-grained horizons are observed in peripheral wells 299-W18-6, 299-W18-7, 299-W18-171, and 299-W18-172.

Radionuclide migration to the top of the Early "Palouse" soil horizon beneath the 216-Z-1A Tile Field appears likely. The lateral extent of radionuclide migration appears to be limited to the edges of the tile field.

216-Z-1 and 216-Z-2 Cribs - Monitoring wells 299-W18-65 and 299-W18-61 (not shown) exhibit elevated gamma response from approximately 3 m (10 ft) to 15 m (45 ft)

below the base of the cribs (Figure A-7). Both wells also exhibit secondary intervals of elevated gamma response near the top of the fine-grained unit of the Hanford formation. Elevated gamma response is also evident beneath the cribs with the Early "Palouse" and Plio-Pleistocene horizons. Whether the elevated gamma response is natural or due to the retention of radionuclides in these fine-grained horizons is difficult to determine.

Radionuclide migration to within 8 m (25 ft) of the top of the Early "Palouse" soil horizon appears evident. Only natural gamma response is observed in monitoring well 299-W-172, located approximately 8 m (25 ft) north of the 216-Z-2 Crib, suggesting that the lateral extent of radionuclide migration is limited.

A.1.4.4 216-Z-7 Crib

A.1.4.4.1 Waste Description. This section briefly summarizes information presented in Tables 2-1 and 2-2, and Sections 2.3 and 4.1.

Source - Laboratory waste from the 231-Z Building and 340 laboratory.

Service Dates - 1946 - 1967.

Fluid Volume Received (Liters) - 79,000,000.

Quantity of Radionuclides Disposed of in Unit (Curies)

Waste Management Unit	Total Pu in gm	^{238}U	^{137}Cs	^{106}Ru	^{90}Sr	^{60}Co	^{239}Pu	^{240}Pu
216-Z-7 Crib	2,000	0.0015	200	5.1×10^{-6}	200	0.0765	114	30.8

A.1.4.4.2 Scintillation Probe Profile Evaluation. Cross Sections G-G' and H-H' through the 216-Z-7 Crib are shown on Figures A-11 and A-12. Figure A-10 displays an isopach map of elevated gamma response in the crib areas. As seen on Figure A-10, elevated gamma response is shown in Well 299-W15-7 from a depth of approximately 3 m (9.1 ft) below land surface to the total depth of the well. Smaller but still significant elevated gamma responses are seen in wells 299-W15-63, 299-W15-62, 299-W15-78, and 299-W15-76. The elevated gamma response (up to 10,000 ct/sec in 299-W15-7) is associated with the Plio-Pleistocene and Early "Palouse" soil units. Well 299-W15-64 exhibits natural gamma response for comparison. The log of Well 299-W15-7 suggests that migration of radionuclides to groundwater has occurred.

A.1.4.5 216-Z-12 Crib

A.1.4.5.1 Waste Description. This section briefly summarizes information presented in Tables 2-1 and 2-2, and Sections 2.3 and 4.1.

Source - 234-5Z process, analytical, and development wastes via 241-Z-361 Settling Tank.

Service Dates - 1959 - 1973.

Fluid Volume Received (Liters) - 281,000,000.

Quantity of Radionuclides Disposed of in Unit (Curies)

Waste Management Unit	Total Pu in gm	^{238}U	^{137}Cs	^{106}Ru	^{90}Sr	^{60}Co	^{239}Pu	^{240}Pu
216-Z-12 Crib	25,000	1.7×10^{-5}	0.53	9.3E-7	0.051	0.00515	1,430	386

1.4.5.2 Scintillation Probe Profile Evaluation. Cross Sections I-I' and J-J' through the 216-Z-12 Crib are shown on Figures A-14 and A-15. An isopach map of elevated gamma response in the crib is shown on Figure A-13. As shown on these figures, there is an elevated gamma response in the northern and central sections of the crib approximately 10 meters below land surface. This zone is approximately 3 m (9.1 ft) thick and reads up to 8,000 ct/sec in well 299-W18-75. Wells around the perimeter of the Crib show lower or natural gamma response (Figure A-13, Wells 299-W18-152 and 299-W18-153). No evidence of migration to groundwater can be seen. An isopach map of elevated gamma response in the crib is shown on Figure A-13.

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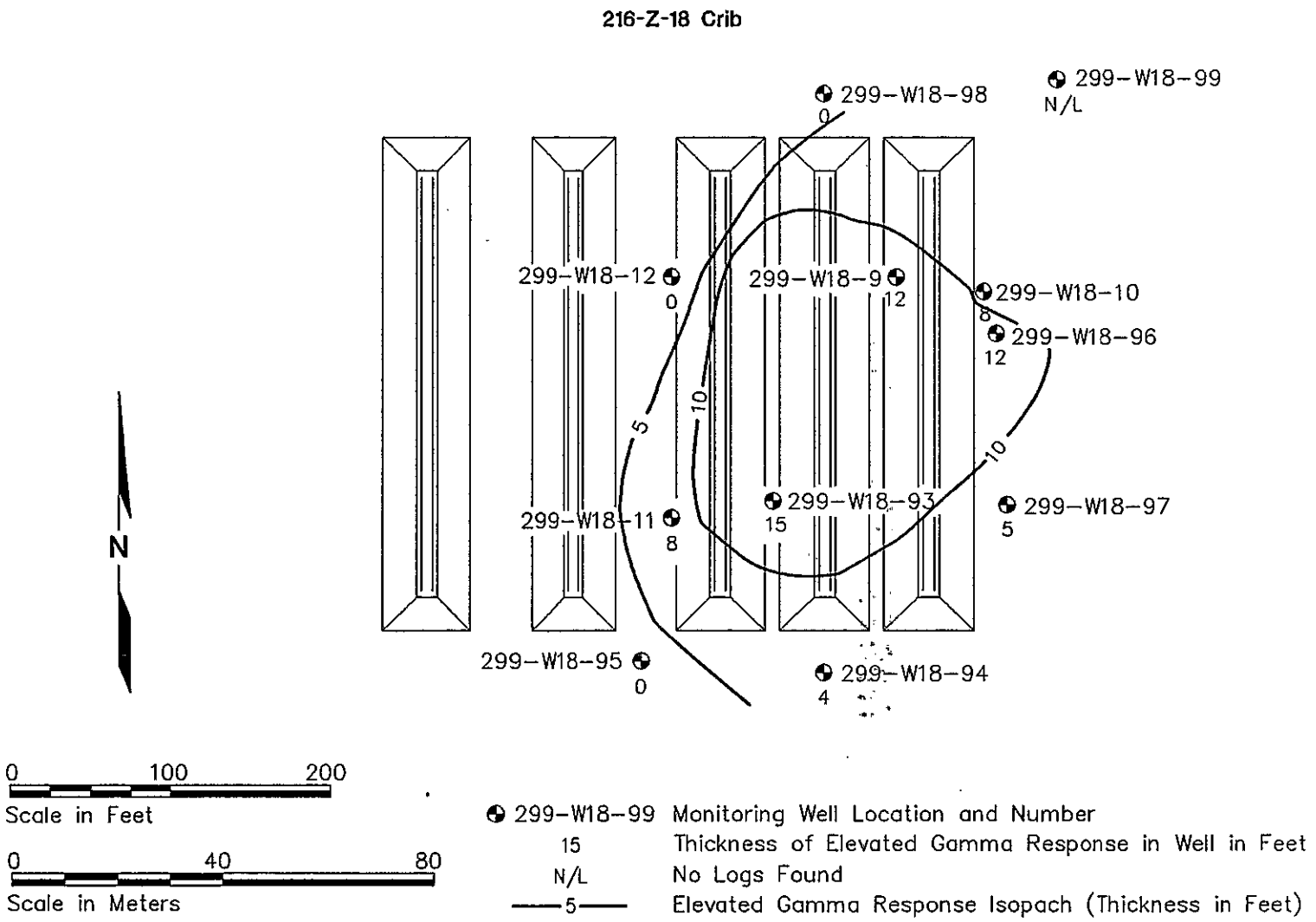

Figure A-1. Elevated Gamma Radiation Isopach Map of the 216-Z-18 Crib.

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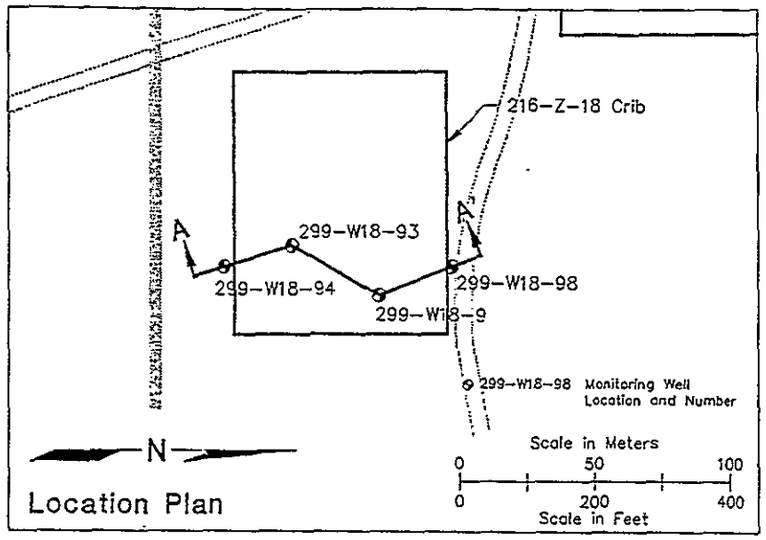

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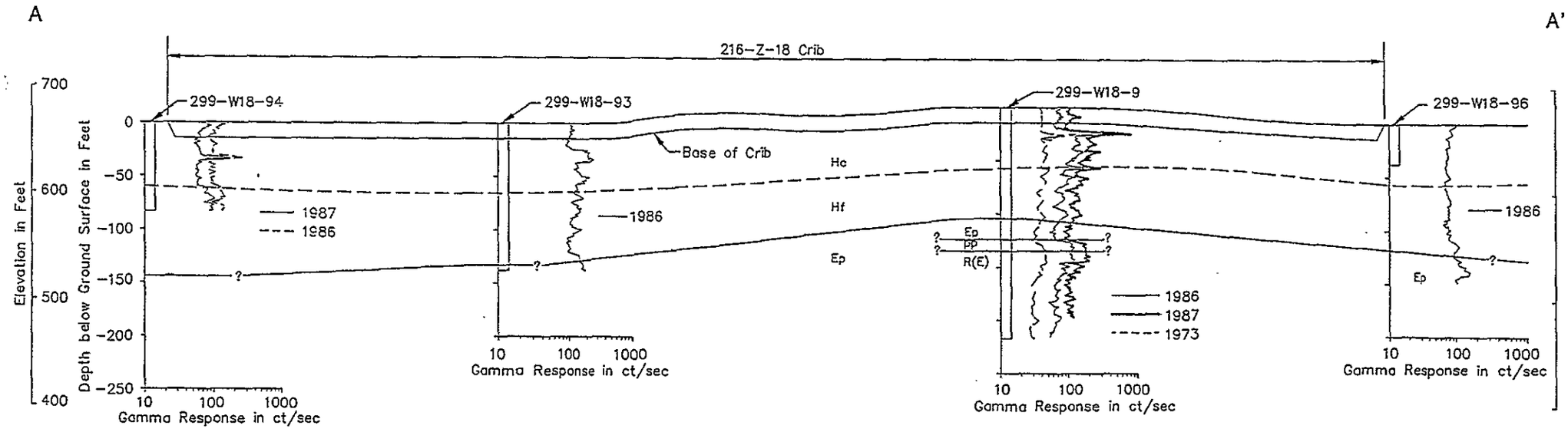
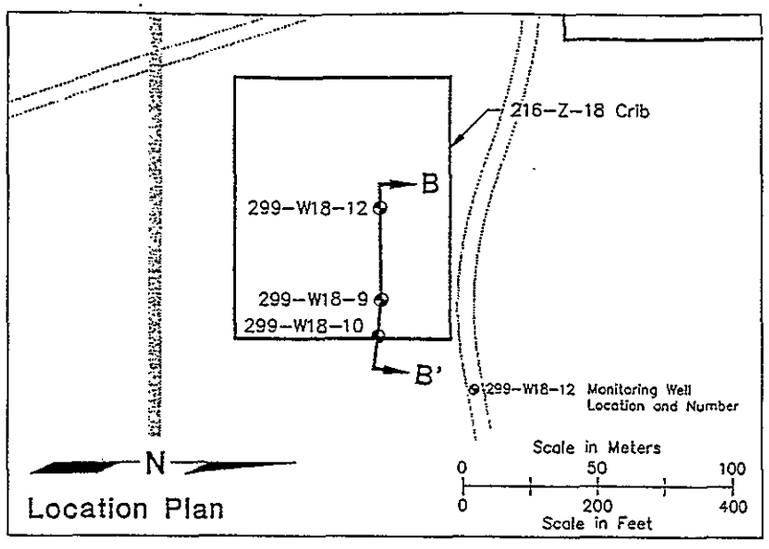
Vertical Scale in Meters
Vertical Exaggeration x 4



Note: Cross section stratigraphy after Lindsey et al. 1991
Refer to Figure 3-15 for legend.

Figure A-2. Scintillation Probe Profile Cross Section A-A' of the 216-Z-18 Crib.



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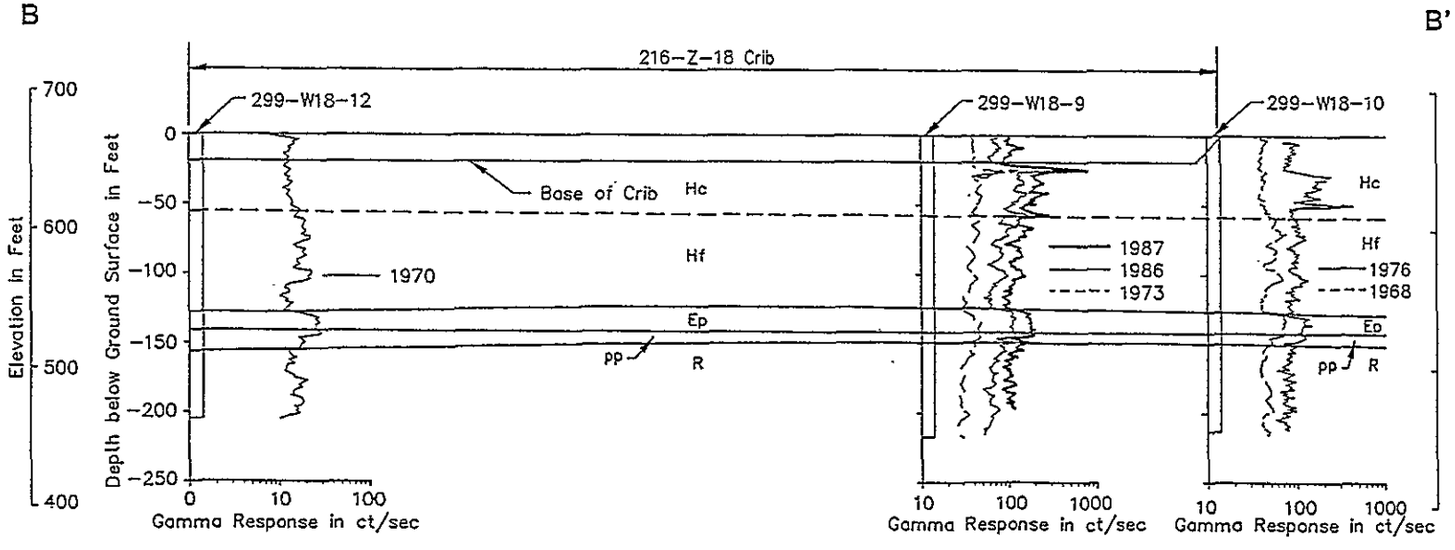
Vertical Scale in Meters
Vertical Exaggeration x 5



Note: Cross section stratigraphy after Lindsey et al. 1991
Refer to Figure 3-15 for legend.

Figure A-3. Scintillation Probe Profile Cross Section B-B' of the 216-Z-18 Crib.

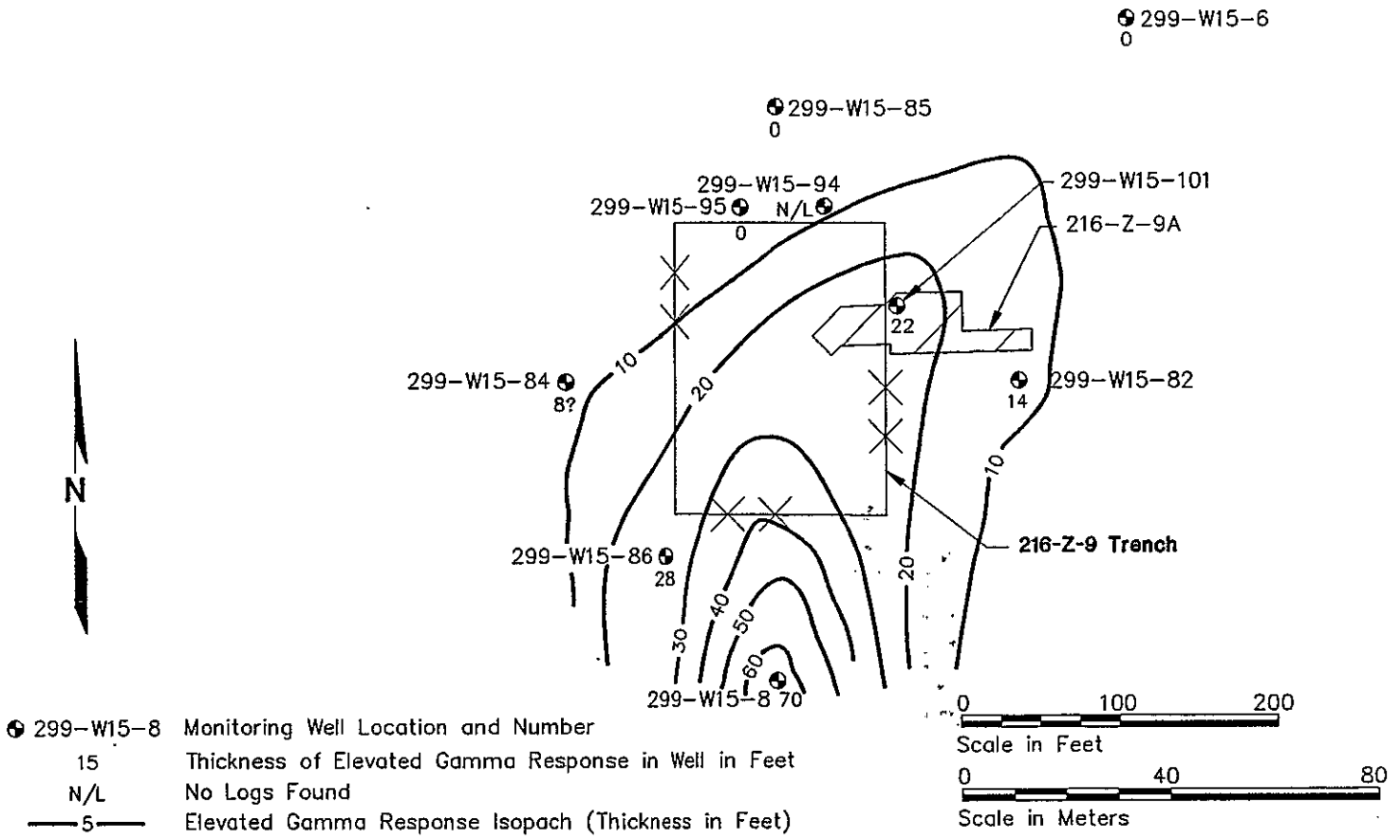


Figure A-4. Elevated Gamma Radiation Isopach Map of the 216-Z-9 Trench.

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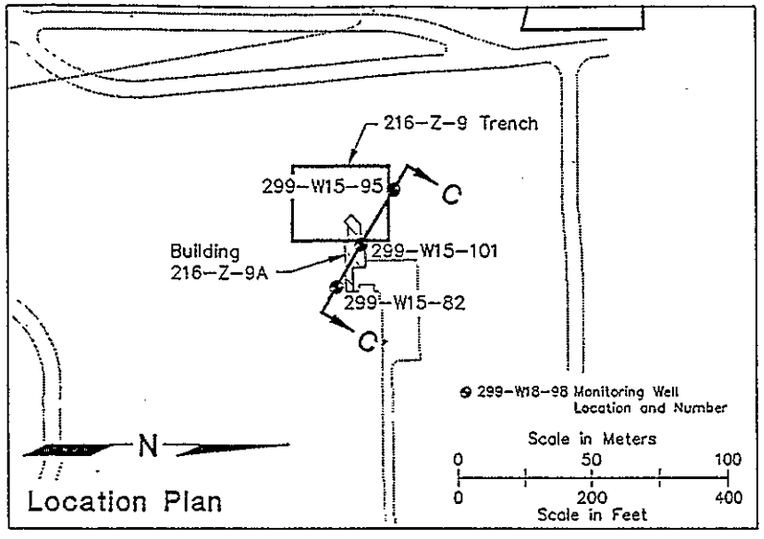

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Vertical Scale in Feet
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Horizontal Scale in Meters
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Vertical Scale in Meters
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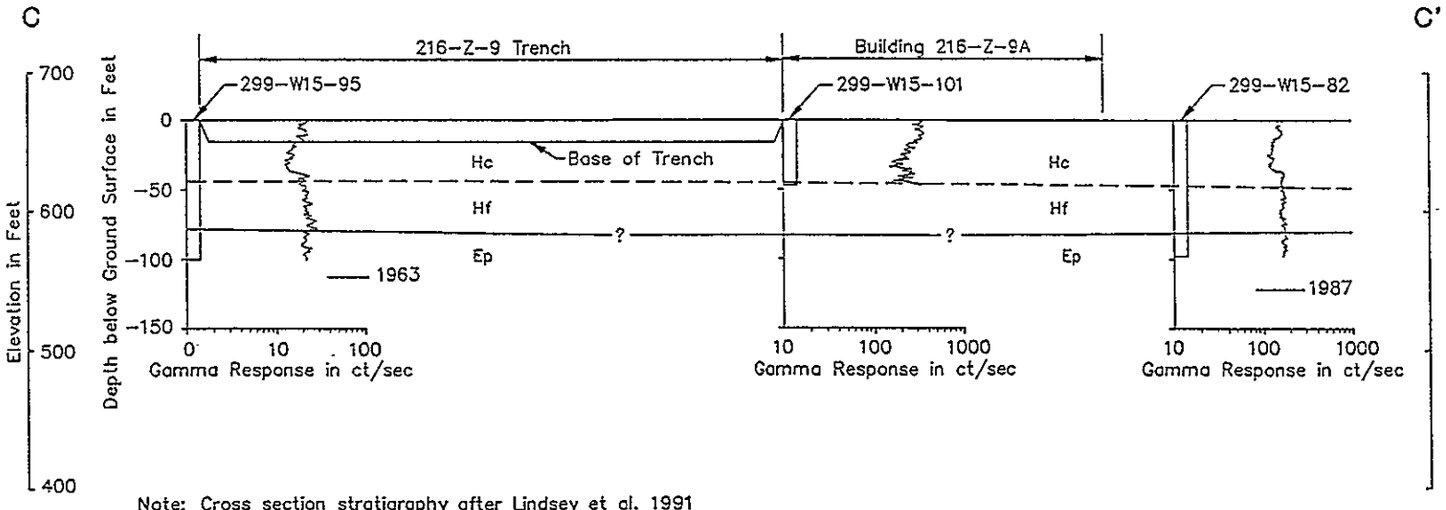
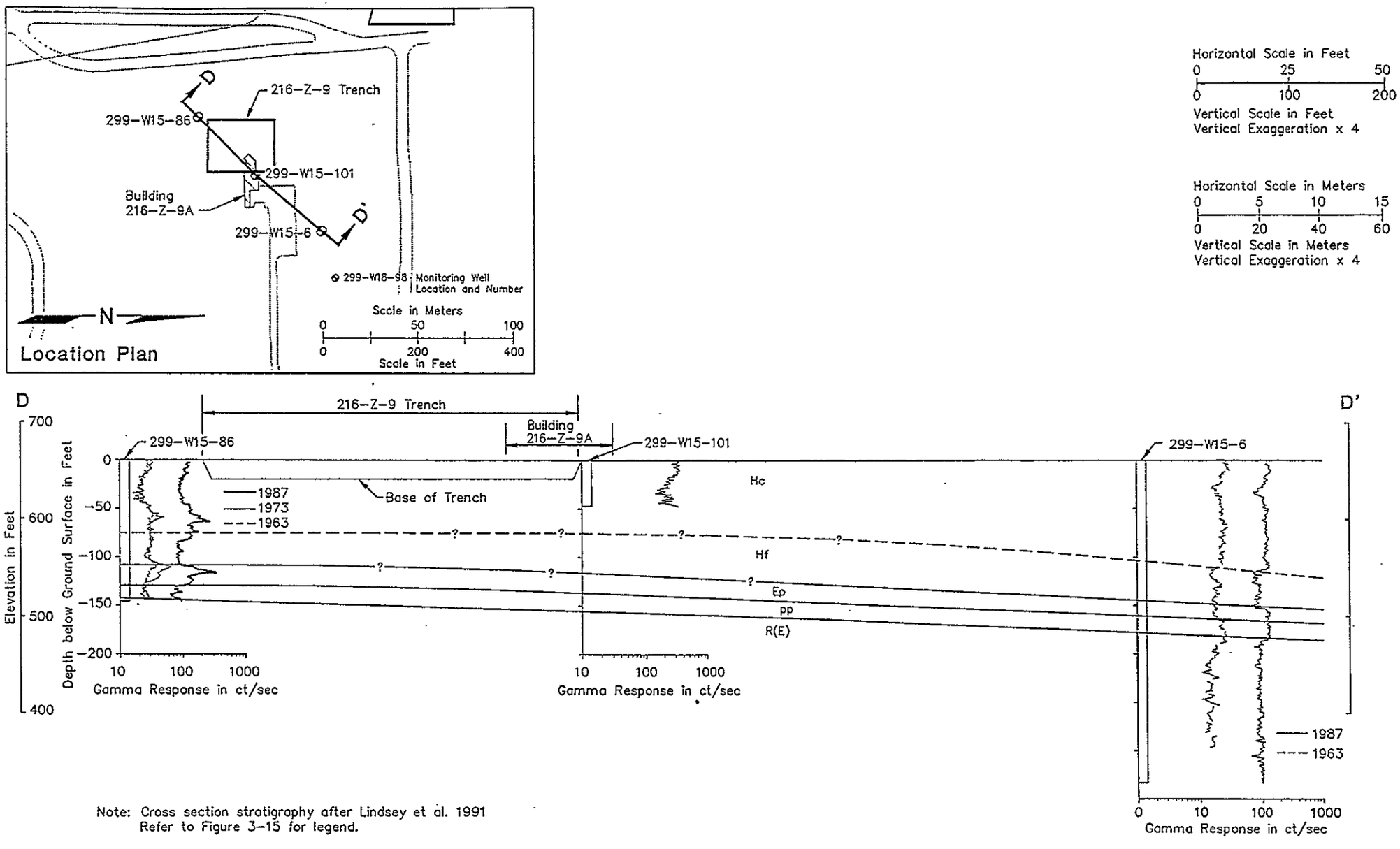


Note: Cross section stratigraphy after Lindsey et al. 1991
Refer to Figure 3-15 for legend.

Figure A-5. Scintillation Probe Profile Cross Section C-C' of the 216-Z-9 Trench.



Note: Cross section stratigraphy after Lindsey et al. 1991
Refer to Figure 3-15 for legend.

Figure A-6. Scintillation Probe Profile Cross Section D-D' of the 216-Z-9 Trench.

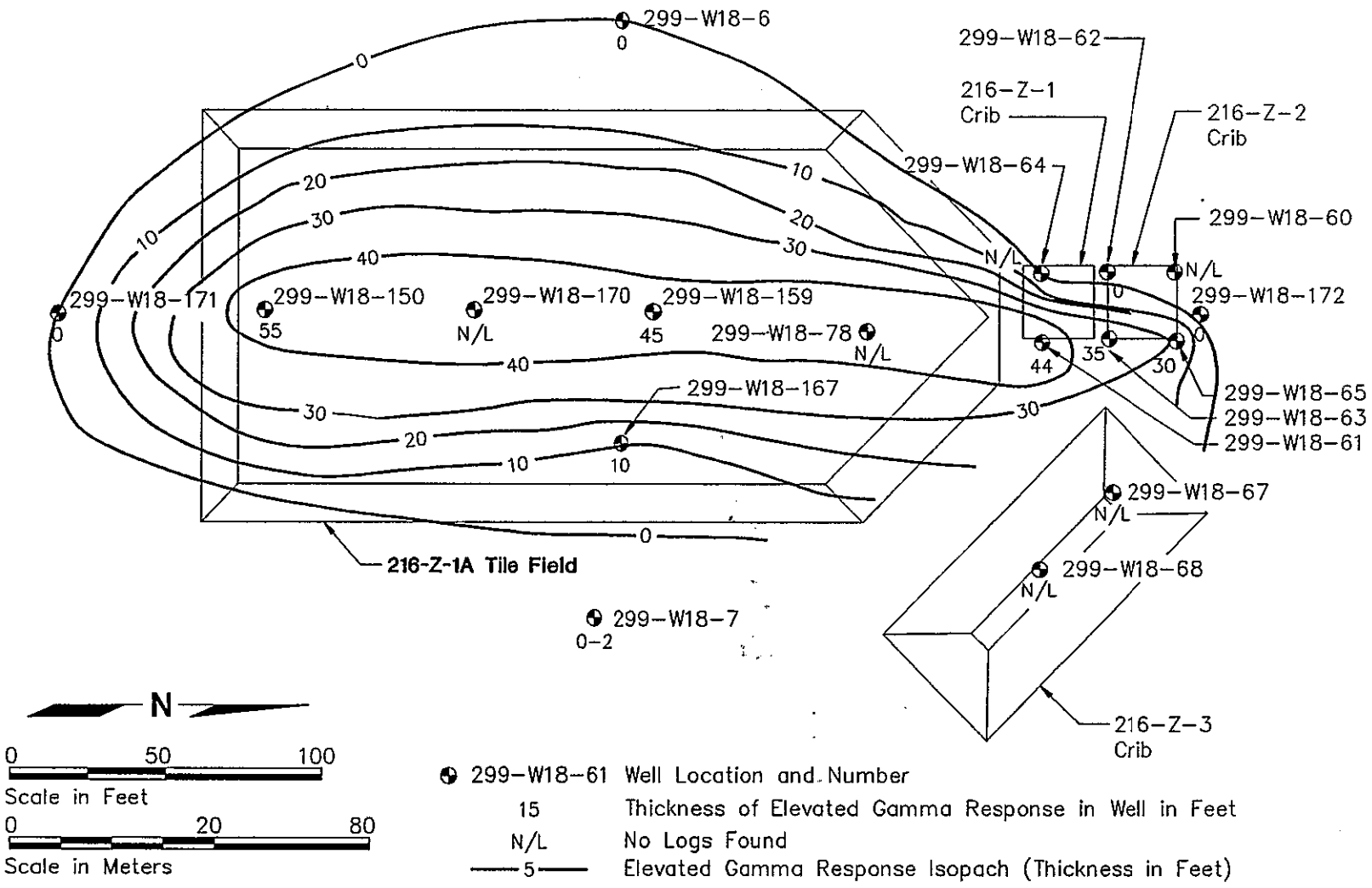


Figure A-7. Elevated Gamma Radiation Isopach Map of the 216-Z-1A Tile Field

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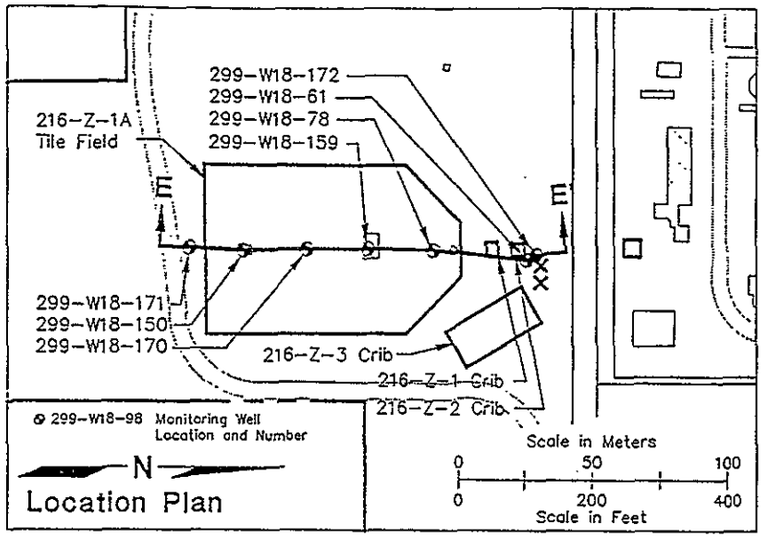

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Horizontal Scale in Meters
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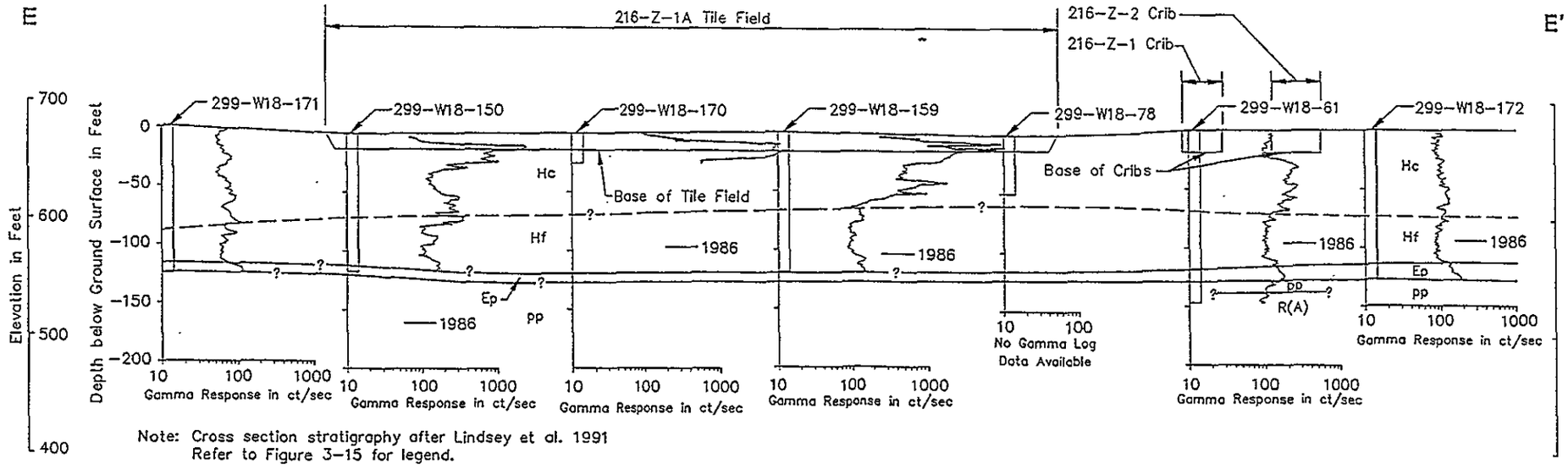
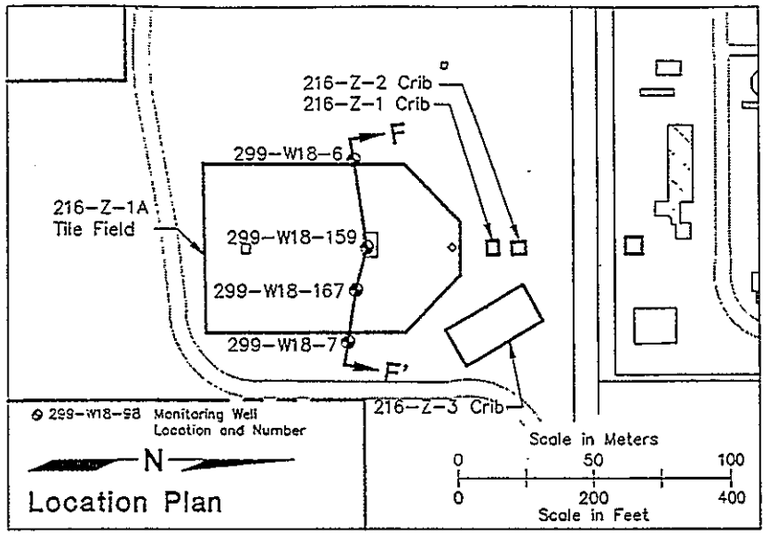
Vertical Scale in Meters
Vertical Exaggeration x 2.5



Note: Cross section stratigraphy after Lindsey et al. 1991
Refer to Figure 3-15 for legend.

Figure A-8. Scintillation Probe Profile Cross Section E-E' of the 216-Z-1A Tile Field.



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Vertical Scale in Feet
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Horizontal Scale in Meters
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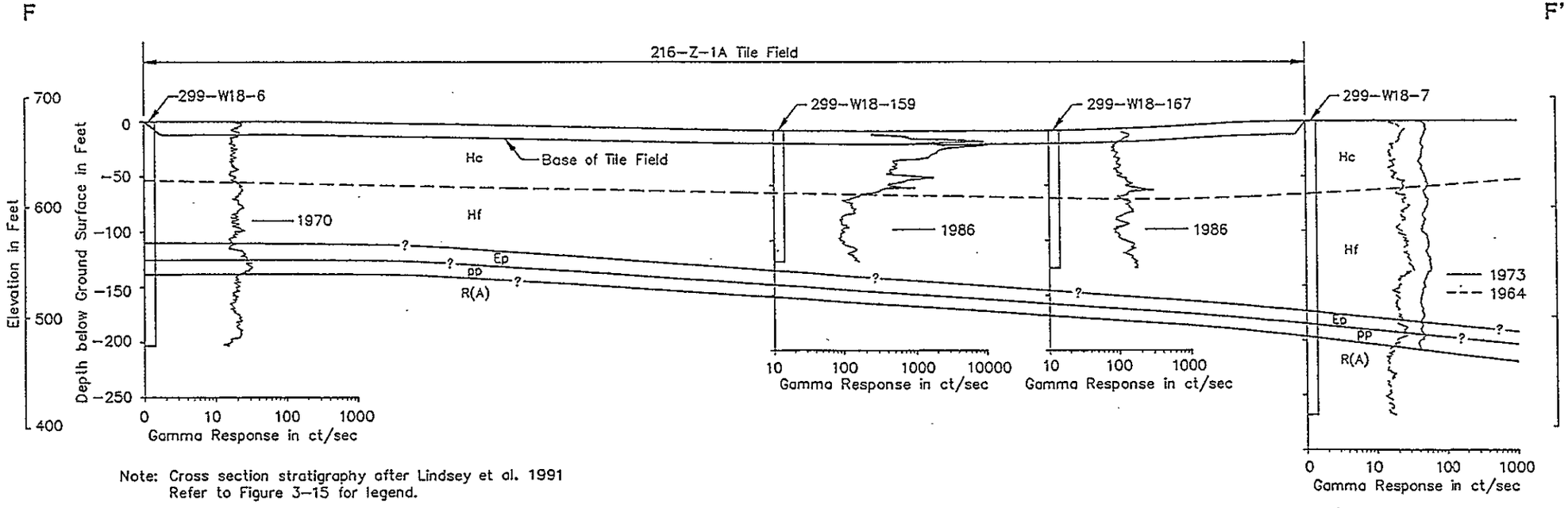
Vertical Scale in Meters
Vertical Exaggeration x 5



Note: Cross section stratigraphy after Lindsey et al. 1991
Refer to Figure 3-15 for legend.

Figure A-9. Scintillation Probe Profile Cross Section F-F' of the 216-Z-1A Tile Field.

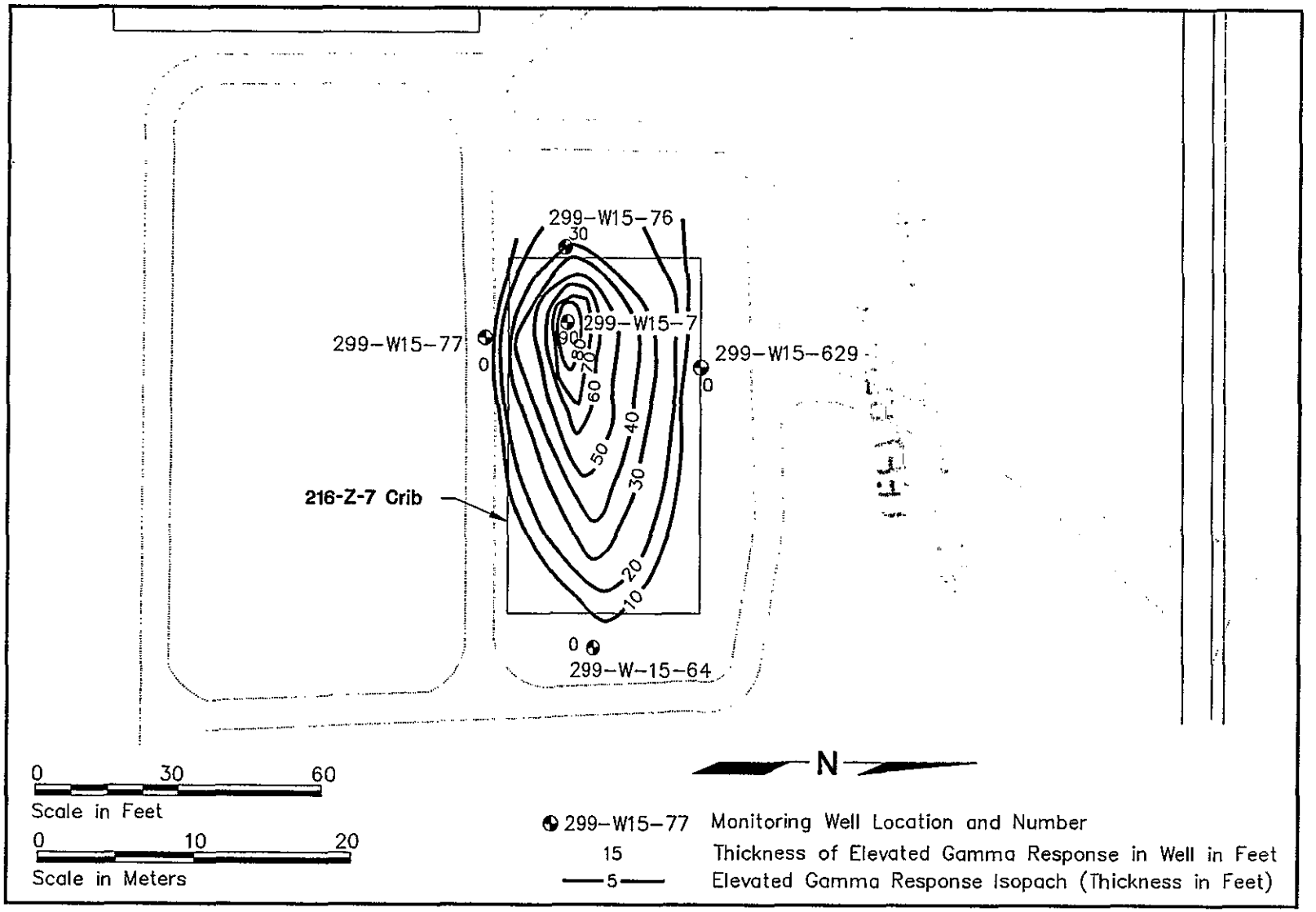


Figure A-10. Elevated Gamma Radiation Isopach Map of the 216-Z-7 Crib.

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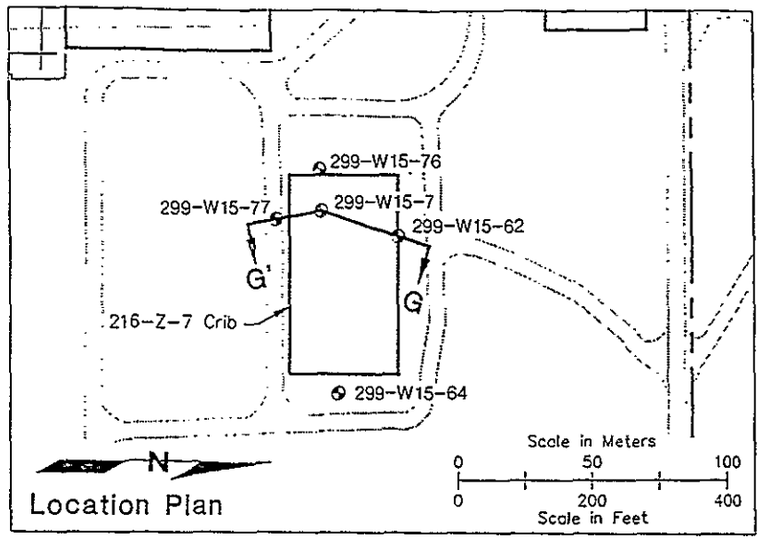

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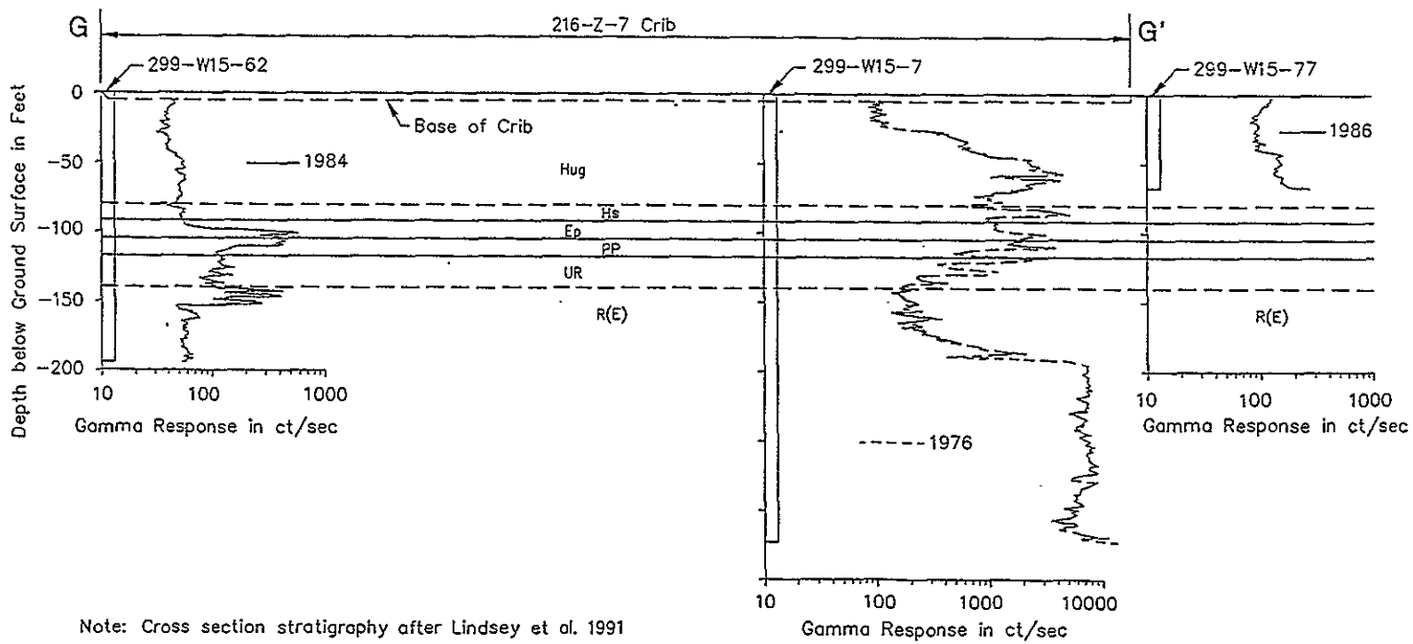
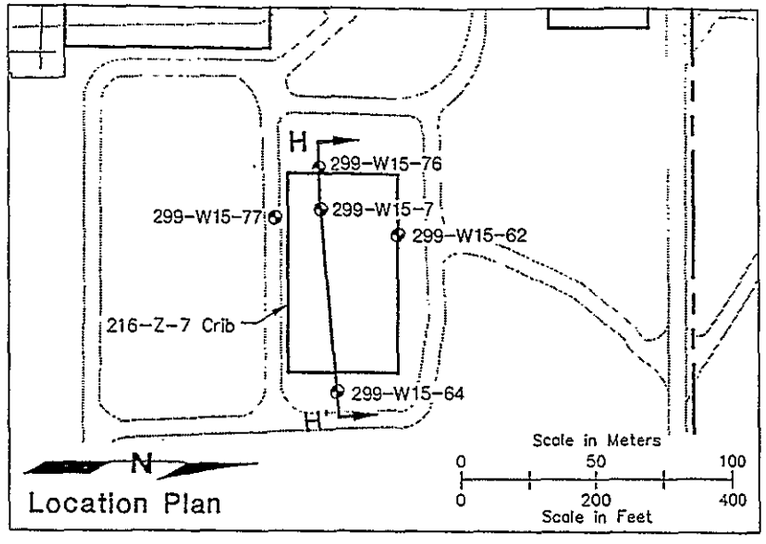
Vertical Scale in Meters
Vertical Exaggeration x 5



Note: Cross section stratigraphy after Lindsey et al. 1991
Refer to Figure 3-15 for legend.

Figure A-11. Scintillation Probe Profile Cross Section G-G' of the 216-Z-7 Crib.



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Vertical Scale in Meters
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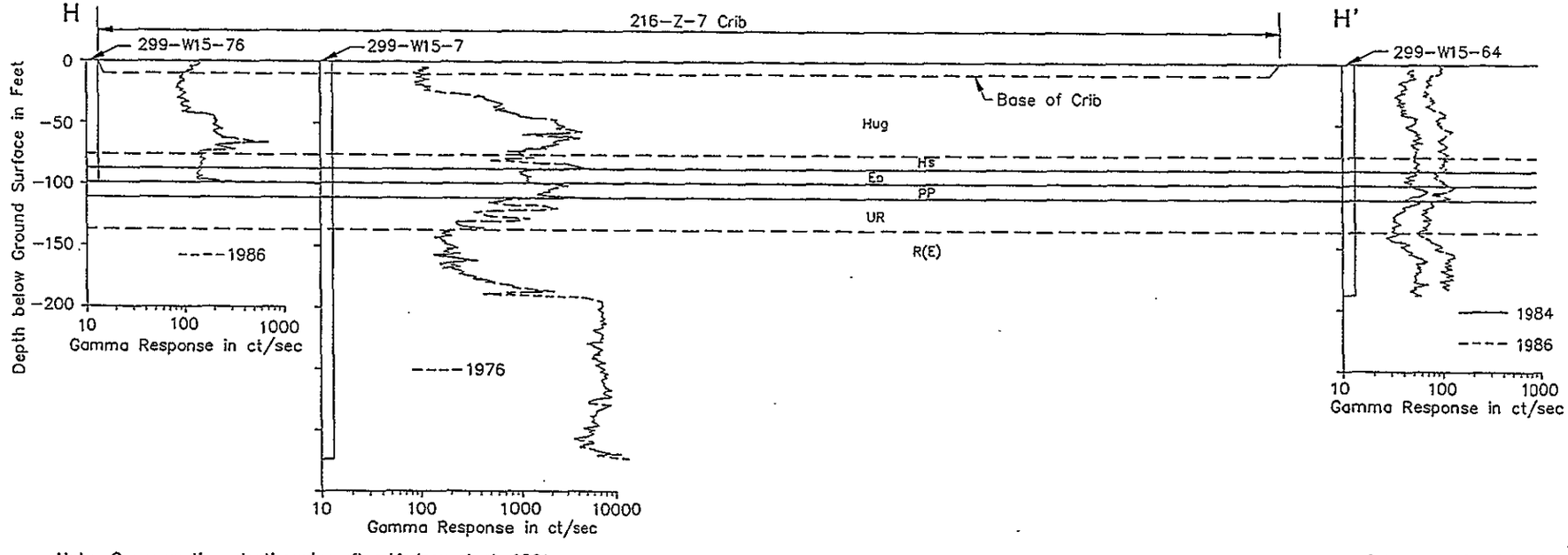

Note: Cross section stratigraphy after Lindsey et al. 1991

Refer to Figure 3-15 for legend.

Figure A-12. Scintillation Probe Profile Cross Section H-H' of the 216-Z-7 Crib.

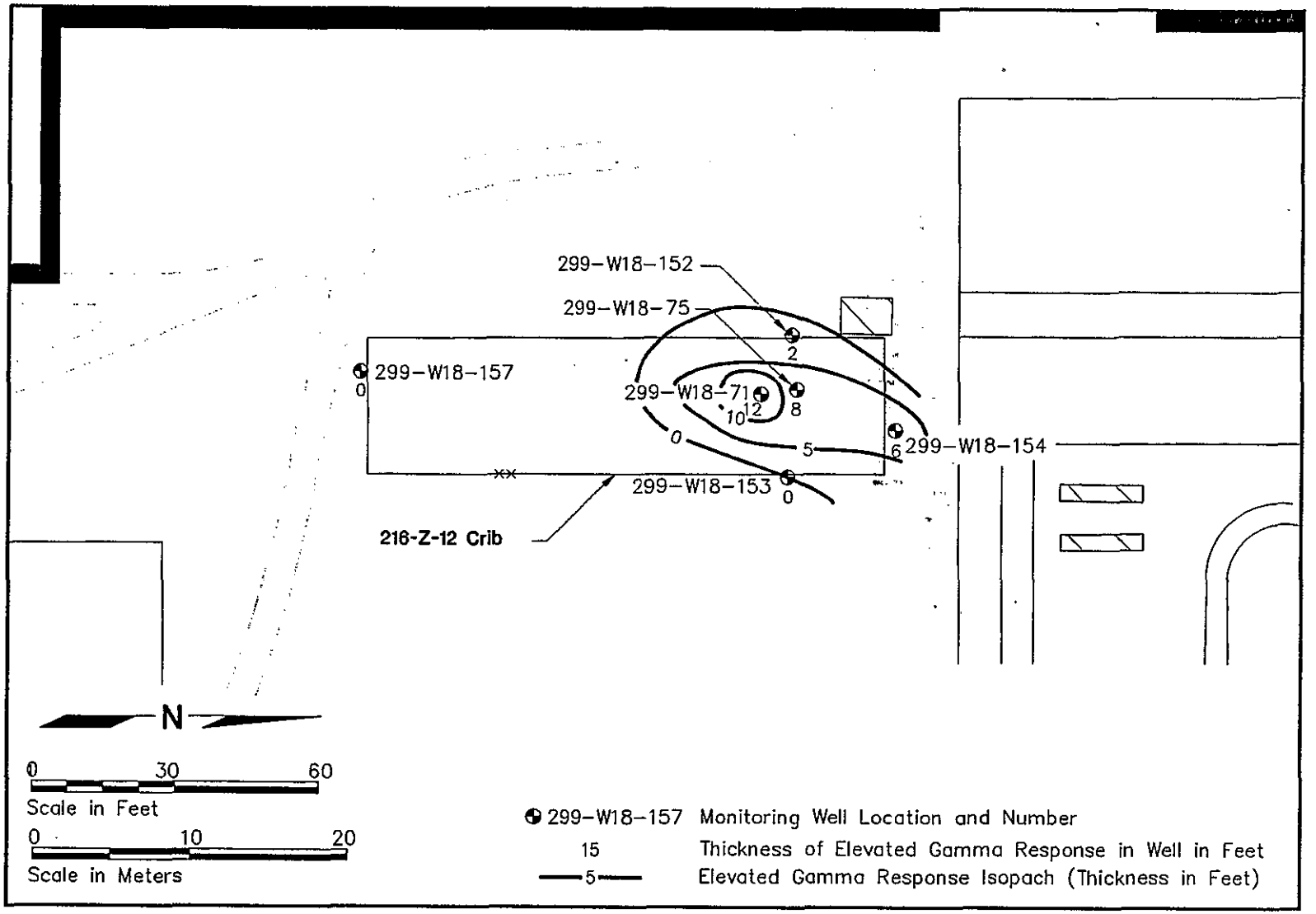

Figure A-13. Elevated Gamma Radiation Isopach Map of the 216-Z-12 Crib.

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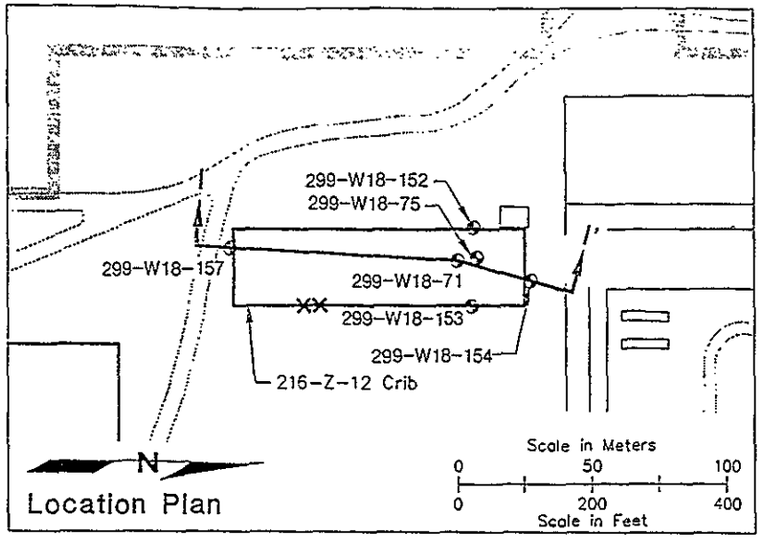

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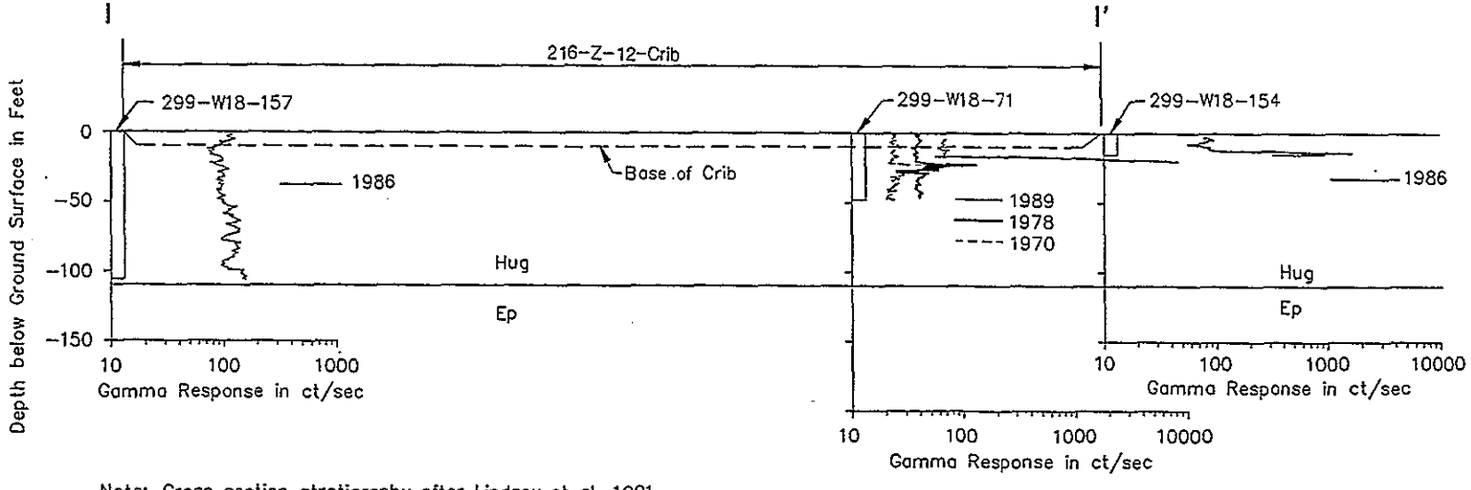
Vertical Scale in Meters
Vertical Exaggeration x 2



Note: Cross section stratigraphy after Lindsey et al. 1991
Refer to Figure 3-15 for legend.

Figure A-14. Scintillation Probe Profile Cross Section I-I' of the 216-Z-12 Crib.

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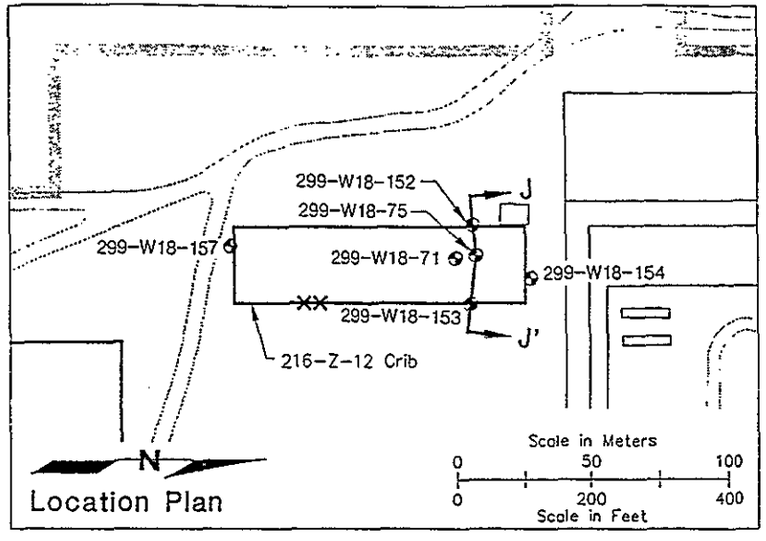

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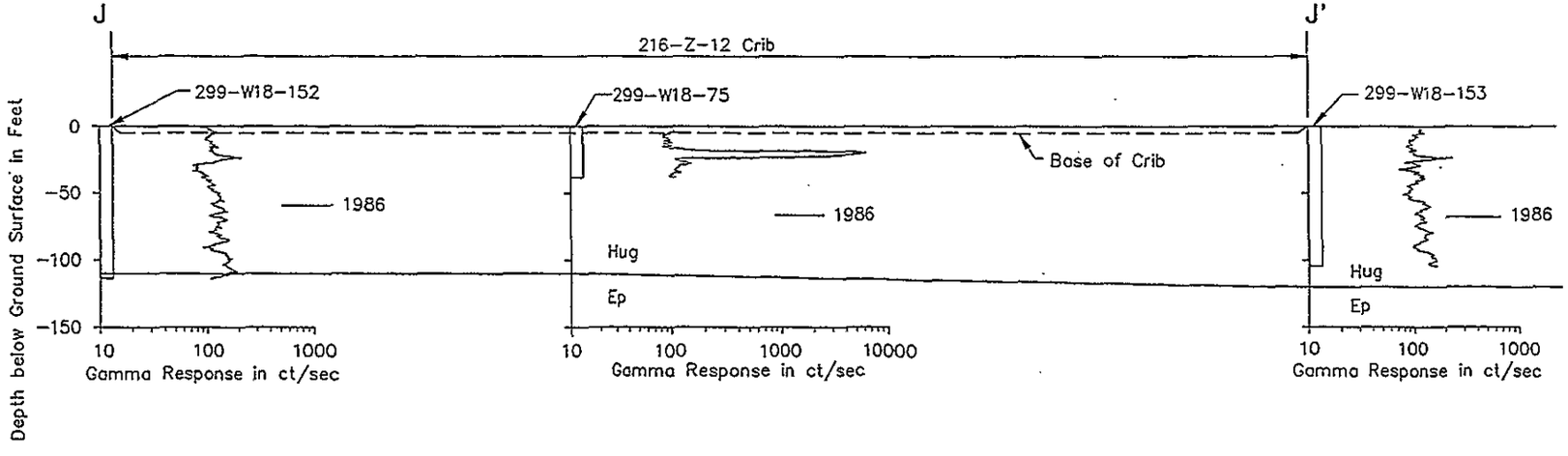

Note: Cross section stratigraphy after Lindsey et al. 1991
Refer to Figure 3-15 for legend.

Figure A-15. Scintillation Probe Profile Cross Section J-J' of the 216-Z-12 Crib.

Table A-1. Moisture Contents of Soil Samples from Z Plant Wells. (Sheet 1 of 5)

Well	Sediment Types	Sample Depth in Meters (Feet)	%H_2O
299-W7-8 (Source: Barton et al. 1990)		0.6 (2)	3.13
		1.2 (4)	2.43
		1.8 (6)	1.98
		2.7 (8.9)	2.02
		3.5 (11.5)	2.18
		4.3 (14)	4.36
		4.9 (16)	3.03
		6.3 (20.5)	3.09
		7.2 (23.5)	5.15
		7.8 (25.5)	5.75
		8.5 (28)	5.64
		9.3 (30.5)	11.70
		9.9 (32.5)	7.40
		10.7 (35)	4.86
		11.3 (37)	13.40
		11.9 (39)	13.40
		12.5 (41)	18.02
		13.4 (44)	4.34
		14.0 (46)	5.30
		14.6 (48)	6.28
		15.3 (50)	6.40
	HC	16.2 (53)	5.45
		16.8 (55)	4.27
	PP	17.4 (57)	9.95
		18.0 (59)	19.19
		18.9 (62)	5.84
		19.5 (64)	5.84
		20.1 (66)	5.17
		20.7 (68)	4.85
		21.4 (70)	5.65
		22.3 (73)	3.82
	E	23.8 (78)	3.00
		29.0 (95)	1.41
		30.5 (100)	0.87
		32.0 (105)	1.37
		33.6 (110)	1.26
		35.1 (115)	1.27
		36.6 (120)	3.26
		38.1 (125)	1.21
		39.7 (130)	1.39
		41.2 (135)	1.12
299-W7-8 (Source: Goodwin and Bjornstad 1990)		1.5 (5)	5.69
		3.1 (10)	2.74
		4.6 (15)	5.47
		6.1 (20)	3.97
	HC	7.6 (25)	5.15
		9.2 (30)	4.22
		10.7 (35)	4.86
		12.2 (40)	2.94

Table A-1. Moisture Contents of Soil Samples from Z Plant Wells. (Sheet 2 of 5)

Well	Sediment Types	Sample Depth in Meters (Feet)	%H_2O
299-W7-9 (Source: Barton et al. 1990)		1.2 (4)	1.79
		1.8-2.4 (6-8)	1.85
		3.7 (12)	2.29
		4.6 (15)	2.68
		6.1 (20)	2.24
		7.6 (25)	2.72
		9.2 (30)	2.91
		10.7 (35)	3.48
		13.7 (45)	4.59
		15.3 (50)	4.45
	HC	16.8 (55)	4.29
		18.3 (60)	4.51
	EP	19.8 (65)	5.27
		21.7 (71)	3.20
		22.3 (73)	3.21
	PP	24.4 (80)	6.59
		26.2 (86)	3.70
		27.5 (90)	3.77
		28.8 (94)	5.27
	UR	31.1 (102)	3.18
		32.3 (106)	2.96
		33.6 (110)	2.16
		34.8 (114)	1.73
		36.6 (120)	1.72
299-W7-7 (Source: Barton et al. 1990)	E	16.8 (55)	3.47
		18.3 (60)	4.06
		19.8 (65)	4.45

Table A-1. Moisture Contents of Soil Samples from Z Plant Wells. (Sheet 3 of 5)

Well	Sediment Types	Sample Depth in Meters (Feet)	%H_2O
299-W15-21 (Source: Barton et al. 1990)		1.2 (4)	10.34
		1.8 (6)	22.84
		4.6 (15)	2.73
		5.8 (19)	3.22
		7.6 (25)	3.27
		8.8 (29)	4.41
		9.9 (32.5)	19.59
		10.5 (34.5)	3.77
		11.6 (38)	3.91
		13.4 (44)	3.24
		14.6 (48)	2.91
		15.9 (52)	3.07
		17.1 (56)	2.19
		18.3 (60)	1.91
		19.8 (65)	2.29
	?_____ HC	30.5 (100)	4.07
		32.3 (106)	9.28
		33.6 (110)	7.60
		35.4 (116)	4.93
		37.8 (124)	15.71
		38.9 (127.5)	6.81
	?_____ HF	40.3 (132)	2.57
	EP	42.1 (138)	3.29
		42.7 (140)	3.40
		45.1 (148)	13.36
		46.4 (152)	10.19
		47.9 (157)	11.42
299-W15-21 (Source: Goodwin and Bjornstad 1990)	HC?	4.6 (15)	3.69
		6.1 (20)	3.83
		7.6 (25)	6.78
		9.2 (30)	14.69
		10.7 (35)	3.76
		12.2 (40)	6.88
		13.7 (45)	9.63
299-W18-26 (Source: Barton et al. 1990)		10.7 (35)	3.72
		12.2 (40)	3.96
		13.7 (45)	3.40
		15.3 (50)	2.66
	HC	16.8 (55)	3.19
	_____	35.1 (115)	7.37
		36.6 (120)	3.41
		38.1 (125)	2.39
		39.7 (130)	2.18
		41.2 (135)	2.06
		42.7 (140)	2.54
	HF	44.2 (145)	5.91
	_____	45.8 (150)	6.68
	EP	47.3 (155)	12.73

Table A-1. Moisture Contents of Soil Samples from Z Plant Wells. (Sheet 4 of 5)

Well	Sediment Types	Sample Depth in Meters (Feet)	%H_2O
299-W15-20 (Source: Goodwin and Bjornstad 1990)	HC / HF	1.5 (5)	3.19
		3.1 (10)	6.06
		4.6 (15)	7.25
		6.1 (20)	12.11
		7.6 (25)	3.19
		9.2 (30)	5.09
		10.7 (35)	3.57
		12.2 (40)	2.92
		13.7 (45)	4.39
		15.3 (50)	17.96
		16.8 (55)	3.11
		18.3 (60)	3.50
		25.9 (85)	7.55
		27.5 (90)	3.12
		29.0 (95)	3.03
		30.5 (100)	3.19
		32.0 (105)	3.60
		33.6 (110)	9.08
		35.1 (115)	4.22
		36.6 (120)	3.24
		38.1 (125)	3.18
		39.7 (130)	3.51
299-W15-19 (Source: Goodwin and Bjornstad 1990)	HC	6.1 (20)	2.73
		7.6 (25)	2.53
		9.2 (30)	3.40
		10.7 (35)	8.28
		12.2 (40)	3.09
		15.3 (50)	2.27
		16.8 (55)	2.34
		18.3 (60)	2.63
		21.4 (70)	5.29
		35.1 (115)	2.74
		36.6 (120)	2.77
		38.1 (125)	3.63
		39.7 (130)	8.19
		40.6 (133)	6.77
		41.2 (135)	9.60

Table A-1. Moisture Contents of Soil Samples from Z Plant Wells. (Sheet 5 of 5)

Well	Sediment Types	Sample Depth in Meters (Feet)	%H_2O
299-W15-23 (Source: Goodwin and Bjornstad 1990)	HC / HF	1.5 (5)	5.69
		3.1 (10)	2.74
		4.6 (15)	5.47
		6.1 (20)	3.97
		7.6 (25)	5.15
		9.2 (30)	4.22
		10.7 (35)	4.86
		12.2 (40)	2.94
		30.5 (100)	3.80
		32.0 (105)	3.40
		33.6 (110)	4.23
		35.1 (115)	4.36
		36.6 (120)	4.43
		38.1 (125)	5.43
299-W15-24 (Source: Goodwin and Bjornstad 1990)	HC?	15.3 (50)	3.49
		16.8 (55)	2.02
299-W7-10 (Source: Goodwin and Bjornstad 1990)	HC	1.5 (5)	3.42
		3.1 (10)	2.46

Notes:
Moisture contents in weight percent H_2O. See Figure 3-15 for key to sediment units.
Sediment contact depths for wells W7-9, W7-10, W15-20, W15-23, and W18-26 taken from Lindsey et al. (1992) (solid line contacts).
Sediment contact depths for wells W7-7, W7-8, and W15-19 taken from Appendix C6, ERA proposal for 200 West Carbon Tetrachloride Plume (DOE-RL 1991b) (solid line contacts).
Sediment contact depths for wells W15-21 and 15-24 interpreted from well log information from Barton et al. (1990) and Goodwin and Bjornstad (1990) (dashed line contacts and question marks).

Table A-2. Calcium Carbonate Contents of Soil Samples from Z Plant Aggregate Area Wells. (Sheet 1 of 4)

Well	Sediment Type	Sample Depth in Meters (Feet)	%$CaCO_3$
299-W7-08 (Source: Goodwin and Bjornstad 1990)		1.2 (4)	3.5
		2.7 (9)	3.1
		4.3 (14)	2.6
		6.4 (21)	1.4
		8 (26)	4.4
		9.5 (31)	0.9
		10.7 (35)	4.8
		11.9 (39)	24.9
		13.4 (44)	0.7
		14.6 (48)	3.8
	HC	16.2 (53)	3.0
	PP	17.4 (57)	20.3
		19 (62)	3.0
		20.1 (66)	1.6
		21.3 (70)	2.0
		22.9 (75)	11.7
	E	23.8 (78)	2.2
		25.9 (85)	1.5
		27.4 (90)	1.2
		29.0 (95)	1.4
		30.5 (100)	1.0
		32.0 (105)	0.5
		33.5 (110)	0.7
		35.0 (115)	1.9
		36.6 (120)	0.1
		38.1 (125)	0.7
		39.6 (130)	0.9
		41.2 (135)	0.7
		42.7 (140)	0.6
		44.2 (145)	0.8
		45.7 (150)	0.2
		47.2 (155)	0.2
		48.8 (160)	0.3
		50.3 (165)	0.1
		51.8 (170)	0.1
		53.3 (175)	0.1
		54.9 (180)	0.1
		56.4 (185)	0.2
		57.9 (190)	0.5
		59.4 (195)	0.2
		61.0 (200)	0.2
		62.5 (205)	0.2

Table A-2. Calcium Carbonate Contents of Soil Samples from Z Plant Aggregate Area Wells. (Sheet 2 of 4)

Well	Sediment Type	Sample Depth in Meters (Feet)	%$CaCO_3$
		64.0 (210)	0.2
		65.5 (215)	0.2
	E	67.1 (220)	0.2
		68.6 (225)	0.2
		70.1 (230)	0.2
		71.6 (235)	0.2
		73.2 (240)	1.1
		74.1 (243)	0.5
299-W-7-9 (Source: Goodwin and Bjornstad 1990)		1.2 (4)	4.01
		2.1 (7)	2.0
		3.7 (12)	1.7
		4.6 (15)	2.9
		6.1 (20)	1.0
		7.6 (25)	1.4
		9.1 (30)	1.3
		10.7 (35)	3.1
		12.2 (40)	6.4
		13.7 (45)	3.0
		15.2 (50)	3.0
	HC	16.8 (55)	5.8
	EP	18.3 (60)	10.1
		19.8 (65)	3.6
		21.0 (69)	2.9
	PP	22.9 (75)	25.4
		24.4 (80)	34.4
		26.2 (86)	0.8
		27.4 (90)	8.7
		29.3 (96)	22
	UR	31.1 (102)	14.7
		32.3 (106)	3.7
		33.5 (110)	1.5
		34.7 (114)	0.8
		36.6 (120)	1.0
		37.8 (124)	0.7
		39.6 (130)	1.3
		40.8 (134)	2.2
		42.1 (138)	2.6
		43.3 (142)	2.2
		44.2 (145)	0.8
	E	45.7 (150)	1.0
		47.2 (155)	0.7
		48.8 (160)	0.4

Table A-2. Calcium Carbonate Contents of Soil Samples from Z Plant Aggregate Area Wells. (Sheet 3 of 4)

Well	Sediment Type	Sample Depth in Meters (Feet)	%$CaCO_3$
		50.3 (165)	0.4
		51.8 (170)	0.2
		53.3 (175)	0.0
		54.9 (180)	0.1
	E	56.4 (185)	0.3
		57.9 (190)	0.2
		59.4 (195)	0.3
		61.0 (200)	0.2
		62.5 (205)	3.0
		64.0 (210)	0.8
299-W15-21 (Source: Barton et al. 1990)		1.2 (4)	4.4
		2.4 (8)	0.7
		4.6 (15)	31.6
		5.8 (19)	2.4
		7.6 (25)	1.0
		8.8 (29)	N/A
		10.7 (35)	1.0
		12.2 (40)	1.0
		13.4 (44)	1.4
		14.6 (48)	1.0
		15.8 (52)	1.6
		17.1 (56)	1.1
		18.3 (60)	1.5
		21.3 (70)	1.6
		22.9 (75)	1.0
		24.4 (80)	0.7
		25.9 (85)	0.6
		27.4 (90)	0.7
		29.0 (95)	0.7
	?____HC____	30.5 (100)	1.9
	HF	32.3 (106)	2.6
		33.5 (110)	19.4
		35.4 (116)	1.1
		36.6 (120)	2.0
		37.8 (124)	5.9
		39.0 (128)	1.6
		40.2 (132)	2.0
	?_____	40.8 (134)	2.0
	EP	42.7 (140)	1.6
		43.9 (144)	2.1
		45.1 (148)	2.3
		46.3 (152)	2.9

Table A-2. Calcium Carbonate Contents of Soil Samples from Z Plant Aggregate Area Wells. (Sheet 4 of 4)

Well	Sediment Type	Sample Depth in Meters (Feet)	%$CaCO_3$
	?_____	47.9 (157)	42.8
	PP	50.3 (165)	6.1
	PP	51.5 (169)	21.6
	?_____	53.3 (175)	16.8
	UR	54.9 (180)	4.8
		56.4 (185)	2.2
	?_____	57.9 (190)	0.7
	E	59.4 (195)	0.3
		61.0 (200)	0.5
		62.5 (205)	0.2
		64.0 (210)	0.2
		65.5 (215)	0.2

Notes:
Calcium carbonate contents in weight percent. See Figure 3-15 for key to sediment units.
Sediment contact depths for well W-79 were taken from Lindsey et al. (1991).
Sediment contact depths for well W7-8 were taken from Appendix C6, ERA Proposal for 200 West Carbon Tetrachloride Plume (DOE-RL 1991b).
Sediment contact depths for well W15-21 were interpreted from well log information from Barton et al. (1990) and Goodwin and Bjornstad (1990).

TABLE.A-2

Table A-3. Air Sampling Results. (Sheet 1 of 4)

Radionuclide in pCi/m³		1985 Result	1985 Error	1986 Result	1986 Error	1987 Result	1987 Error	1988 Result	1988 Error	1989 Result	1989 Error	Average Result
Sample N165: E-SE of Main Z Plant Building Complex												
Strontium-90	max	8.69E-03	— —	2.68E-03	— —	7.34E-05	— —	6.20E-05	7.30E-05	1.70E-04	9.92E-05	— —
	min	4.46E-05	— —	9.57E-05	— —	-1.88E-05	— —	4.10E-05	6.60E-05	0.00E+00	5.58E-05	— —
	avg	2.33E-03	8.84E-03	7.89E-04	2.53E-03	3.53E-05	9.15E-05	5.50E-05	1.00E-05	6.46E-05	7.89E-05	6.55E-04
Cesium-137	max	7.31E-04	— —	6.43E-04	— —	1.10E-03	— —	7.60E-05	6.10E-04	4.46E-04	4.12E-04	— —
	min	-3.04E-04	— —	-6.22E-05	— —	-2.89E-04	— —	-6.20E-04	5.70E-04	-1.09E-04	4.03E-04	— —
	avg	1.88E-04	8.48E-04	1.99E-04	6.14E-04	3.45E-04	1.39E-03	-2.30E-04	3.60E-04	1.81E-04	4.52E-04	1.37E-04
Plutonium-239	max	1.18E-04	— —	4.82E-04	— —	3.41E-04	— —	9.00E-04	— —	2.84E-04	3.82E-05	— —
	min	7.91E-05	— —	3.65E-05	— —	6.49E-05	— —	1.60E-04	— —	1.09E-05	4.91E-06	— —
	avg	9.50E-05	3.29E-05	3.07E-04	3.88E-04	1.98E-04	2.96E-04	4.20E-04	— —	1.64E-04	2.47E-05	2.37E-04
Uranium (total)	max	1.94E-04	— —	8.73E-05	— —	3.20E-05	— —	— —	— —	3.82E-05	1.81E-05	— —
	min	5.27E-05	— —	3.94E-05	— —	9.05E-06	— —	— —	— —	0.00E+00	1.79E-05	— —
	avg	1.25E-04	1.18E-05	6.07E-05	4.92E-05	1.86E-05	1.93E-05	— —	— —	1.30E-05	1.68E-05	5.43E-05

Table A-3. Air Sampling Results. (Sheet 2 of 4)

Radionuclide in pCi/m³		1985 Result	1985 Error	1986 Result	1986 Error	1987 Result	1987 Error	1988 Result	1988 Error	1989 Result	1989 Error	Average Result
Sample N962: SE Corner W-4B												
Strontium-90	max	1.91E-02	— —	5.36E-03	— —	1.06E-02	— —	4.60E-04	1.80E-04	1.61E-03	4.57E-04	— —
	min	1.78E-04	— —	1.59E-04	— —	-1.82E-04	— —	2.20E-04	1.20E-04	7.79E-05	1.47E-04	— —
	avg	5.01E-03	4.87E-03	1.75E-03	4.87E-03	3.57E-03	9.71E-03	3.10E-04	1.00E-04	6.07E-04	2.34E-04	2.25E-03
Cesium-137	max	7.04E-04	— —	2.48E-05	— —	1.00E-03	— —	8.20E-04	7.20E-04	3.45E-03	1.09E-03	— —
	min	-1.10E-04	— —	1.09E-05	— —	4.58E-04	— —	3.40E-04	5.90E-04	4.16E-04	4.25E-04	— —
	avg	3.32E-04	7.60E-04	2.50E-04	1.83E-03	7.33E-04	5.05E-04	4.30E-04	4.40E-04	1.23E-03	8.28E-04	5.95E-04
Plutonium-239	max	1.29E-05	— —	2.48E-05	— —	1.24E-04	— —	1.70E-05	— —	1.19E-04	2.09E-05	— —
	min	0.00E+00	— —	1.09E-05	— —	3.02E-05	— —	8.10E-06	— —	7.34E-06	5.06E-06	— —
	avg	7.42E-06	1.14E-05	1.67E-05	1.18E-05	6.75E-05	8.04E-05	2.40E-05	— —	4.83E-05	1.08E-05	3.28E-05
Uranium (total)	max	1.24E-04	— —	6.32E-05	— —	5.40E-05	— —	— —	— —	8.50E-05	3.35E-05	— —
	min	3.57E-05	— —	2.96E-05	— —	1.57E-05	— —	— —	— —	7.65E-07	2.08E-05	— —
	avg	7.45E-05	8.45E-05	4.89E-05	2.81E-05	2.90E-05	3.47E-05	— —	— —	3.66E-05	2.72E-05	4.73E-05

Table A-3. Air Sampling Results. (Sheet 3 of 4)

Radionuclide in pCi/m³		1985 Result	1985 Error	1986 Result	1986 Error	1987 Result	1987 Error	1988 Result	1988 Error	1989 Result	1989 Error	Average Result
Sample N964: W of W-4B												
Strontium-90	max	1.24E-02	— —	3.80E-04	— —	1.77E-04	— —	1.60E-04	9.70E-05	1.83E-04	1.21E-04	— —
	min	7.42E-02	— —	1.14E-04	— —	1.06E-05	— —	2.90E-05	6.50E-05	-1.00E-05	5.61E-05	— —
	avg	3.25E-03	1.22E-02	2.34E-04	2.19E-04	7.43E-05	1.45E-04	8.40E-05	6.60E-05	8.19E-05	9.03E-05	7.45E-04
Cesium-137	max	2.65E-04	— —	9.33E-04	— —	5.88E-04	— —	1.70E-04	5.50E-04	4.10E-04	5.70E-04	— —
	min	-2.11E-04	— —	-6.10E-04	— —	0.00E+00	— —	-1.00E-04	4.60E-04	-2.41E-04	6.15E-04	— —
	avg	5.37E-05	3.97E-04	6.85E-05	1.33E-03	2.04E-04	5.55E-04	-3.90E-05	2.20E-04	1.03E-04	5.40E-04	7.80E-05
Plutonium-239	max	2.11E-05	— —	1.28E-04	— —	1.08E-04	— —	1.80E-05	— —	3.65E-06	2.85E-06	— —
	min	2.48E-06	— —	2.17E-06	— —	4.95E-06	— —	-5.70E-07	— —	1.61E-05	6.03E-06	— —
	avg	1.20E-05	1.74E-05	3.52E-05	1.24E-04	4.10E-05	9.44E-05	6.20E-06	— —	7.75E-06	4.06E-06	2.04E-05
Uranium (total)	max	1.20E-04	— —	4.50E-05	— —	3.60E-05	— —	— —	— —	5.38E-05	2.33E-05	— —
	min	2.25E-05	— —	2.30E-05	— —	1.02E-05	— —	— —	— —	5.48E-07	1.92E-05	— —
	avg	5.92E-05	8.44E-05	3.56E-05	1.90E-05	2.35E-05	2.22E-05	— —	— —	2.79E-05	2.13E-05	3.66E-05

Table A-3. Air Sampling Results. (Sheet 4 of 4)

Radionuclide in pCi/m³		1985 Result	1985 Error	1986 Result	1986 Error	1987 Result	1987 Error	1988 Result	1988 Error	1989 Result	1989 Error	Average Result
Sample N994: Old Corner 200 West												
Strontium-90	max	— —	— —	1.51E-04	— —	8.61E-05	— —	2.30E-04	1.20E-04	3.00E-04	1.29E-04	— —
	min	— —	— —	2.05E-05	— —	-7.60E-06	— —	1.70E-05	9.30E-05	2.00E-05	8.19E-05	— —
	avg	— —	— —	1.04E-04	1.46E-04	4.33E-05	8.64E-05	8.60E-05	9.80E-05	7.95E-05	9.67E-05	6.26E-05
Cesium-137	max	— —	— —	3.31E-03	— —	5.52E-05	— —	6.10E-04	5.70E-04	2.72E-04	4.92E-04	— —
	min	— —	— —	-1.40E-04	— —	-6.29E-04	— —	1.60E-04	4.90E-04	-3.78E-05	6.06E-04	— —
	avg	— —	— —	1.06E-03	3.91E-03	2.95E-04	6.35E-04	3.10E-04	2.10E-04	2.27E-04	5.47E-04	1.70E-04
Plutonium-239	max	— —	— —	9.12E-06	— —	5.31E-06	— —	2.60E-06	— —	1.30E-06	1.94E-06	— —
	min	— —	— —	2.62E-06	— —	2.17E-07	— —	-5.60E-07	— —	6.51E-07	1.81E-06	— —
	avg	— —	— —	5.76E-06	6.51E-06	3.03E-06	4.23E-06	7.00E-07	— —	1.02E-06	2.08E-06	2.10E-06
Uranium (total)	max	— —	— —	1.05E-04	— —	2.04E-05	— —	— —	— —	5.36E-05	2.91E-05	— —
	min	— —	— —	2.91E-05	— —	8.65E-06	— —	— —	— —	0.00E+00	1.85E-05	— —
	avg	— —	— —	5.98E-05	8.00E-05	1.57E-05	1.00E-05	— —	— —	1.70E-05	1.86E-05	2.31E-05

Notes:
— — indicates radionuclide not analyzed, or results not reported.
Shaded entry indicates result less than error.
Negative values indicate concentration at or near background levels for radioactivity (Ref: 1988 and 1989 data).
Sample error data not available for 1985 through 1987.

Data Sources:
Elder et al. 1986, 1987, 1988, and 1989; Schmidt et al. 1990 and 1992.

Table A-4. Results of Grid Soil Sampling.. (Sheet 1 of 6)

Radionuclide in pCi/g	1985		1986 (1)		1987		1988		1989		Average Result
	Result	Error	Result	Error	Result	Error	Result	Error	Result (1)	Error	
Sample 2W2											
Cerium-141	--	--	--	--	--	--	--	--	--	--	--
Cerium-144	--	--	--	--	--	--	--	--	--	--	--
Cobalt-58	--	--	--	--	--	--	--	--	--	--	--
Cobalt-60	--	--	--	--	--	--	4.60E-03	1.60E-02	--	--	-4.60E-03
Cesium-134	--	--	--	--	--	--	--	--	--	--	--
Cesium-137	--	--	--	--	--	--	6.40E+00	6.50E-01	--	--	6.40E+00
Europium-152	--	--	--	--	--	--	5.90E-02	7.10E-02	--	--	5.90E-02
Europium-154	--	--	--	--	--	--	-2.30E-02	4.70E-02	--	--	-2.30E-02
Europium-155	--	--	--	--	--	--	5.50E-02	6.30E-02	--	--	5.50E-02
Iodine-129	--	--	--	--	--	--	--	--	--	--	--
Potassium-40	--	--	--	--	--	--	--	--	--	--	--
Manganese-54	--	--	--	--	--	--	1.30E-02	1.30E-02	--	--	1.30E-02
Niobium-95	--	--	--	--	--	--	3.20E-02	1.80E-02	--	--	3.20E-02
Lead-212	--	--	--	--	--	--	--	--	--	--	--
Lead-214	--	--	--	--	--	--	6.00E-01	8.80E-02	--	--	600E-01
Plutonium-238	--	--	--	--	--	--	1.70E-03	4.10E-04	--	--	1.70E-03
Plutonium-239	--	--	--	--	--	--	7.90E-01	7.00E-02	--	--	7.90E-01
Ruthenium-106	--	--	--	--	--	--	6.10E-02	1.50E-01	--	--	6.10E-02
Strontium-90	--	--	--	--	--	--	9.10E-02	1.70E-01	--	--	9.10E-01
Technetium-99	--	--	--	--	--	--	--	--	--	--	--
Uranium	--	--	--	--	--	--	3.00E-01	9.20E-02	--	--	3.00E-01
Zinc-65	--	--	--	--	--	--	--	--	--	--	--
Zirconium-95	--	--	--	--	--	--	3.70E-03	2.60E-02	--	--	3.70E-03

Table A-4. Results of Grid Soil Sampling. (Sheet 2 of 6)

Radionuclide in pCi/g	1985		1986 (1)		1987		1988		1989		Average Result
	Result	Error	Result	Error	Result	Error	Result	Error	Result (1)	Error	
Sample 2W3											
Cerium-141	--	--	--	--	--	--	--	--	--	--	--
Cerium-144	--	--	--	--	--	--	--	--	--	--	--
Cobalt-58	1.30E-01	8.00E-02	--	--	--	--	--	--	--	--	1.30E-01
Cobalt-60	a	--	--	--	--	--	1.50E-03	1.70E-02	--	--	-1.50E-03
Cesium-134	a	--	5.00E-02	3.00E-02	--	--	--	--	--	--	5.00E-02
Cesium-137	3.05E+00	3.00E-01	8.70E-01	1.10E-01	--	--	1.30E+00	1.40E-01	--	--	1.74E+00
Europium-152	a	--	--	--	--	--	9.80E-02	8.10E-02	--	--	9.80E-02
Europium-154	a	--	--	--	--	--	1.80E-02	6.10E-02	--	--	1.80E-02
Europium-155	a	--	--	--	--	--	2.60E-02	6.10E-02	--	--	2.60E-02
Iodine-129	--	--	--	--	--	--	--	--	--	--	--
Potassium-40	--	--	--	--	--	--	--	--	--	--	--
Manganese-54	a	--	--	--	--	--	1.70E-02	1.70E-02	--	--	1.70E-02
Niobium-95	a	--	--	--	--	--	3.90E-02	2.20E-02	--	--	3.90E-03
Lead-212	--	--	--	--	--	--	--	--	--	--	--
Lead-214	--	--	--	--	--	--	6.20E-01	8.50E-02	--	--	6.20E-01
Plutonium-238	1.60E-03	6.00E-04	6.00E-04	4.00E-04	--	--	1.00E-03	3.10E-04	--	--	1.07E-03
Plutonium-239	1.70E-01	2.00E-02	4.00E-02	1.00E-02	--	--	3.30E-01	6.40E-02	--	--	1.80E-01
Ruthenium-106	a	--	--	--	--	--	0.00E+00	1.50E-01	--	--	3.30E-01
Strontium-90	1.05E+00	1.90E-01	2.50E-01	5.00E-02	--	--	--	--	--	--	6.50E-01
Technetium-99	--	--	--	--	--	--	--	--	--	--	--
Uranium	3.40E-01	1.10E-01	4.60E-01	1.50E-01	--	--	2.50E-01	8.00E-02	--	--	3.50E-01
Zinc-65	4.40E-01	1.50E-01	--	--	--	--	--	--	--	--	4.40E-01
Zirconium-95	a	--	--	--	--	--	2.00E-02	3.10E-02	--	--	2.00E-02

Table A-4. Results of Grid Soil Sampling. (Sheet 3 of 6)

Radionuclide in pCi/g	1985		1986 (1)		1987		1988		1989		Average Result
	Result	Error	Result	Error	Result	Error	Result	Error	Result (1)	Error	
Sample 2W7											
Cerium-141	--	--	--	--	--	--	--	--	-5.63E-02	7.40E-02	-5.63E-02
Cerium-144	--	--	--	--	--	--	--	--	-2.48E-02	1.02E-01	-2.48E-02
Cobalt-58	a	--	--	--	--	--	--	--	-6.82E-03	2.55E-02	-6.82E-03
Cobalt-60	a	--	--	--	--	--	5.90E-03	1.50E-02	9.28E-03	1.94E-02	7.59E-03
Cesium-134	a	--	5.00E-02	3.00E-02	--	--	--	--	4.96E-02	1.86E-02	4.98E-02
Cesium-137	9.85E+00	7.00E-01	4.50E+00	4.80E-01	--	--	2.40E+00	2.60E-01	1.27E+00	1.39E-01	4.51E+00
Europium-152	a	--	--	--	--	--	3.30E-02	7.20E-02	1.18E-01	7.59E-02	7.55E-02
Europium-154	a	--	--	--	--	--	3.60E-03	5.20E-02	-6.61E-02	6.03E-02	-2.90E-02
Europium-155	a	--	--	--	--	--	4.70E-02	5.40E-02	1.92E-02	5.68E-02	3.31E-02
Iodine-129	--	--	--	--	--	--	--	--	-1.58E-02	3.11E-01	-1.58E-02
Potassium-40	--	--	--	--	--	--	--	--	1.59E+01	1.76E+00	1.59E+01
Manganese-54	6.00E-02	4.00E-02	--	--	--	--	3.70E-03	1.40E-02	-1.74E-03	1.85E-02	2.07E-02
Niobium-95	a	--	--	--	--	--	-1.30E-02	1.70E-02	-8.45E-02	5.93E-02	-4.88E-02
Lead-212	--	--	--	--	--	--	--	--	7.10E-01	8.29E-02	7.10E-01
Lead-214	--	--	--	--	--	--	5.40E-01	7.60E-02	5.32E-01	7.66E-02	5.36E-01
Plutonium-238	2.90E-03	7.00E-04	9.10E-03	2.90E-03	--	--	1.20E-03	3.40E-04	4.50E-04	2.00E-04	3.41E-03
Plutonium-239	7.00E-02	1.00E-02	1.00E-01	2.00E-02	--	--	4.40E-02	4.70E-03	1.13E-02	1.45E-03	5.63E-02
Ruthenium-106	a	--	4.00E-01	2.70E-01	--	--	4.60E-02	1.30E-01	7.92E-02	1.58E-01	1.44E-01
Strontium-90	9.50E-01	1.80E-01	4.30E-01	8.00E-02	--	--	2.10E-01	4.20E-02	1.64E-01	3.42E-02	4.39E-01
Technetium-99	--	--	--	--	--	--	--	--	1.27E-01	1.16E+00	1.27E-01
Uranium	2.60E-01	9.00E-02	3.80E-01	1.30E-01	--	--	2.50E-01	7.90E-02	3.77E-01	1.14E-01	3.17E-01
Zinc-65	a	--	--	--	--	--	--	--	-1.04E-01	5.62E-02	-1.04E-01
Zirconium-95	a	--	--	--	--	--	5.50E-03	2.50E-02	-8.83E-03	4.83E-02	-1.67E-03

Table A-4. Results of Grid Soil Sampling. (Sheet 4 of 6)

Radionuclide in pCi/g	1985		1986 (1)		1987		1988		1989		Average Result
	Result	Error	Result	Error	Result	Error	Result	Error	Result (1)	Error	
Sample 2W17											
Cerium-141	— —	— —	— —	— —	6.90E-03	4.10E-02	— —	— —	2.61E-02	7.53E-02	9.60E-03
Cerium-144	— —	— —	— —	— —	2.70E-02	1.10E-01	— —	— —	8.69E-02	9.44E-02	3.00E-02
Cobalt-58	a	— —	— —	— —	2.40E-03	2.00E-02	— —	— —	-1.57E-02	2.81E-02	-6.65E-03
Cobalt-60	a	— —	— —	— —	1.80E-02	2.00E-02	1.90E-03	1.40E-02	8.89E-03	1.58E-02	-8.33E-03
Cesium-134	a	— —	5.00E-02	3.00E-02	5.20E-02	2.30E-02	— —	— —	4.00E-03	1.52E-02	3.53E-02
Cesium-137	9.60E-01	1.40E-01	5.00E-01	8.00E-02	4.60E-01	6.10E-02	3.00E-01	4.00E-02	4.78E-01	6.20E-02	5.40E-01
Europium-152	1.80E-01	1.40E-01	— —	— —	1.30E-01	6.60E-02	2.10E-02	5.90E-02	4.65E-02	7.45E-02	9.44E-02
Europium-154	a	— —	— —	— —	1.20E-02	4.60E-02	1.40E-02	4.60E-02	-6.28E-03	5.08E-02	6.57E-03
Europium-155	2.00E-01	1.50E-01	— —	— —	6.10E-02	5.80E-02	3.70E-02	4.70E-02	5.38E-02	4.99E-02	8.80E-02
Iodine-129	— —	— —	— —	— —	— —	— —	3.90E+01	3.90E+01	2.52E-01	5.00E-01	1.96E+01
Potassium-40	— —	— —	— —	— —	— —	— —	— —	— —	1.36E+01	1.54E+00	1.36E+01
Manganese-54	a	— —	— —	— —	2.70E-03	2.10E-02	3.60E-03	1.50E-02	-1.78E-03	1.85E-02	-2.69E-03
Niobium-95	a	— —	— —	— —	— —	— —	-1.70E-02	1.60E-02	1.02E-01	6.44E-02	-5.95E-02
Lead-212	— —	— —	— —	— —	— —	— —	— —	— —	8.09E-01	9.32E-02	8.09E-01
Lead-214	— —	— —	— —	— —	— —	— —	4.80E-01	6.60E-02	6.59E-01	8.69E-02	5.70E-01
Plutonium-238	7.20E-03	1.30E-03	3.00E-03	1.00E-03	6.20E-03	1.00E-03	3.10E-02	6.20E-04	2.98E-03	6.45E-04	4.50E-03
Plutonium-239	1.40E-01	1.00E-02	9.00E-02	1.00E-02	1.10E-01	1.20E-02	1.00E-01	1.10E-02	1.34E-01	1.40E-02	1.15E-01
Ruthenium-106	a	— —	— —	— —	1.30E-01	1.50E-01	4.50E-02	1.10E-01	1.91E-02	1.59E-01	6.47E-02
Strontium-90	4.50E-01	8.00E-02	1.70E-01	4.00E-02	1.60E-01	4.20E-02	1.40E-01	2.70E-02	1.27E-01	2.73E-02	2.09E-01
Technetium-99		— —	— —	— —	— —	— —	— —	— —	-7.71E-02	1.15E+00	-7.71E-02
Uranium	3.40E-01	1.10E-01	2.80E-01	9.00E-02	3.10E-01	9.20E-02	2.60E-01	8.10E-02	4.46E-01	1.35E-01	3.27E-01
Zinc-65	a	— —	— —	— —	-1.70E-03	3.90E-02	— —	— —	-1.37E-03	4.56E-02	-1.79E-03
Zirconium-95	a	— —	— —	— —	3.00E-02	3.90E-02	8.20E-03	2.40E-02	3.16E-03	6.04E-02	1.17E-02

Table A-4. Results of Grid Soil Sampling. (Sheet 5 of 6)

Radionuclide in pCi/g	1985		1986 (1)		1987		1988		1989		Average Result
	Result	Error	Result	Error	Result	Error	Result	Error	Result (1)	Error	
Sample 2W22											
Cerium-141	--	--	--	--	--	--	--	--	--	--	--
Cerium-144	--	--	--	--	--	--	--	--	--	--	--
Cobalt-58	a	--	--	--	--	--	--	--	--	--	--
Cobalt-60	3.00E-02	2.00E-02	--	--	--	--	1.10E-02	1.80E-02	--	--	9.50E-03
Cesium-134	a	--	3.00E-02	3.00E-02	--	--	--	--	--	--	3.00E-02
Cesium-137	1.45E+00	1.60E-01	8.30E-01	1.00E-01	--	--	1.00E+00	1.10E-01	--	--	1.90E+00
Europium-152	2.00E-01	1.30E-01	--	--	--	--	8.30E-02	7.60E-02	--	--	1.42E-01
Europium-154	a	--	--	--	--	--	1.80E-02	5.10E-02	--	--	1.80E-02
Europium-155	a	--	--	--	--	--	4.50E-02	5.70E-02	--	--	4.50E-02
Iodine-129	--	--	--	--	--	--	--	--	--	--	--
Potassium-40	--	--	--	--	--	--	--	--	--	--	--
Manganese-54	a	--	--	--	--	--	2.40E-03	1.60E-02	--	--	-2.4E-03
Niobium-95	a	--	--	--	--	--	1.70E-02	1.90E-02	--	--	-1.70E-02
Lead-212	--	--	--	--	--	--	--	--	--	--	--
Lead-214	--	--	--	--	--	--	6.50E-01	8.60E-02	--	--	6.50E-01
Plutonium-238	3.60E-03	9.00E-04	1.80E-03	6.00E-04	--	--	2.40E-03	5.20E-04	--	--	2.60E-03
Plutonium-239	7.00E-02	1.00E-02	3.00E-02	0.00E+00	--	--	7.20E-02	7.50E-03	--	--	5.73E-02
Ruthenium-106	4.40E-01	3.10E-01	--	--	--	--	1.70E-02	1.40E-01	--	--	2.29E-01
Strontium-90	9.40E-01	1.70E-01	5.00E-01	1.00E-01	--	--	4.60E-01	8.70E-02	--	--	6.33E-01
Technetium-99	--	--	--	--	--	--	--	--	--	--	--
Uranium	3.10E-01	1.10E-01	3.90E-01	1.30E-01	--	--	3.50E-01	1.10E-01	--	--	3.50E-01
Zinc-65	a	--	--	--	--	--	--	--	--	--	--
Zirconium-95	a	--	--	--	--	--	3.40E-02	2.90E-02	--	--	3.40E-02

Table A-4. Results of Grid Soil Sampling. (Sheet 6 of 6)

Radionuclide in pCi/g	1985		1986 (1)		1987		1988		1989		Average Result
	Result	Error	Result	Error	Result	Error	Result	Error	Result (1)	Error	
Sample 2WN											
Cerium-141	— —	— —	— —	— —	2.70E-02	2.70E-02	1.40E-02	2.20E-02	2.39E-02	6.77E-02	3.63E-03
Cerium-144	— —	— —	— —	— —	1.20E-02	8.60E-02	— —	— —	-5.54E-02	9.28E-02	-3.37E-02
Cobalt-58	a	— —	— —	— —	1.10E-02	1.40E-02	— —	— —	-9.50E-03	2.52E-02	-1.03E-02
Cobalt-60	a	— —	— —	— —	4.70E-03	1.40E-02	— —	— —	-1.18E-02	1.63E-02	-3.55E-03
Cesium-134	a	— —	3.50E-02	3.00E-02	2.30E-02	1.90E-02	2.40E-03	1.10E-02	5.11E-02	1.71E-02	1.13E-03
Cesium-137	1.48E-01	5.20E-02	1.56E-01	3.90E-02	1.30E-01	2.70E-02	1.30E-01	2.70E-02	1.54E-01	2.80E-02	1.44E-01
Europium-152	a	— —	— —	— —	1.20E-01	7.20E-01	4.20E-03	7.30E-02	3.21E-02	8.83E-02	6.21E-02
Europium-154	a	— —	— —	— —	1.20E-02	5.30E-02	2.50E-02	4.70E-02	2.76E-02	5.52E-02	4.87E-03
Europium-155	a	— —	— —	— —	8.10E-03	4.80E-02	4.40E-02	4.40E-02	5.13E-02	5.28E-02	3.45E-02
Iodine-129	— —	— —	— —	— —	— —	— —	— —	— —	— —	— —	— —
Potassium-40	— —	— —	— —	— —	— —	— —	— —	— —	1.44E+01	1.60E+00	1.44E+01
Manganese-54	a	— —	— —	— —	2.50E-02	1.30E-02	8.60E-03	1.30E-02	1.50E-02	1.87E-02	1.62E-02
Niobium-95	a	— —	— —	— —	— —	— —	— —	— —	-7.52E-02	6.19E-02	-7.52E-02
Lead-212	— —	— —	— —	— —	— —	— —	— —	— —	7.99E-01	8.98E-02	7.99E-01
Lead-214	— —	— —	— —	— —	— —	— —	— —	— —	5.92E-01	7.82E-02	5.92E-01
Plutonium-238	a	— —	— —	— —	8.90E-05	1.50E-04	3.90E-05	1.10E-04	— —	— —	6.40E-05
Plutonium-239	6.00E-03	2.00E-03	5.00E-03	1.00E-03	3.80E-03	8.40E-04	3.60E-03	9.90E-04	— —	— —	4.60E-03
Ruthenium-106	a	— —	— —	— —	1.40E-01	1.10E-01	2.90E-02	1.10E-01	-9.60E-02	1.34E-01	-8.83E-02
Strontium-90	1.09E-01	2.70E-02	5.80E-02	1.70E-02	5.90E-02	1.70E-02	5.00E-02	1.20E-02	— —	— —	6.90E-02
Technetium-99	— —	— —	— —	— —	— —	— —	— —	— —	— —	— —	— —
Uranium	2.99E-01	1.01E-01	4.44E-01	1.47E-01	2.30E-01	1.10E+00	3.40E-01	1.10E-01	— —	— —	3.82E-01
Zinc-65	a	— —	— —	— —	2.00E-02	3.60E-02	— —	— —	-5.24E-02	3.26E-02	-3.62E-02
Zirconium-95	a	— —	— —	— —	2.90E-02	3.00E-02	-1.30E-02	2.40E-02	1.90E-02	5.25E-02	-7.67E-03

Notes:
— — indicates radionuclide not analyzed, or results not reported.
Shaded entries indicate result less than error.
(a) designation indicates radionuclide concentration is less than detectable (ref: 1985 data only).
(1) Sample 2W17b reported for 1986; sample 2w17 not reported.
Negative values indicates concentration at or near background levels for radioactivity.
No data reported for 1990.
Data Sources:
Elder et al. 1986, 1987, 1988, and 1989; Schmidt et al. 1990 and 1992.

Table A-5. 1990 Soil Samples from Z Plant near Building Complex.

Sample No.	Cesium-137 in pCi/g	Plutonium in pCi/g
1	0.4	<0.3
2	<0.3	0.8
3	<0.2	<0.3
4	1.6	2.9
5	0.5	1.5
6	<0.3	<0.3
7	0.5	<0.3
8	0.4	<0.3
9	0.5	<0.3
10	<0.3	0.9
11	0.6	3.9
12	0.4	1.8
13	<0.3	0.7

Notes:
< indicates result below analytical detection limit.
Source: Schmidt et al. 1992.
Sample locations are identified on Plate 2.

Table A-6. Grid Site Vegetation Results for 200 West Area. (Sheet 1 of 5)

Radionuclide in pCi/g	1985 Result	1985 Error	1986 (1) Result	1986 (1) Error	1987 Result	1987 Error	1988 Result	1988 Error	1989 Result (1)	1989 Error	Average Result
Sample 2W2											
Cobalt-58	—	—	—	—	—	—	—	—	—	—	—
Cobalt-60	—	—	—	—	—	—	-5.20E-03	2.00E-02	—	—	-5.20E-03
Cesium-134	—	—	—	—	—	—	—	—	—	—	—
Cesium-137	—	—	—	—	—	—	1.40E-01	3.00E-02	—	—	1.40E-01
Europium-152	—	—	—	—	—	—	1.60E-02	8.40E-02	—	—	1.60E-02
Europium-154	—	—	—	—	—	—	3.50E-02	6.40E-02	—	—	3.50E-02
Europium-155	—	—	—	—	—	—	1.90E-02	4.90E-02	—	—	1.90E-02
Iodine-129	—	—	—	—	—	—	—	—	—	—	—
Niobium-95	—	—	—	—	—	—	-5.40E-02	5.80E-02	—	—	-5.40E-02
Plutonium-238	—	—	—	—	—	—	—	—	—	—	—
Plutonium-239	—	—	—	—	—	—	—	—	—	—	—
Ruthenium-103	—	—	—	—	—	—	—	—	—	—	—
Ruthenium-106	—	—	—	—	—	—	—	—	—	—	—
Strontium-90	—	—	—	—	—	—	—	—	—	—	—
Technetium-99	—	—	—	—	—	—	—	—	—	—	—
Zinc-65	—	—	—	—	—	—	—	—	—	—	—
Zirconium-95	—	—	—	—	—	—	—	—	—	—	—

Table A-6. Grid Site Vegetation Results for 200 West Area. (Sheet 2 of 5)

Radionuclide in pCi/g	1985		1986 (1)		1987		1988		1989		Average Result
	Result	Error	Result	Error	Result	Error	Result	Error	Result (1)	Error	
Sample 2W3											
Cobalt-58	a	—	—	—	—	—	—	—	—	—	—
Cobalt-60	a	—	—	—	—	—	5.30E-03	1.30E-02	—	—	5.30E-03
Cesium-134	a	—	9.60E-02	2.60E-02	—	—	—	—	—	—	9.60E-02
Cesium-137	1.51E-01	6.70E-02	2.10E-01	3.10E-02	—	—	1.90E-01	2.80E-02	—	—	1.84E-01
Europium-152	a	—	—	—	—	—	2.30E-02	5.80E-02	—	—	2.30E-02
Europium-154	a	—	—	—	—	—	1.20E-01	4.20E-02	—	—	1.20E-01
Europium-155	a	—	—	—	—	—	4.70E-04	2.70E-02	—	—	4.70E-04
Iodine-129	—	—	—	—	—	—	—	—	—	—	—
Niobium-95	a	—	—	—	—	—	3.60E-02	3.70E-02	—	—	-3.60E-02
Plutonium-238	a	—	—	—	—	—	—	—	—	—	—
Plutonium-239	a	—	—	—	—	—	—	—	—	—	—
Ruthenium-103	—	—	1.19E-01	4.40E-02	—	—	—	—	—	—	1.19E-01
Ruthenium-106	—	—	—	—	—	—	—	—	—	—	—
Strontium-90	a	—	—	—	—	—	—	—	—	—	—
Technetium-99	—	—	—	—	—	—	—	—	—	—	—
Zinc-65	a	—	—	—	—	—	—	—	—	—	—
Zirconium-95	a	—	—	—	—	—	—	—	—	—	—

Table A-6. Grid Site Vegetation Results for 200 West Area. (Sheet 3 of 5)

Radionuclide in pCi/g	1985		1986 (1)		1987		1988		1989		Average Result
	Result	Error	Result	Error	Result	Error	Result	Error	Result (1)	Error	
Sample 2W7											
Beryllium-7	—	—	—	—	—	—	—	—	1.19E+00	2.22E-01	1.19E+00
Cerium-141	—	—	—	—	—	—	—	—	-1.56E-02	2.01E-02	-1.56E-02
Cobalt-58	a	—	—	—	—	—	—	—	—	—	
Cobalt-60	a	—	—	—	—	—	-1.20E-02	1.90E-02	2.97E-03	1.61E-02	8.02E-03
Cesium-134	a	—	1.12E-01	3.20E-02	—	—	—	—	—	—	1.12E-01
Cesium-137	2.96E-01	1.06E-01	3.04E-01	4.50E-02	—	—	1.20E-01	2.70E-02	8.18E-01	9.07E-02	3.85E-01
Europium-152	a	—	—	—	—	—	-1.20E-02	7.70E-02	6.64E-02	7.30E-02	2.72E-02
Europium-154	a	—	1.33E-01	7.70E-02	—	—	-4.90E-02	6.00E-02	-2.11E-02	5.41E-02	2.10E-02
Europium-155	a	—	—	—	—	—	3.20E-03	4.50E-02	1.75E-02	3.93E-02	1.04E-02
Iodine-129	—	—	—	—	—	—	—	—	-1.84E-02	3.05E-01	-1.84E-02
Niobium-95	—	—	—	—	—	—	—	—	1.56E+01	1.70E+00	1.56E+00
Plutonium-238	a	—	—	—	—	—	-2.30E-02	5.70E-02	1.32E-02	1.92E-02	-4.90E-03
Plutonium-239	—	—	—	—	—	—	—	—	4.10E-01	5.13E-02	4.10E-01
Ruthenium-103	—	—	—	—	—	—	—	—	3.23E-01	5.27E-02	3.23E-01
Ruthenium-106	a	—	—	—	—	—	—	—	1.04E-03	4.40E-04	1.04E-03
Strontium-90	a	—	—	—	—	—	—	—	4.68E-03	9.89E-04	4.68E-03
Technetium-99	—	—	1.70E-01	6.50E-02	—	—	—	—	—	—	1.70E-01
Zinc-65	—	—	2.88E-01	1.66E-01	—	—	—	—	—	—	2.88E-01
Zirconium-95	a	—	—	—	—	—	—	—	1.91E-01	4.04E-02	1.91E-01
Tc-99	—	—	—	—	—	—	—	—	1.43E+00	1.26E+00	1.43E+00
Zn-65	a	—	—	—	—	—	—	—	—	—	0.00E+00
Zr-95	a	—	6.00E-02	5.70E-02	—	—	—	—	-2.50E-03	2.64E-02	2.88E-02

Table A-6. Grid Site Vegetation Results for 200 West Area. (Sheet 4 of 5)

Radionuclide in pCi/g	1985		1986 (1)		1987		1988		1989		Average Result
	Result	Error	Result	Error	Result	Error	Result	Error	Result (1)	Error	
Sample 2W17											
Beryllium-7	—	—	—	—	—	—	—	—	2.13E+00	3.07E-01	2.13E+00
Cerium-141	—	—	—	—	—	—	—	—	-6.42E-03	1.99E-02	-6.42E-03
Cobalt-58	a	—	—	—	—	—	—	—	—	—	—
Cobalt-60	a	—	—	—	1.70E-01	1.60E-01	2.00E-04	1.40E-02	-4.64E-03	1.54E-02	5.52E-02
Cesium-134	a	—	—	—	—	—	—	—	—	—	—
Cesium-137	a	—	1.98E-01	5.90E-02	1.10E-01	2.30E-02	3.20E-02	1.50E-02	5.50E-02	1.61E-02	9.88E-02
Europium-152	1.22E-01	1.00E-01	2.06E-01	1.78E-01	-5.40E-02	7.50E-02	-6.80E-03	5.90E-02	4.50E-02	5.35E-02	6.24E-02
Europium-154	a	—	—	—	-3.50E-02	6.10E-02	1.80E-02	4.10E-02	-1.41E-02	4.88E-02	-1.04E-02
Europium-155	a	—	—	—	—	—	9.70E-04	3.20E-02	2.85E-02	2.99E-02	1.47E-02
Iodine-129	—	—	—	—	—	—	1.60E-01	3.50E-01	-3.87E-02	3.08E-01	6.07E-02
Niobium-95	—	—	—	—	—	—	—	—	1.30E+01	1.45E+00	1.30E+01
Plutonium-238	1.21E-01	6.40E-02	—	—	-3.40E-02	4.10E-02	-3.90E-02	5.40E-02	-5.01E-03	2.23E-02	1.07E-02
Plutonium-239	—	—	—	—	—	—	—	—	5.94E-02	4.46E-02	5.94E-02
Ruthenium-103	—	—	—	—	—	—	—	—	7.17E-02	3.22E-02	7.17E-02
Ruthenium-106	a	—	—	—	—	—	—	—	8.07E-04	3.53E-04	8.07E-04
Strontium-90	a	—	—	—	—	—	—	—	2.39E-02	3.16E-03	2.39E-02
Technetium-99	—	—	8.30E-02	5.10E-02	—	—	—	—	—	—	8.30E-02
Zinc-65	—	—	—	—	—	—	—	—	—	—	—
Zirconium-95	a	—	1.46E-01	4.20E-02	—	—	4.50E-02	1.10E-02	3.08E-01	6.17E-02	1.66E-01
Tc-99	—	—	—	—	—	—	1.30E+00	1.80E+00	1.47E+00	1.26E+00	1.39E+00
Zn-65	—	—	—	—	—	—	—	—	—	—	—
Zr-95	9.80E-02	8.40E-02	6.80E-02	6.20E-02	-3.70E-02	4.30E-02	—	—	6.13E-03	2.91E-02	3.38E-02

Table A-6. Grid Site Vegetation Results for 200 West Area. (Sheet 5 of 5)

Radionuclide in pCi/g	1985		1986 (1)		1987		1988		1989		Average Result
	Result	Error	Result	Error	Result	Error	Result	Error	Result (1)	Error	
Sample 2W22											
Cobalt-58	a	—	—	—	—	—	—	—	—	—	—
Cobalt-60	a	—	—	—	—	—	6.40E-03	1.80E-02	—	—	6.40E-03
Cesium-134	a	—	1.77E-01	3.70E-02	—	—	—	—	—	—	1.77E-01
Cesium-137	a	—	2.57E-01	4.70E-02	—	—	1.10E-01	2.60E-02	—	—	1.84E-01
Europium-152	a	—	—	—	—	—	-2.70E-02	8.70E-02	—	—	-2.70E-02
Europium-154	a	—	—	—	—	—	7.10E-03	5.30E-02	—	—	7.10E-03
Europium-155	a	—	—	—	—	—	3.70E-02	4.70E-02	—	—	3.70E-02
Iodine-129	—	—	—	—	—	—	—	—	—	—	—
Niobium-95	a	—	—	—	—	—	5.50E-02	7.30E-02	—	—	5.50E-02
Plutonium-238	a	—	—	—	—	—	—	—	—	—	—
Plutonium-239	a	—	—	—	—	—	—	—	—	—	—
Ruthenium-103	—	—	1.69E-01	6.00E-02	—	—	—	—	—	—	—
Ruthenium-106	—	—	—	—	—	—	1.90E-01	3.70E-02	—	—	1.69E-01
Strontium-90	a	—	—	—	—	—	—	—	—	—	—
Technetium-99	—	—	—	—	—	—	—	—	—	—	1.90E-01
Zinc-65	a	—	—	—	—	—	—	—	—	—	—
Zirconium-95	—	—	—	—	—	—	—	—	—	—	—

Notes:
— indicates radionuclide not analyzed, or results not reported.
(a) designation indicates radionuclide concentration is less than detectable (ref: 1985 data only).
Results for 1986 reference sample 2W17b; 1986 listing for 2W17 not given.
Shaded entries indicate result less than error.
(1) Sample 2W17b reported for 1986; sample 2W17 not reported.
No data reported for 1990.
Negative values indicate concentration at or near background levels for radioactivity (refer to 1988 and 1989 data).

Data Sources:
Barton et al. 1990 and Goodwind and Bjornstad 1990.

Table A-7. Chemical Analysis Results of Z Plant Well Soil Samples. (Sheet 1 of 8)

Well 299-W7-9					
	Depth in Meters (Feet)				
Chemical	12.2 (40)	31.1 (102)	56.1 (184)	67.1 (220)	73.2 (240)
Nitrate in mg/kg	3.7	6.1	< 1	< 1	< 1
Sulfate in mg/kg	5.1	3.2	11.5	7.1	16.1
Fluoride in mg/kg	< 1	< 1	< 1	< 1	< 1
Chloride in mg/kg	1.4	< 1	2.1	< 1	4.7
Phosphate in mg/kg	< 2	< 2	< 2	< 2	< 2
Bromide in mg/kg	< 1	< 1	< 1	< 1	< 1
Nitrite in mg/kg	< 1	< 1	< 1	< 1	< 1
TOC in mg/kg	< 20	25	< 20	< 20	< 20
Beta in pCi/g	16.8	18.0	17.9	15.8	13.5
Sigma Beta in pCi/g	3.32	3.45	3.43	3.18	2.93
Lo-Alpha in pCi/g	1.73	1.59	1.45	1.71	2.32
Sigma Lo-Alpha in pCi/g	1.78	1.79	1.50	2.01	2.23
Methylene Chloride in μg/kg	< 59	< 67	—	—	—
Chloroform in μg/kg	< 3.4	< 3.9	< 7.6	13	< 3.4
Carbon Tetrachloride in μg/kg	< 0.2	< 0.2	0.20	12	< 0.08
Trichloroethene in μg/kg	< 1.0	< 1.2	< 2.3	8.8	< 1.1
Tetrachloroethene in μg/kg	—	—	< 2.7	4.4	< 1.2
1,1,1-Trichloroethane in μg/kg	< 2.1	< 2.5	< 4.6	23	< 2.1

Table A-7. Chemical Analysis Results of Z Plant Well Soil Samples. (Sheet 2 of 8)

Well 299-W7-9					
	Depth in Meters (Feet)				
Chemical	12.2 (40)	31.1 (102)	56.1 (184)	67.1 (220)	73.2 (240)
Benzene in μg/kg	< 4.5	< 5.2	—	—	—
Toluene in μg/kg	< 10	< 12	< 18	200	< 8.0
1,2-Dichloroethane in μg/kg	—	—	—	—	—
Ethylbenzene in μg/kg	—	—	—	—	—
1,1-Dichloroethene in μg/kg	—	—	—	—	—
trans-1, 2-Dichloroethene in μg/kg	—	—	—	—	—
cis-1, 2-Dichloroethene in μg/kg	—	—	—	—	—
Chlorobenzene in μg/kg	—	—	—	—	—
m- and p-Xylene in μg/kg	—	—	< 20	76	< 9.0
o-Xylene in μg/kg	—	—	< 13	35	< 5.7
Bromodichloromethane in μg/kg	—	—	—	—	—
1,1,2-Trichloroethane in μg/kg	—	—	—	—	—
Fluoromethane in μg/kg	—	—	—	~ 3500	ND

Table A-7. Chemical Analysis Results of Z Plant Well Soil Samples. (Sheet 3 of 8)

Well 299-W7-10						
	Depth in Meters (Feet)					
Chemical	18.3 (60)	24.4 (80)	45.8 (150)	61.0 (200)	67.1 (220)	73.2 (240)
Nitrate in mg/kg	—	—	—	—	—	—
Sulfate in mg/kg	—	—	—	—	—	—
Fluoride in mg/kg	—	—	—	—	—	—
Chloride in mg/kg	—	—	—	—	—	—
Phosphate in mg/kg	—	—	—	—	—	—
Bromide in mg/kg	—	—	—	—	—	—
Nitrite in mg/kg	—	—	—	—	—	—
TOC in mg/kg	—	—	—	—	—	—
Beta in pCi/g	21.3	22.1	18.0	17.7	18.2	17.1
Sigma Beta in pCi/g	3.90	3.90	3.50	3.38	3.61	3.36
Lo-Alpha in pCi/g	7.19	8.00	1.59	2.88	3.10	3.64
Sigma Lo-Alpha in pCi/g	3.01	3.09	1.71	2.08	2.39	2.16
Methylene Chloride in μg/kg	—	—	—	—	—	—
Chloroform in μg/kg	—	< 3	< 5	< 8	< 7	< 8
Carbon Tetrachloride in μg/kg	—	< 0.1	< 0.2	< 0.3	< 0.3	< 0.3
Trichloroethene in μg/kg	—	< 1	< 2	< 3	< 3	< 3
Tetrachloroethene in μg/kg	—	< 0.3	< 0.4	< 0.7	< 0.6	< 0.7
1,1,1-Trichloroethane in μg/kg	—	< 1	< 2	9.1	< 3	< 3

Table A-7. Chemical Analysis Results of Z Plant Well Soil Samples. (Sheet 4 of 8)

Well 299-W7-10						
	Depth in Meters (Feet)					
Chemical	18.3 (60)	24.4 (80)	45.8 (150)	61.0 (200)	67.1 (220)	73.2 (240)
Benzene in μg/kg	—	—	—	—	—	—
Toluene in μg/kg	—	< 6	< 9	< 14	< 12	< 14
1,2-Dichloroethane in μg/kg	—	—	—	—	—	—
Ethylbenzene in μg/kg	—	—	—	—	—	—
1,1-Dichloroethene in μg/kg	—	—	—	—	—	—
trans-1, 2-Dichloroethene in μg/kg	—	—	—	—	—	—
cis-1, 2-Dichloroethene in μg/kg	—	—	—	—	—	—
Chlorobenzene in μg/kg	—	—	—	—	—	—
m- and p-Xylene in μg/kg	—	< 3	< 5	17	< 7	< 8
o-Xylene in μg/kg	—	< 6	< 10	< 15	< 14	< 15
Bromodichloromethane in μg/kg	—	—	—	—	—	—
1,1,2-Trichloroethane in μg/kg	—	—	—	—	—	—
Fluoromethane in μg/kg	—	—	—	—	—	—

Table A-7. Chemical Analysis Results of Z Plant Well Soil Samples. (Sheet 5 of 8)

Well 299-W15-21								
	Depth in Meters (Feet)							
Chemical	1.8 (6)	36.6 (120)	38.1 (125)	42.7 (140)	42.7 (140)	48.5 (159)	67.1 (220)	73.2 (240)
Nitrate in mg/kg	13.6	2.1	5.8	13.2	5.7	‡‡ 38.5	< 1	< 1
Sulfate in mg/kg	3.3	10.8	29.9	10.9	5.3	19.6	12.9	7.7
Fluoride in mg/kg	< 1	< 1	< 1.0	< 1	< 1	< 1	1.1	< 1
Chloride in mg/kg	2.0	2.3	8.6	< 1	< 1	1.2	2.6	1.4
Phosphate in mg/kg	< 2	< 2	< 2.0	< 2	< 2	< 2	< 2	< 2
Bromide in mg/kg	< 1	< 1	< 1.0	< 1	< 1	< 1	< 1	< 1
Nitrite in mg/kg	< 1	< 1	< 1.0	< 1	< 1	< 1	< 1	< 1
TOC in mg/kg	< 20	< 20	< 20	< 20	—	< 20	< 20	< 20
Beta in pCi/g	20.1	24.3	22.9	23.7	—	12.4	16.3	15.9
Sigma Beta in pCi/g	3.68	4.12	3.98	4.06	—	2.77	3.27	3.20
Lo-Alpha in pCi/g	4.62	6.39	3.00	4.51	—	5.46	12.2	4.43
Sigma Lo-Alpha in pCi/g	2.41	2.72	1.94	2.36	—	2.68	3.78	2.29
Methylene Chloride in μg/kg	—	—	—	—	—	—	1051	< 26
Chloroform in μg/kg	—	< 1.3	< 1.1	< 1.2	—	< 1.8	129	31
Carbon Tetrachloride in μg/kg	—	0.31	0.14	0.12	—	2.8	6.2	< 0.1
Trichloroethene in μg/kg	—	< 0.66	< 0.53	< 0.59	—	< 0.90	4.2	< 0.5
Tetrachloroethene in μg/kg	—	< 1.9	< 1.5	< 1.7	—	< 2.6	—	—
1,1,1-Trichloroethane in μg/kg	—	—	—	—	—	—	10	< 1.0

Table A-7. Chemical Analysis Results of Z Plant Well Soil Samples. (Sheet 6 of 8)

Well 299-W15-21								
	Depth in Meters (Feet)							
Chemical	1.8 (6)	36.6 (120)	38.1 (125)	42.7 (140)	42.7 (140)	48.5 (159)	67.1 (220)	73.2 (240)
Benzene in μg/kg	—	—	—	—	—	—	200	< 2.0
Toluene in μg/kg	—	—	—	—	—	—	64	< 4.5
1,2-Dichloroethane in μg/kg	—	—	—	—	—	—	~ 26	—
Ethylbenzene in μg/kg	—	—	—	—	—	—	~ 3	—
1,1-Dichloroethene in μg/kg	—	—	—	—	—	—	~ 300	—
trans-1, 2-Dichloroethene in μg/kg	—	—	—	—	—	—	—	—
cis-1, 2-Dichloroethene in μg/kg	—	—	—	—	—	—	—	—
Chlorobenzene in μg/kg	—	—	—	—	—	—	—	—
m- and p-Xylene in μg/kg	—	—	—	—	—	—	—	—
o-Xylene in μg/kg	—	—	—	—	—	—	—	—
Bromodichloromethane in μg/kg	—	—	—	—	—	—	—	—
1,1,2-Trichloroethane in μg/kg	—	—	< 0.005	—	—	—	—	—
Fluoromethane in μg/kg	—	—	—	—	—	—	—	—

Table A-7. Chemical Analysis Results of Z Plant Well Soil Samples. (Sheet 7 of 8)

Well 299-W15-23						
	Depth in Meters (Feet)					
Chemical	18.3 (60)	47.3 (155)	48.8 (160)	61.0 (200)	67.1 (220)	70.2 (230)
Nitrate in mg/kg	—	—	—	—	—	—
Sulfate in mg/kg	—	—	—	—	—	—
Fluoride in mg/kg	—	—	—	—	—	—
Chloride in mg/kg	—	—	—	—	—	—
Phosphate in mg/kg	—	—	—	—	—	—
Bromide in mg/kg	—	—	—	—	—	—
Nitrite in mg/kg	—	—	—	—	—	—
TOC in mg/kg	—	—	—	—	—	—
Beta in pCi/g	16.7	28.8	17.0	23.1	16.8	18.5
Sigma Beta in pCi/g	3.29	4.65	3.39	4.06	3.41	3.57
Lo-Alpha in pCi/g	2.13	10.1	8.24	1.97	3.45	• 1.18
Sigma Lo-Alpha in pCi/g	1.91	3.58	3.00	1.81	2.29	1.57
Methylene Chloride in μg/kg	—	—	—	—	—	—
Chloroform in μg/kg	< 3	2	—	< 2	2.4	8.8
Carbon Tetrachloride in μg/kg	0.2	0.5	—	< 0.1	3.8	< 0.1
Trichloroethene in μg/kg	< 1	< 2	—	< 1	< 1	< 1
Tetrachloroethene in μg/kg	0.5	1.8	—	< 0.2	< 0.2	< 1.3
1,1,1-Trichloroethane in μg/kg	1.1	2	—	< 1	< 1	< 1

Table A-7. Chemical Analysis Results of Z Plant Well Soil Samples. (Sheet 8 of 8)

Well 299-W15-23						
	Depth in Meters (Feet)					
Chemical	18.3 (60)	47.3 (155)	48.8 (160)	61.0 (200)	67.1 (220)	70.2 (230)
Benzene in μg/kg	200	< 2.0	—	—	—	—
Toluene in μg/kg	75	~ 107	—	< 4	< 3	< 5
1,2-Dichloroethane in μg/kg	—	—	—	—	—	—
Ethylbenzene in μg/kg	—	—	—	—	—	—
1,1-Dichloroethene in μg/kg	—	—	—	—	—	—
trans-1, 2-Dichloroethene in μg/kg	—	—	—	—	—	—
cis-1, 2-Dichloroethene in μg/kg	—	—	—	—	—	—
Chlorobenzene in μg/kg	—	—	—	—	—	—
m- and p-Xylene in μg/kg	< 3	< 5	—	< 2	< 2	< 3
o-Xylene in μg/kg	< 5	< 9	—	< 4	< 3	< 5
Bromodichloromethane in μg/kg	—	—	—	—	—	—
1,1,2-Trichloroethane in μg/kg	—	—	—	—	—	—
Fluoromethane in μg/kg	—	—	—	—	—	—

Data Source: Barton et al. 1990

Table A-8. Chemical Analysis Results of Z Plant Well Soil Samples. (Sheet 1 of 10)

	Well 299-W7-7											
	Depth in Meters (Feet)											
Chemical	1.5(5)	6.1(20)	12.2(40)	18.3(60)	24.4(80)	30.5(100)	36.6(120)	42.7(140)	48.8(160)	54.8(180)	61.0(200)	67.1(220)
Nitrate in mg/kg	1.6	1.8	4.8	4.5	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
Sulfate in mg/kg	24.7	60.7	130	1.1	19.8	28.7	17.3	11.4	18.8	10.2	7.1	8.7
Fluoride in mg/kg	< 1	< 1	< 1	< 1	2.1	2.6	1.3	1.1	1.4	1.0	1.1	1.1
Chloride in mg/kg	1.6	1.1	1.9	1.5	3.3	2.5	2.7	3.0	2.9	3.1	3.4	2.9
Phosphate in mg/kg	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2
Bromide in mg/kg	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
Nitrite in mg/kg	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
TOC in mg/kg	< 20	< 20	< 20	< 20	85	< 20	< 20	< 20	< 20	< 20	< 20	< 20
Beta in pCi/g	12.6	14.1	17.4	18.9	15.3	15.3	18.0	14.1	14.7	12.2	13.5	13.1
Sigma Beta in pCi/g	2.81	3.00	3.39	3.56	3.14	3.15	3.46	2.97	3.04	2.77	2.92	2.39
Lo-Alpha in pCi/g	2.47	3.54	4.70	2.55	3.68	3.53	2.28	1.64	0.171	1.20	2.31	3.33
Sigma Lo-Alpha in pCi/g	1.31	2.55	2.69	1.73	2.05	2.33	1.77	1.92	1.79	1.67	1.94	2.38
Chloroform in μg/kg	< 11	—	—	—	—	< 0.6	< 0.7	—	< 11	< 5.7	—	< 5.6
Carbon tetrachloride in μg/kg	6.5	—	—	—	—	< 0.01	< 0.02	—	0.53	< 0.13	—	< .75
Trichloroethene in μg/kg	< 3.3	—	—	—	—	< 0.2	< 0.3	—	< 3.4	< 1.8	—	< 1.7
Tetrachloroethene in μg/kg	< 3.8	—	—	—	—	< 0.3	< 0.3	—	< 3.9	< 2.0	—	< 2.0
1,1,1-Trichloroethane in μg/kg	< 6.5	—	—	—	—	< 0.4	< 0.5	—	< 6.8	< 3.5	—	< 3.4
Benzene in μg/kg	47	—	—	—	—	< 1.6	18	—	39	< 14	—	41
Toluene in μg/kg	< 49	—	—	—	—	ND	ND	—	< 50	40	—	72
1,2-Dichloroethane in μg/kg	—	—	—	—	—	—	—	—	—	—	—	—

Table A-8. Chemical Analysis Results of Z Plant Well Soil Samples. (Sheet 2 of 10)

Well 299-W7-7												
	Depth in Meters (Feet)											
Chemical	1.5(5)	6.1(20)	12.2(40)	18.3(60)	24.4(80)	30.5(100)	36.6(120)	42.7(140)	48.8(160)	54.8(180)	61.0(200)	67.1(220)
Ethylbenzene in μg/kg	—	—	—	—	—	—	—	—	—	—	—	—
1,1-Dichloroethene in μg/kg	—	—	—	—	—	—	—	—	—	—	—	—
trans-1,2-Dichloroethene in μg/kg	—	—	—	—	—	—	—	—	—	—	—	—
cis-1,2-Dichloroethene in μg/kg	—	—	—	—	—	—	—	—	—	—	—	—
Chlorobenzene in μg/kg	—	—	—	—	—	—	—	—	—	—	—	—
m- and p-Xylene in μg/kg	40	—	—	—	—	< 1.8	< 1.8	—	< 30	< 15	—	< 15
o-Xylene in μg/kg	20	—	—	—	—	< 1.1	< 1.2	—	< 19	< 9.7	—	< 9.5
Trichlorofluoromethane in μg/kg	ND	—	—	—	ND	ND	—	—	~ 1,600	~ 90	—	~ 150

Table A-8. Chemical Analysis Results of Z Plant Well Soil Samples. (Sheet 3 of 10)

	Well 299-W7-8															
	Depth in Meters (Feet)															
Chemical	6.3(20.5)	9.3(30.5)	12.5(41)	14.6(48)	15.3(50)	16.8(55)	18.9(62)	23.8(78)	27.3(90)	33.6(110)	39.7(130)	45.8(150)	51.9(170)	58.0(190)	64.1(210)	70.2(230)
Nitrate in mg/kg	8.6	7.1	14.3	25.4	16.7	29.9	11.7	5.4	3.8	< 1	< 1	< 1	< 1	< 1	< 1	< 1
Sulfate in mg/kg	5.2	7.7	41.6	27.6	32.2	24.8	9.3	1.4	5.1	4.8	3.8	5.1	12.5	9.2	6.9	4.9
Fluoride in mg/kg	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
Chloride in mg/kg	< 1	< 1	3.2	25.3	< 9.6	19.7	5.8	< 1	< 1	< 1	< 1	2.5	1.6	1.8	1.8	1.9
Phosphate in mg/kg	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2
Bromide in mg/kg	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
Nitrite in mg/kg	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
TOC in mg/kg	< 20	30	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20
Beta in pCi/g	16.6	29.1	14.6	19.9	14.2	17.9	19.0	19.9	15.1	13.7	16.6	18.3	11.8	17.0	14.4	16.4
Sigma Beta in pCi/g	3.28	4.65	3.03	3.69	3.02	3.41	3.55	3.62	3.10	2.96	3.27	3.47	2.75	3.32	3.04	3.27
Lo-Alpha in pCi/g	-1.52	2.80	1.97	4.07	3.52	5.16	3.87	2.53	3.42	3.16	5.61	1.73	1.86	4.17	4.07	2.73
Sigma Lo-Alpha in pCi/g	0.901	2.02	2.13	2.14	2.36	2.75	2.02	2.00	2.23	2.45	2.55	1.82	1.98	2.63	2.16	2.45
Chloroform in µg/kg	< 2.3	< 3.5	< 2.3	< 3.2	< 3.4	< 4.5	< 3.5	< 3.2	< 2.5	< 2.9	< 2.6	< 2.2	< 3.4	< 5.1	< 3.3	< 4.0
Carbon tetrachloride in µg/kg	< 0.05	< 0.08	< 0.05	< 0.07	0.09	0.09	0.07	< 0.07	< 0.06	< 0.06	< 0.06	< 0.05	< 0.07	< 0.11	0.30	0.36
Trichloroethene in µg/kg	< 0.7	< 1.1	< 0.7	< 1.0	< 1.1	< 1.4	< 1.1	< 1.0	< 0.8	< 0.9	< 0.8	< 0.7	< 1.1	< 1.6	0.9	< 1.2
Tetrachloroethene in µg/kg	< 0.8	< 1.2	< 0.8	< 1.1	< 1.2	< 1.6	< 1.2	< 1.1	< 0.9	< 1.0	< 0.9	< 0.8	< 1.2	< 1.8	< 1.2	< 1.4
1,1,1-Trichloroethane in µg/kg	< 1.4	< 2.1	< 1.4	< 1.9	2.5	3.2	2.5	< 1.9	1.8	< 1.8	1.8	< 1.3	< 2.1	< 3.1	3.0	3.0
Benzene in µg/kg	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Toluene in µg/kg	< 5.4	< 8.3	< 5.5	< 7.6	165	212	169	< 7.6	126	< 7.1	123	< 5.1	< 8.1	< 12	176	514
1,2-Dichloroethane in µg/kg	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Ethylbenzene in µg/kg	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–

Table A-8. Chemical Analysis Results of Z Plant Well Soil Samples. (Sheet 4 of 10)

	Well 299-W7-8															
	Depth in Meters (Feet)															
Chemical	6.3(20.5)	9.3(30.5)	12.5(41)	14.6(48)	15.3(50)	16.8(55)	18.9(62)	23.8(78)	27.3(90)	33.6(110)	39.7(130)	45.8(150)	51.9(170)	58.0(190)	64.1(210)	70.2(230)
1,1-Dichloroethene in µg/kg	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
trans-1,2-Dichloroethene in µg/kg	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
cis-1,2-Dichloroethene in µg/kg	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Chlorobenzene in µg/kg	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
m- and p-Xylene in µg/kg	< 6.1	< 9.4	< 6.2	< 8.6	< 9.3	< 12	< 9.4	< 8.6	< 6.8	< 7.9	< 7.0	< 5.7	< 9.2	< 14	26	< 11
o-Xylene in µg/kg	< 3.8	< 5.9	< 3.9	< 5.4	< 5.8	< 7.7	< 5.9	< 5.4	< 4.3	< 5.0	< 4.4	< 3.6	< 5.8	< 8.6	6.7	< 6.8
Trichlorofluoromethane in µg/kg	–	–	–	–	–	–	–	210	–	–	–	–	–	–	100	–

Table A-8. Chemical Analysis Results of Z Plant Well Soil Samples. (Sheet 5 of 10)

Well 299-W18-26					
	Depth in Meters (Feet)				
Chemical	12.2 (40*)	40.7 (130)	54.9 (180**)	67.1 (220)	73.2 (240)
Nitrate in mg/kg	2.2	2.1	11.7	< 1	< 1
Sulfate in mg/kg	7.0	3.7	8.2	24.3	7.6
Fluoride in mg/kg	< 1	< 1	< 1	< 1	< 1
Chloride in mg/kg	4.9	< 1	1.2	4.9	2.8
Phosphate in mg/kg	< 2	< 2	< 2	< 2	< 2
Bromide in mg/kg	< 1	< 1	< 1	< 1	< 1
Nitrite in mg/kg	< 1	< 1	< 1	< 1	< 1
TOC in mg/kg	< 20	< 20	< 20	< 20	< 20
Beta in pCi/g	14.8	21.7	24.9	18.7	14.4
Sigma Beta in pCi/g	3.06	3.84	4.20	3.53	3.02
Lo-Alpha in pCi/g	3.25	6.24	3.32	2.06	5.16
Sigma Lo-Alpha in pCi/g	2.52	2.56	2.26	2.24	2.77
Chloroform in μg/kg	—	< 1.8	91	7.9	71
Carbon Tetrachloride in μg/kg	—	0.12	2.3	2.6	4.3
Trichloroethene in μg/kg	—	< 0.90	3.3	< 0.2	< 2.3
Tetrachloroethene in μg/kg	—	< 2.3	—	—	—
1,1,1-Trichloroethane in μg/kg	—	—	4.8	< 0.4	5.7
Benzene in μg/kg	—	—	~ 125	< 0.7	88
Toluene in μg/kg	—	—	161	23	3.9
1,2-Dichloroethane in μg/kg	—	—	~ 31	—	—
Ethylbenzene in μg/kg	—	—	—	—	—

Table A-8. Chemical Analysis Results of Z Plant Well Soil Samples. (Sheet 6 of 10)

Well 299-W18-26					
	Depth in Meters (Feet)				
Chemical	12.2 (40*)	40.7 (130)	54.9 (180**)	67.1 (220)	73.2 (240)
1,1-Dichloroethene in μg/kg	—	—	~ 21	—	~ 55
trans-1,2-Dichloroethene in μg/kg	—	—	~ 24	—	—
cis-1,2-Dichloroethene in μg/kg	—	—	~ 34	—	—
Chlorobenzene in μg/kg	—	—	—	—	—
m- and p-Xylene in μg/kg	—	—	—	—	—
o-Xylene in μg/kg	—	—	—	—	—
Trichlorofluoromethane in μg/kg	—	—	—	—	—

Table A-8. Chemical Analysis Results of Z Plant Well Soil Samples. (Sheet 7 of 10)

	Well 299-W15-19				
	Depth in Meters (Feet)				
Chemical	12.2 (40)	24.4 (80)	36.6 (120)	67.1 (220)	73.2 (240)
Nitrate in mg/kg	1.2	< 1	2.1	< 1	< 1
Sulfate in mg/kg	2.8	22.3	10.8	7.7	44.5
Fluoride in mg/kg	< 1	< 1	< 1	< 1	1.2
Chloride in mg/kg	1.2	1.6	2.3	1.4	22
Phosphate in mg/kg	< 2	< 2	< 2	< 2	< 2
Bromide in mg/kg	< 1	< 1	< 1	< 1	< 1
Nitrite in mg/kg	< 1	< 1	< 1	< 1	< 1
TOC in mg/kg	< 20	< 20	< 20	< 20	< 20
Beta in pCi/g	16.2	22.7	17.9	16.9	27.7
Sigma Beta in pCi/g	3.22	3.95	3.41	3.30	4.49
Lo-Alpha in pCi/g	1.20	6.67	3.48	2.30	5.12
Sigma Lo-Alpha in pCi/g	1.67	2.67	2.61	2.13	2.69
Chloroform in μg/kg	2.6	4.1	2.8	16	168
Carbon Tetrachloride in μg/kg	0.55	1.4	0.56	5.8	8.1
Trichloroethene in μg/kg	3.0	4.4	1.7	< 0.14	0.37
Tetrachloroethene in μg/kg	2.1	3.4	1.3	< 0.39	< 0.21
1,1,1-Trichloroethane in μg/kg	—	—	—	—	—
Benzene in μg/kg	—	—	—	—	—
Toluene in μg/kg	—	—	—	—	—
1,2-Dichloroethane in μg/kg	—	—	—	—	—
Ethylbenzene in μg/kg	—	—	—	—	—

Table A-8. Chemical Analysis Results of Z Plant Well Soil Samples. (Sheet 8 of 10)

	Well 299-W15-19				
	Depth in Meters (Feet)				
Chemical	12.2 (40)	24.4 (80)	36.6 (120)	67.1 (220)	73.2 (240)
1,1-Dichloroethene in μg/kg	—	—	—	—	—
trans-1,2-Dichloroethene in μg/kg	—	—	—	—	—
cis-1,2-Dichloroethene in μg/kg	—	—	—	—	—
Chlorobenzene in μg/kg	—	—	—	—	—
m- and p-Xylene in μg/kg	—	—	—	—	—
o-Xylene in μg/kg	—	—	—	—	—
Trichlorofluoromethane in μg/kg	—	—	—	—	—

Table A-8. Chemical Analysis Results of Z Plant Well Soil Samples. (Sheet 9 of 10)

Well 299-W15-20					
	Depth in Meters (Feet)				
Chemicals	6.1 (20)	24.4 (80)	54.9 (180)	67.1 (220)	73.2 (240)
Nitrate in mg/kg	< 1	< 1	< 1	< 1	< 1
Sulfate in mg/kg	2.7	25.7	12.1	16.3	7.0
Fluoride in mg/kg	< 1	< 1	1.4	3.2	< 1
Chloride in mg/kg	< 1	13.2	1.6	2.4	1.2
Phosphate in mg/kg	< 2	< 2	< 2	< 2	< 2
Bromide in mg/kg	< 1	< 1	< 1	< 1	< 1
Nitrite in mg/kg	< 1	< 1	< 1	< 1	< 1
TOC in mg/kg	< 20	< 20	< 20	< 20	< 20
Beta in pCi/g	13.1	25.1	15.6	13.5	18.7
Sigma Beta in pCi/g	2.89	4.24	3.19	2.92	3.56
Lo-Alpha in pCi/g	8.36	12.5	12.0	10.4	15.4
Sigma Lo-Alpha in pCi/g	2.94	3.58	3.81	3.45	4.33
Chloroform in μg/kg	< 10	< 0.9	187	13	7.5
Carbon Tetrachloride in μg/kg	< 0.4	3.2	9.5	0.3	< 0.5
Trichloroethene in μg/kg	< 3.0	< 0.3	7.6	< 0.3	< 0.3
Tetrachloroethene in μg/kg	—	—	1.6	—	—
1,1,1-Trichloroethane in μg/kg	< 6.4	< 0.6	18	< 0.5	< 0.5
Benzene in μg/kg	< 13	< 1.2	~ 380	14	< 1.1
Toluene in μg/kg	< 29	< 2.6	123	< 2.3	< 2.4
1,2-Dichloroethane in μg/kg	—	—	~ 36	—	—
Ethylbenzene in μg/kg	—	—	—	—	—

Table A-8. Chemical Analysis Results of Z Plant Well Soil Samples. (Sheet 10 of 10)

Well 299-W15-20					
	Depth in Meters (Feet)				
Chemicals	6.1 (20)	24.4 (80)	54.9 (180)	67.1 (220)	73.2 (240)
1,1-Dichloroethene in μg/kg	—	—	~ 457	~ 47	—
trans-1,2-Dichloroethene in μg/kg	—	—	~ 440	~ 47	—
cis-1,2-Dichloroethene in μg/kg	—	—	~ 78	—	—
Chlorobenzene in μg/kg	—	—	~ 10	~ 2	—
m- and p-Xylene in μg/kg	—	—	—	—	—
o-Xylene in μg/kg	—	—	—	—	—
Trichlorofluoromethane in μg/kg	—	—	—	—	—

* Methanol evaporated or leaked from container during transport to analytical laboratory (voltaile organics analyses).
** Volatile organic analysis values compromised, low volume of methanol caused by evaporation or absorption into large amount of soil gas.

Data Source: Goodwin and Bjornstad 1990

Table A-9. Summary of Gamma Scintillation Logging Results. (Sheet 1 of 12)

Waste Management Unit	Well Number	Relative Location	Remarks
Plants, Buildings, and Storage Areas			
232-Z Incinerator	No monitoring wells.		
Tanks and Vaults			
21-Z-8 Settling Tank	No monitoring wells.		
241-Z-361 Settling Tank	No monitoring wells.		
241-Z Treatment Tank	No monitoring wells.		
Cribs and Drains			
216-Z-1A Tile Field	299-W18-6	West of tile field.	Natural gamma response.
	299-W18-7	East of tile field.	Natural gamma response.
	299-W18-56	Northwest portion of tile field.	Elevated gamma response between depths of 10 and 22 m.
	299-W18-57	Northeast portion of tile field.	Elevated gamma response between depths of 5 and 19 m.
	299-W18-58	Southwest portion of tile field.	Elevated gamma response between depths of 12 and 25 m.
	299-W18-59	Southeast portion of tile field.	Natural gamma response.
	299-W18-66	South portion of tile field.	Elevated gamma response between depths of 5 and 29 m.
	299-W18-76	North portion of tile field.	Natural gamma response.
	299-W18-77	North portion of tile field.	Not logged.
	299-W18-78	North portion of tile field.	Natural gamma response.
	299-W18-79	North portion of tile field.	Not logged.

Table A-9. Summary of Gamma Scintillation Logging Results. (Sheet 2 of 12)

Waste Management Unit	Well Number	Relative Location	Remarks
	299-W18-80	North portion of tile field.	Not logged.
	299-W18-81	North portion of tile field.	Elevated gamma response.
	299-W18-85	Southwest of tile field.	Natural gamma response.
	299-W18-86	Southwest of tile field.	Natural gamma response.
	299-W18-87	South of tile field.	Natural gamma response.
	299-W18-89	West of tile field.	Natural gamma response.
	299-W18-149	Northern portion of tile field.	Not logged.
	299-W18-150	Southern portion of tile field.	Elevated gamma response between depths of 2 and 24 m.
	299-W18-158	Northwestern portion of tile field.	Elevated gamma response between depths of 15 and 18 m.
	299-W18-159	Central portion of tile field.	Elevated gamma response between depths of 2 and 20 m.
	299-W18-163	Northeast portion of tile field.	Elevated gamma response between depths of 12 and 14 m.
	299-W18-164	South central part of tile field.	Elevated gamma response between depths of 23 and 30 m.
	299-W18-165	Southwest portion of tile field.	Elevated gamma response between depths of 28 and 29 m.
	299-W18-166	Southwest portion of tile field.	Elevated gamma response between depths of 25 and 30 m.
	299-W18-167	Eastern portion of tile field.	Elevated gamma response between depths of 15 and 18 m.
	299-W18-168	Southeast edge of tile field.	Elevated gamma response between depths of 13 and 19 m.

Table A-9. Summary of Gamma Scintillation Logging Results. (Sheet 3 of 12)

Waste Management Unit	Well Number	Relative Location	Remarks
	299-W18-169	Southeast portion of tile field.	Natural gamma response.
	299-W18-170	South central portion of tile field.	Elevated gamma response between depths of 0 and 8 m.
	299-W18-171	South of tile field.	Natural gamma response.
	299-W18-173	Northern portion of tile field.	Elevated gamma response between depths of 2 and 5 m, and 8 and 11 m.
	299-W18-174	Northern portion of tile field.	Elevated gamma response between depths of 2 and 7 m, and 9 and 12 m.
	299-W18-175	Southern portion of tile field.	Elevated gamma response between depths of 1 and 20 m, and at depths of 23 and 29 m.
216-Z-1 Crib	299-W18-64	Southwest corner of crib.	Elevated gamma response.
	299-W18-65	Southeast corner of crib.	Elevated gamma response between depths of 7 and 20 m.
216-Z-2 Crib	299-W18-60	Northwest corner of crib.	Natural gamma response?[1]
	299-W18-61	Northeast corner of crib.	Elevated gamma response between depths of 7 and 21 m.
	299-W18-62	Southwest corner of crib.	Natural gamma response.
	299-W18-63	Southeast corner of crib.	Elevated gamma response between depths of 7 and 17 m.
	299-W18-172	North of crib.	Natural gamma response.
216-Z-3 Crib	299-W18-67	Northeast part of crib.	Not logged.
	299-W18-68	Central part of crib.	Not logged.
	299-W18-88	Southeast of crib.	Natural gamma response.

Table A-9. Summary of Gamma Scintillation Logging Results. (Sheet 4 of 12)

Waste Management Unit	Well Number	Relative Location	Remarks
216-Z-5 Crib	299-W15-1	East edge of crib.	Elevated gamma response between depths of 30 and 40 m (above the water table), and from 50 to 63 m (below the water table).
	299-W15-52	East of crib.	Not logged.
	299-W15-53	South of crib.	Not logged.
	299-W15-54	West of crib.	Not logged.
	299-W15-55	South side of crib.	Not logged.
	299-W15-56	Southwest side of crib.	Not logged.
	299-W15-57	Southern portion of crib.	Not logged.
	299-W15-58	West of crib.	Not logged.
	299-W15-212	100 m north of crib.	Elevated gamma response between depths of 8 and 23 m.
216-Z-6 Crib	no monitoring wells		
216-Z-7 Crib	299-W15-7	Southwest corner of crib.	Elevated gamma response between depths of 7 and 40 m (above the water table), and from 45 to 100 m (below the water table).
	299-W15-62	North of crib.	Elevated gamma response between depths of 30 and 46 m.
	299-W15-63	North of center of crib.	Elevated gamma response between depths of 26 and 43 m.
	299-W15-76	Southwest of crib.	Elevated gamma response between depths of 13 and 23 m.
	299-W15-77	South of crib.	Elevated gamma response between depths of 12 and 21 m.
	299-W15-78	South of center of crib.	Elevated gamma response between depths of 12 and 21 m.

Table A-9. Summary of Gamma Scintillation Logging Results. (Sheet 5 of 12)

Waste Management Unit	Well Number	Relative Location	Remarks
216-Z-8 French Drain	299-W15-202	<5 m southeast of french drain.	Not logged
	299-W15-213	<5 m northeast of french drain.	Not logged
	299-W15-214	<5 m northwest of french drain.	Not logged
	299-W15-215	<5 m southwest of french drain.	Not logged
216-Z-12 Crib	299-W18-2	Southwest of crib.	Natural gamma response.
	299-W18-4	40 m west of crib.	Natural gamma response.
	299-W18-5	North end of west side of crib.	Elevated gamma response between depths of 5 and 10 m.
	299-W18-8	Northwest part of crib.	Elevated gamma response between depths of 5 and 10 m.
	299-W18-13	Northwest side of crib.	Not logged.
	299-W18-14	North central part of crib.	Not logged.
	299-W18-24	8 m south of crib.	Natural gamma response.
	299-W18-69	North central side of crib.	Elevated gamma response between depths of 5 and 10 m.
	299-W18-70	Northwest part of crib.	Not logged.
	299-W18-71	North central part of crib.	Elevated gamma response between depths of 5 and 10 m.
	299-W18-72	North central part of crib.	Elevated gamma response at depth of 6 m.
	299-W18-73	South central part of crib.	Natural gamma response.
	299-W18-74	South central part of crib.	Natural gamma response.
	299-W18-75	Northern part of crib.	Elevated gamma response between depths of 5 and 9 m.

Table A-9. Summary of Gamma Scintillation Logging Results. (Sheet 6 of 12)

Waste Management Unit	Well Number	Relative Location	Remarks
	299-W18-151	North of crib.	Natural gamma response.
	299-W18-152	Northern end of west side of crib.	Elevated gamma response between depths of 6 and 9 m.
	299-W18-153	Northern end of east side of crib.	Elevated gamma response between depths of 6 and 8 m.
	299-W18-154	North of crib.	Elevated gamma response between depths of 4 and 6 m.
	299-W18-155	North of crib.	Natural gamma response.
	299-W18-156	North of crib.	Not logged.
	299-W18-157	South of crib.	Natural gamma response.
	299-W18-162	North central part of crib.	Not logged.
	299-W18-179	North side of of crib.	Not logged.
	299-W18-180	Northeast part of crib.	Not logged.
	299-W18-181	North central part of crib.	Not logged.
	299-W18-182	Central part of crib.	Not logged.
	299-W18-183	Southern part of crib.	Not logged.
	299-W18-184	Northern part of crib.	Not logged.
	299-W18-182	Northern part of crib.	Not logged.
	299-W18-185	Northern part of crib.	Not logged.
	299-W18-242	Central part of crib.	Not logged.
	299-W18-243	West central part of crib.	Not logged.
	299-W18-244	East central part of crib.	Not logged.
	299-W18-245	West central part of crib.	Not logged.

Table A-9. Summary of Gamma Scintillation Logging Results. (Sheet 7 of 12)

Waste Management Unit	Well Number	Relative Location	Remarks
216-Z-13 French Drain	No monitoring wells.		
216-Z-14 French Drain	No monitoring wells		
216-Z-15 French Drain	No monitoring wells		
216-Z-16 Crib	299-W15-10	South of crib.	Natural gamma response.
	299-W15-11	North of crib.	Natural gamma response.
216-Z-18 Crib	299-W18-9	Northern part of crib.	Elevated gamma response between depths of 6 and 18 m.
	299-W18-10	Northeast side of crib.	Elevated gamma response between depths of 8 and 17 m.
	299-W18-11	Southwest part of crib.	Natural gamma response.
	299-W18-12	Northwest part of crib.	Natural gamma response.
	299-W18-82	South of crib.	Natural gamma response.
	299-W18-83		Natural gamma response.
	299-W18-93	Southeast part of crib.	Elevated gamma response between depths of 7 and 17 m.
	299-W18-94	South of crib.	Elevated gamma response between depths of 9 and 12 m.
	299-W18-95	South of crib.	Natural gamma response.
	299-W18-96	Western part of crib.	Elevated gamma response between depths of 8 and 11 m.
	299-W18-97	East of crib.	Natural gamma response.
	299-W18-98	North of crib.	Natural gamma response.
	299-W18-99	Northeast of crib.	Natural gamma response.

Table A-9. Summary of Gamma Scintillation Logging Results. (Sheet 8 of 12)

Waste Management Unit	Well Number	Relative Location	Remarks
		Reverse Wells	
216-Z-10 Reverse Well	299-W15-51	5 m southeast of reverse well.	Not logged.
	299-W15-59	7 m east of reverse well.	Not logged.
	299-W15-60	10 m southeast of reverse well.	Not logged.
	299-W15-61	<5 m southwest of reverse well.	Not logged.
		Ponds, Ditches, and Trenches	
216-Z-4 Trench	no monitoring wells		
216-Z-9 Trench	299-W15-6	20 m northeast of trench.	Elevated gamma response between depths of 1 and 9 m.
	299-W15-8	Approximately 15 m south of trench.	Elevated gamma response between depths of 15 and 38 m.
	299-W15-9	North of trench.	Natural gamma response.
	299-W15-82	East of trench.	Natural gamma response.
	299-W15-84	West of trench.	Natural gamma response.
	299-W15-85	North of trench.	Natural gamma response.
	299-W15-86	Southwest of trench.	Elevated gamma response between depths of 15 and 38 m.
	299-W15-94	North of trench.	Natural gamma response.
	299-W15-95	North of trench.	Natural gamma response.
	299-W15-101	Northeast of trench.	Natural gamma response.
216-Z-17 Trench	299-W15-204	West of trench.	Not logged.
		Septic Tanks	
2607-Z Septic Tank	no monitoring wells		

Table A-9. Summary of Gamma Scintillation Logging Results. (Sheet 9 of 12)

Waste Management Unit	Well Number	Relative Location	Remarks
2607-Z-1 Septic Tank	no monitoring wells		
2607-WA Septic Tank	no monitoring wells		
2607-WB Septic Tank	no monitoring wells		
2607-W-8 Septic Tank	no monitoring wells		
Transfer Facilities, Diversion Boxes, and Pipelines			
241-Z Diversion Box No. 1	no monitoring wells		
241-Z Diversion Box No. 2	299-W-18-156	Southwest of diversion box.	Not logged
231-Z-151 Sump	no monitoring wells		
Basins			
207-Z Retention Basin	No monitoring wells.		
216-Z-21 Seepage Basin	299-W-15-208	Center of basin.	Not logged.
Burial Sites			
218-W-1 Burial Ground	No monitoring wells.		
218-W-2 Burial Ground	No monitoring wells.		
218-W-2A Burial Ground	No monitoring wells.		
218-W-3 Burial Ground	No monitoring wells		

Table A-9. Summary of Gamma Scintillation Logging Results. (Sheet 10 of 12)

Waste Management Unit	Well Number	Relative Location	Remarks
218-W-3A Burial Ground	299-W7-2	Northern border of burial ground.	Natural gamma response.
	299-W7-3	Northern border of burial ground.	Natural gamma response.
	299-W10-179		Not logged
218-W-3AE Burial Ground	299-W6-2	Southeast of burial ground.	Natural gamma response.
	299-W7-4	Southwest of burial ground.	Natural gamma response.
	299-W7-5	Northern border of burial ground.	Natural gamma response.
	299-W7-6	Northern border of burial ground.	Natural gamma response.
	299-W7-7	Northern border of burial ground.	Natural gamma response.
	299-W7-8	Northern border of burial ground.	Natural gamma response.
	299-W7-10	Southeast corner of burial ground.	Natural gamma response.
218-W-4A Burial Ground	No monitoring wells.		
218-W-4B Burial Ground	299-W15-19	North side of burial ground.	Natural gamma response.
	299-W15-20	Northwest corner of burial ground.	Natural gamma response.
	299-W15-23	West side of burial ground.	Natural gamma response.

Table A-9. Summary of Gamma Scintillation Logging Results. (Sheet 11 of 12)

Waste Management Unit	Well Number	Relative Location	Remarks
218-W-4C Burial Ground	299-W15-14	Northwest portion of burial ground.	Not logged
	299-W15-15	Northwest corner of burial ground.	Natural gamma response.
	299-W15-16	East side of northern portion of burial ground.	Natural gamma response.
	299-W15-17	East side of northern portion of burial ground.	Natural gamma response.
	299-W15-18	West of northern portion of burial ground.	Possibly elevated gamma response between depths of 55 and 58 m.
	299-W15-21	West side of burial ground.	Natural gamma response.
	299-W15-24	Northwest portion of burial ground.	Natural gamma response.
	299-W18-3	North central portion of burial ground.	Natural gamma response.
	299-W18-21	Southwest corner of burial ground.	Natural gamma response.
	299-W18-22	Southwest corner of burial ground.	Natural gamma response.
	299-W18-23	West side of burial ground.	Natural gamma response.
	299-W18-26	West side of burial ground.	Natural gamma response.
	299-W18-84		Natural gamma response.
218-W-5 Burial Ground	299-W7-1	North side of burial ground.	Natural gamma response.
	299-W7-9	North side of burial ground.	Natural gamma response.

Table A-9. Summary of Gamma Scintillation Logging Results. (Sheet 12 of 12)

Waste Management Unit	Well Number	Relative Location	Remarks
	299-W8-1	North side of burial ground.	Natural gamma response.
	299-W9-1	West side of burial ground.	Natural gamma response.
	299-W10-13	South side of burial ground.	Natural gamma response.
	299-W10-14	South side of burial ground.	Natural gamma response.
218-W-6 Burial Ground	299-W6-1	Central portion of burial ground.	Probably natural
218-W-11 Burial Ground	299-W15-2	Northwest side of burial ground.	Probably natural gamma response.
Z Plant Burn Pit	No monitoring wells.		

Source: Fecht et al. 1977, Chamness et al. 1991.
(1) Well reportedly contaminated with alpha-emitting particles.

APPENDIX B

HEALTH AND SAFETY PLAN

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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 Z Plant Source Aggregate Area Management Study (Z 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 Z 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

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.

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 Z 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.

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 Z PLANT AAMS background and known and suspected contamination are described in Chapters 2.0 through 10.0 of the plan. The Z 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 200 Areas at the Hanford Site were 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 Z 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 extract, 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, O_2 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 Z 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 Z 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 U.S. Environmental Protection Agency (EPA) has been designated as the lead regulatory agency, as defined in the Tri-Party Agreement. Accordingly, EPA is responsible for overseeing remedial action activity at this aggregate area and ensuring that the applicable authorities of both the Washington State Department of Ecology (Ecology) 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 Z 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 Z Plant Aggregate Area.

The unit manager from EPA will serve as the lead unit manager. The EPA unit manager will be responsible for regulatory oversight of all activities required for the Z Plant Aggregate Area.

The unit manager from Ecology 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 EPA 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 Z 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.

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 Z 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 Z 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 Z 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 Z 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.

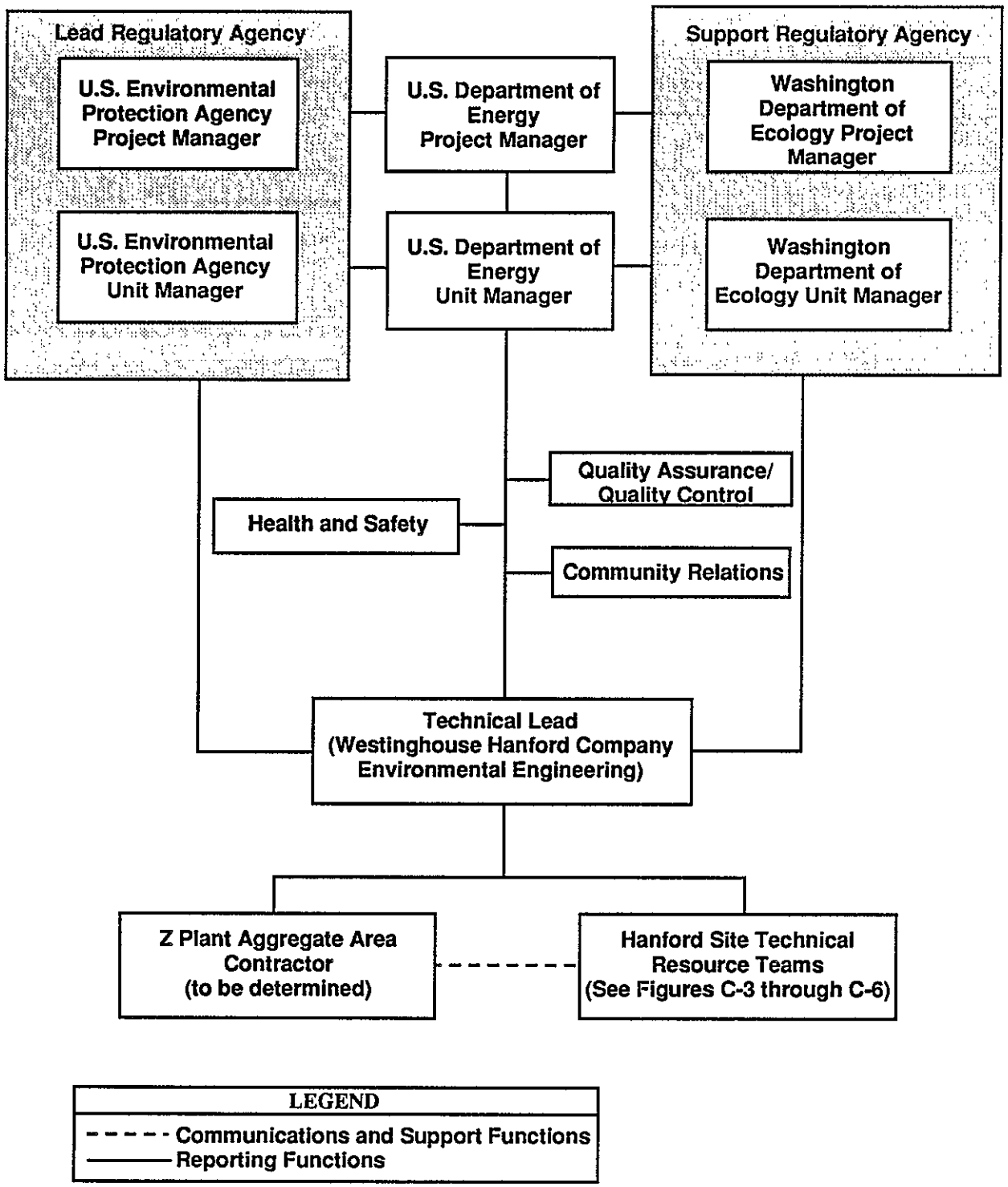

Figure C-1. Project Organization for the Z Plant Aggregate Area Project.

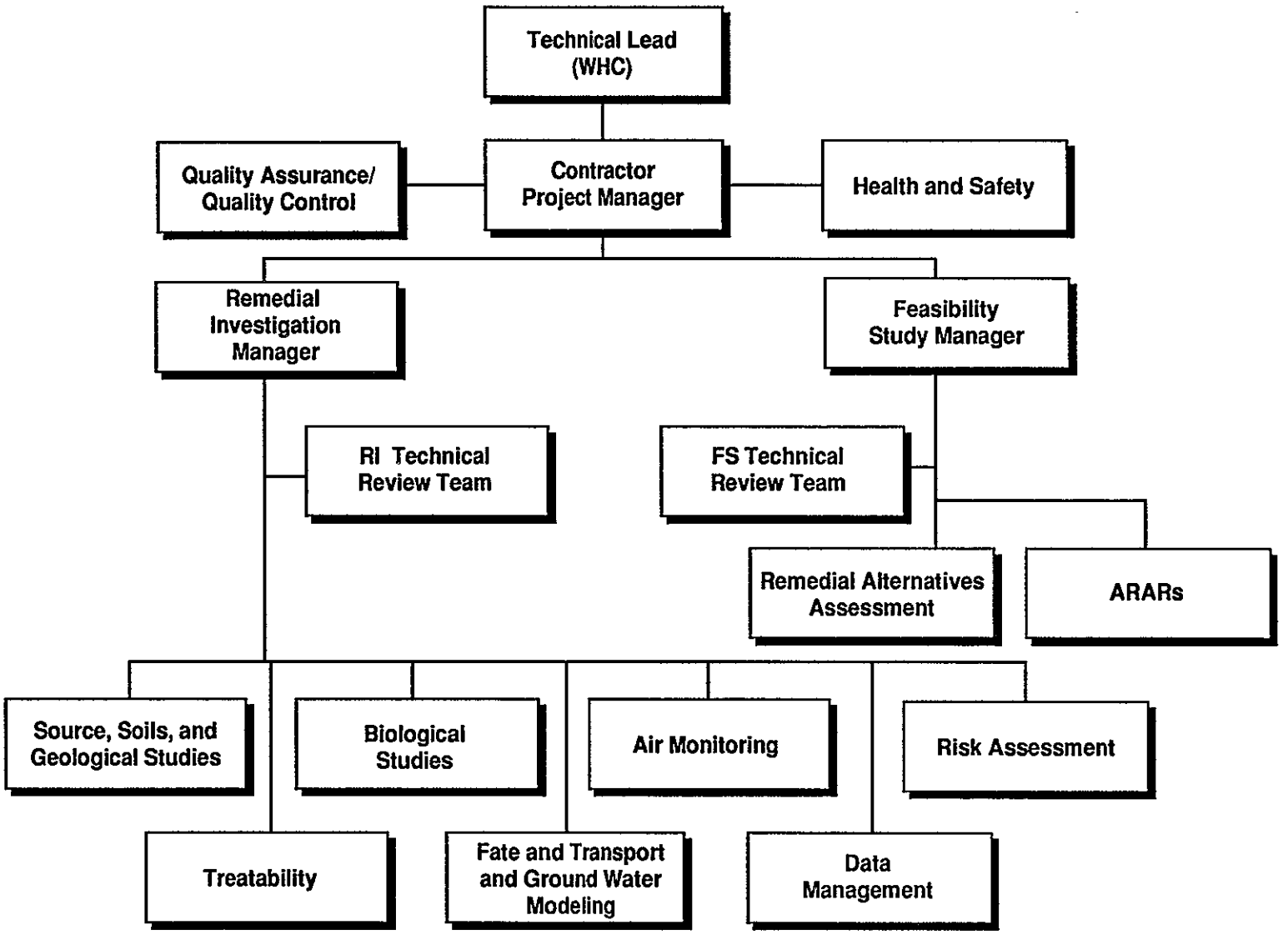

Figure C-2. Example Project Organization for the Z Plant Aggregate Area

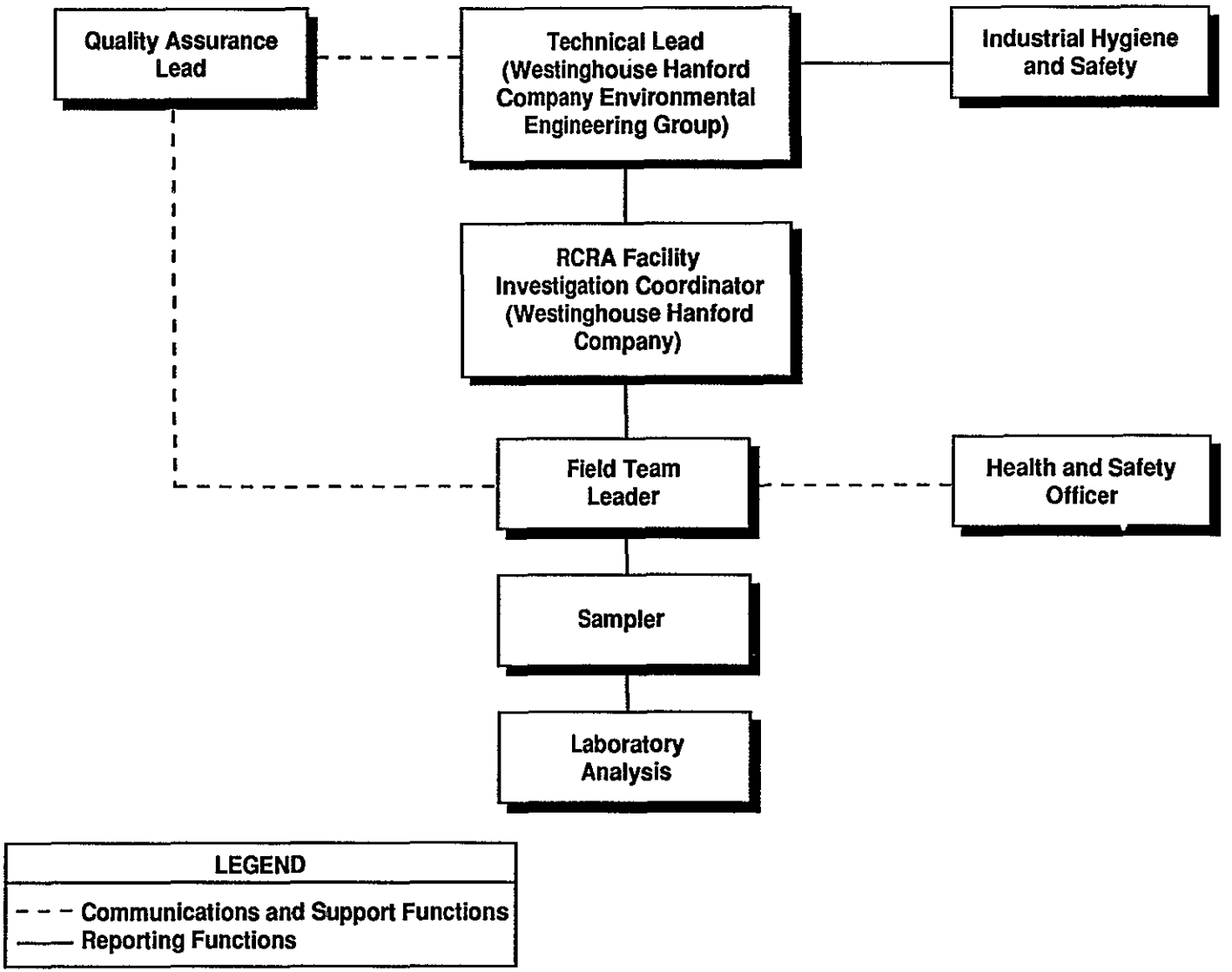

Figure C-3. The Hanford Site Soil Sampling Team.

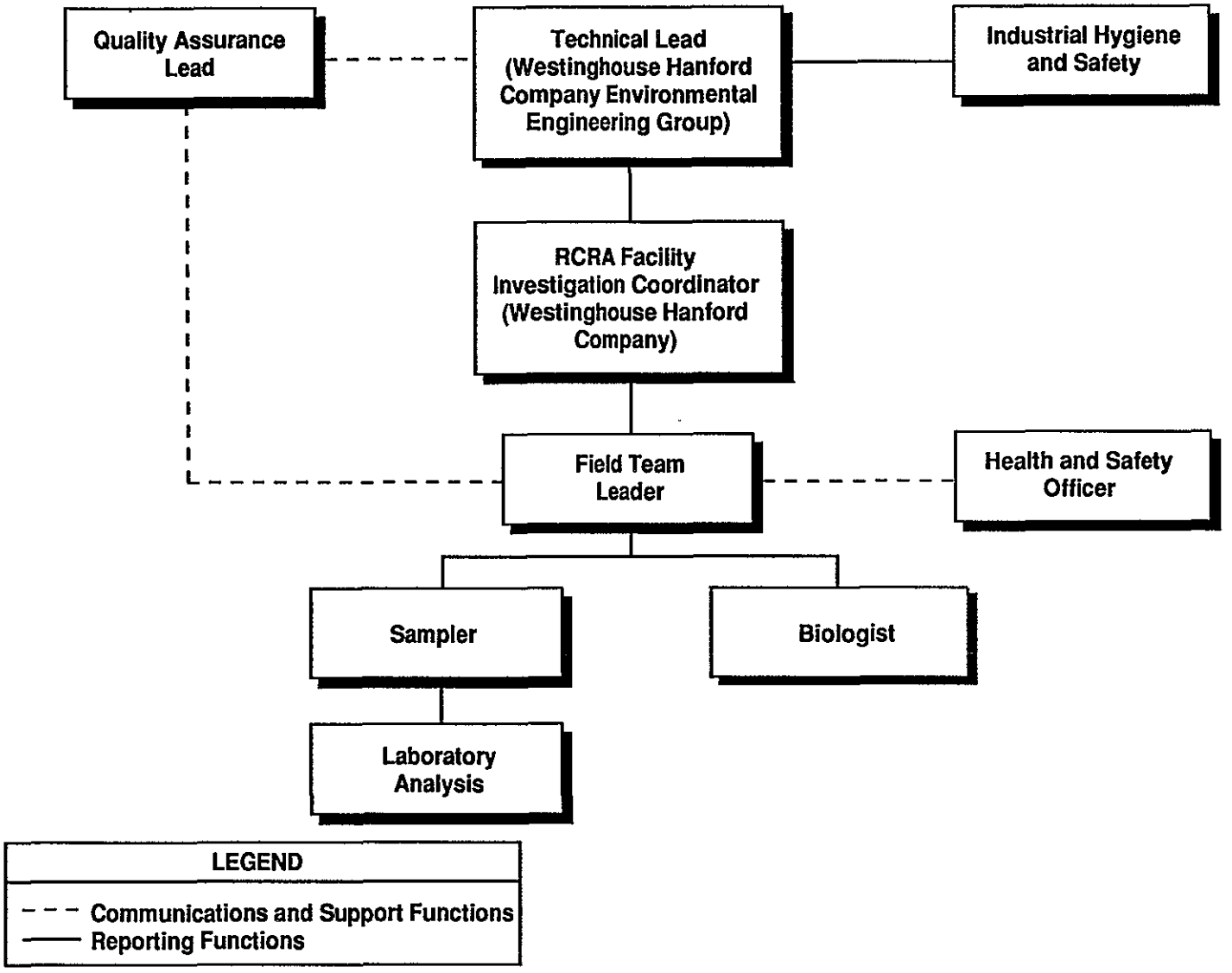

Figure C-4. The Hanford Site Biological Sampling Team.

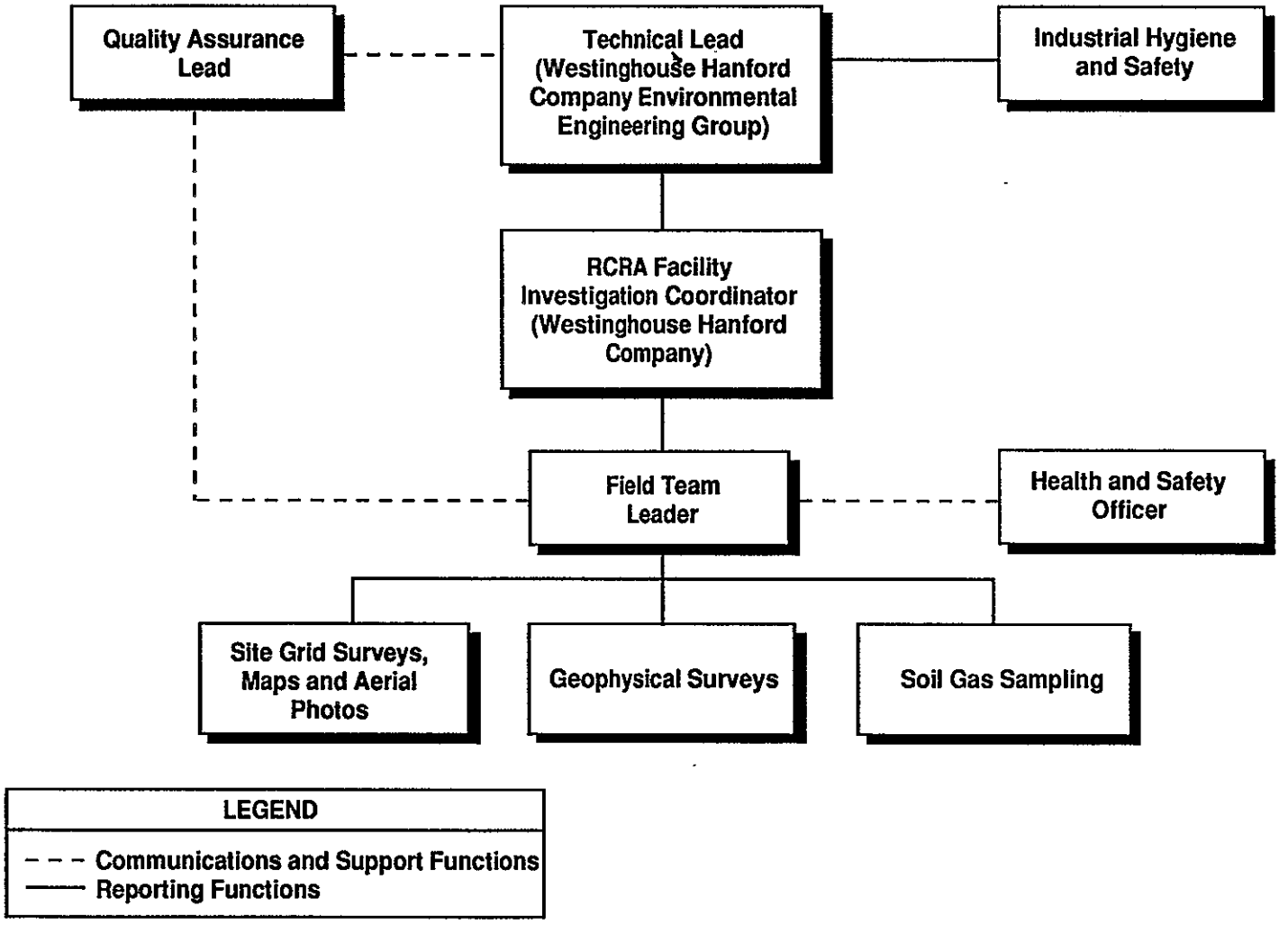

Figure C-5. The Hanford Site Physical and Geophysical Survey Team.

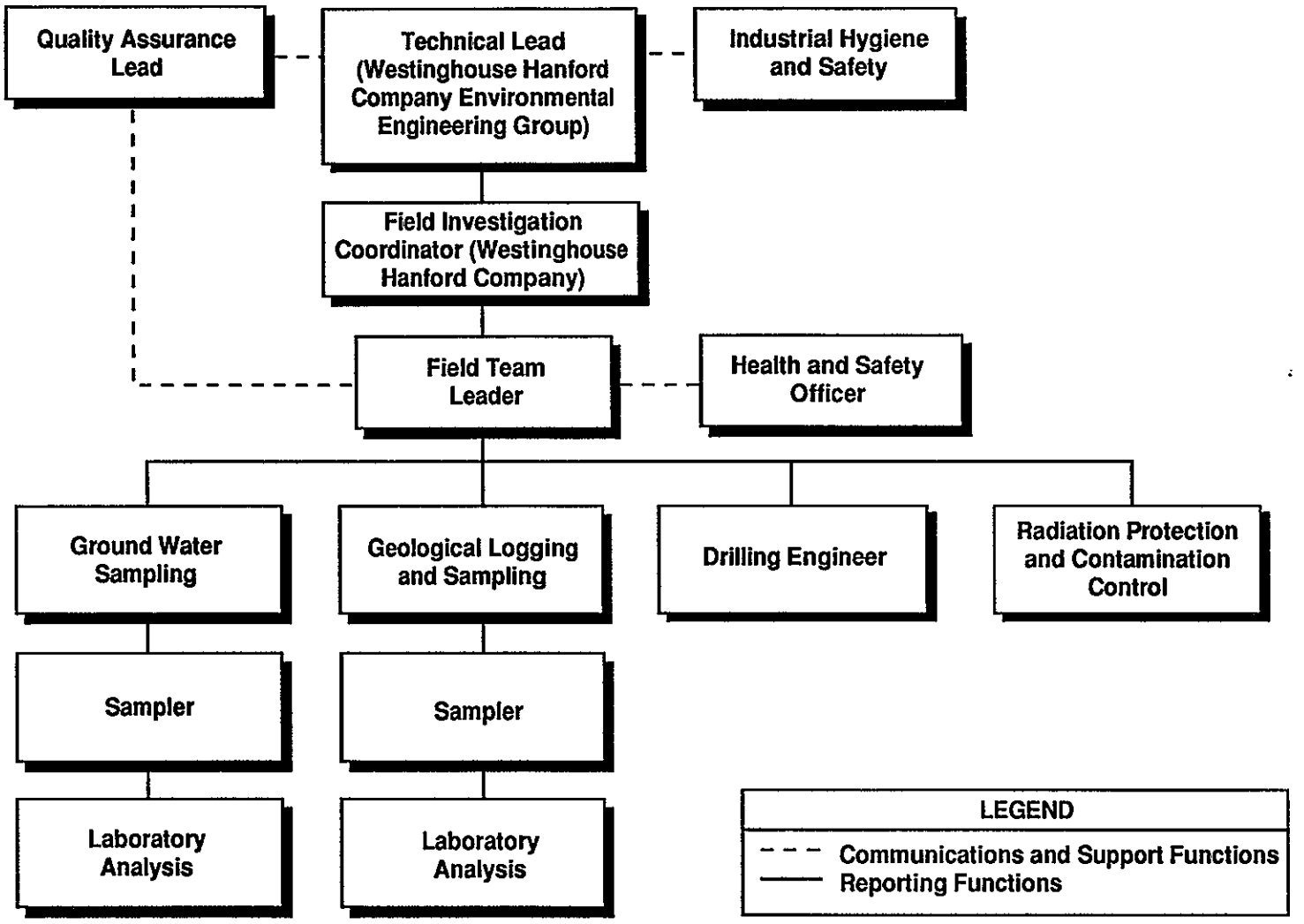

Figure C-6. Drilling, Sampling, and Well-Development Team.

Table C-1. Hanford Site RI/FS Technical Resources. Page 1 of 2

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.

	Technical Resources	
Subject/Activity	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.

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.

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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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 Z 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:

Type of data	Procedure
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:

Data Type	Data location
• 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.

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.

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.

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

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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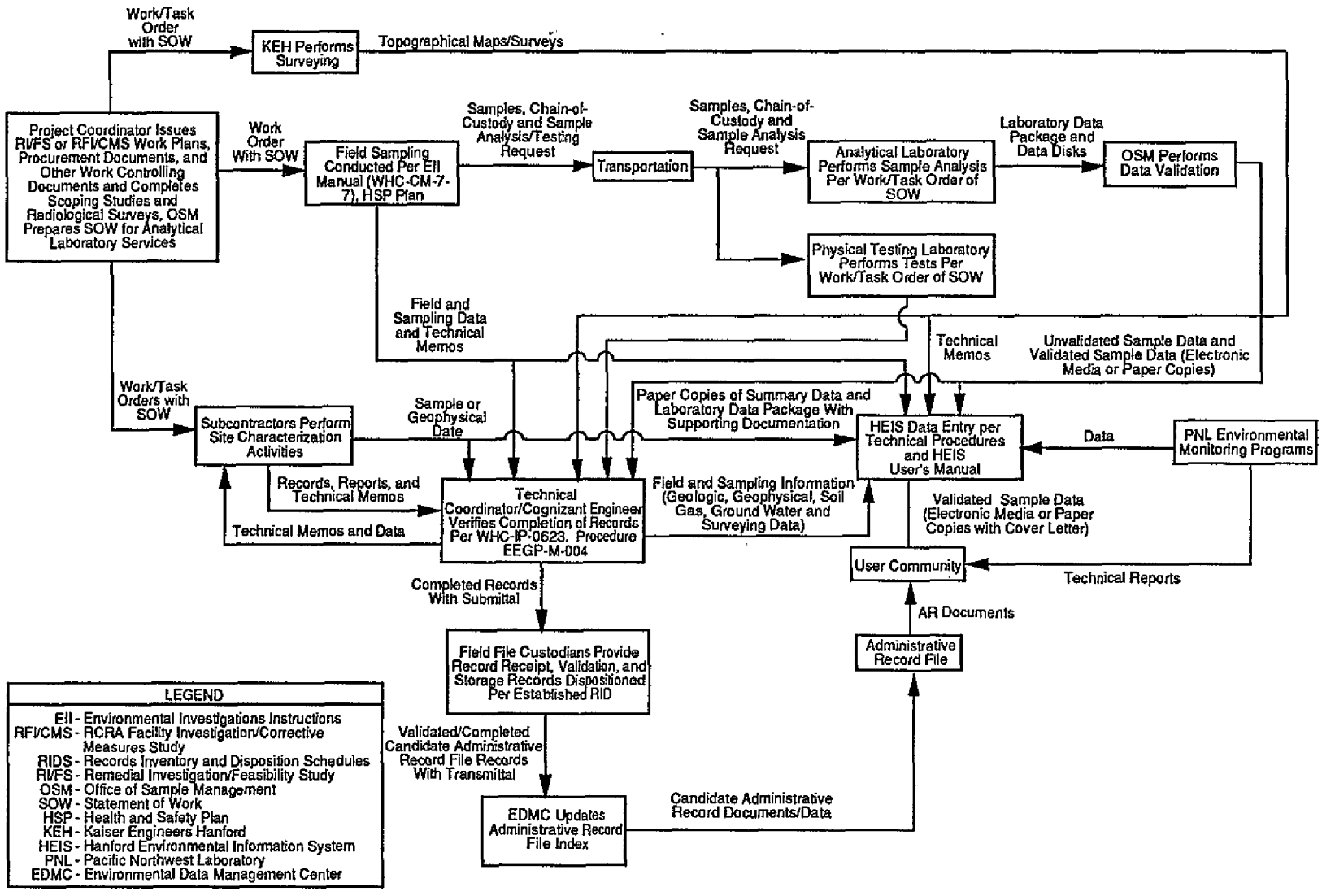

Figure D-1. Environmental Engineering, Technology and Permitting Data Management Model.

Table D-1. Types of Related Administrative Data.

Type of Data	Controlling document/procedure	Record Custodians				
		TR	HEHF	PNL	EDMC	EHPSS
Personnel						
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
Compliance/regulatory						
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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